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DETAILS

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3

8

18

COVER: Overpass constructed on the Trans-Canada Highway in Banff National Park to maintain wildlife connectivity is one of many mitigation measures yielding data valuable for designers and planners. (*Photograph by Jeff Stetz.*)

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.

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ALSO IN THIS ISSUE:

COMING NEXT ISSUE

Transportation's role in disaster preparedness, response, and recovery is the focus of an array of articles in the May–June *TR News*. Among the topics addressed are the challenges of meeting the U.S. national preparedness goal, restoring the disaster response system, sea-based emergency response, and risk management for multimodal infrastructure. Also featured is a first-hand report on the new flood protection system for the subways of Prague, Czech Republic.

Prague Castle and the Vltava River at ordinary high water level. In 2002, river waters flooded the city's subway tunnels, prompting the development of new strategies for prevention.

The Transportation Engineering and Road Research Alliance

Partnering to Advance Pavement and Road-Related Research

RICHARD STEHR AND FRED CORRIGAN

The authors are founding members of the Transportation Engineering and Road Research Alliance (TERRA). Stehr, former Director, Engineering Services Division, Minnesota Department of Transportation, St. Paul, served as a founding cochair of the TERRA Board of Directors; Corrigan, Executive Director, Aggregate and Ready Mix Association of Minnesota, Burnsville, currently serves as cochair of the TERRA board.

Transportation research is key to providing the safe, efficient, and economical movement of people and goods worldwide. As transportation systems grow in complexity, and public demands for high levels of service increase, the public and the private sectors rely on innovative research to meet the changing transportation needs. At the same time, the transportation world is in transition from an era dominated by grand, monolithic construction projects to one in which improved management of capacity and incremental improvements in safety and efficiency are the goals of innovation.

Organizations that seek to foster innovative research must address the needs of diverse stakeholders—including government agencies, private industries, and academic institutions. The Transportation Engineering and Road Research Alliance (TERRA) seeks to meet this challenge by encouraging collaboration among stakeholders within the state of Minnesota and on a national and international level.

Track Record of Success

TERRA builds on the successful track record of the Minnesota Road Research Project (MnROAD), a

Aerial view of the MnROAD facility, a long-productive test site now open to collaborative research through the Transportation Engineering and Road Research Alliance.

Diamond grinding procedures to restore the ride and texture of concrete pavements are tested and evaluated at MnROAD.

pavement research facility operated by the Minnesota Department of Transportation (DOT) since 1994. MnROAD is one of only a handful of facilities nationwide that give scientists and engineers the ability to carry out long-term research on materials and on construction techniques in real-world conditions.

MnROAD has hosted many experiments on a range of topics, providing insight into the performance of traditional and innovative road construction. The return on investment has been solid—the estimated statewide savings on materials and maintenance costs easily outweigh the cost of constructing and operating the facility.

MnROAD is one facet of pavement research in Minnesota. The success of MnROAD is due in large part to collaboration with other pavement research facilities, such as Minnesota DOT's Materials Laboratory and the Accelerated Pavement Testing facility operated by the University of Minnesota's civil engineering department. These facilities offer additional physical capabilities and have served as reservoirs of expertise in the development of TERRA's research program.

MnROAD is now beginning a second phase of operations, with planning under way for reconstruction of the facility. The new technical capabilities will be complemented by a new governance structure and a new model of transportation research that focuses on forming effective public–private partnerships and on enabling collaboration among transportation agencies.

New Model for Road Research

Minnesota DOT sought a new governance structure for MnROAD that would respond flexibly to the needs of many stakeholders. A task force with representatives of government, industry, and academia was convened to evaluate the approaches of other major research facilities and to develop new ideas for expanding the use of MnROAD. The meetings were facilitated by the Center for Transportation Studies at the University of Minnesota. The task force recommended that pavement research in Minnesota should be shaped by collaboration among a variety of stakeholders within the state and beyond its borders.

The new governance structure for MnROAD reflected the goal of expanding the use of the facility and its capabilities, as well as the economic and logistic realities of carrying out research at a large pavement research center. Stakeholders within the state pointed out that increasing the volume and scope of the research would require additional guidance and funding. At the same time, an analysis of the market for MnROAD's research services showed that collaborative research between multiple stakeholders would provide clear benefits to all parties. Operating a pavement research facility like MnROAD may not be cost-effective for every state, but collaborative research governance makes it possible to leverage the strengths of a single facility for multiple users. TERRA's research program will focus on MnROAD's capabilities, transforming the facility from a resource for Minnesota to a regional, national, and international research center.

Building on past successes is key. Preventive maintenance and rehabilitation research will provide a foundation for the effective and economical management of road infrastructure. Construction and reconstruction will benefit from research into mechanistic–empirical design, including materials characterization, the use of recycled materials, and

Infrared imagery was used to study techniques for the application of hot-mix asphalt.

surface characteristics. Finally, MnROAD will continue with nonpavement research, such as the testing of intelligent vehicles.

Holistic Approach

Public–private partnerships and intergovernmental collaboration are TERRA's cornerstones. A holistic approach to research brings different perspectives and needs to bear in charting a course for the future. The three chief categories of stakeholders represented within TERRA are transportation agencies, private-sector industry, and academic research:

◆ Local, state, and federal transportation agencies seek to provide efficient and cost-effective roads for their constituents. Minnesota DOT's investment in building and funding MnROAD research has led to significant savings in materials and maintenance. A collaborative research structure will enhance cooperation among regional governments and help to overcome institutional barriers.

◆ To remain competitive and to deliver state-of-the-art solutions, private industries seek to capitalize on the latest research results. Industry has not had a direct influence on the agenda for research, nor has there been a mechanism to allow industry associations to contribute to funding the research that benefits their members.

◆ University faculty and other researchers provide the technical expertise to identify promising new research directions and to stay at the forefront of pavement design. By working closely with transportation agencies and industry representatives, researchers can put their ideas into action more effectively.

Representative Board

The composition of TERRA's board of directors reflects the focus on public–private partnerships. New members will be added to the board as research initiatives attract additional stakeholder interest from industry and from government agencies outside Minnesota. Initial members of the board include representatives of

◆ Minnesota DOT, the owner and operator of MnROAD and a major funder of pavement research, represented by leaders in pavements and construction;

◆ Minnesota's Local Road Research Board (LRRB), established by state legislation in 1959 to bring county and city engineers together with leaders from Minnesota DOT and researchers from the state university system to identify and fund research relevant to the state's road system—LRRB has been a long-time supporter of pavement research and contributor to the MnROAD facility;

Pavement cores extracted from hot-mix asphalt sections at MnROAD.

◆ The University of Minnesota, a partner in the development of MnROAD and home to many of the researchers using the facility, represented by the director of the Center for Transportation Studies and the head of the Department of Civil Engineering;

◆ The pavement and road construction industries—key partners in delivering pavement products and practices developed through research—currently represented by members of the Minnesota Asphalt Pavement Association, the Aggregate and Ready Mix Association, the American Concrete Pavement Association, the Concrete Paving Association of Minnesota, and the Associated General Contractors of Minnesota; and

◆ The Federal Highway Administration, a contributor to the initial construction and to the reconstruction of MnROAD.

Entrepreneurial Endeavor

With stakeholders from different segments of transportation, the new governance structure allows TERRA to take a more entrepreneurial approach to research at MnROAD than was feasible before. No longer determined solely by the needs of the agency operating the facility, the research program can address problems offering the greatest potential benefits to TERRA stakeholders.

Delivering a high-quality road system is a complex endeavor that requires a range of interests working together. Transportation agencies need industry to provide the best-quality products and services; private contractors rely on researchers to develop innovative approaches; and researchers apply scientific methods to problems that arise in the transportation system. Research programs shaped by the insights of multiple stakeholders have an advantage in addressing these interlocking priorities.

The collaborative, entrepreneurial approach to pavement research at TERRA offers many benefits. TERRA provides a framework for collaboration among stakeholder groups that otherwise may have difficulty coming together. The TERRA approach encourages new ways of thinking about research problems—emphasizing partnership and cooperation to address the large-scale challenges facing engineers and policy makers.

Beyond the Borders

TERRA's partnership model of road research is fundamentally linked to the reconstruction of the MnROAD facility. As new partners join, their research priorities are helping to determine the projects to initiate, as well as the types of pavement cells and instrumentation to construct. Each member organization contributes fees to support the operation of TERRA; Minnesota DOT continues to support the operation of MnROAD, with specific research projects funded through cooperative agreements or by state funds.

TERRA also seeks to build collaboration beyond the state's borders, bringing together other states and international partners to take advantage of MnROAD's capabilities. Three new relationships exemplify this collaborative research. Each of these new TERRA board members will have the opportunity to shape the research agenda as the reconstruction of MnROAD progresses:

◆ The Center for Transportation Research and Education (CTRE) at Iowa State University—CTRE researchers have collaborated previously with Minnesota DOT and the University of Minnesota's Center for Transportation Studies on research involving pavements. This partnership allows TERRA to strengthen the connection between two nationally recognized university research centers.

◆ Michigan DOT—Michigan's road network is affected by many of the same issues of climate and materials performance that Minnesota and other states of the Upper Midwest face. The partnership will provide Michigan with access to a state-of-the-art laboratory and will give Minnesota researchers the benefits of Michigan DOT's experience in pavement research and road engineering. In addition, collaboration on pavement research will lay the groundwork for other cooperative ventures between the Michigan and Minnesota DOTs.

◆ The Norwegian Public Roads Administration—Working with European colleagues will expand TERRA's research perspectives and lead to additional opportunities to collaborate with research groups outside the United States.

New Avenues

TERRA's focus on cooperative research is changing the way that Minnesota DOT approaches pavement research. For example, Minnesota DOT and the Aggregate and Ready Mix Association of Minnesota—an industry member of the TERRA board—

MnROAD

Meeting the Needs of Pavement Researchers

The creation of the MnROAD pavement research facility was a major milestone in the history of pavement research in Minnesota. With the state investing more than $100 million annually in pavement construction and maintenance, Minnesota DOT realized that even incremental improvements in materials and techniques would lead to significant savings for taxpayers. But a unique and ambitious facility would be required to make these advances. In 1991, work began at a site roughly 40 miles northwest of the Minneapolis–St. Paul metropolitan area; in 1994, with an investment of $25 million, MnROAD opened to traffic, and researchers began collecting data.

The MnROAD facility comprises two distinct sections. The mainline section is a 3.5-mile portion of Interstate 94 carrying live traffic. The traffic can be diverted onto an alternate, parallel segment, allowing crews to work safely on the pavement sections and instrumentation without disturbing traffic flow. This High-Volume Roadway receives an average of 785,000 equivalent single-axle loads (ESALs) on portland cement concrete (PCC) or 488,000 ESALs on hot-mix asphalt (HMA) in the outer lane every year.

The original mainline section was constructed with 23 pavement test cells, including 5-year and 10-year pavement designs with both HMA and PCC materials. In 1997, eight additional

MnROAD building, with a five-axle trailer passing on the Low-Volume Roadway immediately behind, and Interstate 94 and the High-Volume Roadway in the background.

are partnering on a pilot study of pervious concrete slabs constructed in a parking area at MnROAD. This partnership grew directly out of discussions of research priorities between TERRA members.

The initial study will focus on performance and durability issues such as the effects of freezing on drainage and the ability of pervious materials to handle heavy truck loading. A successful initial study will lead to the inclusion of pervious concrete in reconstructed sections of the MnROAD Low-Volume Roadway to evaluate pervious material in controlled conditions.

Another important avenue for collaborative research is FHWA's Transportation Pooled Fund program, which encourages stakeholders to form partnerships to address shared research needs. TERRA is soliciting participants for several proposed studies to be carried out at MnROAD, on topics including recycled materials, environmental effects, and pavement materials characterization.[1]

Bringing people and organizations together to solve common problems is a powerful strategy for innovation. Through a collaborative approach to pavement and road engineering research, TERRA has set out to realize the benefits of this strategy. As the reconstruction of the MnROAD facility ushers in new research capabilities, TERRA will recruit new partners to create a research agenda that benefits the critical transportation infrastructure.

[1] More information on these proposed studies is available at www.TerraRoadAlliance.org.

Test road shows a variety of wear and tear for study.

Acknowledgment

Peter Park Nelson, Center for Transportation Studies, University of Minnesota, assisted in writing this article.

pavement cells were added: six to evaluate the performance of the Superpave® HMA materials and construction specifications developed by the Federal Highway Administration; and two to study ultrathin whitetopping. In 2003, as the pavements of the original cells reached the end of their projected life spans, significant repairs were carried out to stabilize the test cells until scheduled reconstruction and to study the effects of different maintenance activities. Reconstruction of the test cells in 2007 will usher in a new phase of MnROAD operations.

A strain gage is installed at the MnROAD facility.

In contrast to the live traffic of the mainline section, the Low-Volume Roadway (LVR) addresses research projects that require a controlled environment. A 2.5-mile, two-lane closed loop adjacent to the mainline section, the original LVR was constructed with 17 pavement test cells, several of which have been reconstructed. Traffic is limited to a single 18-wheel, five-axle tractor-trailer that operates under two different loading configurations—each in a different lane—to evaluate the effects of legal and overweight loads. The amount of time operating in each configuration is varied to ensure that both lanes receive an equal number of ESALs.

MnROAD incorporates an extensive electronic data collection and storage system, supplementing the manual inspection and sampling of the test pavements. More than 4,500 sensors initially were installed in pavement and subgrade layers to measure temperature, moisture, frost depth, strain, and deflection. Additional installations have augmented these sensors as some deteriorated and as new sensing needs were identified. Data from these sensors are conveyed via fiberoptic links to Minnesota DOT's Materials Research and Engineering Laboratory in Maplewood, and are stored in a database for use by researchers.

The reconstruction of the pavement test cells to address the research needs of new TERRA members will begin this year. The repairs and enhancements should be complete within one to two years, depending on the scope and phasing defined by stakeholders. MnROAD will continue to meet the needs of pavement researchers for years to come.

—Richard Stehr and Fred Corrigan

Ethanol Takes Off

Trends in the Use of a Renewable Fuel for Transportation

WILLIAM D. WARREN

After many years of slow-to-modest increases in use as a motor fuel, ethanol has entered a period of rapid growth. A renewable fuel, ethanol enjoyed a modest level of use around World War I. In the 1920s, however, ethanol yielded to gasoline.

After the petroleum crisis of 1979, the prices of petroleum ranged from $5 to more than $40 per barrel on the spot market, and ethanol reemerged as a fuel option (*1–2*). Although the price of oil has risen, corn prices have been stable—at country elevators in Illinois, the price of corn has remained around the $2 per bushel value for more than 35 years. The April 21, 2006, edition of *The Federal-State Grain Market News* reported that the prices posted at country elevators in the Springfield region for Number 2 yellow corn ranged from $2.11 to $2.24 per bushel. The price of oil ranged from $55 to $78 per barrel in 2006.

Recent Growth

Table 1 presents ethanol consumption values for selected years. Most of the ethanol consumed in the United States is in what is frequently called gasohol—a 10 percent mixture with gasoline. The quantities presented in the table are estimates based on state gasoline tax receipts; the data do not represent the total amount of ethanol consumed by highway transportation activities. Consumption by government agencies and school districts would increase the Table 1 values by 3 to 4 percent. Between 1983 and 2004, ethanol consumption in the transportation sector expanded more than eightfold.

PHOTO: REUTERS/CORBIS

TABLE 1 Estimates of Transportation Sector Ethanol Use, 1983–2004 (gallons)

Year	Ethanol Consumption	Change in Consumption	Growth Factor Ratio/1983
1983	425,487,000	—	—
1988	813,768,000	388,281,000	0.91
1993	978,814,000	165,046,000	0.39
1998	1,296,820,000	318,006,000	0.75
2003	2,748,931,000	1,452,111,000	3.41
2004	3,654,905,000	2,358,055,000	5.54

The table contains three sets of values. The second column indicates the amount of ethanol consumed in that year. The third column presents the change in consumption for each period. The right-hand column offers a ratio that describes growth by dividing the increments of change in the third column by the 1983 value for ethanol consumption.

Table 1 reveals three growth patterns. The periods of 1983 to 1988 and of 1993 to 1998 manifest distinct patterns of growth, with annual averages of 60 million to 75 million gallons of increased ethanol consumption. The 1988 to 1993 period is characterized by slow growth—the increments of new consumption average approximately 33 million gallons per year. Consumption expands rapidly—almost tripling—during 1998 to 2004. The change in consumption for 2004 yields a growth ratio almost 5.5 times larger than the total production for 1983. Ethanol consumption grew by 905 million gallons in 2004.

The ratios of growth illustrate changes in consumption for the four time periods shown in the table, and the 1998 to 2004 period presents a large deviation. Increases in the price of petroleum have affected the attractiveness of ethanol as a fuel mixture. Also influential are rules by the Environmental Protection Agency (EPA) requiring the use of oxygenates in

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PHOTO: WISCONSIN FARM BUREAU

Gas pump in U.S. Midwest offers gasoline blends with up to 10 percent ethanol, as well as E-85, a mixture with up to 85 percent ethanol.

motor fuels in metropolitan regions with air pollution problems. In several states, most of the ethanol consumption is through a gasoline mix that is 5.5 percent ethanol, to meet the EPA oxygenate requirements.

State-by-State Distribution

Three major changes occurred in the geographic distribution of ethanol consumption in the highway sector during 1998 to 2004 (Figure 1). First, California became the leading state for ethanol use, increasing consumption from 63 to 589 million gallons. California uses a mix with 5.5 percent ethanol as a replacement for methyl tertiary butyl ether (MTBE), which has been associated with ground water pollution. Second, New York and Connecticut became primary consumers. Third, the Midwestern states of Illinois, Michigan, Minnesota, and Ohio registered large increases in ethanol use.

The data in the Figure 1 map were classified according to value thresholds that were set arbitrarily. The first category includes the 13 states that used no ethanol. The second category contains 19 states with consumption values up to 50 million gallons of ethanol. This group consumed a total of 306 million gallons of ethanol; by contrast, Illinois consumed 421 million gallons in 2004.

The remaining states accounted for 91.7 percent of U.S. ethanol consumption for transportation. Of these, the 10 states that comprise the third group in Figure 1 consumed between 50 and 150 million gallons of ethanol: 5 are either in or border the Midwest; and 3 exceeded 100 million gallons of ethanol consumption—Indiana, 140 million gallons; Iowa, 117 million gallons; and Wisconsin, 109 million gallons. Missouri, North Carolina, and Virginia consumed 89 to 99 million gallons of ethanol in 2004. This group of states accounted for 22.8 percent of the ethanol that was used as motor fuel.

The highest category on the map consists of seven states that consumed 66 percent—or 2.4 billion gallons—of the ethanol that was used by the transportation sector. Four of the seven states are located in the Midwest, where ethanol production facilities are concentrated. Three states—California, Connecticut, and New York—have coastal locations and are responding to the EPA requirements for fuel oxygenates.

Changes in Ethanol Use

Almost two-thirds of the states used small amounts of ethanol, but four states—the top four listed in Table 2—consumed more than one-half of the nation's production in 2004. The changes in ethanol consumption from 1998 to 2004 are mapped in Figure 2.

The first group in Figure 2 consists of states in which ethanol consumption declined or registered small growth. Texas experienced the largest decline in consumption, from 62 million gallons to 23 million gallons; Ohio reported a decline of 21 million gallons. In 28 states, the increase in ethanol consumption in 2004 was less than 10 million gallons.

The second group in Figure 2 comprises states that increased consumption by 10 to 50 million gallons. This group includes some smaller states, such as

FIGURE 1 Gallons of U.S. ethanol consumption by state, 2004.

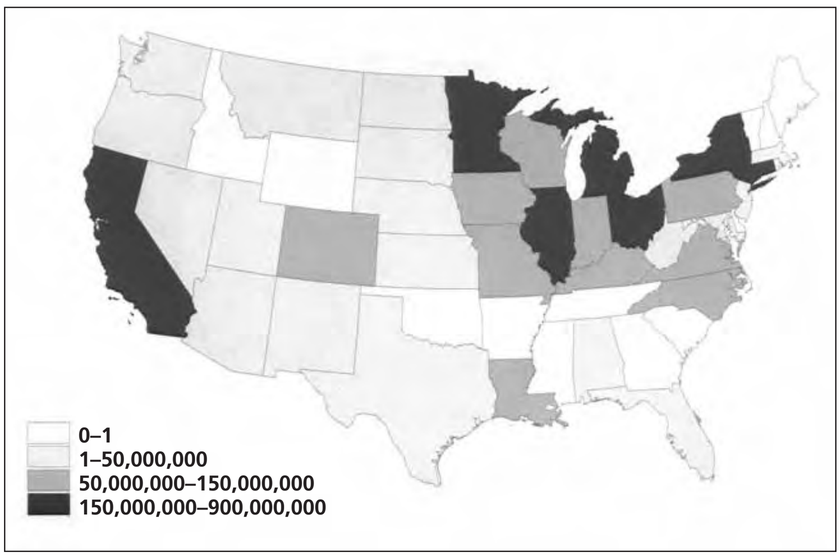

TABLE 2 Estimates of Transportation Sector Ethanol Use, 1998–2004 (gallons)

State	Ethanol Use, 2004	Ethanol Use, 1998	Change Since 1998	% Change 1998 to 2004
California	899,426,000	63,205,000	836,221,000	1323.03
Illinois	421,305,000	212,170,000	209,135,000	98.57
New York	303,526,000	15,483,000	288,043,000	1860.38
Minnesota	276,693,000	198,754,000	77,939,000	39.21
Ohio	191,630,000	212,130,000	20,500,000	–9.66
Michigan	165,864,000	33,150,000	132,714,000	400.34
Connecticut	159,063,000	3,205,000	155,858,000	4862.96
Indiana	140,247,000	56,787,000	83,460,000	146.97

FIGURE 2 Change in ethanol use by state, 1998–2004 (gallons).

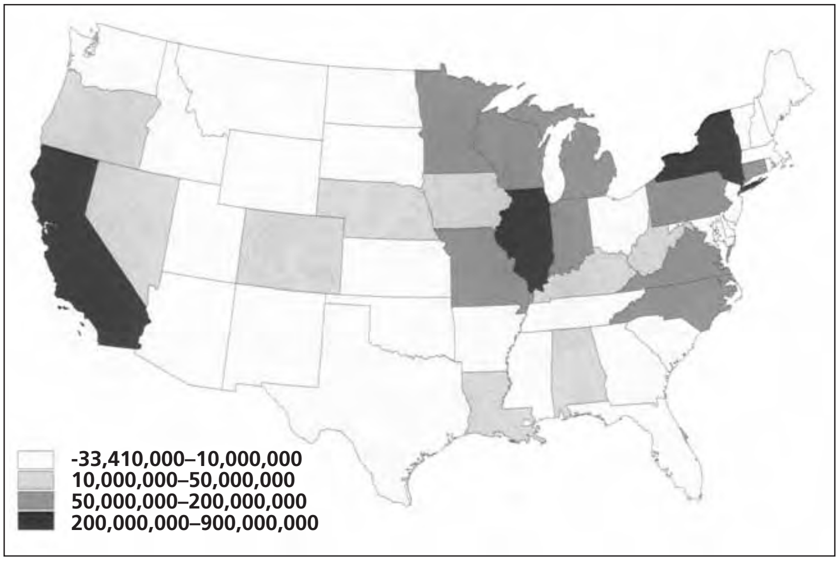

FIGURE 3 Per capita ethanol use by state, 2004 (gallons).

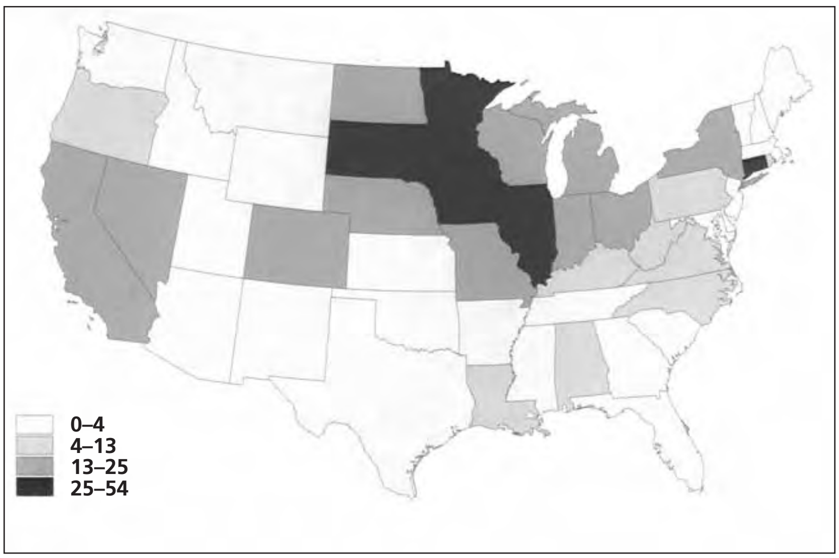

TABLE 3 Per Capita Ethanol Consumption, 1998–2004 (gallons)

State	Per Capita Use, 2004	Per Capita Use, 1998	Difference	Percent Change
Minnesota	54.3	42.1	12.2	29.0
Connecticut	45.5	9.0	44.6	4,955.6
Iowa	39.5	23.7	15.8	66.7
Illinois	33.1	17.6	15.5	88.1
South Dakota	31.0	24.4	6.6	27.1
California	24.9	1.9	23.0	1,210.5
Indiana	22.5	8.2	14.3	174.4
Nebraska	21.3	11.9	9.4	79.0
Wisconsin	19.7	6.2	13.5	217.7
New York	18.9	0.9	18.0	2,000.0

Nebraska and Iowa, that have established ethanol use. Proportionally some of these states are important consumers, but the small populations reduce the potential for growth. This group also includes more populous states, such as Colorado and Louisiana, with established markets for ethanol and consequently limited opportunities for growth.

The third group in Figure 2 consists of states that expanded ethanol consumption by 50 million to 200 million gallons. Notable in this group is Connecticut, which increased use by 156 million gallons. Use in Michigan increased by 133 million gallons, with impressive gains in Minnesota, Indiana, Pennsylvania, and North Carolina. Five of the nine states in this category are located in the Midwest, and the remainder are on the Atlantic coast.

The highest category includes only three states with a range of growth extending from 209 million to 836 million gallons. More than 57 percent of the growth in ethanol consumption occurred in these three states, which also had the highest use values in Figure 1.

California led all states with 836 million gallons of new ethanol use in the transportation sector. New York was second with 288 million gallons, and Illinois was third, with 209 million gallons. Until 2000, the Midwest monopolized ethanol use; the maps and tables indicate that ethanol consumption has expanded from the original core region as markets have developed on both the East and West Coasts.

Per Capita Use Patterns

The per capita aspects of ethanol use reveal other patterns and provide new insights into the prospects for growth and change. Values for per capita use of ethanol as a motor fuel are presented in Figure 3 and Table 3.

The distribution pattern for ethanol use per capita by state ranges from 0 in the 13 states that reported no consumption to 54.3 gallons per year in Minnesota. The median value for per capita ethanol consumption was 27.2 gallons; 45 states recorded per capita use that was less than the median. The average use per capita in the United States was 12.4 gallons of ethanol in 2004.

The lowest category in Figure 3 ranges from 0 to 5 gallons of ethanol use per person per year and contains 25 states. Texas, Georgia, and Florida are some of the large states in this category. The next category ranges from 6.1 to 15 gallons of ethanol consumption per person, and contains 9 states, including the populous states of Pennsylvania, North Carolina, and Virginia.

Thirty-four of the 50 states are in the lower quartiles of ethanol use. When the per capita use in these states is compared with that for Minnesota, Connecticut, or Illinois, the potential for market growth is striking.

The third mapping category consists of 11 states with annual use ranging from 15.1 to 30 gallons; some of these states are listed in Table 3. Several major ethanol-consuming states are in this group, including California (24.9 gallons), Wisconsin (19.7 gallons), and New York (18.9 gallons). Minnesota can serve as a benchmark to indicate the potential growth for ethanol consumption in these states. All of these states have values that are lower than the mean value of 27.2 for the distribution. In Figure 1, South Dakota and Nebraska ranked among the lower quartiles, but as shown in Table 3, the states rank fifth and eighth, respectively, in per capita consumption.

Five states form the highest category of per capita use, with Minnesota leading the way and Connecticut second. Four of the top five are located in the Midwest and have been established as major consuming areas since the 1980s; the New England states in the past have not been significant consumers of ethanol.

In Table 3, the 1998 values of per capita ethanol use are subtracted from the 2004 values, yielding growth values that are calculated into percents of change. Connecticut, California, and New York produced the highest values of growth. Connecticut's per capita consumption of ethanol exploded from 0.9 to 44.6 gallons between 1998 and 2004, a gain of 4,955.6 percent. New York expanded from 0.9 to 18.0 gallons as per capita consumption increased by 2,000 percent. California, Iowa, and Illinois registered large per capita increases.

Determinants of Use

The most important influence on the expansion of ethanol consumption is the EPA mandate for oxygenates in the gasoline for most of the nation's metropolitan regions. This regulation continues to increase ethanol consumption.

A Midwest location is the second most important determinant of the changing pattern of ethanol distribution. This is something like a home court advantage, because many of the states have policies that support the ethanol industry. For example, Minnesota has mandated that all gasoline sold in the state must be 20 percent ethanol. Illinois recently enacted similar legislation.

Photo: Bob Nichols, USDA

Corn at this farm is grown exclusively for use in fuel ethanol.

Some states have provided support through subsidies encouraging the use of ethanol fuels—for example, providing seed money for new manufacturing facilities, assisting in site selection for new biorefineries, and offering monetary grants to service stations for installing pumps for E-85, a mixture with up to 85 percent ethanol. The local advantage includes behavioral patterns—in these regions, people prefer gasohol fuels even when the cost is more than that of neat gasoline.

Media Debates

The media often cite the ethanol subsidy as a determinant in the expansion of ethanol fuels. Pronouncements range from the favorable to the hypercritical.

Groups opposed to ethanol use point out that the subsidy amounts to 50 to 55 cents per gallon.[1] The production of 3 billion gallons of ethanol with a subsidy of 50 cents would require $1.5 billion—a calculation that probably overstates the subsidy benefit. The subsidies for ethanol are complex, including a tax exemption of 5.4 cents from the 18.4 cents-per-gallon federal excise tax; as well as three tax credits, including the biomass derivatives credit, the alcohol mixtures credit, and the pure alcohol fuel credit.

A general subsidy for corn prices provides a benefit of about 18 cents per gallon of ethanol—but corn flakes and corn bread also benefit from this price support. In 2002, the U.S. Department of Agriculture (USDA) provided a total of $7.2 million in subsidies to the ethanol industry for research and development and for seed money for new production facilities. A single new medium-size biorefinery costs $50 million to $60 million.

Environmental groups, taxpayer associations, and the petroleum industry are critical of the ethanol subsidy. Some consider ethanol fuels for transportation to be "unsustainable, subsidized food burning."[2] According to David Pimentel of Cornell University, 131,000 BTU are required to produce 1 gallon of ethanol, which contains only 77,000 BTU (*3*). Pimentel further asserts that the subsidy is the only reason for the ethanol industry's existence.

In 2002 Taxpayers for Common Sense stated that the subsidy to the ethanol industry is lost revenue that "now exceeds $1 billion per year" (*4*). The petroleum industry also wants to terminate the ethanol subsidy. The *Detroit Free Press* quoted a senior executive of a major petroleum company who called for ending the subsidies to the ethanol industry: "We've never been a supporter of subsidies under any conditions, because they distort market signals" (*5*).

The National Corn Growers Association has

[1] zfacts.com/p60.html.

[2] www.news.cornell.edu/ releases/Aug01.

Photo: Tom Richard, Pennsylvania State University

Pro-Corn, LLC, fuel ethanol refinery in Preston, Minnesota, produces more than 36 million gallons annually.

pointed out that petroleum companies receive more than $5 billion in subsidies through foreign tax credits, largely for the construction of manufacturing facilities overseas for products intended for the U.S. marketplace (*6*). Citing a USDA study, the association maintains that ethanol produces 167 BTU for every 100 BTU consumed in production, for a net energy balance of 1.67 to 1; moreover, previous comparisons had omitted the energy for extracting the petroleum, transporting it to a refinery, refining the petroleum, and then operating the tanker services that transport the gasoline to American ports.

Supply of Feedstocks

A major concern is the availability of ethanol. The supply of corn is plentiful, but biorefineries are operating near capacity. According to TwinCities.com, 95 biorefineries in 20 states produced 3.9 billion gallons of ethanol in 2005. This is three times as much ethanol as was consumed in 1998. New plants are under construction, but can new construction keep pace with rising demand?

The Renewable Fuels Standard in the Energy Policy Act of 2005 mandates a minimum annual level of renewable fuels, such as ethanol and biodiesel, at 7.5 billion gallons by 2012. If the growth rate for ethanol continues steady, production should be between 9 and 10 billion gallons in 2012.

Corn prices are another concern raised in media reports, although corn prices have been stable over the years. According to Dakota Ethanol, the price for corn delivered on April 20, 2006, was $1.87 per bushel. Adjusted for inflation, corn prices have declined during the past 50 years. The feedstock requirements of the ethanol industry have had little effect on corn prices. The 1987 drought and the 1993 floods prompted modest price increases, despite causing substantial reductions in the yield.

The National Corn Growers Association predicts that implementation of the Renewable Fuels Standard will cause only a slight rise in corn products. If corn continues to provide more than 95 percent of the feedstock for the renewable fuels industry after 2012, prices may increase.

Emerging Renewable Fuels

Four sources of renewable fuels may serve the transportation sector in the near future:

- Corn-based ethanol, which is established;
- Biodiesel, which is becoming established;
- Cellulosic ethanol; and
- Sources for fuel cells.

Biodiesel fuels come from a variety of feedstocks. In the Midwest, the soybean frequently is the source. In other parts of the United States, waste cooking oil supplies the feedstock; many types of vegetable oils can serve as a source material.

Use of the soybean as a feedstock may allay the concerns of many environmentalists that the biofuel industry's reliance on corn will damage the nation's soil resources. The soybean is a legume and has the property of fixing nitrogen in the soil.

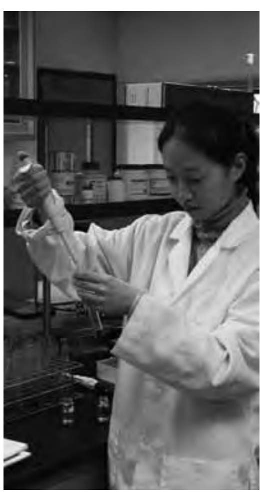

Photo: Tom Richard, Pennsylvania State University

Researcher at Pennsylvania State University tests results of a fermentation technique applicable to converting biomass into transportation fuels.

Ethanol and Energy Independence

In his State of the Union address, January 24, 2007, President George W. Bush proposed that the United States pursue energy independence by developing the facility to produce 30 billion gallons of renewable fuel per year by 2017. Highway consumption of gasoline is approximately 135 billion to 140 billion gallons per year, and the consumption of special fuels—primarily diesel—is approximately 35 billion gallons per year.

The current legislative target is to produce up to 7.5 billion gallons of corn-based ethanol per year by 2012. In 2001, the United States produced 9.5 billion bushels of corn; one bushel can produce 2 gallons of ethanol. The upper limit for corn-based ethanol production, however, is probably between 9 and 10 billion gallons per year, because corn is a food staple and is required for many other products, from fodder to whiskey.

The President's policy proposal therefore requires the augmentation of other biofuels such as biodiesel and cellulosic ethanol. Developing the infrastructure and production facilities for these new sources will require large capital investments.

Switching from fossil fuels to renewable fuels and implementing conservation technologies will reduce emissions of greenhouse gases substantially and will allow the United States to anchor its energy future on a more sustainable base. Corn-based ethanol can play an important part in the President's proposed initiative, because the technology already is in place, but new technologies must be developed and implemented to reach the target for enhancing energy independence by 2017.

—William D. Warren

Approximately 20 percent of the motor fuel consumed in the United States is diesel, creating distinct possibilities for the expansion of biodiesel. Railway locomotives and river tugboats also could consume biodiesel.

Cellulosic ethanol may offer the greatest potential for biofuels development (7). Potential source materials include hybrid poplar; switch grass; corn stover—that is, the stems and leaves of corn; comfrey, a perennial herb; and other hay crops. Research and development have progressed slowly, but the past two federal budgets have increased the funding, with $54 million for "biomass and biorefinery research and development" for Fiscal Year (FY) 2005, an estimated $91 million in FY 2006, and an estimated $120 million for FY 2007.[3] Progress has been made in the chemistry of the manufacturing process, manufacturing techniques, and potential feedstocks.

A scientific report has suggested that a sustainable supply of cellulosic ethanol could reach 1.3 billion tons, which would replace 30 percent of current U.S. petroleum consumption. In some instances, the feedstock could be a perennial cover crop, reducing tillage and protecting against erosion. Moreover, the well-to-wheel (WTW) model created by Michael Wang of Argonne National Laboratory for calculating greenhouse gas emissions from internal combustion engines shows that cellulosic ethanol reduces greenhouse gas emissions by approximately 80 percent, compared with emissions from a gasoline-powered engine. The WTW model calculated a reduction of 20 to 30 percent with corn-based ethanol compared with gasoline.

Fuel cell–powered vehicles would be virtually emission-free. Research into this technology is continuing. The U.S. budget included $96 million in FY 2005, an estimated $155 million in FY 2006, and an estimated $196 million in FY 2007 for research and development of fuel cell power. Demonstration fuel cell models are in service, but competitive fuel cell–powered vehicles may not be available for 15 years.

Future for Ethanol

Ethanol consumption will continue to increase in the next 5 to 10 years. With 10 percent and 20 percent fuel mixtures now common, and with the increasing availability of E-85 fuel, the Midwest probably will continue to dominate the distribution pattern for ethanol fuels. The use of 5.5 percent ethanol fuel is likely to expand in states that currently consume small amounts of ethanol. Some of the states that consumed no ethanol probably will begin to use the 5.5 percent, oxygenated fuel to meet air quality standards. In the next five years, biodiesel is likely to be the motor fuel that establishes new marketing territories.

[3] U.S. Budget for Fiscal Year 2007, p. 390.

Photo: Clare Hinrichs, Pennsylvania State University

Harvest of switch grass is stored at an Iowa State University research facility in Ottumwa for use in biofuel development.

Cellulosic ethanol may be introduced as a fuel for the transportation sector in the near future. Four features will determine the emergence of cellulosic ethanol and the progression of the established biofuels market:

- Technological advances are necessary if market growth is to continue.
- Future petroleum prices will be critical. If the era of "cheap oil" has come to an end, the renewable fuel industry can realize substantial benefits.
- The geopolitics of the Middle East—particularly instability in the region—is a stimulus for American domestic energy development.
- The need to counteract the greenhouse effect, global warming, and environmental problems associated with climate change can lead to mandates against the consumption of fossil fuel and could provide an impetus for enhancing the renewable fuel sector.

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PHOTO: TONY CLEVENGER–WTI

The Trans-Canada Highway bisects the Bow River Valley, Alberta, a World Heritage Site.

HIGHWAYS Through Habitats

The Banff Wildlife Crossings Project

TONY CLEVENGER

The author is Research Wildlife Biologist with the Road Ecology Program, Western Transportation Institute at Montana State University, Bozeman.

Banff National Park and its environs in Alberta, Canada, are among the world's best testing sites for innovative passageways to mitigate the effects of roads on wildlife. The major commercial Trans-Canada Highway (TCH) bisects the park, but a range of engineered mitigation measures—including a variety of wildlife underpasses and overpasses—has helped maintain large mammal populations for the past 25 years and has allowed the gathering of valuable data.

Push for Research

Less than 100 years ago, the first car to reach Banff National Park traveled a dusty, narrow road from Calgary. By the early 1970s, four paved lanes of the TCH linked Calgary to the park's east gate. In the park, vehicles funnelled onto a two-lane highway section. As traffic increased, so did the accidents.

In 1978, therefore, Public Works Canada proposed "twinning" the highway—that is, expanding it to four lanes—from the east gate to the Banff town site. A second proposal followed, to twin the highway from Banff town site to the Sunshine Road. This provoked a

PHOTO: JEFF STETZ

One of two overpasses constructed on the Trans-Canada Highway in Banff National Park to maintain wildlife connectivity.

debate, because many people believed that a larger highway would kill more wildlife and harm the park, but others argued that a larger highway would ensure safer travel for people. The debate was intense, but the effect of a larger highway on wildlife was studied more closely than ever before.

The first twinning project was approved with the goals of improving travel safety for people and of reducing the road kill of deer and elk. Highway fencing and the use of wildlife underpasses were recommended. At the time, however, the effects of a fenced highway on ungulates were not known. Information on where to locate the wildlife crossings, how many to create, or what kinds of underpasses deer and elk would use also was limited. Although sparse, the available data were assembled to guide the decisions.

While the first twinning phase was in construction, the second was approved. The debate about highway twinning in the park continued, along with a push for scientific research and improved knowledge about the effects of roads on wildlife.

Monitoring Results

The TCH reconstruction included 24 wildlife crossings—22 underpasses and 2 overpasses—to ensure wildlife connectivity. Consistent evidence of the performance and effects of these crossings is needed to support implementation by transportation and resource management agencies. Although the installation of wildlife crossings is increasing, some organizations remain skeptical about the conservation benefits.

In 1996, Parks Canada contracted for long-term research to monitor the Banff highway mitigation measures. Researchers have employed a variety of methods to monitor animal use of the wildlife crossings, such as regularly raking the track beds clean, deploying infrared-operated cameras, and checking the structures every three days year-round. The 10 years of project research are providing information about crossing structures at an unprecedented level of scientific rigor. Moreover, the research is being performed in an area that leads the world in the planning, design, and performance assessment of wildlife crossings.

Monitoring the track pads has shown that 10 species of large mammals have used Banff's 24 crossings more than 84,000 times as of January 2007. The research suggests that the animals experience a learning curve—they need time to locate the wildlife crossings and to feel secure using the structures before crossing regularly. For example, grizzly bear crossings have increased from 7 in 1996 to more than 100 in 2006. Long-term monitoring demonstrates that the mitigation measures have reduced the traffic-related mortality of all large mammals on the TCH by more than 80 percent—a significant boost for maintaining viable wildlife populations.

Photo: Tony Clevenger–WTI

One of 22 wildlife underpasses constructed to mitigate the twinning of the busy Trans-Canada Highway in Banff National Park.

Healthy, functioning ecosystems require viable wildlife populations. Knowing the effect of these crossing structures on the population levels, therefore, is critical. Although the structures should enhance population viability, no studies to date have addressed the related benefits.

Obtaining data on individuals in a population can be problematic, because wide-ranging, fragmentation-sensitive species like bears typically occur in relatively low densities and have low reproductive rates. Demonstrating that crossings provide population-level benefits—for example, allowing the movement of adult males and females across roads, as well as the dispersal, survival, and reproduction of the young—usually requires 15 to 20 years of intensive monitoring of radio-marked mammals.

Modern molecular techniques, however, have made it possible to identify individual animals, their sex, and genetic relatedness from only a few hairs. These innovations can provide a powerful, relatively inexpensive, and noninvasive way to acquire critical information about genetic interchange facilitated by crossings, without having to capture or see the animals.

Photo: Laurel Hicks

Grizzly bear using a wildlife overpass in Banff National Park.

PHOTO: TONY CLEVENGER–WTI

A two-strand system of barbed wire and sticky string was used to snag hair samples to yield DNA profiles of individual animals using a wildlife underpass.

Pilot Study

In 2004 and 2005, a noninvasive technique was pilot-tested for obtaining DNA from the animals using the wildlife crossings. With DNA obtained from an animal's hair, researchers can create the equivalent of a genetic fingerprint. The unique DNA allows scientists to identify each individual and determine its sex and ancestry.

Sampling System

A hair-sampling system was set up at two underpasses of the TCH in Banff. The system consisted of two strands of sticky string spanning the width of the underpass (see photo, this page). Barbed wire was intertwined to enhance the efficiency of the system to obtain hairs with sufficient tissue for DNA analysis.

The target species were large carnivores, primarily bears; therefore the strands were suspended at 30 cm and 75 cm above the ground. Page wire and brush behind posts were used to funnel the animals toward the hair-sampling setup. Animal hair left on the barbs or on the sticky string was collected daily and sent to a laboratory to identify the species and the individuals within each species.

The hair-sampling systems also were monitored by video 24 hours a day to assess how the technique was working and to watch the wildlife responses to the slightly modified underpasses. The video footage allowed the researchers to identify and correct experimental flaws, as well as any negative effects on the wildlife.

Mitigating Transportation's Disruption of Ecosystems

JOHN BISSONETTE AND CHRISTOPHER HEDGES

The annual costs of personal injuries and property damage from animal–vehicle collisions are considerable, but mitigation measures have met with uneven success. Moreover, many smaller species of animals that do not pose a threat to vehicles in collisions may experience habitat loss and fragmentation from roadway alignments, because transportation corridors limit the natural movement of wildlife, affecting individual species and ecosystems.

Research has contributed to the development of wildlife crossings, but additional data are needed on the effectiveness of the crossings and on the most effective measures for a particular species in a particular landscape. Crossings that work well for one species may not for others. State departments of transportation therefore need guidance on the use and effectiveness of wildlife crossings to mitigate habitat fragmentation and to reduce the number of animal–vehicle collisions on roadways. Concerted and purposeful activity is needed to link transportation and ecological services into a context-sensitive process of planning, construction, and monitoring and to provide the kinds of data that highway planners, engineers, or biologists can generalize to different situations.

Under NCHRP Project 25-27, Evaluation of the Use and Effectiveness of Wildlife Crossings, a research team at Utah State University is developing guidelines for the selection, configuration, and location of crossing types, as well as suggestions for the monitoring, evaluation, and maintenance of crossings. Guidance on the use of wildlife crossings to mitigate habitat fragmentation and to reduce the number of animal–vehicle collisions will rely on a large-scale, context-sensitive framework and on sound ecological principles.

The guidelines will aim for landscape permeability—effective connectivity that restores an ecosystem's integrity. At the same time, the guidelines must allow for cost-effective mitigation of the effects of transportation infrastructure.

The research will assess current practice, as well as the use of data and models to evaluate the safety effectiveness of wildlife crossing measures, to identify collision-prone locations, and to evaluate how to place the crossings. The study also will examine the effect of roads on the quality of the immediately adjacent habitat. The guidelines will be released as a web-based electronic decision tool. The research is scheduled for completion this summer.

Bissonette, a research scientist with the U.S. Geological Survey Utah Cooperative Fish and Wildlife Research Unit and a professor at Utah State University, Logan, is principal investigator for NCHRP Project 25-27, and Hedges is senior program officer, TRB.

Results

During the 2005 field season, carnivores made a total of 56 approaches to the two pilot underpasses; 43 of the approaches were by bears (24 black bears and 19 grizzly bears). Bears turned around or avoided the underpasses less than 10 percent of the time—two of the black bears and one of the grizzly bears approached but did not enter.

The success rate for hair capture was high for both bear species; more than 90 percent of the time, bears passing through the underpasses left hair—the grizzly bears left hair on 94 percent of their crossings. For both bear species, 81 percent of the hair samples yielded sufficient DNA for genetic profiling. Nine different bears used the two underpasses during the 3½-month period in 2005: five grizzly bears (three females, two males) and four black bears (two females and two males).

Effectiveness of Structures

Following the success of the hair-snagging experiment, a three-year doctoral study at Montana State University was launched in 2006 to assess the population-level benefits of the Banff crossings. This requires collecting DNA from animals using the crossings to ascertain which individuals are contributing to gene flow and interchange between the populations separated by the TCH.

The DNA data from hair samples of animals using the crossing structures will be compared with DNA data from a broader segment of the population, to provide a scientifically rigorous assessment of the conservation benefits of the Banff wildlife crossings. The results will help evaluate the effectiveness of the wildlife crossing structures in promoting genetic and demographic connectivity.

In addition, performance monitoring continues at all 24 wildlife crossing structures in Banff. The results will provide measurable data on the value of the different crossing structures in maintaining or restoring wildlife populations. The Banff research results have guided the design and location of 17 new crossings to be built in the latest phase of the TCH twinning project near Lake Louise—a prime example of yet-evolving science applied to inform transportation management planning. This experience and expertise should help raise international awareness and prove valuable for other regions worldwide.

Outreach and Education

The Banff Wildlife Crossings Project is sharing scientific findings through a mix of venues to inform the general public, students, and transportation professionals about the effectiveness of the 22 underpasses and 2 overpasses. The research has led to the following:

PHOTO: TONY CLEVENGER–WTI

A wolf pack with pups, photographed by a remote-sensing research camera, traverses a wildlife overpass along the Trans-Canada Highway.

- Seventeen peer-reviewed scientific journal articles;
- Four graduate theses on the effects of the TCH on natural resources in Banff National Park;
- Two workshops for transportation professionals on mitigating the effects of highways on wildlife;
- The cover photograph on the fourth edition of *Essentials of Conservation Biology*, a popular college textbook by Richard B. Primack, published by Sinauer Associates;
- Field trips throughout the year for professionals and other interested individuals;
- A full-color poster produced as an outreach to kindergarten through high school classes;
- An exhibit at the Whyte Museum of the Canadian Rockies from May to October 2006, which informed more than 19,000 park visitors from around the world; and
- Extensive media coverage—television, radio, and print—with stories appearing in the *New York Times*, on the Canadian Broadcasting Corporation, and in many other media outlets across North America.

Public–Private Partnership

Since 2005, the research, outreach, communications, and funding of the Banff Wildlife Crossing Project have been the result of a public–private partnership: a federal agency, a university transportation center, a nonprofit organization, and three North American conservation-based foundations. The partners include Parks Canada; the Western Transportation Institute at Montana State University; Friends of Banff National Park; and the Henry P. Kendall, Woodcock, and Wilburforce Foundations.

For more information on the research or the project, contact:

- Tony Clevenger, Research Scientist, WTI; 403-760-1371; tony.clevenger@pc.gc.ca;
- Rob Ament, Road Ecology Program Manager, WTI; 406-994-6423; rament@coe.montana.edu; or
- www.coe.montana.edu/wti.

P O I N T   O F   V I E W

Thinking Big

Lessons from the Washington Metro

Z A C H A R Y   M .   S C H R A G

The author is Assistant Professor of History, George Mason University, Fairfax, Virginia. His book, The Great Society Subway: A History of the Washington Metro, *was published by the Johns Hopkins University Press in 2006; he also researched and wrote* Building the Washington Metro: An Online Exhibit *(http://chnm.gmu.edu/metro/).*

Entering one of the underground stations of the Washington Metro is like stepping into the future. The soaring vaults, soft lighting, and murmuring air conditioning evoke less of the industrial subways of New York and Boston and more of the gleaming space stations of a science fiction movie. But just as Star Wars was set "a long time ago, in a galaxy far, far away," Metro is the creation not of the future, but of the past. Metro emerged from the 1960s, a period when Americans dared to think big.

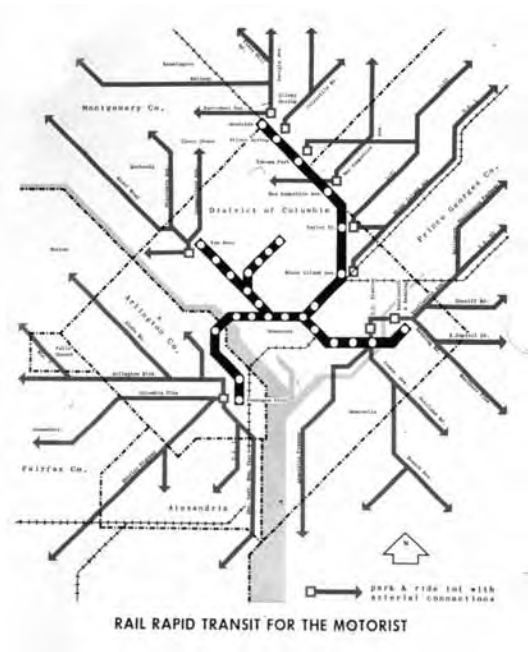
Thinking big has long been out of fashion, especially in transportation. Economists repeatedly have warned against rail plans that promise low cost and high patronage. Recent books like *Mega-Projects: The Changing Politics of Urban Public Investment* and *Megaprojects and Risk: An Anatomy of Ambition* show that rail transit overruns are part of a much broader pattern of disappointingly expensive infrastructure (*1–2*). Yet Metro's story shows that by thinking big, local and federal officials built a transit system that changed the history of the nation's capital.

Competing Visions

Metro did not begin big, physically or conceptually. In the 1950s, Congress was moving away from rail and had mandated the removal of Washington's streetcars. The National Capital Planning Commission's Mass Transportation Plan, released in 1959, called for a 329-mile web of highways to carry commuter traffic. Eight of the radial highways would carry express buses, although not in dedicated lanes. Almost as an afterthought, the plan included two rapid rail routes, comprising about 33 route miles. The enormous highway plan provoked one of the first freeway revolts in the nation. If Richard Nixon had won the White House in

PHOTO: WMATA, COURTESY OF LARRY LEVINE

Even after 30-plus years, Metrorail's station designs retain a futuristic look.



In 1965, the U.S. National Capital Transportation Agency proposed a rail transit system on a modest scale (see thick dark route lines above center of map), designed to complement automobile routes (shown by gray lines) into Washington, D.C. The plan received Congressional approval, but was superseded in 1967 with the creation of the Washington Metropolitan Area Transit Authority, which gained approval for a 98-mile regional system.

1960, Washington likely would have been dominated by freeways—like most American cities.

Instead, the new president was John F. Kennedy, a man with great faith in the federal government. In his inaugural address, Kennedy called on Americans to ask what they could do for their country, and throughout his presidency he sought to use federal power to improve the public realm. In 1962, for example, he endorsed a call for a federal architecture that could "provide visual testimony to the dignity, enterprise, vigor, and stability of the American government."

Kennedy replaced the national experts who had been in charge of planning for Washington with local activists, many of whom had opposed the 1959 highway plans. Prominent among these was Darwin Stolzenbach, who was appointed to head the new National Capital Transportation Agency. Stolzenbach reversed established principles of transportation planning—instead of using rail to supplement highways, he called for an 89-mile rail system to allow massive cutbacks in the highway web. The plan proved enormously controversial; highway proponents nationwide denounced Stolzenbach as a zealot. As a result, Stolzenbach lost his job, and his rail plan was scaled back to 25 miles. Yet Stolzenbach had given highway opponents time to mobilize, and they took up the cause of transit as an alternative to freeways.

The approval of the 25-mile plan also gained the attention of local officials in Washington's Maryland and Virginia suburbs. In 1967, the officials persuaded Congress to transfer transit planning to a local body, the Washington Metropolitan Area Transit Authority. The challenge now was not to devise a thrifty plan to sell to Congress, but to win local bond referenda by promising service to every part of the region. As planner Thomas B. Deen, who had worked for Stolzenbach, later explained, in such circumstances "it's easier to sell a billion dollar project than a hundred million dollar project." Washingtonians went even further, proposing a 98-mile regional system, at an estimated cost of $1.828 billion in 1968 dollars. Factoring in 5 percent inflation and 10 percent contingency, an estimated $2.525 billion would be spent between 1968 and 1980.

Flaws and Virtues

Like many megaprojects, Metro went well over budget, costing more than $10 billion in nominal dollars by completion of the originally planned system in 2001. Most of this increase was a result of 1970s inflation, but even in constant 1968 dollars, Metro cost approximately $3.8 billion—50 percent more than projected. Planners had hoped that farebox revenues would cover the operating costs; the income offsets close to two-thirds.

But if Metro embodies the central flaw of megaprojects, it also showcases some of their virtues. First, it took a megaproject to kill a megaproject. If the freeway opponents of the 1950s and 1960s merely had whined about the destructiveness of multilane, open-

Photo: WMATA, courtesy of Larry Levine

Groundbreaking for Metrorail at Judiciary Square, circa 1968.

Metrorail has relied on a regional consensus for transit. Model railcars attracted crowds near the national Mall, circa 1968.

cut roads, they could have been dismissed as grouchy impediments to progress. Instead, by championing rail, they offered a credible alternative to the equally expensive downtown freeways that would have scarred central Washington forever.

Second, Metro built a regional consensus for transit. In Atlanta's suburbs, commuters figured that they could depend on freeways alone, but Washington's neighbors knew that they would need rail to get downtown. Even as costs rose in the 1970s, Maryland and Virginia voters stayed loyal to Metro, and today they remain passengers on Metro's crowded trains. Riders on each of Metro's five lines may suspect that their own line is the most crowded, but in general Metro acts as a unifier and a leveler, providing a service shared by city dwellers and suburbanites, rich and poor, white and black, young and old.

Third, Metro's scale has helped create the kind of transit-oriented development that many cities only dream about. A developer who builds an office building or condominium close to a Metro station gains access not to a single corridor but to an entire region, benefiting from what economists call "network effects." Just as each copy of a software application enhances the value of all the others—because each user is more likely to find someone with whom to swap files—each of Metro's stations makes access to the other 85 more precious. As a result, much of central Washington, along with key suburban station areas, is far more transit- and pedestrian-friendly than most American cities.

All of these factors have worked together to make Metro vital to the Washington region and the nation's second-busiest rail transit system, after the New York subway. In the summer of 2006, ridership repeatedly topped 750,000 rides per day, for a total of more than 200 million rides in Fiscal Year 2006. These high numbers, however, understate Metro's impact, because many people who are not daily riders still benefit. A spouse who rides Metro spares the expense of an additional family car; a neighbor who rides does not compete for space on the roads; anyone who enjoys city life can be grateful that central Washington remains a magnet for shopping, museums, restaurants, theaters, and sports events, including—once again—professional baseball. Metro makes all of this possible.

Frugality and Values

In the frugal 1970s, the high costs for Metro and other rail projects led the federal government away from the metropolitan-scale planning that had created Metro. The Ford administration called for "transit development through incremental steps" to replace "the most expensive and most glamorous transit solutions." This frugality remains central to federal policy—even today, despite local governments' willingness to pay more for improved service, planners of a proposed Metro extension to Tysons Corner, Virginia, struggle against policies that demand the cheapest solution to an immediate problem.

Thrift is a virtue, but Americans as consumers spend far more on luxurious houses, furnishings, and vehicles than their financial advisers would consider prudent. As citizens, Americans have taxed themselves to build parks, hospitals, universities, and stadiums, not in the expectation of an immediate return on investment, but in the hope of making the public realm as grand as the private.

Unsentimental economic analysis, although crucial to sound planning, by itself cannot determine whether a project is worth building. In building Metro, Washingtonians did not seek the cheapest transportation system, but one best suited to the kind of city they wanted for themselves and their children. As Washingtonians today consider Metro extensions, and as other cities ponder their transit systems, they would do well to consider the values they hold dear.

In 1964, President Lyndon Johnson called for a Great Society, which he defined, in part, as "a place where the city of man serves not only the needs of the body and the demands of commerce but the desire for beauty and the hunger for community." In our more cynical time, these words may sound too dreamy to serve as the basis of public policy. But every Metro rider knows just how concrete the Great Society could be.

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.*

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TRB 2007 ANNUAL MEETING HIGHLIGHTS

The Interchange of Transportation Research

Highlights from TRB's 2007 Annual Meeting

1 Secretary of Transportation Mary E. Peters (*center*) takes questions from reporters at a press conference that followed her address at the Chairman's Luncheon on Wednesday, January 24.

2 Special guest, former Secretary of Transportation Norman Y. Mineta (*left*) greets National Academy of Engineering President William A. Wulf at the Chairman's Luncheon.

Annual meeting photographs by Cable Risdon Photography

Approximately 10,400 transportation researchers, practitioners, and administrators representing government, industry, and academia from the United States and abroad gathered in Washington, D.C., January 21–25, 2007, to participate in the 86th Annual Meeting of the Transportation Research Board. The 5-day program offered attendees a variety of opportunities for information sharing and interaction with more than 3,000 presentations in nearly 600 sessions; 80 specialty workshops; 350 meetings of committees, subcommittees, and task forces; and many additional events, including a Chairman's Luncheon address by Mary E. Peters, U.S. Secretary of Transportation.

The meeting's spotlight theme, Transportation Institutions, Finance, and Workforce, was featured in sessions that crossed all modes and disciplines. Details and highlights appear on the following pages.

GETTING ACQUAINTED

1 Conference attendees received prompt attention at the general registration desk.

2 Imad Basheer, California Department of Transportation (Caltrans); Jean Landolt, Federal Highway Administration (FHWA); and Nadarajah Sivaneswaran, FHWA, pause to consult the 264-page Annual Meeting program between sessions.


1


2

WELCOME!

3 Aviation Group Chair James M. Crites, Fort Worth International Airport, assists first-time attendee Silpa Yanduru, Purdue University.

4 Leanna Depue, Missouri Department of Transportation (DOT), briefs new and young attendees during the Welcome Session.


3


4

TECHNICAL ACTIVITIES COUNCIL

5 Chairs of nine of the groups within the Technical Activities Division coordinate the development of annual meeting program content.


5

5 (*TAC Council, left to right:*) Mark R. Norman, TRB; Robert M. Dorer, Research and Innovative Technology Administration (RITA); Marcy S. Schwartz, CH2M Hill; Paul Bingham, Global Insight Inc.; Arlene L. Dietz, A&C Dietz Associates; Neil Pedersen, Maryland State Highway Administration, Chair; Shelly R. Brown, Shelly Brown Associates; Leland D. Smithson, Iowa DOT; Karla Karash, TranSystems Corporation; L. David Suits, North American Geosynthetics Society; and Robert C. Johns, University of Minnesota. (Not pictured: Leanna Depue and James M. Crites.)

SPOTLIGHT SESSIONS

6 Cing-Dao (Steve) Kan, George Washington University, speaks on Keys to Building a Robust Research Program.

7 David King, UCLA, speaks on Meeting the Education and Training Needs of the Transportation Profession. Panel members include (*left to right*) Martin Richards, Consultant; Gary Thomas, Texas Transportation Institute (TTI); and Melissa S. Tooley, TTI.


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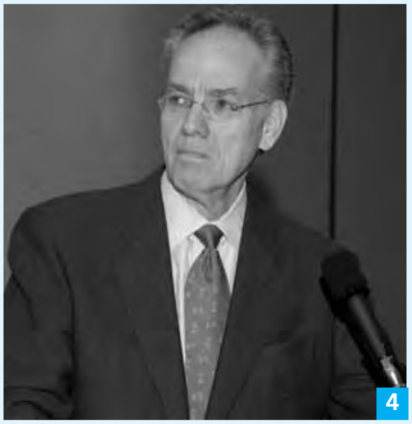

6 *(U.S. DOT representatives, left to right:)* Nicole R. Nason, National Highway Traffic Safety Administration; Krista Edwards, Pipeline and Hazardous Materials Safety Administration (PHMSA); J. Richard Capka, FHWA; John H. Hill, Federal Motor Carrier Safety Administration (FMCSA); John A. Bobo, Jr., RITA; and Marion Blakey, Federal Aviation Administration (FAA).

SPOTLIGHT SESSIONS
(continued)

1 Christopher Kane, Washington Group International, addresses Design-Build Project Delivery in Public–Private Partnerships.

2 Barbara Martin, BGM Associates, fields questions in the session Building the 21st Century Workforce.

3 Martin A. Spitzer, Heinz Center for Science, Economics, and the Environment, provides feedback to an audience member during his presentation at the Transportation Information Needs from TRB Standing Committees session.

4 Jeffrey N. Shane, U.S. DOT, moderated discussion during the U.S. Department of Transportation Dialogue: Congestion and Other Initiatives session.

5 TRB Executive Director Robert E. Skinner, Jr. (*center*), tries out Doug MacDonald Challenge winner Paul C. Haase's (*left*) project on maximizing throughput. Haase was awarded a $1,000 check by MacDonald (*right*), Secretary of Washington State DOT, and the TRB Congestion Pricing Committee.

6 U.S. DOT administrators shared insights and participated in discussion on key transportation issues, including the U.S. DOT Congestion Initiative.

7 Mohan Gupta, FAA; Darcy Zambiak, Jacobs Conservancy; Lourdes Maurice, FAA; and Ed McQueen, FAA, engage audience members in a dialogue on ways to conduct, assemble, and evaluate research on aviation and the environment.

SESSIONS AND WORKSHOPS

1 Structures Section Chair Mary Lou Ralls, Ralls Newman, speaks at a session on the status and future of accelerated bridge construction in the United States.

2 Jean-Pierre Medevielle, European Conference of Transport Research Institutes, and Guy Bourgeois, Institut National de Recherche sur les Transports et leur Securite, participate in the International Research Roundtable.

3 Tom Cherrett, Transportation Research Group, makes a discussion point during a session on urban freight planning.

4 Planning committee for the 40th Annual Human Factors in Transportation Workshops.

5 Alison Smiley, Human Factors North, presents the Human Factors in Transportation Workshops luncheon address.

6 Hyun-A Park, Spy Pond Partners, moderates discussion on topics including customers, credibility, finance, and funding in the AASHTO CEO Forum Report.

7 Capacity audiences were common at sessions.

8 Niki Kringos, Delft University of Technology, Netherlands, discusses findings of an experimental–computational study to measure aggregate–mastic bond strength in the presence of moisture with Dan Micco, PQ Corporation.

9 Poster sessions provided attendees the opportunity to learn about some of the latest research and have one-on-one discussions with authors.

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4 *(Human Factors in Transportation Workshops Planning Committee, front row, left to right:)* Thomas Raslear, Federal Railroad Administration (FRA); Neal Lerner, Westat; Suzanne E. Lee, Virginia Tech Transportation Institute; Christopher Monk, George Mason University; Gregory W. Davis, Turner–Fairbank Highway Research Center; Richard Pain, TRB; (*standing, left to right*) Fred R. Hanscom, Transportation Research Corporation; Daniel V. McGehee, Human Factors and Vehicle Safety Public Policy Center; Helmut T. Zwahlen, Ohio University; Alex Landsburg, Computer Sciences Corporation; and Richard P. Compton, National Highway Traffic Safety Administration (NHTSA).

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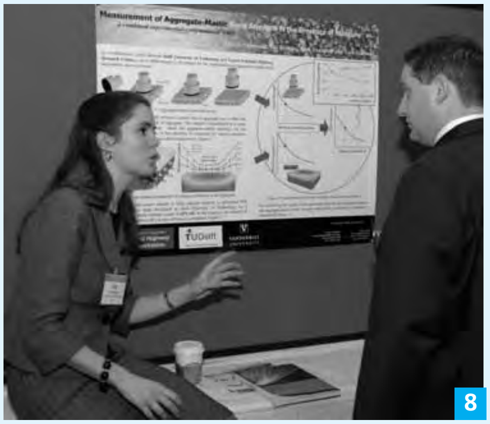

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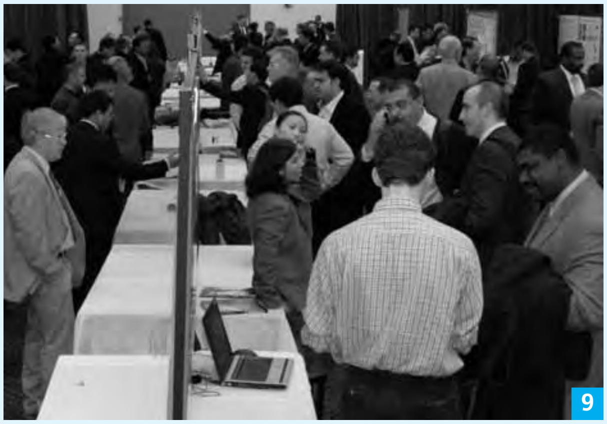

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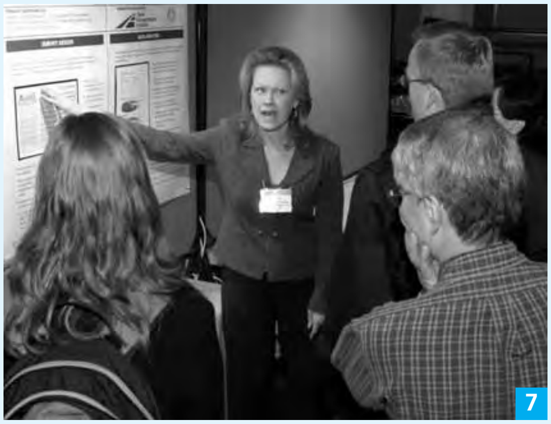

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1 Shin-Ting (Cindy) Jeng, University of California, Irvine, discusses measurement of freeway corridor performance based on vehicle reidentification with William Johnson, Trends Consulting.

2 Frederick C. M. Wegman, Netherlands Institute for Road Safety, and Letty Aarts, Institute for Road Safety Research, Netherlands, describe the conception and development of their book, *Advancing Sustainable Safety*.

3 William Tansil, Michigan DOT, moderates discussion concerning transportation applications of restricted-use technology.

4 Daniel S. Turner, Council of University Transportation Centers, listens as Wesley C. Lum, Caltrans, speaks in a session on Meeting the Challenge to Achieve a Nationally Coordinated Research Program.

5 Susan Sillick, Montana DOT, asks a question of the session panel.

7 Linda K. Cherrington, TTI, presents research on transit surveys.

8 Walter McManus, University of Michigan Transportation Research Institute, offers the latest news on Fuel Prices and Transportation.

9 Jean Luc Poncelet, World Health Organization, offers perspectives on How Global Public Health Epidemics Affect the World of Transportation.

6 The first annual award for best poster in bituminous materials was presented to John T. Harvey (*left*) and Qing Lu, University of California, by Bituminous Materials Section Chair James S. Moulthrop, Fugro Consultants.

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COMMITTEE MEETINGS

1 Frederick D. Hejl, TRB (*right*), briefs members of the Nanotechnology-Based Concrete Materials Task Force.

2 Outgoing chair of the Committee on Travel Survey Methods, Johanna P. Zmud (*right*), Nu Stats Partners, receives a certificate of appreciation from incoming chair Kara Kockelman, University of Texas.

3 Aviation Security and Emergency Management Task Force chair Bonnie A. Wilson enjoys a light moment with colleagues.

SPECIAL EVENTS

4 Mark Norman, TRB, briefs a luncheon meeting with state DOT research officials.

5 Past TRB Executive Committee Chair E. Dean Carlson, Carlson Associates, pays tribute to fellow past TRB Executive Committee Chair Tom Larson, who passed away in 2006.

MAKING CONNECTIONS

6 Many attendees networked during breaks between activities and events.

7 Emily Goodenough, Visual Risk Technologies, and Reuben Goldblatt, KLD Associates, exchange ideas between sessions.

EXHIBITS

8 Students from the Cardozo Senior High School Trans Tech Academy hosted an exhibit and attended sessions, guided by Shirley C. McCall (*left*), the 2004 Sharon D. Banks Award recipient.

3 (*Clockwise from lower left:*) U.S. Secretary of Transportation Mary E. Peters; Carol A. Murray, New Hampshire DOT; C. Michael Walton, University of Texas; John A. Bobo, Jr., RITA; J. Richard Capka, FHWA; John R. Njord, Utah DOT; Linda S. Watson, LYNX–Central Florida Regional Transportation Authority; Michael D. Meyer, Georgia Institute of Technology; and TRB Executive Director Robert E. Skinner, Jr.

CHAIRMAN'S LUNCHEON AND AWARDS

1 U.S. Secretary of Transportation Mary E. Peters spoke before a capacity audience at the Chairman's Luncheon.

2 Incoming Executive Committee Chair Linda S. Watson (*left*), former AASHTO Executive Director Francis B. Francois (*center, left*), and Anne P. Canby, Surface Transportation Policy Partnership (*center, right*) greet U.S. Secretary of Transportation Mary E. Peters.

3 At the invitation of U.S. Secretary of Transportation Mary E. Peters, officers of the TRB Executive Committee joined her for an informal discussion.

4 NAE Chairman Willam A. Wulf introduces U.S. Secretary of Transportation Mary E. Peters at the Chairman's Luncheon.

5 Robert E. Skinner, Jr., TRB (*right*), presents Francis B. Francois with the Frank Turner Medal for Lifetime Achievement in Transportation.

6 Linda S. Watson (*left*) presents Anne P. Canby, Surface Transportation Policy Partnership, with the W. N. Carey, Jr., Distinguished Service Award.

7 Herbert H. Richardson, TTI, speaks after receiving the Roy W. Crum Distinguished Service Award.

8 Outgoing Executive Committee Chair Michael D. Meyer (*left*) presents the George S. Bartlett Award for Outstanding Contribution to Highway Progress to Neil J. Pedersen, Maryland State Highway Administration.

DISTINGUISHED LECTURE AND AWARDS FOR OUTSTANDING PAPERS

1 Genevieve Giuliano, University of Southern California, delivers the Thomas B. Deen Distinguished Lecture on the Changing Landscape of Transportation Decision Making.

2 Technical Activities Council Chair Neil Pedersen (*left*) presented the lecture award plaque to Giuliano, joined by past TRB Executive Director Thomas B. Deen.

3 Roger P. Bligh and Dean C. Alberson represented a group of four coauthors from Texas Transportation Institute honored with the K. B. Woods Award for outstanding paper in the design and construction of transportation facilities. (Not pictured: Nauman M. Sheikh and Akram Y. Abu-Odeh.)

4 D. Grant Mickle Award recipients.

The Fred Burggraf Award recognized outstanding papers by young researchers:

5 In planning and environment, Elise Miller-Hooks, University of Maryland, and Hao Tang, Fed Ex Express Corporation;

6 In design and construction, Jason Weiss and Gaurav Sant, Purdue University, and (not pictured) Pietro Lura, Technical University of Denmark; and

7 In operations and maintenance, Paolo Perco, University of Trieste, Italy.

4 The D. Grant Mickle Award for outstanding paper in the operation, safety, and maintenance of transportation facilities was presented to Samer H. Dessouky, Imad L. Al-Qadi, and Shih-Hsien Yang, University of Illinois, Urbana–Champaign. (Not pictured: Mostafa A. Elseifi.)

8 Greg Marsden, University of Leeds, U.K., accepted the Charley V. Wootan Award for outstanding paper in policy and organization on behalf of coauthors Charlotte Kelly, University of Leeds, and Carolyn Snell, University of York.

9 The Pyke Johnson Award for outstanding paper in transportation systems planning and administration was accepted by Matthew Barth, University of California, Riverside, on behalf of coauthors John Collins, George Scora, Nicole Davis (now with the International Sustainable Systems Research Center), and Joseph Norbeck.

Watson Chairs 2007 TRB Executive Committee

Linda S. Watson is 2007 Chairman of the TRB Executive Committee, succeeding Michael D. Meyer. Debra L. Miller will serve as Vice Chair, replacing Carol A. Murray, who has stepped down from her position as Commissioner of the New Hampshire Department of Transportation.

Watson is CEO of Lynx–Central Florida Regional Transportation Authority in Orlando. She previously served as general manager of the Corpus Christi Regional Transportation Authority and assistant general manager of the Fort Worth Transportation Authority in Texas. Watson chaired the Transit Cooperative Research Program (TCRP) Oversight and Project Selection Committee from 2000 to 2003 and has served on the TRB Executive Committee's Subcommittee on Planning and Policy Review and on TCRP panels.

Miller is secretary of the Kansas Department of Transportation (KDOT) and also has served as director of Kansas DOT's Division of Planning and Development. She chaired the joint National Cooperative Highway Research Program and Transit Cooperative Research Program Project Panel on Commuting in America III. She also is active on many other TRB committees.

Meyer, a professor in the School of Civil and Environmental Engineering, Georgia Institute of Technology, will continue to serve on the Executive Committee through 2009. He also chairs the Subcommittee on Planning and Policy Review and serves on several Technical Activities committees and NCHRP panels.

Joining the TRB Executive Committee are J. Barry Barker, Executive Director, Transit Authority of River City, Louisville, Kentucky; Tracy Rosser, Vice President, Corporate Traffic, Wal-Mart Stores, Inc., Bentonville, Arkansas; Rosa C. Rountree, Executive Director, Georgia State Road and Tollway Authority, Atlanta; and Steve Williams, Chairman and CEO, Maverick Transportation, Inc., Little Rock, Arkansas.

1 2007 TRB Executive Committee Chair Linda S. Watson introduces award winners during the Chairman's Luncheon.

2 Watson presents outgoing Chair Michael D. Meyer with a plaque in recognition of his leadership.

A TRB LEGEND RETIRES

3 Robert Reilly, TRB Director of Cooperative Research Programs, retired after 35 years of service in March. The TRB Executive Committee honored Reilly at the Annual Meeting with a commemorative resolution, citing his "superb leadership," as well as "outstanding judgment, integrity, and extraordinary dedication." Chair Michael D. Meyer and Executive Director Robert E. Skinner, Jr., presented the tribute. In February, FHWA Administrator J. Richard Capka personally presented Reilly with the FHWA Administrator's Public Service Award.

EXECUTIVE COMMITTEE

1 Chair Michael D. Meyer guides the Executive Committee through an ambitious agenda; Linda S. Watson (*left*) succeeds him for 2007.

2 TRB Executive Director Robert E. Skinner, Jr., fields a question about institutional policy.

3 Henry G. (Gerry) Schwartz (*right*), Washington University, contributes to discussion during the business meeting; at his left is Debra Miller, Kansas DOT, who is Executive Committee Vice Chair for 2007; also shown are Marcy S. Schwartz (*left*), CH2M Hill, and James R. Hertwig, CSX Intermodal.

4 John C. Horsley (*center*), AASHTO, explains the complexities of the Congressional budget process affecting transportation research.

Joining discussions are **5** Steve Williams (*right*), Maverick Transportation, Inc., with Rebecca M. Brewster, American Transportation Research Institute; **6** Rosa Clausell Rountree, Georgia State Road and Tollway Authority; **7** J. Edward Johnson, NASA; **8** Terry Shelton, FMCSA; **9** Tracy L. Rosser, Wal-Mart Stores, Inc.; **10** Anne P. Canby (*left*), Surface Transportation Policy Partnership, with Susan Hanson, Clark University; **11** Pete K. Rahn, Missouri DOT; and **12** Craig Rockey, Association of American Railroads.

Honoring Long-Term Leadership and Service

TRB awarded emeritus membership to 41 individuals, honoring their significant, long-term contributions and outstanding service through participation on TRB standing committees. The 2007 group of honorees, recognized at the Annual Meeting, are listed below.

Policy and Organization

Francis B. Francois
Transportation History

Peter G. Koltnow
Transportation History

Damian J. Kulash
Transportation History

V. Setty Pendakur
Transportation in the Developing Countries

Henry L. Peyrebrune
Transportation Issues in Major U.S. Cities

Richard R. Stander, Sr.
Transportation History

Planning and Environment

Ronald S. DeNadai
Environmental Analysis in Transportation

David L. Greene
Alternative Transportation Fuels

Ryuichi Kitamura
Traveler Behavior and Values

T. Keith Lawton
Transportation Demand Forecasting

Hani S. Mahmassani
Telecommunications and Travel Behavior

Bruce D. McDowell
Metropolitan Policy, Planning, and Processes

Patricia Lyon Mokhtarian
Telecommunications and Travel Behavior

James T. Nelson
Transportation-Related Noise and Vibration

Poulicos Prastacos
Transportation and Land Development

Danilo J. Santini
Alternative Transportation Fuels

Design and Construction

Nicholas R. Close
Landscape and Environmental Design

Ronald J. Cominsky
Management of Quality Assurance

Mark P. Gardner
Highway Traffic Monitoring

Daniel P. Johnston
Concrete Materials and Placement Techniques

G. John Kurgan
Construction Management

Joe P. Mahoney
Full-Scale and Accelerated Pavement Testing

Gale C. Page
Characteristics of Nonbituminous Components of Bituminous Paving Mixtures

Jacob Uzan
Strength and Deformation Characteristics of Pavement Sections

James C. Wambold
Surface Properties–Vehicle Interaction

Operations and Maintenance

John P. Burkhardt
Maintenance and Operations Management

Michael J. Markow
Maintenance and Operations Management

Hoy A. Richards
(*deceased, November 9, 2006*)
Highway–Rail Grade Crossings

Marshall L. Stivers
Maintenance and Operations Management

Jonathan Upchurch
Traffic Control Devices

Emeritus members of the Transportation History Committee included (*left to right*) Richard R. Stander, Sr.; Peter G. Koltnow; and (*right*) Francis B. Francois; committee Chair Alan Pisarski (*second from right*) presented the awards. (Not pictured: Damian J. Kulash.)

Legal Resources

Orrin F. Finch
Contract Law

System Users

Michael J. Cynecki
Pedestrians

Hans Laurell
Alcohol, Other Drugs, and Transportation

Allan F. Williams
Alcohol, Other Drugs, and Transportation

Public Transportation

John P. Aurelius
Commuter Rail Transportation

Gregory P. Benz
Intermodal Transfer Facilities

Bruce Horowitz
Commuter Rail Transportation

Michael A. Kemp
Public Transportation Marketing and Fare Policy

John W. Schumann
Light Rail Transit

Aviation

Geoffrey David Gosling
Aviation System Planning

Agam N. Sinha
Airfield and Airspace Capacity and Delay

U.S. Department of Transportation
Federal Highway Administration

Mechanically Stabilized Earth Walls on the Interstate Highway System

Thirty Years of Experience

DANIEL ALZAMORA AND RICHARD J. BARROWS

The authors are with the Federal Highway Administration: Alzamora is Geotechnical Engineer, Lakewood, Colorado; and Barrows is Geotechnical Team Leader, Western Federal Lands Highway Division, Vancouver, Washington.

Mechanically stabilized earth (MSE) is a construction technique that alternates layers of compacted soil and reinforcing elements to build retaining walls and embankments. The reinforcing elements, which can be either steel or synthetic, interact with the soil by friction and confinement and provide tensile capacity. The combination of soil and reinforcement behaves as a gravity mass that retains lateral earth pressures.

The Interstate Highway System, which celebrated its 50th anniversary in 2006, has used MSE techniques for approximately 34 years. One of the earliest MSE walls in the United States was constructed on California State Highway 39, northeast of Los Angeles, in 1972. Since then, MSE walls have gained popularity and are accepted by most transportation departments as a standard retaining wall for fill or for embankment support.

Problem

Retaining walls previously were rigid structural elements constructed from traditional materials such as concrete and steel; this approach had an exemplary track record. The MSE concept was a radical departure from the status quo. The argument that the change would produce cost savings, however, could not persuade decision makers to take on the risk of the new, unproven structures. Many technical questions remained—particularly about the soil-reinforcement interaction, the face deformation, and the durability of the reinforcing elements of MSE walls.

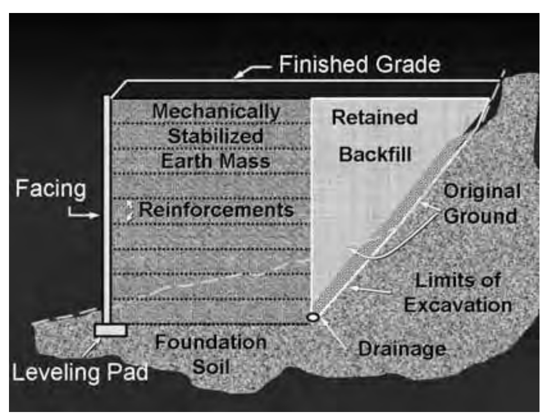
The early design methods mostly applied to proprietary MSE wall systems and often were difficult to verify. Each design method offered a different way to calculate the system's internal stability. The approaches differed not only in how to calculate the vertical stress but in how the stiffness of the reinforcement elements affected the calculations. Stiffness became increasingly significant as more types of reinforcement were developed and began competing with each other.

Solution

The National Cooperative Highway Research Program's *NCHRP Report 290: Reinforcement of Earth Slopes and Embankments* assembled a comprehensive literature review of MSE systems (*1*). The report reviewed earth reinforcement systems, as well as reinforcement mechanisms, behavior, applications, designs, and durability. This was the first step in bringing MSE wall design out of the commercial realm and into the domain of practicing engineers and researchers.

The guidelines for the internal stability of MSE walls have involved several design methods and have undergone significant changes through research and practical experience. The Federal Highway Administration (FHWA) produced a research document, *Behavior of Reinforced Soil*, that examined MSE walls and slope systems and evaluated bar mats, strips, geosynthetic sheets, soil nails, and anchored systems.

This research was the foundation for FHWA's design and construction guidelines, which set out to develop a procedure for any type of reinforcement (*2*). The simplified coherent gravity method was the result of this work, an effort to merge and clarify the preferred design approach. The American Association of



Cross section of a typical MSE wall.

State Highway and Transportation Officials' technical committee on substructures and walls calibrated the new procedure with full-scale case history data for MSE walls and adopted the procedure.

NCHRP Report 290 and the FHWA report referenced all of the MSE-related research that had been performed as of 1990. Since then, significant research has included the following:

- *Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines*, from FHWA (FHWA-SA-96-071); and
- *Development of the Simplified Method for Internal Stability Design of Mechanically Stabilized Earth (MSE) Walls*, from the Washington State Department of Transportation (Research Report WA-RD 513.1).

Ongoing research activities include the MSE Wall Pooled Fund Study and its extension, which is addressing the design of MSE walls using marginal backfill soils; and NCHRP Project 24-22, Selecting Backfill Materials for MSE Retaining Walls, which also is addressing the use of marginal backfill soils.

Application

U.S. highways now have more than 60,000 MSE walls commonly constructed to heights that exceed 35 feet. The highest transportation-related wall is an impressive 140 feet, along the third runway at Seattle–Tacoma International Airport. Today more than 9 million square feet of MSE walls are built for transportation applications each year.

Benefits

Gravity walls or cantilever cast-in-place (CIP) concrete walls have worked well and are economical for some situations but in most cases cannot compete with MSE walls. The construction of MSE walls has become easier, faster, and more economical, particularly for fill projects, because the backfill material sometimes is available onsite. In addition, MSE walls can be built quickly from prefabricated materials such as precast concrete panels or modular blocks.

Transportation Research Record 1414: Segmental Concrete MSE Walls, Geogrid Reinforcements, and Soil Nailing provided case histories of the use and of the construction performance of MSE walls made of segmental concrete units (3). The construction of MSE walls generally costs 30 to 50 percent less than that of CIP concrete walls, depending on the wall height. The current estimated annual cost savings from the construction of MSE walls instead of CIP walls on the Interstate system is $180 million.

MSE walls also have greater flexibility and can tolerate significantly more total and differential settlement than can CIP concrete walls. MSE walls therefore offer viability to some design schemes that otherwise could not be possible.

The 140-ft high MSE wall at Seattle–Tacoma International Airport allowed for a critically needed third runway.

The introduction of MSE walls more than 30 years ago has changed the design and construction of highways. The benefits of MSE walls will be realized for another 30 years; more changes are to come. Two pioneers of this technology should be acknowledged: the French architect–engineer, Henri Vidal, who developed metallic-reinforced MSE; and Dick Bell of Oregon State University, who introduced geosynthetic MSE. Also noteworthy are the many research and development efforts by academia, industry, and public agencies.

References

1. Mitchell, J. K., and W. C. B. Villet. *NCHRP Report 290: Reinforcement of Earth Slopes and Embankments*. TRB, National Research Council, Washington, D.C., 1987.
2. Christopher, B. R., S. A. Gill, J.-P. Giroud, I. Juran, J. K. Mitchell, F. Schlosser, and J. Dunnicliff. *Reinforced Soil Structures, Volume 1: Design and Construction Guidelines*. FHWA-RD-89-043, Federal Highway Administration, November 1990.
3. *Transportation Research Record 1414: Segmental Concrete MSE Walls, Geogrid Reinforcements, and Soil Nailing*. TRB, National Research Council, Washington, D.C., 1993.

For more information contact Daniel Alzamora, Geotechnical Engineer, Federal Highway Administration, Resource Center, 12300 West Dakota Avenue, Suite 340, Lakewood, CO 80228, 720-963-3214, fax 720-963-3232, daniel.alzamora@dot.gov; and Richard J. Barrows, Geotechnical Team Leader, Federal Highway Administration, Western Federal Lands Highway Division, 610 East 5th Street, Vancouver, WA 98661, 360-619-7704, fax 360-696-7945, rich.barrows@fhwa. dot.gov.

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 (phone 202-334-2952, e-mail gjayaprakash @nas.edu).

Daniel S. Turner

University of Alabama

Community involvement, outreach, and leadership mark Daniel Turner's 31-year transportation career. As a professor at the University of Alabama, and director of the Alabama University Transportation Center and Homeland Security Institute, Turner works with students both in and out of the classroom and serves as a mentor to many faculty members.

Turner has experience in both academia and industry in transportation. He earned bachelor's and master's degrees in civil engineering from the University of Alabama in 1968 and 1970, respectively; and in 1980, he earned a doctorate in civil engineering from Texas A&M University. He has served as an assistant professor and professor of civil engineering, as well as in other positions of academic leadership. On the industry side, he worked as a surveyor and designer for an engineering consulting firm, and he managed a land surveying company, Turner–Meadows Land Surveying, in 1975.

"Young engineers will need to work together to provide the next generation with sufficient mobility to ensure both personal satisfaction and economic competitiveness."

Throughout his career, Turner has emphasized to his students and mentees the importance of being involved in professional organizations in the transportation community. He has served in many transportation-related organizations at the local, regional, and national levels; he is currently president of the Council of University Transportation Centers and is a past president of the American Society of Civil Engineers (ASCE).

"When I was a civil engineering student at the University of Alabama, my favorite professor stressed professional involvement, and I followed his advice and example," Turner explains. "Many young professors arrive at their first jobs with wonderful technical skills, but they face serious challenges trying to jumpstart their research, teaching, and service activities while working to gain tenure. Professional involvement is an excellent way for them to create a foundation for careers in transportation."

Turner's involvement with TRB began in 1993, when he joined the Operational Effects of Geometrics Committee—he later chaired the committee, which recognized his long-term leadership and service with an award of emeritus membership. He has since chaired the National Cooperative Highway Research Program (NCHRP) Project Panel on Alternatives to Design Speed for Selection of Roadway Design Criteria and the TRB Technical Activities Operations Section. He has served on the Utilities Committee, the Committee on Research Priorities and Coordination in Highway Infrastructure and Operations Safety, and other TRB committees and NCHRP project panels.

"TRB is a clearinghouse for the latest transportation information," Turner comments. "It provides an ideal environment for a young professor or college graduate to network, communicate ideas with peers, and expand intellectual horizons."

Concerned about the transportation challenges of the future, Turner believes that young engineers in the United States have their work cut out for them: "The citizens of the United States have been so well served by transportation that they are becoming an 'instant' generation. Young engineers will need to work together to provide the next generation with sufficient mobility to ensure both personal satisfaction and economic competitiveness."

Turner has lectured before audiences both international and domestic, including members of ASCE, the Japan Society of Civil Engineers, the Institute of Transportation Engineers, the American Association of State Highway and Transportation Officials, the National Safety Council, and TRB. He has published widely and his work has appeared in many journals, magazines, and other publications.

Because the future of transportation depends on the ability of transportation students to follow in the footsteps of their predecessors, Turner believes that scholarships are a necessary component in ensuring student success. He is vice president of the Alabama Section of the Institute of Transportation Engineers Scholarships, a not-for-profit organization that provides financial assistance to qualified civil engineering students pursuing studies at accredited universities in Alabama.

"Scholarships are important—they made my own education possible," Turner observes. "My wife and I have tried to reflect our appreciation of this by endowing a scholarship in my parents' memory, contributing to other endowed scholarships, and giving gifts to many individual students. We hope that these opportunities will continue to be available to all who need them."

Tulinda Larsen

Commonwealth Business Media

As managing director of Commonwealth Business Media's (CBM) BACK aviation consulting service, Tulinda Larsen applies expertise acquired during her 30-year career in aviation and transportation to develop strategic and technical solutions for CBM clients.

Before joining CBM and BACK, Larsen served the transportation industry in diverse roles. She began her career at the U.S. Department of Transportation in 1975 as a staff economist on an in-house task force for regulatory reform in the trucking and aviation industries. In 1977, she served briefly as a transportation economist for the National Transportation Policy Study Commission before joining the Regional Airline Association (RAA).

As vice president of RAA, Larsen represented U.S. regional airlines and airline industry product and service suppliers before Congress, federal agencies, and industry organizations. Larsen served also as a delegate on the U.S.–Canadian bilateral negotiating committee for open skies and received peer recognition for her contributions addressing the needs of disabled airline passengers. In 1980, she took a two-year leave of absence from RAA to serve as the president of the Alaska Air Carriers Association and as the executive director of the Alaskan Aviation Safety Foundation.

"At TRB, I've found unique opportunities to expand my professional understanding of the [aviation] industry and my network of contacts."

Larsen maintains that her most rewarding contribution to the transportation community is her work with the Community Air Service Coalition (CASC). Created by airport executives and airline industry groups concerned about reduced commercial airline service to many non-hub airports, CASC's mission is to promote, encourage, and expand commercial airline service to small airports in the United States.

"In 2004, several communities approached BACK to help organize a coalition of organizations interested in improving air service to small airports," Larsen explains. "Seeking support for the program, we approached both an airplane manufacturer and an airplane engine manufacturer about providing seed money needed to create CASC."

After receiving that grant, BACK partnered with East Tennessee State University and prepared a study to assess the economic contribution of non-hub airports to the U.S. air transportation system. CASC then hosted two successful networking sessions where non-hub airport representatives met one-on-one with airline representatives.

From 2005 to 2006, CASC held live teleconferences for non-hub airport officials to discuss such topics as the 2006 Small Community Air Service Development Grant Program guidelines and the impact of U.S. Airways' bankruptcy on non-hub airports. CASC also hosted a live discussion with Government Accountability Office Director Gerald Dillingham. Larsen is confident that CASC will continue to bring more air traffic to non-hub airports: "CASC is still in its early years but we have already provided real benefits to small airports."

In addition to her work at CASC, Larsen is researching the U.S.–China transportation relationship and emerging markets: "Although air freight is only 1 percent of the total trade volume between the United States and China, the share is expected to grow as access to the Chinese market is liberalized. CBM is using PIERS maritime import–export data to model the expected developments in air freight. It's an exciting time for transportation professionals working on international trade issues."

A member of TRB's Light Commercial and General Aviation Committee, Larsen encourages young transportation professionals to interact and network with their peers by joining transportation organizations: "TRB has been a very important part of my career and I encourage young transportation professionals to participate in committees and other organizational activities as early as possible. At TRB, I've found unique opportunities to expand my professional understanding of the industry and my network of contacts."

Larsen's enthusiasm for the aviation and transportation communities is demonstrated by her service and contributions to many organizations. She is a licensed private pilot and a member of the *Regional Aviation News* editorial board. She is a member of the International Trade Data Users board of directors and a member of the International Aviation Women's Association; the Aero Club of Washington, D.C.; and the Aviation Transportation Research International Forum.

A graduate of The George Washington University, Washington, D.C., Larsen holds a bachelor's degree in political science and a master's degree in economics. She is pursuing a doctoral degree in international business administration, and has authored articles on aviation-related topics in magazines such as *Overhaul and Maintenance* and *Air Cargo World,* as well as in books, journals, and other publications.

Jenks Succeeds Reilly as Director of Cooperative Research Programs

Christopher W. Jenks

Crawford F. Jencks

Christopher W. Jenks succeeded Robert J. Reilly as director of TRB's Cooperative Research Programs (CRP), and Crawford F. Jencks was appointed deputy director, March 2007.

Reilly retired after 34 years of distinguished service with TRB. A structural engineer, Reilly was an assistant professor of civil engineering at the University of Maryland before joining TRB in 1972 as a projects engineer in the National Cooperative Highway Research Program (NCHRP). He was appointed CRP director in 1985. NCHRP grew significantly under his leadership, and additional cooperative research programs were launched for Transit (1992), Airports (2005), Freight (2006), and Hazardous Materials (2006).

Reilly also served as secretary of the American Association of State Highway and Transportation Officials' Standing Committee on Research since 1985. He was a member of the original *TR News* Editorial Board.

Jenks joined TRB in 1993 after 14 years in transit service planning and operations at the Fairfax County Department of Transportation, Virginia. After a brief stint at the Washington Metropolitan Area Transit Authority, he returned to TRB in 2000 as manager of the Transit Cooperative Research Program. He has also managed the Airport Cooperative Research Program and the Commercial Truck and Bus Safety Synthesis Program.

Crawford F. Jencks manages NCHRP and assumes management responsibilities for the Hazardous Materials Cooperative Research Program and the National Cooperative Freight Research Program. Before joining TRB in 1979, he served the Federal Highway Administration as an area engineer and assistant planning and research engineer.

QUALITY CONTROL—TRB Intelligent Transportation Systems (ITS) Committee members (*left to right*) Alan Clelland, Siemens ITS; Timothy Schoechle, Consultant; Richard Doering, TransCore; Steven Shladover, University of California, Berkeley; and William Kelly, Catholic University, discuss options for expediting the development and deployment of standards for the U.S. Department of Transportation ITS Standards program at a February 23, 2007, meeting in the National Academies' Keck Center, Washington, D.C.

COOPERATIVE RESEARCH PROGRAMS NEWS

Identifying Airport Air Pollutants

Agencies and communities near airports often request the Federal Aviation Administration (FAA) to include in National Environmental Policy Act (NEPA) and state-level documents analyses of the health impacts of hazardous air pollutants (HAPs). Information on the emission, transformation, and transportation of aircraft and other airport-related HAPs and their health impact, however, is limited.

Recent studies include airport development program environmental impact statements for Philadelphia International Airport and Chicago O'Hare International Airport, and a human health risk assessment at Oakland International Airport. In addition, FAA is assembling an emissions inventory guidance document to establish a nationally consistent methodology for quantifying HAPs from aircraft engines. In Transportation Research Circular E-CO 89, *Critical Issues in Aviation and the Environment 2005*, the TRB Environmental Impacts of Aviation Committee noted that recent studies are only a starting point in the effort to improve understanding of HAPs and their impacts.

Aerodyne Research, Inc., Billerica, Massachusetts, has been awarded a $100,000, 1-year contract [Airport Cooperative Research Program (ACRP) 02-03, FY 2006] to produce a prioritized agenda of research needs for aircraft and other airport-related sources of HAPs. These needs will include identifying the types of HAPs emitted; sources, detection, and measurement; and health and other environmental impacts.

For further information, contact Christine Gerencher, TRB, 202-334-2970, cgerencher@nas.edu.

TRB Meetings 2007

May

15 North American Freight Transportation Data Workshop
Washington, D.C.
Thomas Palmerlee

20–23 Freeway and Tolling Operations in the Americas
Houston, Texas

30 TRB Aviation Group Midyear Meetings
Washington, D.C.

June

3–7 21st Annual Southeastern States Equipment Managers Conference*
Asheville, North Carolina
Frank Lisle

3–8 1st North American Landslide Conference*
Vail, Colorado

18 Executive Forum: Reducing Traffic Congestion—Real Opportunities*
Washington, D.C.
Frederick Hejl

18–21 11th International Conference on Mobility and Transport for Elderly and Disabled People: TRANSED 2007*
Montreal, Quebec, Canada

24–27 9th International Conference on Low-Volume Roads
Austin, Texas

24–27 3rd Urban Street Symposium
Seattle, Washington

July

6 Transforming Transportation Organizations: Tools and Techniques for Organizational Development
Chicago, Illinois
Martine Micozzi

6–7 Environmental Analysis in Transportation Committee Workshop
Chicago, Illinois
Christine Gerencher

7–9 2007 Joint Summer Meeting
Chicago, Illinois

7–9 32nd Annual Summer Ports, Waterways, Freight and International Trade Conference
Chicago, Illinois

8–11 46th Annual Workshop on Transportation Law
Philadelphia, Pennsylvania
James McDaniel

8–11 Waste Management and Resource Efficiency in Transportation Committee Meeting and Workshop
Ft. Worth, Texas

9–10 Meeting Freight Data Challenges Workshop
Chicago, Illinois

9–11 2007 Transportation Planning and Air Quality Conference*
Orlando, Florida

9–12 4th International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design*
Stevenson, Washington
Richard Pain

16–18 Water Resources and the Highway Environment: Impacts and Solutions
Sanibel Island, Florida

22–24 2007 International Conference of Transportation Engineering*
Chengdu, China
Thomas Palmerlee

22–25 2007 TRB Noise and Vibration Summer Meeting
San Luis Obispo, California

23–25 Regional Transportation Systems Management and Operations Committee Summer Meeting
Woods Hole, Massachusetts
Richard Cunard

29–Aug. 1 Highway Capacity and Quality of Service Committee Summer Meeting
Charlotte, North Carolina
Richard Cunard

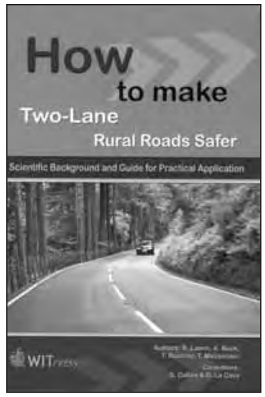
August

8–10 5th International Conference on Maintenance and Rehabilitation of Pavements and Technological Control*
Park City, Utah

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.

How to Make Two-Lane, Rural Roads Safer
R. Lamm, A. Beck, T. Ruscher, T. Mailaender. WIT Press, 2007; 118 pp.; $85; 1-84564-156-6.



In most countries, two-lane roads compose approximately 90 percent of rural road networks and are the sites of more than 60 percent of road fatalities worldwide. Authors examine the relationship between high accident rates and the road geometry of two-lane, rural road locations.

Because accidents are not often evenly distributed throughout a road network, locations with high accident rates often may be symptomatic of factors other than driver error—factors that may be characterized by the road itself. This book presents a methodology for quantifying measures of design consistency, operating speed consistency, and driving dynamic consistency.

Safety criteria are combined into a single module for a simplified general overview of the safety evaluation process. Included are case studies, comparative analyses of accidents, and an investigation of the effects of road equipment on traffic safety.

Cutting Transport CO_2 Emissions: What Progress?
ECMT–OECD, 2007; 264 pp.; $94; 92-821-0382-X.

This report reviews the progress that Organization for Economic Cooperation and Development and European Conference of Ministers of Transport countries have made in reducing transportation-related CO_2 emissions; analyzes more than 400 existing and in-development abatement measures; identifies policies that will be most effective at improving energy efficiency; and makes recommendations to assist future policy making.

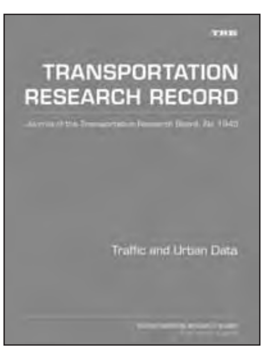
Authors maintain that despite significant efforts to curb transportation-related CO_2 emissions in some countries, emissions have increased steadily during the last 10 years. Slowing the growth of CO_2 emissions will require more government action and proactive measures from transportation sector industries.

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

TRB PUBLICATIONS

Traffic and Urban Data
Transportation Research Record 1945
Topics in this volume include determining locations and spacing patterns for inductive loop road detector placement on Interstate corridors; a California county's integrated geographic information system database for traffic analysis; characterizing truck traffic in California to aid in mechanistic–empirical pavement design; an evaluation of redesigned quartz piezoelectric weigh-in-motion sensors; using cell phones as a means to access urban traffic data; the significance of statistical changes in traffic volume during holidays; and more.

2006; 117 pp.; TRB affiliates, $36; nonaffiliates, $48. Subscriber category: planning and administration (IA).



Construction
Transportation Research Record 1946
Authors address subjects in construction management, quality assurance, concrete pavements, and hot-mix asphalt. Specific topics include the use of flowcharts to facilitate comprehension of construction contracts and to improve preliminary cost estimates for transportation projects through early item quantity prediction; seismic tests to evaluate the quality of hot-mix asphalt; and thermal imaging to investigate temperature effects on the performance of hot-mix asphalt.

2006; 170 pp.; TRB affiliates, $45; nonaffiliates, $60. Subscriber category: materials and construction (IIIB).

Rigid and Flexible Pavement Design 2006
Transportation Research Record 1947
This volume presents studies on a variety of topics in pavement design. Papers include an investigation of the effects of dowel misalignment on joint opening behavior in concrete pavements; an evaluation of pavement slab strain as a result of environmental loads; the effect of slab curling on the development of cracking at saw-cut notches and long-term joint movement in highway concrete pavement sections; the response of early-age, continuously reinforced concrete pavement to environmental loading; and testing stainless steel hollow-tube and epoxy-coated steel dowels for long-term performance to reduce pavement life-cycle costs in jointed concrete slabs.

2006; 192 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber category: pavement design, management, and performance (IIB).

Management and Delivery of Maintenance and Operations Services
Transportation Research Record 1948
This five-part volume focuses on outsourcing and quality assurance, work-zone traffic control and safety, pavement markings, winter maintenance, and weather and surface transportation. Paper topics include work-zone speed-limit enforcement devices; an automated work-zone information system to reduce peak-hour delay during construction; a system for managing pavement marking performance; models for predicting winter storm costs; alternative chemicals for snow removal on highways; and a road weather severity index.

2006; 176 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber category: maintenance (IIIC).

Pavement Rehabilitation, Strength and Deformation Characteristics, and Surface Properties–Vehicle Interaction 2006
Transportation Research Record 1949
This volume is divided into three parts. Part 1: Pavement Rehabilitation addresses such topics as a fast-track reconstruction approach for a heavily trafficked long-life pavement rehabilitation project on I-15 in Southern California; a nondestructive method for determining the moduli of reclaimed layers in thin-surface hot-mix asphalt pavements; and a procedure for identifying the extent and depth of stripping within in-place hot-mix asphalt pavement sections. Part 2: Pavement Strength and Deformation Characteristics presents research on the evaluation of fatigue cracking and permanent deformation of asphalt pavements with varying air voids and on a mechanistic pavement analysis with fatigue cracking and rutting models validated with response and performance measurements from asphalt pavements. Part 3: Pavement Surface Properties–Vehicle Interaction contains an analysis of the effectiveness of longitudinally grooved pavement in preventing automobile hydroplaning; a program to reduce wet-weather traffic accidents at the network level; and more.

2006; 180 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber category: pavement design, management, and performance (IIB).

Manual on Service Life of Corrosion-Damaged Reinforced Concrete Bridge Superstructure Elements
NCHRP Report 558
This report examines step-by-step procedures for assessing the condition of corrosion-damaged bridge elements. It also explores procedures that can be used to estimate the expected remaining life of reinforced concrete bridge superstructure elements and to determine the effects of maintenance and repair options on service life.

2006; 59 pp.; TRB affiliates, $24; nonaffiliates, $32. Subscriber categories: bridges, other structures, and hydraulics and hydrology (IIC); materials and construction (IIIB); maintenance (IIIC).

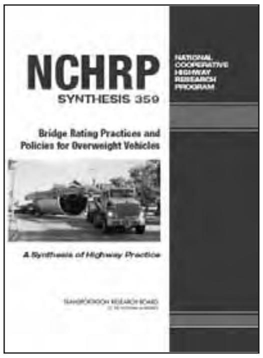
Communicating Changes in Horizontal Alignment
NCHRP Report 559
Guidelines are presented for the use of traffic control devices that communicate changes in the horizontal alignment of two-lane, two-way rural roads. Changes are recommended to the *Manual on Uniform Traffic Control Devices,* along with additional research into the development of an expert system to assess the need for traffic control devices at specific locations and to take into account motorists' reactions to changes in the advisory speed.

2006; 35 pp.; TRB affiliates, $22.50; nonaffiliates, $30. Subscriber category: highway operations, capacity, and traffic control (IVA).

Improving Pedestrian Safety at Unsignalized Crossings
NCHRP Report 562 and TCRP Report 112
This joint NCHRP–TCRP report provides guidelines for selecting pedestrian crossing treatments for unsignalized intersections and midblock locations. Quantitative procedures in the guidelines use key input variables—such as pedestrian volume, street crossing width, and traffic volume—to recommend a crossing treatment from one of four categories. The report also includes recommendations to revise the *Manual on Uniform Traffic Control Devices for Streets and Highways* pedestrian warrant for traffic control signals. The joint project received an achievement award from the Institute of Transportation Engineers in 2006.

2006; 99 pp.; TRB affiliates, $26.25; nonaffiliates, $35. Subscriber categories: operations and safety (IV); public transit (VI).

Development of LRFD Specifications for Horizontally Curved Steel Girder Bridges
NCHRP Report 563
Research findings that informed the development of design specifications for horizontally curved steel girder bridges are presented. The American Association of State Highway and Transportation Officials (AASHTO) has adopted the specifications, which are



included in the 2005 Interims to the third edition of the *AASHTO LRFD Bridge Design Specifications*.

2006; 69 pp.; TRB affiliates, $24.75; nonaffiliates, $33. Subscriber category: bridges, other structures, and hydraulics and hydrology (IIC).

Field Inspection of In-Service FRP Bridge Decks
NCHRP Report 564
Guidance is provided for the in-service inspection of fiber-reinforced polymer (FRP) bridge decks. Part 1 contains recommended field procedures, evaluation guidelines, and reporting standards for periodic inspection of in-service FRP bridge decks. Part 2 includes documentation of the research effort that led to the development of Part 1.

2006; 163 pp.; TRB affiliates, $31.50; nonaffiliates, $42. Subscriber category: bridges, other structures, and hydraulics and hydrology (IIC).

Evaluation of Best Management Practices for Highway Runoff Control
NCHRP Report 565
How to select best management practices (BMPs) for highway runoff control is the subject of this report. The BMPs seek to avoid or mitigate the negative impacts of pollutants carried by rainfall into groundwater and receiving waters and include traditional treatments applied at or near the sources of the pollutants, as well as a more distributed approach, known as low-impact development.

2006; 132 pp.; TRB affiliates, $36.75; nonaffiliates, $49. Subscriber categories: planning and administration (IA); energy and environment (IB); bridges, other structures, and hydraulics and hydrology (IIC).

Volumetric Requirements for Superpave® Mix Design
NCHRP Report 567
Presented are findings from two coordinated research projects investigating changes to the recommended Superpave mix design criteria for voids in mineral aggregate, voids filled with asphalt, and air voids content to enhance the performance and durability of hot-mix asphalt.

2006; 46 pp.; TRB affiliates, $23.25; nonaffiliates, $31. Subscriber category: materials and construction (IIIB).

Riprap Design Criteria, Recommended Specifications, and Quality Control
NCHRP Report 568
Recommended are a design approach, filter requirements, material and testing specifications, construction and installation guidelines, and inspection and quality control procedures for riprap at streams and riverbanks.

2006; 216 pp.; TRB affiliates: $33.75; nonaffiliates: $45. Subscriber category: design (II); materials, construction, maintenance (III).

Comparative Review and Analysis of State Transit Funding Programs
NCHRP Report 569
In this report, analyses supplement information collected in the U.S. Department of Transportation Bureau of Transportation Statistics annual survey of state public transportation funding. Also presented are peer analyses; straightforward, visual displays of results; and a framework for conducting peer analyses.

2006; 94 pp.; TRB affiliates: $26.25; nonaffiliates: $35. Subscriber category: planning and administration (IA); public transit (VI).

Bridge Rating Practices and Policies for Overweight Vehicles
NCHRP Synthesis 359
This synthesis explores overweight vehicle permit processes and includes information on state and provincial bridge rating systems, bridge evaluation practices, and permit policies as they relate to overweight and oversize vehicles. Also presented are specifications, software types, treatment of nonstandard configurations, and allowance for in-place dead loads; processes of permit review; and the responsibilities of personnel assigned to permit review.

2006; 108 pp.; TRB affiliates, $27; nonaffiliates, $36. Subscriber categories: bridges, other structures, and hydraulics and hydrology (IIC); highway operations, capacity, and traffic control (IVA).

Rock-Socketed Shafts for Highway Structure Foundations
NCHRP Synthesis 360
Summarized and presented is information on the use of rock-socketed shafts to support transportation structures; emerging and promising technologies; the principal challenges in advancing the state of the practice; and suggestions for improvements in the use and design of rock-socketed shafts.

2006; 136 pp.; TRB affiliates, $29.25; nonaffiliates, $39. Subscriber categories: bridges, other structures, and hydraulics and hydrology (IIC); soils, geology, and foundations (IIIA).

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TR NEWS

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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 also should 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 improve a reader's understanding of 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 photographs 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 appears. 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.

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- 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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