TR NEWS

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THE INTERSTATE AT 50: RETROSPECTS AND PROSPECTS

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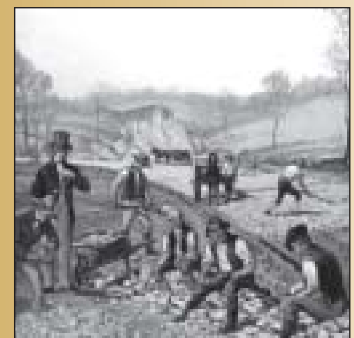

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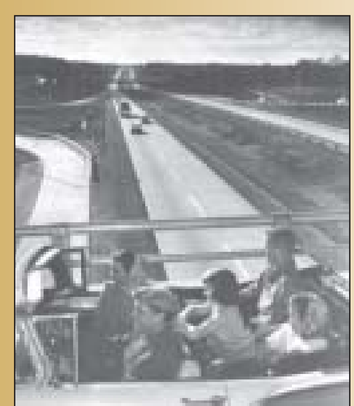

COVER: The sense of freedom, adventure, and advancement embodied in the Interstate system is conveyed in this photo from a mid-1960s public awareness campaign of the Portland Cement Association. The accompanying caption asked, "Transportation system or lifestyle?"

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

The July–August *TR News* continues to commemorate transportation history with a feature article on the early years of state highway departments, many of which are marking centennials. Other articles offer insights into the culture-sensitive design and construction of Four Bears Bridge in North Dakota (*photo, right*), Pennsylvania's high-tech approach to conserving historic transportation resources, and the viability of the fuel tax and alternatives for transportation funding.

North Dakota DOT

CELEBRATING THE INTERSTATE'S ANNIVERSARY

Source: Portland Cement Association

The Interstate Highway System has always been there for many Americans—to them, celebrating its 50th anniversary is like celebrating the birthday of television. Believe it or not, there was a time before television, and those who can remember the time before the Interstate probably also can remember the time before television. The Interstate and television both developed and became indelible components of American life in the 1950s and 1960s.

But the Interstate, as a product of governmental actions, is more important than television, which is a commercial product. Television's role in society was the result of millions of individual decisions tapping into the massive capacities of the American communications system and the consuming public. The development of television followed the classic logistics curve—starting slowly, then reaching take-off with a period of rapid growth; as saturation of ownership approaches, the demand levels out. The computer, the Internet, the Walkman, and the cell phone, among recent phenomena, have followed the same pattern, which has repeated over and over in the past 50 years. Such consumer phenomena are inexorable.

There is nothing inexorable about public works. To make a massive program like the Interstate come to completion is a much more laborious task, requiring time, money, skilled people, and—above all—perseverance by many public officials over long periods of time.

We can celebrate the anniversary of television's invention, which was followed by a hundred million decisions by consumers that made it a social phenomenon. Celebrating the Interstate, however, requires that we recognize the conceptualization, the engineering feats, the funding, and the realization of the dream by many people in our profession working together for their entire careers.

This issue of *TR News* takes the opportunity to acknowledge that tremendous body of work and to examine all aspects of its legacy. The articles in turn ask us to consider our own accomplishments and challenges in the light of this great work of our predecessors.

—Alan E. Pisarski
Chair, Transportation History Committee

Editor's Note: Appreciation is expressed to Jonathan Gifford, Professor, School of Public Policy, George Mason University, and Secretary of the Transportation History Committee, and to Frederick Hejl, Senior Program Officer, TRB, for their efforts in developing this issue of *TR News*.

CELEBRATING THE INTERSTATE'S 50TH ANNIVERSARY

HOW THE INTERSTATE SYSTEM CAME TO BE

Tracing the Historical Process

BRUCE E. SEELY

The author is Professor of History and chairs the Department of Social Sciences at Michigan Technological University, Houghton. He is a member of the Transportation History Committee and of the National Cooperative Highway Research Program Project Panel on Future Options for the National System of Interstate and Defense Highways.

On June 29, 1956, President Dwight D. Eisenhower signed a bill authorizing the funding of the National System of Interstate and Defense Highways. This bill, however, was not the beginning of the Interstate Highway system. Eisenhower's signature culminated a process that began in the 1930s and that provoked contentious debates from the late 1940s onward over how to pay for highway construction in the United States.

The 1956 legislation was the product of choices made by many individuals and organizations over a span of almost 20 years. Those who were involved in selecting among the alternatives did not know how things would turn out. Tracing the historical process behind the Interstate Highway System is complicated but instructive.

Grounded in Federalism

Congress first provided funds for a national highway network in 1916, creating an administrative system grounded in federalism. This federal-aid highway program shared authority and funding with the states, resulting in the federal-state partnership that endures today.

The federal agency that has overseen this program—first as the Bureau of Public Roads (BPR) and now as the Federal Highway Administration—has enjoyed a reputation as the unrivaled source of technical expertise on every aspect of highway construction. Thomas H. MacDonald, BPR chief from 1919 to 1953, shared in and contributed to the agency's esteemed reputation.

MacDonald and BPR fostered the development of technical and administrative capacity at the state level. After 1921, these joint state and federal efforts focused on the nation's "seven percent system," the limited mileage of primary and secondary roads that each state selected for its share of federal aid. Primary roads comprised 3 percent of the nation's highways that linked cities and larger towns and formed the U.S.-numbered system.

Planning Methodology

Even as BPR and state highway departments worked to improve this basic rural road network, federal engineers began developing approaches to plan road construction. Their outlook, however, was narrow and limited—their primary concern was determining the economic value of better roads; gaining a sense of where the demand for road improvements was most acute was secondary.

Beginning in 1922 in Cleveland, Ohio, and Cook County, Illinois, engineers and economists slowly developed a planning methodology. Initially the planners emphasized the value of time saved and the benefits of undamaged freight shipments, but soon they were counting vehicles and urging the states to use origin–destination surveys to understand motorists' desires and travel behavior. By 1930, 11 western states had organized surveys at BPR's urging.

Highway planning efforts became more sophisticated during the 1930s and allowed BPR engineers to respond to alternative conceptions of the nation's highway system. The American fascination with cars continued despite the Depression, as attested by a

SOURCE: FHWA

Thomas H. MacDonald (*left*), Bureau of Public Roads (BPR) Chief from 1919 to 1953, has been called "the towering figure of road transportation in the 20th century." His deputy, H. S. Fairbank (*right*), headed up the BPR Division of Information and created the framework for statewide highway planning surveys.

Source: Dwight D. Eisenhower Library

PAST PRELUDE—The first Transcontinental Motor Convoy of 1919 consisted of 81 motorized Army vehicles that crossed the United States from east to west. The convoy set a world record pace, traveling 3,251 miles from Washington, D.C., to San Francisco in 62 days, only 5 days behind schedule. The average speed was 6 miles per hour, progressing an average of 58 miles per day. The convoy followed the Lincoln Highway, now U.S. 30, which included 1,800 miles of dirt roads, wheel paths, desert sands, and mountain trails. Lt. Col. Dwight D. Eisenhower participated in the convoy as a Tank Corps observer. "The old convoy…started me thinking about good, two-lane highways, but Germany…made me see the wisdom of broader ribbons across the land," Eisenhower wrote in his 1967 memoir, *At Ease.*

steady increase in gasoline tax receipts, the only state-level revenue source that did not decline during the decade.

Envisioning a National System

Road projects dominated work-relief efforts. But some favored spending money on a different kind of road. The vision drew on the German autobahns, launched by Hitler in 1933 to employ workers and promote an automobile culture. The German roads captured attention in the United States, especially among highway engineers and road builders.

Several congressmen were attracted by the concept of a national system of advanced highways as a work-relief measure. Most of the plans—such as one advanced by Representative J. Buell Snyder of Pennsylvania in 1938—called for three east–west highways and five or six north–south roads to be paid for by bonds that would be retired by user tolls.

The goal was to put people to work, not to meet specific traffic needs. Several plans envisioned a national road authority that would undertake the construction.

Not surprisingly, most federal and state highway officials disliked these plans and their premises. To them, roads that failed to meet real traffic demands were wasteful. The next generation of BPR planning activities provided an enormous volume of data to support this argument.

Counting Traffic

MacDonald's deputy, H. S. Fairbank, proposed systematic ways of collecting traffic data and designed standard reporting forms. IBM produced the first automatic vehicle counters.

Fairbank tested the approach in Michigan, where the Highway Department had established 598 traffic counting stations by 1929. Beginning in 1936, BPR required every state to implement a statewide highway planning survey using Fairbank's manuals to record comparable data. Congress authorized use of federal-aid funds for the surveys, and by 1938, the surveys were generating detailed views of highway use.

From these data, BPR concluded that toll-based superhighways not only would fail to address pressing traffic needs but would generate insufficient toll revenue to pay off the bonds.

Intellectual Foundation

In 1937, President Franklin D. Roosevelt, a road enthusiast, asked BPR to study the congressional proposals. The report became a landmark document in American highway history. *Toll Roads and Free Roads* refuted the toll financing plan and the routes proposed in the various bills but was more charitable to the concept of a system of high-standard highways. Those roads, however, had to fit the nation's highway needs—resources were too scarce to waste.

Fairbank's staff prepared a map for a 26,000-mile system that could be constructed under federal-aid mechanisms, earning the designation of free roads. The highway planning survey data indicated that the most pressing highway needs were in and near cities.

This finding led BPR to urge that more funds be allocated to urban roads. The idea did not appeal to

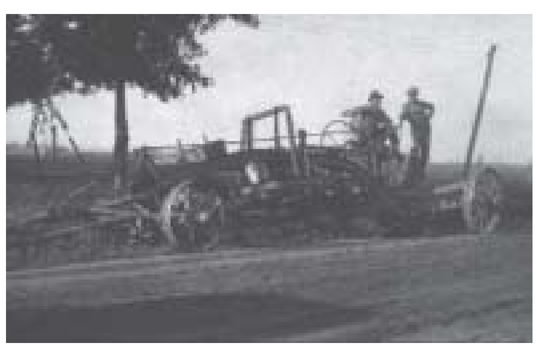


Photo: AASHTO

Road building—here, with a World War I surplus, chain-driven distributor—was a frequent work-relief project during the Great Depression.

Roosevelt, however, who feared the enormous costs of urban highways. The President directed BPR to alter that section of the report; the introduction was changed, but not the data analysis. *Toll Roads and Free Roads*, released in 1939, provided the intellectual foundation for the Interstate system.

Alternative Models

Individual members of Congress were not alone in circulating alternative models for highway projects during the late 1930s. Backed by loans from the Public Works Administration, officials in Pennsylvania in 1939 began constructing a modern turnpike from Carlisle, near Harrisburg, west to Irwin, near Pittsburgh.

Echoing their usual analysis of toll highways, BPR experts predicted the project would prove a financial failure, but the toll receipts exceeded expectations. Motorists and truckers almost immediately urged extension of the road, demonstrating a willingness to pay a premium for speed and convenience.

Futurama Effect

This response helps explain the popular fascination with another road vision of the time, Norman Bel Geddes' fanciful projection of 1960s roads for General Motors's pavilion at the 1939–1940 World's Fair in New York. Perhaps the fair's most popular exhibit, Futurama showed 12-lane superhighways and 120-miles-per-hour speeds.

BPR and MacDonald disparaged Bel Geddes as an interloper and dismissively contrasted his designs with BPR's more careful engineering approach. Nevertheless, state highway engineers acknowledged that the Futurama inspired public support for a new level of highways.

President Roosevelt shared the public's enthusiasm for Bel Geddes' conception and acted on the excitement generated by the fair and by the release of *Toll Roads and Free Roads*. In 1941, he appointed a National Interregional Highway Committee to explore details more thoroughly.

Although Norman Bel Geddes' Futurama exhibit at the 1939 World's Fair featured dramatic and complicated high-speed highway interchanges, it also projected high-rise developments with urban traffic on multilevel roadways.

Interregional Committee

Chaired by MacDonald with Fairbank as committee secretary—and eventually primary author of the report—the committee included Frederic Delano, who had just finished chairing the National Resources Planning Board; city planner Harland Bartholomew; G. Donald Kennedy, highway commissioner of Michigan and president of the American Association of State Highway Officials; California highway engineer C. H. Purcell; former governor of Alabama Bibb Graves; and Rexford Tugwell, a New Deal planner.

The war initially slowed their work, but by 1943 the committee was motivated by fears that the end of the war might bring a return to the Depression. The committee assembled an enormous amount of information from the planning surveys and laid out three road system scenarios varying in length from 34,000 to about 48,400 miles.

Postwar worries also prompted the suggestion to alter the federal-aid matching ratio from 50:50 to 75:25. The committee's 1944 report shaped the Federal-Aid Highway Act of 1944, which added an Interstate Highway System of 40,000 miles to the existing primary, secondary, and rural federal-aid systems. Although the legislation failed to provide funds specifically designated for the new roads, by 1947 BPR engineers and state highway department leaders had released a map of the basic location of rural routes, postponing the designation of 5,200 miles of Interstate roads in and around cities.

Postwar Traffic Boom

With the end of the war, traffic and travel increased, but postwar road construction started slowly, to the chagrin of politicians, motorists, and truckers. Record numbers of vehicle-miles were posted each year from 1946 through 1952, and vehicle registrations jumped from 31 million to 44.7 million between 1945 and 1949. As MacDonald had predicted in 1944, "Everyone in the United States is waiting for the close of the war to get a car to go someplace."

Yet only in isolated spots on the East or West Coasts could states afford to launch an Interstate project. The problem went much deeper than the lack of designated funds for Interstate construction. Congress had increased the size of federal-aid appropriations in 1944 to $500 million per year, but more money was not the answer for many states.

Many states struggled to provide the required 50:50 match for their additional federal-aid dollars, and the volume of unspent federal-aid allocations reached $500 million in late 1947—enough to justify suspending the 1949 appropriation. More money for Interstates would not have helped, and in 1949 and 1950, Congress decided that $450 million per year was all the states could match. The postwar inflation and shortages of some road-building materials during the Korean conflict slowed construction programs.

Under pressure to address the problem, Congress instead debated about road funding. Contentious hearings in 1948, 1950, and 1952 produced no agreement on how to proceed. Proponents of rural and secondary, urban, and interstate networks all argued for more funds. Congress added a pittance—$25 million—for the Interstate network in 1952, but the general problem of limited state finances persisted.

Congress was stymied by the magnitude of the problem and by the costs of the answers.

States Take Action

During this stalemate, a handful of states with strong highway departments attempted to attack the problem on their own. California worked on Los Angeles freeways; Robert Moses expanded the Long Island parkways; officials in Chicago and Detroit launched urban expressways.

North Carolina was typical of many states that attempted to improve interstate routes using primary road funds. Several Eastern and Midwestern states emulated Pennsylvania and created toll-financed rural toll roads. Maine acted first, followed in rapid succession by New Hampshire, Maryland, West Virginia, Ohio, Oklahoma, Colorado, New Jersey, New York, Indiana, and Illinois.

By October 1953, 762 route miles of toll highways were open, with another 1,100 miles under construction in 11 states. These roads improved service for long-distance travelers but did not address municipal problems. State planners deliberately routed the high-speed highways around, not into, urban areas.

As BPR had predicted, some roads did not pay for themselves—for example, in West Virginia and Oklahoma. In short, toll roads were not a universal solution for building better highways for the increasing numbers of drivers.

The Administration Responds

The answers had to come from the political arena, and President Eisenhower deserves the credit for starting that process. In his memoirs, Eisenhower reported a sense of urgency for several reasons, including the wave of traffic. The 10 million new vehicles registered between 1952 and 1955 more than equaled the total number of vehicles in Britain and France. At the same time, governors were pressing for changes, such as removing the federal gas tax so that states could gain revenue.

Although the Korean conflict dominated their agenda, Eisenhower's domestic staff started studying the highway problem in late 1953 and early 1954. Treasury Secretary George M. Humphrey, Undersecretary of Commerce for Transportation Robert Murray, and Commerce Secretary Sinclair Weeks were involved, but Arthur Burns, chair of the Council of Economic Advisers, was most influential in shaping these studies.

General John Bragdon was assigned to explore highway plans based on premises different from those of the federal-aid system. The presidential advisers believed that Interstate roads should be constructed by the federal government, not under federal-aid principles, because the Interstates had national importance and because efficiencies could be achieved.

SOURCE: PENNSYLVANIA DOT

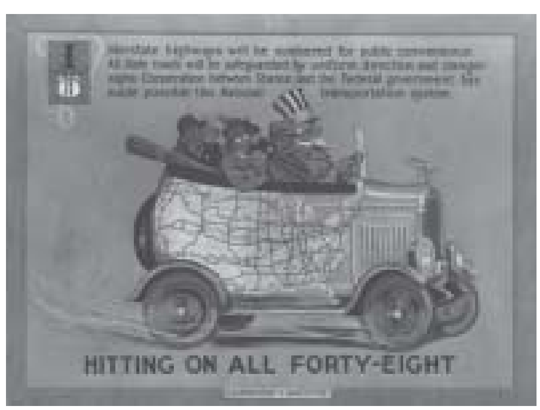
Cars line up at the Blue Mountain Interchange at the opening of the Pennsylvania Turnpike, October 1, 1940. Billed as the "road of the future," the turnpike has been incorporated into Interstates 70 and 76.

The advisers wanted the roads to be self-liquidating, collecting tolls to repay bonds. Toll receipts from heavily used routes would offset losses elsewhere; such transfers were not possible under the federal-aid principle.

The economists hoped to use highway construction as a counter-cyclical economic tool, subordinating the road program to the state of the economy. They wanted Interstate roads to bypass, not enter, cities. Like Roosevelt, Eisenhower and his aides feared the costs of urban road construction.

New Rationale

In 1954, Congress had increased road appropriations to $875 million, with $175 million for Interstate highways, but the structural financial problems remained. In July, Eisenhower arranged to deliver a speech to the governors but was unable to make it because of a death in the family; Vice President Richard Nixon substituted. The speech did not cover all of the administration's discussions but created a stir by proposing to spend $5 billion a year for 10



SOURCE: AASHTO

Members of the Clay Committee present President Eisenhower with their report and recommendations on financing a national interstate highway network, January 11, 1955: (*left to right*) Lucius D. Clay, Frank Turner, Steve Bechtel, Sloan Colt, William Roberts, and Dave Beck. Eisenhower points to a page with a map of the proposed system.

years on highways, mostly for Interstate routes between cities.

The speech also alluded to the civil defense implications of these roads, raising an argument with powerful public relations appeal during the early years of the Cold War. This new rationale for urban Interstates had no effect on the roads' design or location, but it added political momentum.

After the well-received speech, Eisenhower appointed an Advisory Committee on a National Highway Program, chaired by former general and wartime colleague Lucius Clay. Other members included San Francisco engineer Stephen Bechtel, Teamsters Union President Dave Beck, Bankers' Trust President Sloan Colt, and Allis Chalmers CEO William Roberts. Francis Turner, a BPR engineer, was named executive secretary, and BPR provided staff support.

Continuing Problems

The committee quickly reviewed options and gathered input from all concerned parties. Most highway officials and road supporters were unwilling to endorse some of the administration's goals. For example, Pyke Johnson, former director of the Automobile Chamber of Commerce and the Automotive Safety Foundation, as well as a close friend and longtime supporter of MacDonald, was part of an advisory group from the highway community that pressed to retain the federal-aid approach. In other words, the committee faced the continuing problem of which roads to build and how to pay for them.

Clay's group produced a report by January 1955 that had as its centerpiece a federally constructed Interstate program that would cost $25 billion over 10 years, paid for by bonds and tolls. They urged creation of a National Highway Authority to deal with finances, with BPR serving as the technical authority. The federal-aid program was to continue for the so-called ABC system of primary, secondary, and urban roads.

Bragdon bitterly blamed BPR's "horse and buggy" thinking for the committee's failure to endorse all the administration's ideas. But when Eisenhower forwarded the report to Congress in late February, leaders in both parties proved even more resistant to changing the federal-aid highway program as Eisenhower and the Clay Committee proposed.

Several factors were at play, including traditional partisan politics. Democrats, who controlled the Senate, were not eager to give Eisenhower a major victory just before a presidential election year. But Republicans also had issues, including the challenge of reconciling the staggering cost of the program with their philosophical abhorrence of big government.

Legislative Proposals

Amid these concerns, Senator Albert Gore of Tennessee chose not to wait for the Clay bill to emerge from the House, which by precedent first considered highway legislation. Because Senator Harry Byrd of Virginia, powerful chair of the Finance Committee, refused to support a bond financing plan, Gore proposed adding $10 billion to the federal-aid program for Interstate construction, with an adjusted matching requirement of 75:25. The Senate rejected the Clay plan and then easily passed the Gore bill in May 1955.

On the House side, Representative George Fallon of Maryland also doubted Clay's plan could win support, so he introduced a bill to create the National System of Interstate and Defense Highways, with increased user taxes—especially on gasoline—to be dedicated informally to the project. Fallon also proposed shifting the matching ratio to 90:10. He drew on the assistance of BPR's Turner in drafting the bill, relying on federal agency expertise as House Roads committee chairs had done since the 1910s.

Fallon's bill failed to win a majority, although the Clay bill suffered an even worse defeat. In addition to partisan challenges, the bills received adamant opposition from the oil industry, trucking associations, tire producers, and others who were to pay for the new roads. Although the year had started on a positive note, 1955 ended with the hopes of many road supporters dashed.

Brighter Prospects

Yet as the legislative season dawned for 1956, the prospects for a road bill looked brighter, mainly because the truckers and the tire and oil industries had reconsidered their stance on new taxes. In addition, BPR had issued its first information on the programming of the urban sections of the Interstate system, releasing the famous "Yellow Book" with its crude route outlines for more than 5,000 miles in metropolitan areas. This added immediacy to the situation and meant that many more Congressional districts could now see the immediate effect of the legislation.

BPR had been working on several technical studies of financing needs, toll roads, and the costs of utility relocation at the requests of Congress and the administration since 1954. This willingness to turn thorny problems over to the highway engineers for resolution reflected the continuing confidence that many elected representatives—especially members of the two road committees—felt toward the technical and nonpartisan experts at BPR. The reports helped remove many of the sticking points that confronted a larger highway program in Congress.

In 1956, the political discussions resumed in the House, because the Senate had approved Gore's bill. In the House, Fallon reintroduced a revised bill, calling for $24.8 billion over 13 years for construction of an Interstate system of about 40,000 miles. The federal–state matching ratio for these roads would be 90:10. The bill also included additional funds for all other components of the federal-aid road network.

House Appropriations Committee chair Hale Boggs of Louisiana added a key provision to the funding mechanism by requiring that all new tax revenue go into a Highway Trust Fund. These tax revenues would accumulate in the fund to meet construction expenses. With that assurance, the House passed the bill on April 27.

The Senate debated the new bill, concerned about the cost, but passed its version after Byrd successfully introduced amendments controlling expenditures from the trust fund. A joint House–Senate conference worked until June 25 to reach an agreement. President Eisenhower signed the bill without fanfare in a room at Walter Reed Army Medical Center, where he was being treated for ileitis.

Shaping the Approach

With the end of a decade of rancorous political discourse about road priorities and fiscal policy, the massive road construction program began. BPR engineers had played their traditional role, unobtrusively guiding the development of highway policy by providing the pivotal technical expertise. They had worked with the Congressional leaders of both parties, with the Clay committee, and with the administration, helping shape an approach to road construction that reflected the agency's long-held ideals.

Bragdon was not completely wrong in blaming BPR for overturning the new vision crafted by Eisenhower appointees. Through dogged persistence, the engineering-based visions that emerged during the 1930s finally came to fruition.

The consequences of the engineers' efforts were both positive and detrimental, planned and unintended. The funding and administrative structure they helped put in place in 1956 advanced construction by removing much of the process from politics—especially the contentious question of funding—in the interest of efficiency and speed.

Among the most unexpected results of this action was the emergence of popular resistance to building roads into and through cities, parks, and areas of scenic beauty—in part because the process allowed little public input. This eventually caused engineers in the state and federal highway bureaucracy to lose their position of primacy over highway construction in the United States. After 1956, highway engineers never again would dominate the highway policy scene as they had.

On August 2, 1956, Missouri became the first state to award a contract with the new Interstate construction funding. Of three contracts signed that day, the Missouri State Highway Commission first authorized a contract for work on U.S. Route 66—now Interstate 44—in Laclede County; the other contracts were for work on U.S. 40—now I-70, the Mark Twain Expressway—in St. Louis and for another section of the highway in St. Charles County. Work started August 13.

CELEBRATING THE INTERSTATE'S 50TH ANNIVERSARY

THE EXCEPTIONAL INTERSTATE HIGHWAY SYSTEM

Will a Compelling New Vision Emerge?

JONATHAN GIFFORD

The author is Professor, School of Public Policy, George Mason University, Arlington, Virginia, and was a visiting fellow at the Transportation Research Board for 2005–2006. He chairs the TRB Transportation and Land Development Committee.

America's Interstate Highway System is the envy of the world. China, India, and the European Union are working to produce comparable systems. Yet the Interstate system is exceptional in American history—so exceptional that it is almost un-American.

What is exceptional is the degree to which the federal government dominated the planning and financing of the Interstate. The federal government has played a role in the development of most of the nation's major infrastructure systems, but its role in the development of the Interstate system was extensive, including planning, financing, organizational structure, and research and development.

Federal Involvement

The development of the U.S. primary highway network began in 1921, when the Bureau of Public Roads[1] provided a 50 percent match of funds for highways on the federal-aid system. Federal agents strictly controlled the designation of federal-aid highways, working in partnership with the states.

A formula that included land area and population was used to allocate financing. States would receive federal funds only as a reimbursement for completed work that had been inspected and approved by a federal official.

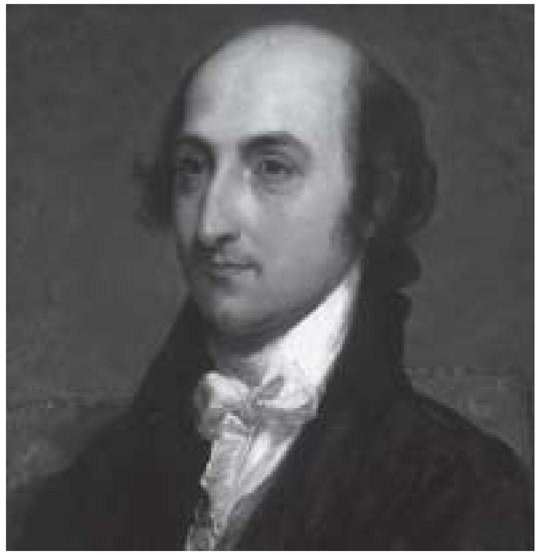
The development of the Interstate expanded the role of the federal government. The expansion started with the federal plans of the 1930s and the creation of the Highway Trust Fund in 1956, which provided 90 percent financing for the construction of Interstate highways.

The Interstate system was delineated through a highly centralized process of negotiation with each state, subject to a fixed, legislated cap on total mileage. Uniform design standards applied systemwide. Again, federal funds were available only on a reimbursement basis. Relatively uniform planning

[1] Now the Federal Highway Administration.

PHOTO BY CAL BRIGGS, UTAH DOT

Construction of I-80 in Utah.



Albert Gallatin (*above*), Secretary of the Treasury under President Thomas Jefferson, developed the first plan for a national network of roads and canals, shown in the map at left. (Map is from Goodrich, C. *Government Promotion of American Canals and Railroads,1800–1890*. Columbia University Press, New York, 1960.)

procedures were adopted—the four-step model—and national legislation for environmental assessment was added when that concern came to the fore.

Contrasting Models

Few of the nation's major infrastructure systems have had such a strong, centrally planned path of development. Air navigational aids and the later air traffic control system had a strong federal presence beginning in the 1920s, although Pan Am and United Airlines played important roles early on. Intercity passenger rail has had a dominant federal presence since the establishment of Amtrak in 1971, and a strong federal regulatory presence before that. Agricultural water reclamation in the western United States had strong involvement by the U.S. Bureau of Reclamation and later by the U.S. Army Corps of Engineers.

The nation's other major systems—railroads, electric power, telecommunications, water supply, and water treatment—were the product of much more bottom-up development trajectories, with a much less central role for the federal government.

Historic Roots

Reliance on bottom-up system development was not accidental. The founding fathers engaged in intense debates over what they called "internal improvements." The early Federalists, led by Alexander Hamilton, argued that although the Constitution gave the federal government no explicit authority to make internal improvements, that power was implied.

Thomas Jefferson's Republican party, concerned about giving too much power to the federal government, took a dim view of that interpretation. Initially, the Republicans opposed the use of federal power to make internal improvements such as roads and canals. Yet when they gained the presidency in 1801, the Republicans became much more comfortable with the idea of federal authority.

Jefferson's Secretary of the Treasury, Albert Gallatin, developed the first systematic proposal for a national network of roads and canals, which he submitted to Congress in 1808 (*1*). Gallatin's plan may be called the first plan for a national highway and canal system (see map, this page).

The National Road was the second U.S. road to use the McAdam principle of compacting broken pieces of rock that weighed less than 6 ounces and were smaller than a 2-inch ring; the process took 5 years to pave 73 miles by 1830. (Detail from painting by Carl Rakeman, courtesy of FHWA.)

Gallatin's plan was never realized, and federal support for internal improvements never materialized, with a few exceptions like the National Road—approximately today's U.S. 40—the Chesapeake and Delaware Canal, and the breakwater in Lewes, Delaware. Centrally planned systems of internal improvements did not reemerge until the early 20th century highway program.

American Federalism

Although most U.S. infrastructure systems developed from the bottom up, the national government still played an important role. For example, the federal government provided enormous subsidies for the development of the railroad system in the 19th century, giving away 131 million acres of land as an incentive to build out the network (2). But this is not the same as centrally planning a whole system.

Similarly, the federal government allowed AT&T's monopoly over telephone service for much of the 20th century, yielding a system that was centrally planned and developed. But again, this is not the same as the federal government planning a whole system.

The highway program also developed in the context of American federalism, with significant deference to states' rights and responsibilities. Federal-aid highways are owned and operated by states. Federal financial aid was for capital costs only, restricted originally to initial construction and later expanded to include reconstruction and rehabilitation. States then and now have the option to forgo federal funds and escape many federal regulations governing highway planning, construction, and operation—although none do.

The Interstate as an Exception

Many have come to view the dominant federal role in the Interstate system as normal, because it was the norm for the past half century. Yet compared with its role in other major systems in the nation's history, the federal role in the Interstate system is exceptional.

The Interstate is exceptional in another way. The program commanded widespread support from Congress and the states for almost four decades, from 1956 to the early 1990s. The total cost of the system in 2001 dollars is $418 billion. During that time, the Interstate program was subject to almost no earmarking of projects. No other federal capital program survived as long without becoming the target of legislative earmarking.

Eroding Consensus

This exceptional period, however, appears to be drawing to a close. The recent reauthorization bill, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, contained

China's Central Planners and the History of the Interstate

In 1996, a delegation from the State Planning Commission of the People's Republic of China visited Stanford University in California for a course on the development of market economies. The approximately 20 participants represented a variety of areas within the commission, with expertise in finance, economics, planning, and engineering.

The Chinese economy at the time was emerging from decades of a powerful central planning approach to governance. The Stanford program included lectures on the development of two of America's major infrastructure systems, the electric power system and the Interstate Highway System.

Chauncey Starr, the founder of the Electric Power Research Institute, lectured first on the development of the U.S. electric power system. Asked afterwards about the lecture, he commented, "They just didn't get it. All morning they kept asking, 'Where was the plan? Where was the plan?' 'There was no plan,' I told them. 'The system developed from the bottom up. Only later did it grow into today's integrated national system.' But they wouldn't accept that there wasn't a plan."

The next lecture on the development of the Interstate system met with a different response. The lecture described the development of the primary highway system beginning in the 1920s, when the Bureau of Public Roads provided a 50 percent match of funds for highways on the federal-aid system. The delegates' questions immediately turned to the concerns of central planners: "How was the mileage allocated among the states?" "How was financing allocated?" "What controls were in place over design and construction?"

The lecture next described the development of the Interstate, starting with the plans of the 1930s and the creation of the Highway Trust Fund in 1956, which provided 90 percent of the financing for the construction of Interstate highways. Again, their questions focused on the concerns of central planners: "How were mileage and funds allocated?" "How were design and construction monitored and controlled?" "How were location decisions made?"

What was the difference between the electric power system and the Interstate system? One was centrally planned, and the other was not. To the delegates of the world's then-largest planned economy, that distinction made all the difference.

—Jonathan Gifford

more than 6,000 earmarked projects. Congress is no longer deferring to the judgment and guidance of the engineers and experts who designed and built the Interstate system. The exceptional consensus vision that brought the Interstate into being is eroding, and this erosion places the transportation system at risk.

The needs of the system are huge. The population served by the surface transportation system is growing rapidly. Traffic growth is likely to continue with economic and population growth. Traffic congestion plagues most American cities. The Interstate system is reaching its design life in most places and requires expensive reconstruction and renewal.

The system's capacity to meet those needs is sharply limited. Public support for expanding the highway system to accommodate new demand seems to be tepid at best, if not hostile.

There is no apparent appetite to raise the federal gas tax, even though the gas tax as a source of funding is being eroded by inflation. Alternative fuels not subject to the gas tax are already in use. Earmarked projects are taking an increased share of funds, and little help can be expected from a federal budget that is in danger of being absorbed by retirement and medical entitlements.

In short, the state of normalcy to which the transportation community has become accustomed for the past half century is ending. The challenge to today's generation of transportation leaders is how to follow the Interstate's extraordinary opening act.

New Visions

Several possible new visions for the highway system are being discussed:

◆ **Connecting the United States to the world economy.** The American Association of State Highway and Transportation Officials and others have begun to highlight the highway system's role in connecting the United States to the world economy. This vision has freight as one of its central themes, as well as the increases in freight traffic that will arise from expansion in global trade.

◆ **Privatization.** Another possible vision, supported by the Reason Foundation, a public policy research group in Los Angeles, and others, is to expand dramatically the role of the private sector in financing system renewal, expansion, and operation. Approaches to such expansion range from traditional toll road financing to long-term concessions, such as Chicago's recent lease of the Chicago Skyway for $1.8 billion. These approaches might move American highway system development closer to the approaches traditionally pursued in France and elsewhere in Europe.

SOURCE: LIBRARY OF CONGRESS

The lease of the Chicago Skyway may provide a model for financing system renewal, expansion, and operation through the private sector.

◆ **National investment corporation.** Felix Rohatyn, a former Lazard Freres investment banker, and Warren Rudman, a former U.S. senator, have advanced one variant of a privately financed system. They propose a national investment corporation that would issue 50-year government-guaranteed bonds to fund improvements in highways, transit, high-speed rail, and airports, as well as schools and other infrastructure (3).

The idea is not completely novel—the Clay Commission appointed by President Dwight D. Eisenhower to help resolve disputes about paying for the original Interstate program also had proposed bond financing through a national corporation. Similar ideas had been advanced during the Depression. Both times the proposal proved politically unpalatable.

Yet some have criticized the national investment corporation proposal as "central planning writ large." The critics warn that toll road revenues could be applied to wasteful but politically correct projects (4).

◆ **Vehicle infrastructure integration.** The intelligent transportation systems community is advancing vehicle infrastructure integration (VII) as another vision. VII would enable vehicles to communicate directly with a detector-rich infrastructure network to allow automatic crash avoidance, road departure warnings, and delivery of other safety and consumer services.

The VII concept entails a network of 200,000 roadside installations—roughly one for every significant traffic signal in the nation. These installations would communicate with transponders in vehicles, and transponder-equipped vehicles would communicate with each other. The institutional and financial arrangements for the system are yet to be worked out.

◆ **Operations.** Also proposed is a national operations-oriented vision along the lines of "traveling coast to coast with no unexpected delay." Any delay

The original Interstate construction required durable materials (*above*). The next phase also may call for a "wired" system equipped with high-tech intelligent transportation devices.

on the system would be detected and communicated to travelers in advance. This vision could have the compelling simplicity and appeal of the Interstate system's original promise of coast-to-coast travel without a traffic signal.

◆ **Environmental harmony.** Environmental interest groups have not yet coalesced around a vision for the future of the highway system, although the concept of "smart growth" has received considerable attention. A system vision that is environmentally focused would include bike- and pedestrian-friendly communities, development that is clustered to ease service by public transit, and tolls and incentives to discourage driving alone, minimizing the need for additional highway capacity.

Some in the public health community, concerned about obesity and sedentary lifestyles, favor land use–transportation arrangements that support active lifestyles. Many others, however, question the links between obesity, transportation, and land use.

◆ **Expanded rail.** Rail figures prominently in some plans. On the freight side, some would like to shift as much traffic as possible to rail, with containers and trailers on flat cars, at least for the long-haul portion of a movement. Railroad companies have seen this as a potential business opportunity for some time, and European countries have invested heavily in this strategy. Success stories are difficult to find, although freight increasingly moves via containers.

On the passenger side, high-speed rail has been a focus. Advocates envision a network of services that would capture a significant share in intercity markets up to 500 miles apart. Such services may or may not have a role for Amtrak, and may have an expanded role for states. Lurking in the future is the dream of magnetic levitation or maglev trains. All face the issue of cost.

Websites Commemorating the 50th Anniversary of the Interstate Highway System

American Association of State Highway and Transportation Officials
http://interstate50th.org/
American Society of Civil Engineers
www.asce.org/history/monuments_millennium/highway.cfm
American Road and Transportation Builders Association
www.artba.org/50th/50th.htm
Federal Highway Administration
www.fhwa.dot.gov/interstate/50_splash.htm
www.fhwa.dot.gov/interstate/homepage.cfm

State Departments of Transportation
Colorado—www.dot.state.co.us/50Anniversary/index.cfm
Florida—www.fl-interstate.com
Georgia—www.dot.state.ga.us/50th/index.shtml
Illinois—www.IL50.com
Iowa—www.iowainterstate50th.com/
Kansas—www.ksdot.org/interstate50th/
Minnesota—www.dot.state.mn.us/interstate50/
Nebraska—www.dor.state.ne.us/i-80-anniv/index.htm
Ohio—www.dot.state.oh.us/interstate50
Oregon—www.oregon.gov/ODOT/COMM/interstate50.shtml
Rhode Island—www.dot.state.ri.us/news/50th.htm
South Carolina—www.dot.state.sc.us/getting/50year_ann.shtml
Tennessee—www.tninterstate50.com/
Texas—http://tti.tamu.edu/interstate_anniversary/
Virginia—www.virginiadot.org/infoservice/100years/interstates.asp
Wisconsin—www.dot.wisconsin.gov/library/history/50/

—Compiled by Jessica Fomalont, Assistant Librarian, TRB

This list illustrates the range of visions under discussion. Nothing approaching consensus is apparent—but this is not surprising. The original Interstate program spanned a 20-year gap between conception in the 1930s to full funding in 1956. The debate about a national system of high-speed highways began before World War I.

Yet no comparable vision today seems likely to yield consensus support as the Interstate did. Therefore it is possible that federal leadership, which was essential for the Interstate network and subsequent surface transportation planning, development, and financing, will continue to erode.

Ominous Prospect

If the Interstate is an exception that cannot be replicated, where does that lead? One dark vision of the future federal surface transportation program may be found in the history of the U.S. Army Corps of Engineers. Founded in 1824, the Corps has a long tradition of fine engineering.

Early on, Congress supported the Corps in the development of a significant system of internal improvements. This also was an exception to our nation's history of deferring to states, localities, and the private sector in the development of infrastructure, but it was short-lived. After only 15 years, Congress cut back support for system-level development and shifted the support to individual projects.

Today, every dollar of the Corps' multibillion dollar civil works budget is earmarked to a specific project by Congress, and many observers preface descriptions of the work with the term "pork barrel." The surface transportation program could fol-

High-speed rail (*far left, the Eurostar in London's Waterloo station*) and maglev trains offer potential alternatives to Interstate expansion.

low the Corps of Engineers model and evolve toward continued project-level focus and legislative earmarking.

That prospect is ominous, but not hopeless. Today's challenging situation provides a valuable opportunity to explore new systems, as well as new institutional and financial arrangements to allow the systems to develop and flourish. To paraphrase the late Peter Drucker, the present is the enemy of the future. Thomas Hughes, the historian of technology, makes the same point: old systems suffocate new ones.

Most readers have observed in their lifetimes how new systems can displace their parent systems. The federal government forced the breakup of AT&T in 1984, paving the way for two decades of extraordinary innovation and development in communications. Where would that industry be today if the AT&T monopoly had remained intact?

Evolving Features

No one knows how the surface transportation system will evolve. The Interstate system will remain in use for generations, and the public is certain to demand continued renewal. Looking forward, several features appear likely:

◆ **The private sector will play a larger role in financing.** Given the state of the federal budget, the aversion to increasing the gas tax, and problems with the future of the gas tax, federal financing is unlikely to lead the way as it did by providing 90 percent of the financing for the Interstate.

◆ **Future federal support will be influenced increasingly by politics.** Despite calls for an end to earmarking, a return to a system driven by expert planning instead of political control will be difficult.

◆ **Vehicle infrastructure integration will expand.** Significant accomplishments in the area of electronic toll payment already are in place. The institutional issues are formidable, but if these can be addressed, significant system performance increases are possible.

A Contest of Values

An important lesson of the Interstate is that a thoughtfully engineered system can bestow enormous benefits. Although far from perfect, the Interstate system has made extraordinary contributions to the nation's quality of life. The Interstate is exceptional among the nation's major infrastructure systems in the magnitude of the federal role and in the duration of the federal commitment to building out the system.

No vision as compelling as that of the Interstate has yet emerged. Achieving an Interstate-like consensus—a worthy objective—may not be possible. Limiting the exploration of alternatives to those that require a consensus would be a mistake, leading to more of the same. In this extraordinary time, it is imperative to explore new systems, new institutional and financial arrangements, new roles, and new responsibilities.

Conceiving and realizing the nation's transportation future will be an ongoing contest among often strongly held views about mobility, accessibility, equity, environmental stewardship, economic competitiveness, and resource conservation. This contest is not only about the technical and engineering efficiency of the transportation system—it is about values.

The transportation leaders of the mid-20th century wrestled with these issues and created the vision that brought the Interstate program into being. Today's transportation leaders have an equal obligation to forge a new future. That could be their most important legacy.

References

1. U.S. Department of the Treasury. *Report of the Secretary of the Treasury on the Subject of Public Roads and Canals*. William Duane, Philadelphia, 1808.
2. Williamson, J., and D. Steele. *Federal Aid to Domestic Transportation: A Brief History from the 1800s to the Present*. Library of Congress, Congressional Research Service, Washington, D.C., 2003.
3. Rohatyn, F. G., and W. Rudman. It's Time to Rebuild America: A Plan for Spending More—and Wisely—on Our Decaying Infrastructure. *Washington Post*, December 13, 2005, p. A27.
4. Poole, R. W., Jr. The Emerging Threat to Toll Revenues. *Public Works Financing*, No. 202, February 2006, pp. 23–24.

CELEBRATING THE INTERSTATE'S 50TH ANNIVERSARY

THE SOCIAL IMPACTS OF THE INTERSTATE HIGHWAY SYSTEM

What Are the Repercussions?

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Interstate highways have had broad social effects on the United States. The Interstates have not only altered how the nation travels, and how much, but also have changed the structure of communities and regions and the choices that residents are able to make on where to live, work, shop, and play.

For many, the social impacts of the Interstates have been positive: increased access, mobility, and options for individuals, households, and firms. For others, however—especially for those not able to own or drive a car—the Interstates have decreased access and mobility by undermining the viability of alternative modes of transport. Similarly, some communities have developed because of the Interstates, but others never have recovered from Interstate construction and are subjected to Interstate-related noise and emissions.

The Interstate Highway System also has had profound impacts on American institutions. The Interstate program helped create highway departments with a strong set of norms, values, and beliefs that continue to guide organizational missions, day-to-day activities, and views of the department's role in society. In turn, the program has led to changes in government organization, sometimes to counteract the dominant focus on highway building. The redistribution of power and authority from independent highway commissions to governors and legislators and from state highway departments to metropolitan planning organizations is an example of institutional change sparked by the Interstate program and its impacts.

Dominant Technology

The social impacts have been wide-ranging because the Interstate Highway System is a dominant technology. Except during peak periods of use in urban areas, Interstates offer speed and ease of travel substantially better than those available with other modes. The Interstates, however, require mass ownership and operation of mass-produced, affordable automobiles on the operator side of the system.

The Interstate, together with privately owned vehicles, quickly displaced or reduced the role of earlier technologies such as passenger and freight rail systems. In smaller cities and those that have developed with the automobile, the Interstates have displaced transit. In older, denser cities, transit continues to play a major role but often has failed in the suburbs.

As massive works of engineering, the Interstates also have dominated the landscape. Highways are cultural icons and landmarks, but their meaning has varied—in some cases, the roads were a "technological sublime" and a form of engineering as art, but in other cases, the road was a "monster" that ripped through urban fabric or through natural landscapes, wreaking havoc.

Facilitator of Changes

Interstate highways have played a major role in the suburbanization of the United States, but they were not the first transportation technology to do this, nor was transportation the only factor in suburbanization. Residential suburbanization followed the outward deployment of rail and streetcar technologies, and the trend accelerated with increased ownership of mass-produced automobiles.

Other contributors to suburbanization included the local government practice of zoning industries out of the cities and in the urban fringe; industrial production practices and technologies that favored single-floor layouts, requiring large amounts of land; housing policies and practices that favored home ownership and suburban locations—such as redlining or withholding home loans in the inner city and older suburbs, tax deductions for mortgage interest, and mass production of housing on greenfield tracts; de jure and de facto segregation by race and income; and the modernist idea that new is improved. Retail and service employment followed the population shifts outward, often attracted by the lower cost of land and by a business environment that was less regulated.

The Interstates facilitated these moves but the same shifts occurred along other, lower-design primary roads as well, supporting the conclusion that many centripetal forces were operating. Big-box retail and other new forms of doing business that depend on easy access to a large market area require automobiles but can work with less-than-Interstate facilities.

Standards and Professional Life

The Interstate Highway System was a massive endeavor that occupied many years of transportation professionals' careers, from the 1950s through the 1970s and beyond. To get the job done, highway departments established rigid chains of command and sharp hierarchies—a military model of organization.

In addition, the program imposed uniform, federally established design standards nationwide, to minimize conflicts and to produce a homogeneous flow with an emphasis on speed, safety, and efficiency as primary values. Road design was by the book. Civil engineering programs began to have trouble attracting the best students, in part because the work was seen as routine, with less room for creativity and innovation than other fields could offer.

New Forms of Organization

Only a few observers—such as Lewis Mumford and Daniel P. Moynihan—predicted conflicts when the Interstates reached the city. The standard Interstate design did not fit all urban areas, and freeway revolts erupted in San Francisco, Boston, New Orleans, Memphis, Washington, Baltimore, Los Angeles, Sacramento, Phoenix, and many other cities.

The freeway revolts led to organizational change. By the early 1960s, Congress required that highway projects in metropolitan areas be approved through a process involving local elected officials. Several state legislatures dismantled independent highway commissions and gave more authority to appointed secretaries of transportation who could be pulled back from unpopular projects.

The image of the Interstate highway program and programs such as urban renewal as a "federal bulldozer," disregarding social and environmental effects, helped produce additional legislation that required environmental impact assessment and an increased role in decision making for local elected officials and community residents. Highway departments began to add—sometimes uneasily—new units that addressed community and environmental factors, and regional agencies evolved into metropolitan planning organizations.

Legacies and Evolving Impacts

The Interstate Highway System remains the dominant transportation system in the United States, although the growth in international trade suggests that ports and airports are the new driving engines of the economy. The Interstates are the major commuting corridors, the main routes for intercity travel and intercity freight, and the major links to ports and airports nationwide. Their many roles in shaping American social and cultural arrangements continue to unfold. Their impacts remain major considerations for planners.

SOURCE: TEXAS DOT ARCHIVE LIBRARY

Construction of I-45 approaches central Houston, Texas, circa 1961.

The Interstate highways are facing problems. The facilities are old, and funds for maintenance and reconstruction are not easy to find. The highways continue to have negative effects as well as positive ones, dividing communities and exposing nearby populations to noise and emissions. Some bypassed communities have benefited from traffic relief, but others have suffered as land uses along former major arteries have lost markets. Congestion on urban Interstates has pushed traffic back to some of these arterials during peak periods, creating a new set of challenges and perhaps opportunities.

The legacy of the freeway revolts of the 1960s and 1970s can be found in social justice and environmental organizations in many cities. Regional planning agencies have continued to gain in authority in most areas and have taken over part of the decision making from state highway departments.

Highway departments also are changing. Most now plan for high-occupancy vehicle lanes as well as automobile lanes, and the tight grip of uniform standards is beginning to loosen with context-sensitive design guidelines. Megaprojects that include something for everyone and attempt to mitigate or compensate for every possible adverse impact can be seen as another legacy of the freeway revolts.

All of these changes can be viewed as social consequences of the Interstate Highway System. The system has changed the way that the nation lives, works, and plays; has had a long-lasting imprint on the civil engineering profession; has spawned new organizations; and has shaped the nation's landscapes and points of reference. Even after 50 years, the effects of the Interstate Highway System continue to unfold.

CELEBRATING THE INTERSTATE'S 50TH ANNIVERSARY

INDUSTRIES ON THE INTERSTATES

What Is the Best Location?

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Build a highway, and they will come. That was the hope of those who wanted to attract more business to local communities, and it was the fear of those who did not want to attract any more development. There are many examples of new industrial and office parks built alongside Interstate highways and at interchanges. Yet there are many more examples—tens of thousands of miles of highways—with no business activity at all alongside.

An Interstate highway does not lead automatically to new development. Other location factors—such as access to markets, proximity of the workforce, and availability of utilities—also are necessary for attracting businesses.

Matter of Logistics

The impact of Interstate highways on industry can be measured in more than the savings in travel times between cities—the system has enabled a dramatic evolution in business location and development patterns. The speed and reliability of Interstate highways expanded the labor market for firms, the range of suppliers that firms could choose, and the size of the customer base that could be served with same-day deliveries. Some industries were able to realize economies of scale with larger manufacturing plants and warehouses. The Interstates brought industrial growth to outlying areas that formerly had been too far from cities but now were within a day's round trip.

Areas that were still too isolated and distant from urban markets, however, were not helped as much. Research findings have confirmed that the greatest impacts of the Interstate system on business growth occurred in nonmetropolitan areas adjacent to metropolitan areas (*1*).

The system's reliability dramatically improved delivery schedules. The Interstate highways provided a passing lane to get around slow-moving vehicles and did away with at-grade intersections that caused backup delays. The Interstate system also brought more uniformity to overpass heights and bridge weights.

The expanded market reach, greater reliability, and the connectivity to intermodal terminals introduced a new level of logistics planning. The system facilitated just-in-time manufacturing and stocking systems, which in turn led to supply chain corridors, such as Auto Alley, which has attracted seven automobile manufacturers and hundreds of suppliers to locate along the I-65 and I-75 corridors from Alabama and Tennessee to Kentucky, Indiana, and Ohio. Businesses along a multistate corridor can draw from different labor markets yet still be part of a same-day delivery system.

Strategic Interchanges

Industrial and commercial businesses often had sprawled along older highways for many miles, but the Interstates focused new business development near interchanges or along routes accessible to interchanges. A study funded by the Federal Highway Administration found that the impacts of new Inter-

SOURCE: MIDDLETOWN ECONOMIC DEVELOPMENT CORP.

Industrial, warehouse, and retail development clustered at the intersection of I-75 and Ohio State Route 122, Middletown, Ohio.

state highways on economic development varied widely. Some of the case studies that probed into local business locations showed that new industrial parks usually were built near interchanges or along local highways that easily connected to interchanges with the Interstate routes. New logistics and warehousing centers were locating at interconnections between north–south and east–west highways in the vicinity of labor markets and with the necessary zoning and utilities in place (2).

A 10-year tracking of new manufacturing plant locations in Wisconsin shows that industrial plants were built primarily along

- ◆ Interstate highways,
- ◆ Other four-lane highways that did not have the Interstate designation but had similar access control features, and
- ◆ Rural two-lane highways that had easy access to an Interstate highway interchange (*3*).

Intermodal Connections

The Interstate Highway System and its intermodal connections have provided a model for investment in interregional transportation systems elsewhere. The Trans-European Network, for example, is a $100 billion effort to improve transportation connectivity across Europe.

Nonetheless, transportation investments still are necessary to support the changing pattern of industries in the United States. With the expansion of large regional, national, and international markets for many goods, freight ton-miles are growing at a faster rate than the population. As international exports also gain a larger share of the U.S. economy, the nation's system of international gateways—airports, marine ports, and border crossings—is facing new demands. Because the Interstate Highway System provides access for goods movement to and from these gateways, demands will arise for new investment to support the changing role of Interstate highways in our nation's continuing development.

FHWA AND AECOM

Domestic and foreign-owned automotive plants and suppliers in the northern section of the I-65 and I-75 corridor, with network of links to other Interstates.

References

1. Rephann, T. J., and A. M. Isserman. New Highways as Economic Development Tools: An Evaluation Using Quasi-Experimental Matching Methods. *Regional Science and Urban Economics*, Vol. 24, No. 6, 1994, pp. 723–751.
2. Jack Faucett Associates and Economic Development Research Group. *Economic Effects of Selected Rural Interstates*. Federal Highway Administration, 2005. www.fhwa.dot.gov/planning/econdev/county.htm.
3. *A Study of New and Expanding Manufacturing Plants in Wisconsin During 1990–1996*. Wisconsin Department of Transportation, Madison, 2001.

EDGE CITY, JUST OFF THE INTERSTATE

Boon or Bane?

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That the Interstate Highway System has reshaped development patterns in the United States probably would not surprise its creators. In 1961, as the Interstate system was hitting full stride, a report by Wilbur Smith and Associates (WSA), *Future Highways and Urban Growth*, pointed out that "freeways are magnets for commercial development" and cited some of the early beneficiaries, including Roosevelt Field on Long Island, Century City in Los Angeles, and Route 128 outside Boston. The WSA report also recognized that forces already were pushing development toward suburbanization:

- Retail shopping centers were locating strategically in suburban trade areas,
- The market for downtown office space was largely stagnant, and
- Population growth was occurring primarily in the suburbs of large metropolitan areas.

Edge City Evolution

The rapid growth that was transforming America became evident by the 1980s, when new skylines appeared in the suburbs, which author Joel Garreau called "edge cities" (*1*). According to Garreau, edge cities were places that "went from country to city in the last 30 years, about when the Interstate system really started taking hold of the country."

Edge cities were commercial centers with large amounts of office and retail space and were defined by the automobile and supporting highways. Examples include Post Oak/Galleria outside Houston; King of Prussia outside Philadelphia, identified on highway signs as "Mall Next Four Exits"; and the ultimate placeless moniker, "287 and 87," at the intersection of two Interstates in New Jersey. Edge cities are the product not of urban planners who know how people should behave, but of developers who know what people want and how people act.

While planners moaned and Garreau enthused about edge cities, which were organized largely around major Interstate routes, a new form of suburban development emerged that was even more troubling to planners. Robert Lang of Virginia Tech identified the next evolution as edgeless cities, characterized by

- Low-scale office development,
- No center,
- Single-use, unconnected structures accessible only by automobile,
- Vast areas,
- More rapid growth than edge cities, and
- Dispersion throughout suburban areas.

Atlanta, often cited as an exemplar of sprawl, illustrates the impact of edgeless cities. In the 1990s, edgeless cities grew around Atlanta at the expense of edge cities. Although edge cities captured 25 percent of metropolitan office space—exceeding the 24 percent share downtown—the edgeless cities contained 41 percent of the metropolitan office space, according to Lang's estimate (2). Edgeless cities appear to be an example of extreme sprawl—no clustering, no economies of scale, and no travel options, requiring a car even for lunch and daytime errands.

Fixing Edge Cities

Edgeless cities present enormous challenges for planners, but there are some ideas and examples for fixing edge cities (*3*):

- **Break up the superblocks and increase connectivity.** If customers can patronize a variety of businesses more easily, walking becomes an option, transit becomes feasible, and the place becomes more attractive to users and more profitable for commerce.
- **Embrace mixed uses.** Mixed uses create critical mass and a sense of place. They also offer opportunities for short internal trips, which can be made on foot. In most cases, however, mixed use requires changes in zoning codes.
- **Create a pedestrian-friendly place.** Breaking up superblocks and creating nearby destinations to encourage walking is not enough. Careful attention to managing traffic and creating a more attractive pedes-

The Denver Tech Center, Denver's premier edge city, was originally conceived as a less expansive alternative for businesses, 15 miles on the Interstate from downtown. The center now has more jobs than downtown, but growth in the corridor has created one of the worst bottlenecks in the United States. A mammoth project called T-Rex is reconstructing and expanding the Interstate and adding transit service. (Photo by Gregg Gargan, Colorado Department of Transportation.)

trian environment will help people want to walk.

◆ **Create a public–private partnership.** Because most new edge cities are in unincorporated municipalities, changing them requires collaboration—best handled through a partnership—among property owners, businesses, and government.

◆ **Share and manage parking.** Vast parking areas are a defining feature of most new edge cities. To improve the quality of the place, it is essential to manage the parking but allow businesses to share and create a one-stop experience.

Protecting Interstate Service

These measures may fix some of the problems that edge cities pose for development and transportation. But because of limited plans for expanding urban highways, the future challenge is how to protect Interstates from losing excess service to unplanned growth. Without effective efforts to channel growth into infill or to areas that are closer to the metropolitan centers, housing markets may expand geometrically as consumers search for affordable places to live. The leapfrogging of commercial centers to more distant locations will prompt residents to move even farther for housing.

Areas on the fringe have some of the least congested and fastest-moving segments of urban Interstates—at least for a while. Regional strategies are needed to protect such scarce transportation capacities by containing and clustering commercial growth as much as possible, which also will improve the sustainability of suburban commercial centers.

References

1. Garreau, J. *Edge City: Life on the New Frontier*. Doubleday, New York, 1991.
2. Lang, R. E. *Edgeless Cities: Exploring the Elusive Metropolis*. Brookings Institution Press, Washington, D.C., 2003.
3. Booth, G., et al. *Ten Principles for Reinventing Suburban Business Districts*. Urban Land Institute, Washington, D.C., 2002.

CELEBRATING THE INTERSTATE'S 50TH ANNIVERSARY

THE ENGINEERING OF THE INTERSTATE HIGHWAY SYSTEM

A 50-Year Retrospective of Advances and Contributions

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The Interstate Highway System now marking its 50th anniversary is the largest and most expensive public works project in U.S. history. The Interstate's role in promoting economic development, strengthening the nation's defense, and facilitating vehicular travel is well known, but its impact on engineering and technology is not widely understood.

Although some of the technology and engineering expertise needed for this massive undertaking was already in place, the 42,500-mile Interstate Highway System was a complex engineering effort without precedent in the history of transportation. Many advances and techniques developed as the project progressed.

On the Shoulders of Giants

When President Dwight D. Eisenhower signed the Federal-Aid Highway Act of 1956 that authorized the Interstate project, the concept of a national highway system had been under investigation for many years. Enormous challenges were associated with the bold plan for a limited-access highway system that would link the contiguous 48 states. For example, the geography, geology, and climate of the United States varied greatly from state to state, as did the expertise in highway engineering and construction.

Lessons from Rail

The experience of the railroad era demonstrated the feasibility of constructing a national transportation system. Railroad building began on a massive scale after the Civil War (1861–1865). By 1880, the system included about 94,000 miles of track, which peaked at more than 254,000 miles in 1918, at the end of World War I.

Engineers learned important lessons about soil behavior, drainage, structural design, and grading that would prove useful to the engineers building roads in the 1930s and 1940s. Railroad construction proceeded without the kinds of equipment and technology that were available for highways in the 1950s. Many highways followed along the right-of-way of previously constructed railroads.

Photo: Connecticut DOT

Connecticut's Merritt Parkway—shown here near Fairfield—was built in the 1930s and served as a model for the Interstates.

Highway Precedents

Limited-access highways in America were not unknown in 1956. Parkways and freeways had been constructed in several states between 1920 and 1945. The Henry Hudson and Bronx River Parkways in New York, the Merritt Parkway in Connecticut, and the Arroyo Seco Parkway in Los Angeles are early examples of highways that served as models for the Interstates.

Perhaps the best example of an early limited-access highway is the Pennsylvania Turnpike. Modeled after the German autobahns, the Pennsylvania Turnpike opened in 1940 with higher geometric and design standards than had been applied in the United States. The facility still serves as a major east–west artery in Pennsylvania and is now a segment of the Interstate system. Interstate design standards would be based on similar principles.

Bridge and Tunnel Models

Many railroad and highway bridges and tunnels were constructed in the 19th and early 20th centuries, well before Interstate highways. The Holland Tunnel, which opened in 1927, connected lower Manhattan with New Jersey. It was the world's first long, underwater, mechanically ventilated tunnel. The twin-tube design consisted of 115,000 tons of cast iron and 130,000 cubic yards of concrete. The Lincoln Tunnel, the second tunnel under the Hudson River, opened in 1937 and remains a significant crossing for the New York metropolitan area. Both tunnels served as models for those to be constructed during the Interstate era for highway and rail transit.

The George Washington Bridge, completed in 1931, connected New York City with northern New Jersey. Built over a four-year period, its two steel towers with a span length of 3,500 feet are embedded deep in rock and concrete. The towers rise more than 600 feet to support steel suspension cables that contain more than 107,000 miles of wire. The bridge carries approximately 300,000 vehicles per day and is one of the most heavily traveled bridges in the world.

In 1937, the Golden Gate Bridge connected San Francisco to Northern California. Its 4,200-foot span is an engineering achievement that continues to serve as a major artery for the California highway system.

World War II Experience

World War II had an impact on the development of the highway engineering expertise that would be needed to design and build the Interstate. Military engineers faced large and complex challenges in the European and Pacific theaters. Many construction projects—including roads, bridges, airstrips, and harbor facilities—were completed quickly and under adverse conditions.

The Golden Gate Bridge between San Francisco and Northern California took 4 years to build; Golden Gate Strait below is 400 feet deep, and the bridge's two towers rise 746 feet.

When hostilities ended in 1945, many returning servicemen enrolled in engineering schools funded by a federal grant known as the GI Bill. Some attended state or private universities that were redirecting their training and research programs toward this new area of studies. Schools such as the University of California at Berkeley, Yale University, and Northwestern University were early leaders in highway engineering and traffic management education.

State highway departments, as well as the U.S. Bureau of Public Roads[1] (BPR) and consulting firms, eagerly employed engineering graduates to embark on careers that would center on the Interstate system.

World War II also advanced the state of U.S. construction practice. Servicemen returning from the war had experience with construction equipment. In addition, the expanding manufacturing sector brought the development of highway construction equipment to a new level of performance.

Overcoming Constraints

Several unique engineering problems faced the engineers who were tasked with building the Interstate system. The problems centered around three constraints: the size of the project, the scope of the project, and the time required to complete the project.

The enabling legislation had anticipated completion within 13 years, but engineers soon learned that the scope and cost of the project would greatly exceed early estimates of the materials and personnel required. In contrast to earlier projects, in which the major challenge was conquering nature, the

[1] Now the Federal Highway Administration.

The Lincoln Tunnel under the Hudson River between New York City and New Jersey was an engineering achievement that provided know-how for the building of the Interstate system.

Photo: AASHTO

Construction on the Pennsylvania Turnpike in the late 1930s. The Interstate precursor raised U.S. geometric and design standards for highways.

Interstate system was conceived as a means to connect cities and to relieve traffic congestion. Consequently, engineers were constructing these facilities in a difficult and more hostile environment.

The Interstate Highway System became known as the most extensive engineering project since the construction of the Great Pyramids. The complexity and challenges of the project greatly exceeded those faced by earlier builders of the nation's transportation infrastructure. Contractors expended about 2.6 billion person-hours building Interstate highways and used more than 1.5 million tons of explosives to excavate material in large cut sections and tunnels.

State Preparations

Although the federal government provided at least 90 percent of the cost, individual highway departments were responsible for building the segments of the system within their state. The Federal Aid Road Act of 1916 required all states to establish a department of highways as a condition for receiving federal funds. Only a few states, however, had the expertise and the engineering staffs qualified to design and construct highways at an Interstate scale.

Many agencies competed to secure qualified engineers; those who were hired became "the Interstate generation." States such as New York, California, and Pennsylvania had organizations with seasoned employees who were prepared for the challenges. In-house staff, contractors, and consultants would establish working relationships during the course of the Interstate program.

States shared enthusiasm and excitement for the work. Ellis Armstrong, BPR Commissioner from 1958 to 1961, predicted "many obstacles" and conceded, "We're up against a pretty tough schedule." Nonetheless he believed that the industry would respond and the Interstates could be built on schedule.

State highway engineers recognized the Interstate as a challenge and an opportunity of a lifetime. Although the desire to succeed was strong, concerns arose that shortages of engineers, materials, construction equipment, and contractors could hinder completion.

Uniformity in Practice

Fortuitously, by 1956, through the efforts of BPR, the American Association of State Highway Officials[2] (AASHO), and the Highway Research Board[3] (HRB), a network was in place for creating and transmitting technical information between state highway departments. The process for communication and the establishment of design policies had been perfected during the first half of the 20th century, long before the Interstate system was begun, during a period when highway building was an active priority in many states.

◆ BPR, established in 1893 as the Office of Road Inquiry, helped state and local governments to create road projects that would employ workers during the Great Depression of the 1930s and spearheaded the federal government's involvement in national highway building, including the Interstate system.

◆ AASHO, formed in 1914, facilitated coordination between states, brought an orderly arrangement to road systems, established standards for construction, and promoted highway development.

◆ HRB, organized in 1920 as part of the National Research Council associated with the National Academy of Sciences, established relationships between the states and the federal government to serve as a facilitator of highway research and to assist in dissemination of new information to the highway community.

These three organizations were instrumental in developing uniformity and consistency in engineer-

Researchers film and record data after a test truck crosses a bridge during the AASHO Road Test, which contributed to the development of design criteria and standards for the Interstates.

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

[3] Now the Transportation Research Board.

ing practice throughout the country, a necessity for the successful completion of a system with the Interstate's scale. Engineers could tailor design criteria to special conditions, and lines of communication emerged as the nation was inventing the modern discipline of highway engineering.

Design and Construction Standards

An important feature of the Interstate is the uniformity in design practice to assure safety and efficient operations. Design standards could be modified, however, as innovations and new techniques were developed.

In partnership, AASHO and BPR assembled and codified the knowledge gained by states before the Interstate project and communicated the information to all state highway departments. The partnership proved valuable in sharing technical knowledge and in establishing consensus within the engineering community.

Research Studies

The policies published by AASHO were the result of proven engineering research and experience, based on studies conducted by BPR, the National Cooperative Highway Research Program (NCHRP) established under HRB in 1962, state research laboratories, and universities. The partnership effectively disseminated information in such subject areas as geometric design, pavement and bridge design, highway capacity, and traffic control.

Highway departments could build Interstate projects because of these established standards, which were based on results secured from state practice. Many states had minimal experience in building limited-access highways. Yet through creativity, sensitivity, and engineering practice, each state could construct highways that were uniform in some respects, but also unique to the settings.

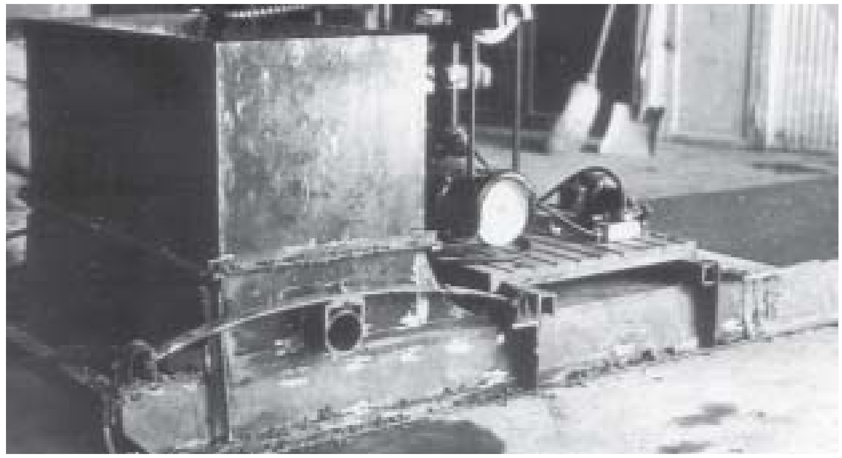
AASHO Road Test

One of the most significant research projects of the Interstate era was the AASHO Road Test, conducted between 1958 and 1960. The purpose of the project was to develop pavement design criteria for Interstate conditions. Standards for asphalt and concrete pavements and for bridge design would assure a long design life that could withstand expected increases in heavy truck travel.

The testing was conducted in Ottawa, Illinois, and consisted of more than 800 concrete and asphalt pavement sections arranged in six loops. Each lane on the loop carried traffic with axle loads ranging from 2,000 to 30,000 pounds.

Test vehicles, driven by members of the U.S. Army, traveled around the loops continuously for more than two years. The pavement conditions were measured and analyzed to produce pavement design relationships describing how various pavement structures would deteriorate with exposure to traffic.

The results became the basis for pavement design practice in the United States and throughout the world. The AASHO Road Test advanced knowledge of pavement structural design, pavement performance, load equivalencies, climatic effects, and the design of short-span bridges.



SOURCE: IOWA DOT

Prototype slip-form paver, developed in the Iowa DOT laboratory in Ames, produced sidewalk-size sections of concrete in 1948, and soon yielded a model that produced sections 9 feet wide and 6 inches deep.

Advances in Technology

The construction of the Interstates produced significant advances in civil engineering technology, particularly in asphalt and concrete pavements, drainage, bridge design, soil mechanics, and traffic forecasting.

In 1876, Belgian chemist Edmund DeSmedt supervised the asphalt paving of Pennsylvania Avenue in Washington, D.C., and in 1891, George Bartholomew paved Main Street in Bellefontaine, Ohio, with concrete. Soon other cities in the East and Midwest began paving their roads.

Paved roads, however, rarely ventured outside of cities. When automobiles arrived, the need for hard-surface roads was critical, prompting efforts to discover how to build better pavements.

Engineers had limited knowledge of the properties of concrete and asphalt before the Interstate, especially about the wearing and load-bearing characteristics. Between 1945 and 1955, the total number of automobiles in the nation doubled to 61 million. States had conducted quality testing of pavements, but the requisite knowledge was not developed until the AASHO Road Test. The Interstates were to be designed for 20 years of service, but many sections lasted many more years, and some portions have carried three to four times the loads for which they were designed.

Telegraph Pass, Interstate 8, near Yuma, Arizona.

Asphalt

Asphalt technology greatly improved during World War II because military aircraft required surfaces that could withstand heavy loads. But Interstate construction called for larger equipment than was available. Electronic leveling controls, extrawide finishers for paving two lanes at once, and vibratory steel-wheel rollers were developed. Innovative construction techniques that now are considered state of the art included rubblization and crack-and-seat methods, which enabled the use of worn roadbeds as the foundation for asphalt surfacing.

The basic principles of highway construction remain the same, but many elements have changed in the past 50 years. Recent improvements in asphalt pavement design include Superpave®, stone-matrix asphalt, and open-graded friction courses. Superpave—which stands for Superior Performing Asphalt Pavement—can be tailored to climate and traffic and has shown durability in highway performance. The open-graded friction course design has improved surface drainage of water, reducing hydroplaning and skidding.

Research to produce a quieter, more durable, and economical paving material continues. Under way is the development of warm-mix asphalt, which may lower the production and construction temperature for asphalt pavement material by 50 to 100 degrees. This new technology would require less energy to produce the mix; would reduce emissions, fumes, and odor; and would age more slowly in production, making it less prone to cracking.

Concrete

Concrete generally has a higher initial cost than asphalt but lasts longer and has lower maintenance costs. The first concrete roads were primitive, and each was unique to the builder. From the 1920s until 1960, the concrete for pavements was produced on-site. With the development of a large central mixer, concrete trucks could take the mix directly to the project site, improving the speed of the concrete placement and the quality of the mix. The central plant mixer was up to 12 times faster than on-site production.

Another advance in concrete paving was the slip-form paver, developed in an Iowa laboratory in 1947. Two years later, a slip-form paver was available that produced a section 9 feet wide and 6 inches deep. With the construction of the Interstate, larger and more efficient pavers were developed, greatly increasing construction workers' productivity.

Other improvements in concrete technology include fiber reinforcement and superplasticizers for admixtures. High-performance concrete was introduced in 1987. Areas of ongoing research on concrete pavements include improving information for inputs into pavement management systems, comparing the performance of alternative designs under dynamic loads, finding solutions to durability problems, and developing more economical ways of recycling and reconstructing old pavements.

The goal is to devise mixtures that are economical and long-lasting. Although high-quality concrete was available in small quantities at the inception of the Interstate, quality control often was sacrificed for speedy construction. Engineers and contractors later fully understood the implications of high-quality concrete for durability and longevity.

Culverts and Drainage

The Interstate also advanced drainage techniques, including culvert design and materials. Before the Interstate, culverts were made of clay or concrete, and during the 1950s, highway builders used metal or concrete culverts.

Today the development of plastic pipes has provided engineers with another alternative. In a recent project in Salt Lake City, Utah, for example, corrugated polyethylene pipe allowed completion of a $1.5 billion project on I-15 in time for the 2002 Winter Olympics. The pipe's long length reduced the number of joints, saving labor and installation time.

Bridges

As noted earlier, many long- and short-span bridges for railroads and highways had been constructed before the Interstate. For example, the Brooklyn Bridge opened in 1883.

Yet the dramatic progress in bridge engineering during the Interstate years is illustrated by a partial list of advances that came into widespread use on highway bridges during the past 50 years: prestressed concrete, segmental construction, high-performance concrete, high-strength steel, weathering steel, welded connections, computerized analysis and design, cable-stayed spans, elastomeric bearings, epoxy-coated reinforcement, radiographic inspection, and bridge management systems.

Planning

Travel forecasting was necessary for Interstate planning because the design had to size the system to accommodate traffic volumes 20 years into the future. In contrast to other aspects of engineering design, the state of the art in travel forecasting was in its infancy.

Large-scale urban transportation planning studies had been initiated in cities such as Chicago, Detroit, and Los Angeles. The pioneer effort was the 1955

Paving the Way with Research and Innovation

The Kansas Interstate Example

RICHARD L. McREYNOLDS

In the dark of night, a car zips along Interstate 70 toward the deceleration ramp at California Avenue. No one else is on the road.

Veering out of control, the car smashes head-on into a sign. When the driver finally is able to stop, he pinches himself to see if he is still alive. He scratches his head, wondering why he wasn't killed. Then he shrugs, throws his car back into gear, and zooms away.

At the speed the car was traveling, the driver should have died. The car should have been demolished, split in half. As it is, the car isn't dented. The driver hasn't suffered a scratch.

Why?

The sign post the careening car hit was a product of research. The post was joined in such a way it withstood normal wind but broke off when struck by a car traveling at more than 30 miles per hour. The sign flew over the top of the car, and neither the sign nor the post was seriously damaged.

In unfavorable weather conditions, fogging of concrete—here, during placement on an I-70 bridge—reduces cracking on new decks.

This incident, with a few conjectures, was reported in the *Topeka State Journal*, January 18, 1967. It was part of a feature article about the importance of the research that the Kansas Highway Commission[1] was doing to protect the traveling public—as well as the taxpayers' investment in the highway system.

Research always has played an essential role in building and maintaining the nation's transportation system. The Kansas Highway Commission cooperated with the Texas Transportation Institute, 11 other states, and the Bureau of Public Roads[2] to develop the break-away sign post more than 40 years ago, and research on sign posts and other roadside obstacles continues.

The first segment of the National System of Interstate and Defense Highways designated by the Federal-Aid Highway Act of 1956 was completed in Kansas on November 14, 1956. During the building of the Interstate System across Kansas, many research studies were conducted, and the technologies that were developed have played a role in building safer and more durable public roadways.

Among the advances that research related to Interstate 70 has made possible are the following:

◆ **Drake device.** Frank Drake, an engineer with the Kansas Highway Commission, developed a mechanism for cross-slope control of asphalt paving machine screeds or leveling devices, which allowed for the placement of a smoother asphalt pavement. The Drake device is the basis for the automatic, electronic screed controls now incorporated into all pavers. The Drake device was required for equipment in Kansas in the 1950s and other states soon adopted it.

◆ **Durable (Class I) concrete aggregate.** Research showed that by evaluating individual beds of rock in limestone quarries, the department could identify sources of freeze–thaw resistant limestone for crushing into concrete aggregate. Implementation of this finding, along with a concrete freeze–thaw testing program that evaluates aggregates from each of the ledges, has extended the service life of concrete pavements produced since 1980.

◆ **Optimized mix design.** With the optimized mix design, concrete pavement consolidates much more easily than with previous mixes, yielding higher strengths for the same amount of cement. The mix design reduces the amount of cement needed, easily obtains good density and air void systems, and yet yields pavements that are as strong as or stronger than pavements with other mixes. Studies show that higher-density pavements are less prone to faulting.

◆ **Bridge deck protective systems.** Several different types of high-performance concrete have been used for bridge deck construction and reconstruction of I-70 and for the bridges over I-70. These include new bridge deck overlays with silica fume or ground blast furnace slag admixtures. In addition, the rehabilitation of bridge decks with Kansas System dense concrete overlays, Iowa System dense concrete overlays, and polymer concrete two-coat broom and seed methods has extended the service life of many bridges.

◆ **SuperPave® with quality control and quality assurance testing.** All bituminous pavements placed on I-70 in the late 1990s have used this pavement design system, which evolved from research sponsored by the Strategic Highway Research Program. Kansas was the first state to implement concurrently the SuperPave binder and mix design spec-

[1] Now the Kansas Department of Transportation.
[2] Now the Federal Highway Administration.

The author is Engineer of Research, Kansas Department of Transportation, Topeka, and a member of the TRB Library and Information Science for Transportation Committee and the National Cooperative Highway Research Program Project Panel on Performance Measurement Tool Box and Reporting System for Research Programs and Projects.

I-button electronic device installed on an Interstate 70 bridge to record pavement temperatures; the data assist in modifying concrete curing specifications to increase durability.

ifications and the quality control and quality assurance (QC–QA) testing specification. The contractors perform the QC testing, and KDOT staff or representatives are responsible for the QA testing. To support this specification, Kansas State University has developed a Certified Inspector Testing and Training program.

◆ **Bituminous recycling.** Several methods have been used on I-70 to recycle in-place pavements for reconstruction and to extend the life of bituminous pavements. These include partial and full-depth projects, as well as surface, hot, and cold methods, depending on pavement conditions.

◆ **Use of Class C fly ash.** I-70 construction projects have used many tons of Class C fly ash—a waste product of the electric power industry—for subgrade stabilization, cold in-place recycling of bituminous pavement, concrete pavement, and slurry injection of wide depressed transverse pavement cracks.

◆ **Passive cathodic protection of bridges.** Cathodic protection uses a sacrificial zinc foil layer beneath an overlay to protect the steel reinforcement in bridge decks from corrosion caused by chloride intrusion.

◆ **I-buttons.** Embedded at various depths in concrete, i-buttons are small electronic devices used to investigate temperature changes over time. The i-button stores the temperature every few minutes for several days and then is "read" with a special device that captures the stored information. Findings from a research project on an I-70 bridge west of Topeka, Kansas, in the summer of 2003, for example, showed that temperatures were more severe than expected. As a result, curing specifications were modified so that bridge deck concrete would undergo less stress during curing and would gain durability.

◆ **Curing specifications.** In 1994, Kansas was the first state to require a full seven-day wet burlap cure for concrete and in 1995 was the first to require fogging of concrete during placement when the ambient weather conditions were not acceptable. These specifications have reduced bridge deck cracking on new bridge decks. Because of its research with the University of Kansas on ways to reduce bridge deck cracking, Kansas DOT serves as the lead on a $950,000 pooled-fund project supported by the Federal Highway Administration and several states.

◆ **Bridge repair with epoxy injection.** Epoxy injection technology, first investigated by Kansas DOT researchers in the 1970s, recently was used to repair the debonded deck on the I-135 bridge over I-70 in Salina, Kansas. The method is less costly than removal and replacement of the affected deck areas. Kansas DOT researchers developed another use of epoxy injection that involved angle-drilling of cracked bridge girders, insertion of extra reinforcing steel, and then epoxy injection into the void and surrounding cracks to strengthen the bridge and extend its life. Several bridges on I-70 were repaired using this technique, although some have been replaced. The technique had saved an estimated $25 million statewide in bridge repair costs by 1990.

◆ **Air-void analyzer.** This device allows real-time evaluation of concrete air voids to ensure that the concrete does not fail prematurely from freezing and thawing. Immediately after the pavement is placed, a concrete sample is taken for analysis. Testing takes about 30 minutes, so that changes can be made to the mix on the same day, if necessary. Kansas was the first state to incorporate use of this device in pavement specifications.

The construction of the Interstate Highway System across the country required the development of ways to improve safety, cut costs, reduce maintenance, and increase the effectiveness of materials. Research is ongoing to expand on the advances that were made during the height of Interstate construction. The findings will help to ensure that the roads built today are the safest and most cost-effective possible.

"Over the years, many dedicated people have worked to give Kansas a top-notch transportation system and to improve the art of highway construction," Kansas DOT Secretary Debra Miller observed at the department's 75th anniversary celebration, April 1, 2004.

Kansas claims the first segment of the Interstate system that was completed under the Federal-Aid Highway Act of 1956, 8 miles of concrete pavement for U.S. 40.

Chicago Area Transportation Study, which developed a series of models to forecast traffic patterns and flow based on a four-step methodological procedure that included trip generation, trip distribution, modal split, and traffic assignment. Many of these models are still in use today.

Other contributors were Alan Voorhees, whose seminal paper, "A General Theory of Traffic Movement," proposed a "gravity model" for forecasting trip origins and destinations. His planning firm and others completed many transportation studies applying these principles. BPR perfected the planning methods developed for the Interstate, which have been implemented in many urban transportation studies in the United States and worldwide.

Operations and Safety

Travel monitoring was another challenge for highway engineers. Among the many advances in this area is the first high-tech roadway, the 27-kilometer Glenn Anderson Freeway–Transitway, I-105 in Los Angeles. This Interstate section, which opened in 1993, features the latest in highway technology, with sensors buried in the pavement and links to computers that allow technicians to monitor traffic flow. In addition to meters that help regulate traffic on ramps, closed-circuit television cameras alert officials to accidents on the highway.

Road safety standards also have improved in the past 50 years. As early as 1960, researchers were developing reflective markings for highway pavements. Other developments include guardrail designs such as the Jersey Barrier, breakaway signs, clear zones, and reflectorized traffic signs. Construction zone practices assure safety for highway workers. Statistics show that the Interstates have had the best safety record of all classes of roadways.

Other Advances

The Interstate has brought with it many advances that have contributed not only to the highway, but to many other engineering projects. Engineers have adapted highway design to comply with environmental laws and regulations. For example, in Florida's Everglades, the construction of I-75—known as Alligator Alley—included underpasses that allow the endangered Florida panther and other wildlife to cross under the highway. Improved drainage also has enhanced the flow of water within the Everglades.

The Chesapeake Bay Bridge–Tunnel in Norfolk, Virginia, opened in 1964 and was named one of the "Seven Engineering Wonders of the Modern World" in a 1965 competition. The structure connects Virginia Beach and Norfolk to Virginia's Eastern Shore, with bridges and tunnels that total 17.6 miles in length and that feature two mile-long tunnels beneath the ocean bottom to allow passage of commercial and military ships.

SOURCE: MASSACHUSETTS TRANSIT AUTHORITY

Boston's 14-year Central Artery–Tunnel Project, known as the Big Dig, has reconfigured the juncture of I-90 and I-93.

The most recent engineering challenge was the I-90 and I-93 Central Artery–Tunnel Project, or Big Dig, in Boston, Massachusetts. The original elevated highway was chronically congested, plagued by sharp turns and many entrance and exit ramps.

Engineers employed the slurry wall technique to create 120-foot deep concrete walls on which the old highway could rest while a new road was constructed below. The concrete walls also stabilized the construction site and prevented cave-ins during the tunneling. Completed over budget and five years behind schedule, the $15 billion project nonetheless is considered an outstanding engineering accomplishment.

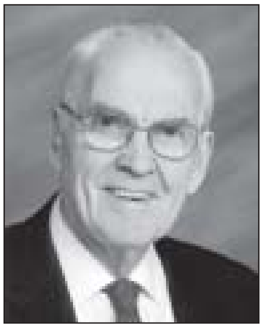
Looking Ahead

Engineers will continue to address challenges in maintaining, improving, and adapting the Interstate Highway System to the needs of the future and to the information age. The can-do attitude of the Interstate generation remains the standard for transportation engineers today and in the future.

As Stephen D. Bechtel, Jr., a noted engineer and highway builder, has stated: "For those of us who are fortunate to have been trained and to serve as engineers, there is great satisfaction in working on historic and important infrastructure projects. They improve the quality of life, in both safety and convenience, and facilitate improved commerce and economic growth around the world."

As the 21st century begins, the engineers and planners who designed and built the Interstate Highway System are in the twilight of their careers. It is important to remember the lessons learned and skills acquired in completing the Interstate Highway System. The torch has passed to a new generation of transportation engineers who will face new challenges in a fast and changing technological world.

RETROREFLECTIONS AND FUTURE DIRECTIONS



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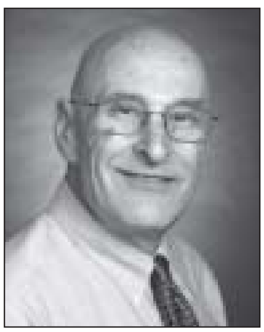


Sussman

Carlson

Reaching into Cities

ALAN M. VOORHEES

Urban transportation planner; past Chair, TRB Executive Committee (1972); deceased December 2005

Working at the Automotive Safety Foundation in 1955, I heard from various sources that the Interstate program did not have the support of local governments because they did not know what they were going to get. There were no plans for Interstates in urban communities.

Then I was asked to find some cities that had freeway plans and to estimate the cost of building the Interstate in urban areas. No city had good plans, but we did develop an estimate for urban areas. The original proposal was for $70 billion—we doubled that, and the bill was passed overnight.

The Sagamore conference in New York was the first in a series that started the development process for planning the Interstate system in urban areas. The conferences were cosponsored by the Bureau of Public Roads, the Highway Research Board, and the American Municipal Association and focused on highways and urban planning after the passage of the transportation reauthorization bills. The plans developed in the conferences, however, often did not match up with the plans that had been used for the cost estimates.

Moving Toward Sustainability

JOSEPH M. SUSSMAN

JR East Professor of Civil and Environmental Engineering, Massachusetts Institute of Technology, Cambridge; past Chair, TRB Executive Committee (1994)

Asked about the impact of the French Revolution, Henry Kissinger famously said, "It's too early to tell." Perhaps it is too early to tell about the Interstate system, too.

There is no question about the extraordinary role of the Interstate in the United States and the world. The Interstate is a product of the U.S. agenda for economic growth, implemented at the close of World War II, when political leaders were concerned that the nation would fall back into the economic depression of the 1930s.

The idea was to invest in highway transportation—and to an extent, in air transportation—to enable a substantial period of economic growth. In this, the Interstate has been a success. Sustained economic growth has been a primary characteristic of the United States during the last half of the 20th century and into the 21st.

But the Interstate also has planted the seeds for the explicit consideration of sustainability as the overarching design consideration for the transportation system of the future. Sustainability entails balancing equitable economic growth and development with stewardship of the environment. The sustainability movement in the United States has roots in the social movements that protested against the negative impacts of the Interstate—the "stop the highways" movements in San Francisco and Boston are two examples.

Mobility and economic growth remain critical U.S. policy objectives, even with the close of the Interstate era. But the Interstate also has laid the groundwork for sustainable transportation as a policy objective within a framework of sustainable development for the United States and perhaps the world. Its full impact is still to be seen.

Freedom and Transformation

E. DEAN CARLSON

President, Carlson Associates, Topeka, Kansas; former Executive Director, Federal Highway Administration, and former Secretary, Kansas Department of Transportation; past Chair, TRB Executive Committee (2002)

In 1956 I was working for the Nebraska Department of Roads on a route study of Interstate 80 from Grand Island to North Platte to decide which side of the Platte River would be most suitable. A friend who was interested in right-of-way activities asked me to keep him posted on the outcome. I did not do that, because I wanted no part in land speculation.

But that friend also was certain that the Interstate would have the most dramatic impact on the landscape and the economy since the building of the railroads. I thought then he might be exaggerating, but after 50 years I think he underestimated the impacts.

The impact of the Interstates has exceeded that of the railroads or of any other innovation in transportation because the system brought freedom to the individual. It is hard to imagine America without the Interstate system. I am pleased to have worked for 50 years in helping to achieve the transformation that the system made possible.

Building Block for Innovation

WILLIAM L. GARRISON
Professor Emeritus, Civil and Environmental Engineering, University of California, Berkeley; past Chair, TRB Executive Committee (1973)

The Interstate was a latecomer to the automobilization story that goes back to the highway improvement programs of the 1910s and 1920s. Did the Interstate distort, as well as augment, a story already well along? Did the Interstate system serve as a model for federal programs that use the we-will-withhold-your-money-unless-you-do-what-we-say style of exerting power? Those questions deserve answers, but here are responses to the questions of where we are and what to do.

Congestion is increasing. Capacity increases too often require breathtakingly high costs and are easily resisted by those who are affected adversely—unless substantial amounts of money are bled for mitigation. Consequently, efficient traffic operations and facility preservation are priorities, as is financing. Fuel and related taxes are hammered by escalating costs, and funds are siphoned by the highway-funds-as-cash-cow attitudes and actions of those who divert funds to other purposes.

What to do? Experience shows that legacy systems can suffocate new systems but also can be replaced by new systems. The Interstate may provide a building block for innovation—the new is built partly from old building blocks, as the economist Joseph Schumpeter observed in 1934. Also available are cadres of highly skilled and professional actors and agencies—that is, the highway establishment. The Interstate therefore may be in the recipe for improved services and improved futures, instead of a deadweight in a dynamic economy.

Experience and logic say that discovery beats prescription every time. Exploration to match new combinations of facilities, vehicles, and operations to markets may establish the Interstate's role in creating opportunities to do old things in new ways and to do new things—that may be the road to improved futures.

Strategic Advantage in the Global Marketplace

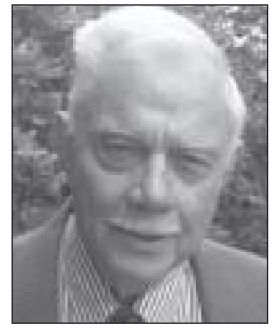
T. R. LAKSHMANAN
Director, Center for Transportation Studies, Boston University

The Interstate Highway System, constructed at a total cost of $58.5 billion (in 1957 dollars) was a wise public investment, with major transformational impacts on the economy, society, and lifestyles of the United States.

The Interstate highways have spawned a variety of economic effects: for highway users, increased mobility and time savings; for consumers, a larger shopping selection and lower average consumer prices; and for firms, lower assembly and delivery costs, the capacity to consolidate production and distribution sites and to expand outputs, and reductions in inventory costs to just-in-time levels.

Studies for the U.S. Department of Transportation suggest that highways accounted for 25 percent of the national productivity increases in the American economy between 1950 and 1989. Aided by the Interstate system and the contemporaneous advent of jets and containers, firms expanded their markets, knitting together and economically developing the far-flung regions of the country, creating an integrated, nationally sourced and coordinated production system by the early 1980s.

In recent decades, with the globalization of the American economy, the transportation infrastructure has been important to the competitiveness of U.S. firms, enhancing U.S. trade and augmenting industrial productivity with logistical savings, locational flexibility, and economies of scale in the provision of public capital. These characteristics have added production value and strategic advantage to U.S. firms in the global marketplace.



Garrison

Lakshmanan

Borrone

Deen

Renewing the Commitment to Road Safety

LILLIAN C. BORRONE

Chairman, Eno Transportation Foundation; former Assistant Executive Director, Port Authority of New York and New Jersey; past Chair, TRB Executive Committee (1995)

One of the Interstate Highway System's most important achievements in the past 50 years has been its crucial role in deepening the national commitment to making travel on America's highways safer and more efficient.

The system was a landmark in safety engineering, producing new highways designed to offer reasonable road safety at speeds of up to 75 miles per hour. Moreover, as the system encouraged mobility, it helped to raise awareness about the need for more safety measures.

Ten years after the legislation that created the Interstate system, Congress passed the National Traffic and Motor Vehicle Safety Act. Seat belts became standard equipment. Padded dashboards, air bags, collapsible steering wheels, children's car seats, and other improvements followed.

William Phelps Eno, the "father of traffic safety," would be proud of these achievements, but he also would have recognized that transportation professionals concerned about safe mobility have much work to do. With more than 42,000 people losing their lives on the nation's highways each year, the commemoration of the Interstate system's 50th anniversary should renew the commitment to developing and promoting better road safety policies and technologies.

Boundless Benefits— But Some Negative Impacts

THOMAS B. DEEN

Consultant; former Executive Director, TRB (1980–1994)

The Interstate system was one of the largest public works projects of all time. Given its geographical extent over our vast decentralized country, the system was a triumph of concept, engineering, planning, administration, and finance. Its impacts since its completion have been equally vast and comprehensive, extending into every aspect of society, whether geographic, economic, social, or political.

Most Americans accept these generalities, but there is less consensus about whether the impacts have been, on balance, primarily positive. This is in sharp contrast to the flow of positive impacts that were expected after the passage of the Federal-Aid Highway Act of 1956, which set the program in motion.

I had just taken my first job that year after finishing my schooling. Working for the mayor of a medium-sized city that was choking on its growing traffic, I strongly believed—along with my professional colleagues—that a major expansion of the highway system would be an unmitigated good.

We—and most of the public—believed that we could make better cities by routing the new roads through slum areas, using excess lands to build new neighborhoods, and expanding economic opportunities. Little did we know of the problems of displaced families, disrupted neighborhoods, negative environmental impacts, environmental justice, or the impending problems with energy supplies.

Today I have not changed my views that the Interstate was a boundless benefit to America, but I also acknowledge that some negative impacts are part of its legacy. Any new transportation program that includes urban areas will have to accommodate a public that is more sensitive to environmental, energy, and development concerns than people were a half century ago. A better understanding of both the positive and negative impacts will be required.

Assembling a Bold New Vision

DANIEL L. DORNAN
Senior Consulting Manager, AECOM Consult, Inc., Naples, Florida

For me as a baby boomer born in the early 1950s, the Interstate Highway System was what the U.S. space program would become in the 1960s—a massive and highly visible infrastructure initiative that reflected the highest vision, technology, and capabilities of the nation.

The Interstate system was instrumental in distributing much of the urban population away from the central cores of congested cities, which were vulnerable to nuclear attack. In doing so, the Interstate system launched one of the greatest voluntary population relocations in the history of the world, as urbanites flocked to the urban fringes and created a new urban form called the suburb. This stimulated economic development—pent up since the end of World War II—along the Interstate corridors.

The Interstate system permitted prompt mobilization of civil defense and military resources for domestic or international emergencies. The system was a major boost to the motor carrier industry, leading to greater modal competition in the surface freight industries and to the deregulation of the railroad and trucking industries in the 1970s and 1980s. Interstate highways became the primary surface transportation arteries for moving people and goods across the United States.

Dornan

In celebrating the accomplishments of the generation that envisioned and built what many consider to be one of the wonders of the modern world, this generation faces the daunting task of preserving and expanding the Interstate system to meet the needs of the next generation. With limited funding and many institutional impediments, the challenge is to assemble a bold new vision that will capture the nation's imagination, apply the latest technologies, and serve as a testament to what the United States can achieve when it pulls together for the common good.

This will require retooling the entire program to accommodate program diversity and competition, innovative funding and project delivery, and the flexibility to apply best practices in funding, financing, operating, and managing these critical infrastructure assets. As a major competitor in the global economy, the United States can adapt the program and thrive, or it can resist change and wither. We owe it to the previous generation to extend their vision and to the next generation to enable theirs.

The humorist Will Rogers once said that the cause of congestion in America is that government agencies build the roads and private companies build the cars. Cars are produced in a competitive marketplace and sold to customers who select the best value. Roads generally are built by government agencies as a public monopoly and treated as sunk costs, so that the level of service is a function of unbridled demand. To move forward, the Interstate system needs to become more competitive in its service offerings, introduce pricing in the most congested urban areas, and provide the necessary resources and methodologies to preserve its long-term future.

Will Rogers also quipped: "I'll tell you how to solve Los Angeles' traffic problem. Just take all the cars off the road that aren't paid for." This is how the United States traditionally has treated the building of roads under the Federal-Aid Highway Program—begin development only when funds are available to pay in full. The U.S. highway program needs to transition from a Soviet-style program to a capitalist-style enterprise.

VISION, INSPIRATION, AND PERSEVERANCE

Concluding Thoughts

ALAN E. PISARSKI

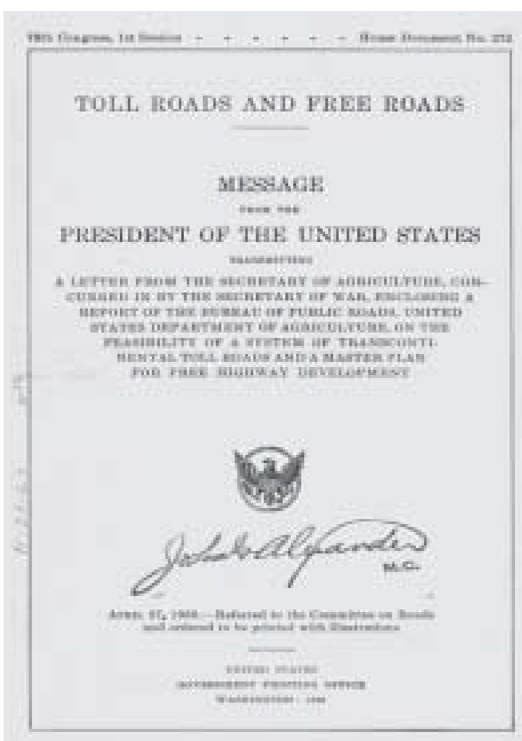
The author, a transportation consultant in Falls Church, Virginia, is Chair of the TRB History Committee and of the Data and Information Systems Section. He also chairs the National Cooperative Highway Research Program Project Panel on Using American Community Survey Data for Transportation Planning.

Among my earliest recollections of the Interstate was when I was working part-time for a construction firm while still in college. The firm was part of the consortium building the Long Island Expressway (LIE), and I got to drive on it each morning on the way to work, months before it opened to the public—probably the last time anyone drove the LIE at the speed limit in the peak hour.

The 50 years we are celebrating mark the anniversary of the funding plan for the Interstate, passed in the Federal-Aid Highway Act of 1956. That funding plan put the Interstate program on the map. The concept and the plan had been around for at least 20 years, and something like an official map dated back to 1944.

This celebration gave me the opportunity to read in full two of the great works of our profession: *Toll Roads and Free Roads* from 1939 and *Interregional Highways* from 1944. These documents are a revelation. Both reports should be made more available, and both should be read by people in our profession. Republishing these documents would expand the understanding of all members of our profession.

President Dwight D. Eisenhower in the Oval Office.



TOLL ROADS AND FREE ROADS

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES

TRANSMITTING

A LETTER FROM THE SECRETARY OF AGRICULTURE, CONCURRED IN BY THE SECRETARY OF WAR, ENCLOSING A REPORT OF THE BUREAU OF PUBLIC ROADS, UNITED STATES DEPARTMENT OF AGRICULTURE, ON THE FEASIBILITY OF A SYSTEM OF TRANSCONTINENTAL TOLL ROADS AND A MASTER PLAN FOR FREE HIGHWAY DEVELOPMENT

The books are largely the product of the genius of one man, Herbert S. Fairbank, for whom the Turner-Fairbank Highway Research Center is partly named. For many decades Fairbank was the right hand of the Chief of the Bureau of Public Roads Thomas H. MacDonald. Some still around today participated with Fairbank in that work and deserve our recognition and our thanks.

Genius and Persistence

But the Interstate required another kind of genius—a genius for inspiring people to do great things, a genius for organizing and setting challenges and then achieving them. That was the genius of Dwight David Eisenhower. The word genius and Eisenhower do not usually appear in the same sentence. Like many others, I saw two Eisenhowers—the hero of the "Crusade in Europe" and the avuncular character who became President 10 years later. Yet his genius for

What They Were Expecting, What They Got—and What We Got—from the Interstate Highway System

	1956 Actual	1965 Forecast	1965 Actual	2006 Actual
Population	169 million	180 million+	194.3 million	300 million
Vehicles	54 million	81 million	90.3 million	237 million
VMT	628 billion	814 billion	888 billion	3 trillion
GNP	$357 billion+	$500 billion+	$720 billion+	$13 trillion+

VMT = vehicle miles traveled; GNP = gross national product

organizing an effort, inspiring people to action, and putting in place the tools that would permit them to succeed made the Interstate possible.

Many of us with the myopia of the present may have a vision of the past in which the Interstate was inexorable—it was guaranteed, it had to be, or maybe it always was—because it is such a mainstay of our world today. But the Interstate did not have to be. Frank Turner told me about the crushing defeat of the plan for the Interstate in 1955 (*TR News* 213, March–April, 2001)—the plan had to be sold and sold again. People like Turner and President Eisenhower had to work continuously to make their vision part of the national vision. They were men who would come back from setbacks and defeats and try again and succeed.

Eisenhower's State of the Union addresses in 1954, 1955, and again in 1956 show that it took inspiration and perseverance on the part of many to create the Interstate system and to make it a success. Eisenhower's message to Congress in 1955 reveals the scale of his vision:

> *Together the uniting forces of our communication and transportation systems are dynamic elements in the very name we bear—United States. Without them, we would be a mere alliance of many separate parts.*

Today the United States is not "a mere alliance of separate parts" in large degree because of the great vision of our predecessors whom we celebrate in this 50th anniversary year.

Safety and Saved Lives

Since its inception, the Interstate has had an exemplary safety record. The system demonstrated that high-speed movement can be accommodated safely. In its early years the fatality rate was less than 3 per 100 million vehicle miles of travel (VMT)—almost half the rate on non-Interstate facilities.

The Interstate demonstrated the value of good safety-conscious design for all facilities, and as a result, Interstate and non-Interstate facilities have improved dramatically. Today the fatality rate on non-Interstate facilities is lower than that of the Interstate in its early days and in 2004 reached the lowest level recorded in the United States—1.46 per 100 million. The fatality rate on the Interstate system also has improved markedly, with levels now well below 1 per 100 million VMT.

These low rates, however, still are unacceptable, representing more than 42,600 fatalities per year. Fifty years ago, President Eisenhower cited 36,000 roadway deaths as one reason to build the Interstate system; in contrast, considering the nearly fivefold increases in the numbers of vehicles and VMT, we can see tremendous progress. The lives saved during those 50 years are perhaps the most important tribute to the systems we have created.

Interstate interchanges near Kansas City, circa 1963.

Assessing the Condition and Estimating the Longevity of Rock Reinforcement Systems

RICHARD LANE

The author is Engineering Geologist, New Hampshire Department of Transportation, Concord.

Rock fall is increasingly a concern as the larger slopes along the Interstate highways constructed 30 to 40 years ago weather and become unstable. Transportation agencies have used metal reinforcements to stabilize highway rock slopes for more than 35 years. Corrosion of the metal elements and loss of anchorage can shorten the service life of these installations. Evaluating the condition and determining the remaining service life of the systems is a good asset management strategy.

Problem

Rock reinforcement systems have a limited performance history, and accurately determining the condition of the reinforcement elements is difficult; therefore assessing a system's longevity is critical. Although the expected design service life of unprotected rock reinforcement systems is 50 years, conditions and installation procedures vary from site to site and can greatly affect the service life.

Replacement and repair of these systems can be expensive and difficult. The New Hampshire Department of Transportation (DOT) installed its first reinforcement to stabilize a highway rock slope in the early 1970s. Although New Hampshire DOT conducts annual inspections of 10 rock reinforcement sites, inspectors lacked a consistent method for determining the actual condition of the rock reinforcement.

Solution

New Hampshire DOT initiated a two-phase research study to assess the condition of a 32-year-old rock reinforcement along I-93 in Woodstock. The first phase involved measuring the corrosiveness of the surrounding environment and performing nondestructive testing (NDT) on selected reinforcement elements.

Samples of weathered rock and groundwater were tested for pH, resistivity, moisture conditions, and sulfate and chloride ion concentrations. A rate loss model was used to determine potential metal loss from corrosion and to estimate the remaining life of the reinforcement.

Rock bolts wired for nondestructive testing.

The study used four NDT methods, recommended for evaluating metal tensioned systems in the final report from National Cooperative Highway Research Program Project 24-13 (*1*). Two were electrochemical: half-cell potential measurement and measurement of polarization current; and two involved wave propagation techniques: the impact echo test and an ultrasonic probe.

The electrochemical tests identify the presence of corrosion or the vulnerability of the reinforcement steel to corrosion. The wave propagation techniques assess the severity of the corrosion, diagnose the loss of prestress and the lack of grout cover, determine if the cross section had been compromised, and identify locations of potential bending.

The anomalies identified by the NDT were investigated with destructive testing to reveal or confirm distressed elements. Calibrating and verifying the NDT results with destructive testing provided an effective method for identifying areas of possible corrosion, for assessing the condition of the reinforcement system, and for estimating the service life.

The second phase, which was a pooled fund study, used destructive testing to verify results from Phase I. The techniques included the lift-off testing of selected rock reinforcement and the physical, chemical, and metallurgical testing of steel and grout samples retrieved from exhumed reinforcement.

The grout condition was evaluated by observation of the coverage of the reinforcement, by the consistency of the grout, and by the physical properties of the grout mix. Bulk specific gravity and absorption were used to determine the effectiveness of the grout as a barrier against moisture and to mitigate the intrusion of elements that could cause corrosion.

Examination of the exhumed metal elements consisted of visual observations of corrosion and measuring the pit depths and the loss of section. Sample metal reinforcements were subjected to tension tests to measure the percentage of elongation and to determine the corresponding stress-strain curves. Metallurgical tests included a spectrographic analysis to assess the metal composition, and a metallographic examination to observe the microstructure of the thread bar material.

Destructive testing verified that the electrochemical tests correctly identified the presence of corrosion. The lift-off tests and direct measurements confirmed the echo test results. Measurements on exhumed rock reinforcement verified that the greatest loss of section was within the free length behind the anchorage assembly.

Application

Woodstock was a unique site for determining the effectiveness of these techniques because of the age of the reinforcement, the environmental conditions, the variety of installation procedures, and the use of different types of grout.

The loss of measured cross section of the unprotected portion of the rock reinforcement was consistent with the predictions from the mathematical models for the service life of unprotected steel and with the observations from the NDT. Measuring the corrosiveness of the environment therefore is a reasonable method for predicting the remaining service life.

The NDT was a good indicator of the condition of the rock reinforcement but sometimes did not identify specific features that needed rehabilitation along the length of an individual reinforcement. Destructive test methods are the most direct way to assess the condition but are often too expensive and time consuming for extensive use on a large number of reinforcement elements.

Benefits

The research demonstrated that a combination of NDT and destructive tests can provide a cost-effective, technical approach for identifying specific rock reinforcement elements that need replacement or rehabilitation.

Loss of cross section of rock bolt from corrosion.

Overcoring to exhume rock reinforcement.

The initial concern was that nearly all the reinforcement at the Woodstock site would need to be replaced in the near future, at a cost of more than $1.5 million. The results of NDT and destructive testing, however, indicate that only a portion of the reinforcement will require replacement or rehabilitation, at an estimated cost of $400,000—a potential savings of $1.1 million for the site.

Additional savings may be realized from accurate calculations of longevity, which allow optimal use of the reinforcement and timely scheduling of remedial work. Early condition assessment and timely remedial action can prevent rock fall damage to property and injuries to the traveling public.

Benefits can be realized by applying this technology at other sites in New Hampshire and in other states. This approach for assessing the condition of buried rock reinforcement provides a sound technical basis for planning future maintenance and rehabilitation activities, resulting in cost savings. This is a valuable tool in prioritizing long-term budgets for remediation and in making effective use of limited construction resources.

For further information contact Richard Lane, New Hampshire DOT, Bureau of Materials and Research, Box 483, Concord, NH 03301, phone 603-271-3151, fax 603-271-8700, e-mail dlane@dot.state.nh.us.

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

Reference

1. *NCHRP Report 477: Recommended Practice for Evaluation of Metal Tensioned Systems in Geotechnical Evaluations.* Transportation Research Board, National Research Council, Washington, D.C., 2002.

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

L. David Suits

North American Geosynthetics Society

Geosynthetics are synthetic products and materials used to improve the performance of grounds or foundations in geotechnical engineering. L. David Suits's career in geosynthetics spans three decades. As Executive Director of the North American Geosynthetics Society (NAGS), Suits is responsible for assisting colleagues with technical decision making, developing programs and ideas to promote and carry out the mission of the society, and devoting time to making NAGS more visible to the engineering and academic communities.

Before accepting the position at NAGS, Suits spent 37 years at the New York State Department of Transportation (NYSDOT) in the Geotechnical Engineering Bureau. He joined NYSDOT in 1968, serving first as a junior engineer; he went on to serve as assistant soils engineer in 1969, and soils engineering laboratory supervisor in 1976. During his time at NYSDOT, Suits was involved in many research studies on the use and performance of geosynthetics.

"Don't be confined by the 'four walls' of your employment organization—become involved in outside professional activities."

"Activity in the area of research has opened many doors for me," he says. "I came to know, on a first-name basis, many of the geosynthetic innovators and pioneers. I also had the opportunity to be a contributor to a new technology that not only enabled cost savings for civil engineering projects, but improved methods of construction and in many instances enabled a project to be constructed."

Suits was able to participate in projects and professional activities outside NYSDOT. In the mid-1970s, during the planning stages of a design to replace the old West Side Highway in New York City, Suits and a group of colleagues demonstrated to the Environmental Protection Agency (EPA) that a geotextile curtain could provide sufficient protection against potential contamination from the Hudson River, a likely result of proposed dredging. Using samples of the river water and soil that was to be dredged, Suits and his team developed several new geosynthetic testing techniques and devices to demonstrate the capabilities of the geotextile curtain.

"At one point, we decided to see how the river water, without any of the dredged soil, would affect the geotextile," Suits recalls. "The naturally suspended material in the water plugged the geotextile in six hours. The EPA asked no more questions."

Although the design for the West Side Highway replacement was not implemented, some of the test methods developed by Suits and his colleagues were adopted as standard test methods for geosynthetics by the ASTM (American Society for Testing and Materials) International Committee on Geosynthetics.

Suits advises young engineers: "Don't be confined by the 'four walls' of your employment organization—become involved in outside professional activities." He adds, "The potential for new research opportunities aside, I always knew and still know that if a question or problem arises for which I—or my immediate office associates—don't have the answer, I can get on the phone and get an answer in a short time."

Suits's involvement in TRB began when he attended meetings of the Subsurface Drainage Committee in the 1970s. He joined the committee in 1983 and served as chair from 1990 to 1996. He has chaired the Geosynthetics Committee, Soil Mechanics Section, the Design and Construction Group, and the National Cooperative Highway Research Program's (NCHRP) Project Panel on Implementation Plan for Automating Highway-Materials Testing. Currently, he is a member of the TRB Technical Activities Council.

In addition to his work at NAGS, Suits serves as an adjunct professor for the geosynthetics design graduate course at the Rensselaer Polytechnic Institute, Troy, New York. He is a graduate of Clarkson University, Potsdam, New York, where he earned bachelor's and master's degrees in civil engineering in 1967 and 1969, respectively.

He has received many awards for his work in geosynthetics, including NYSDOT's Excellence in Engineering Award in 1991 for work in geosynthetics, and the department's Award of Excellence in 1995 for work in the revision of AASHTO specification M-288 on geotextiles. In 2006, Suits was named an emeritus member of the TRB Geosynthetics Committee.

Gale C. Page

Florida Department of Transportation

Gale Page has worked in pavement technology for more than 40 years. He began his career in 1965 at the Wisconsin Department of Transportation as a project manager and supervisor working in highway planning, design, and construction contract administration. For the past 26 years, he has been the engineer responsible for all flexible pavement–related specifications, testing, and research, and for the performance analysis of in-place flexible pavements for the Florida Department of Transportation (DOT).

Working for Florida DOT, Page contributes to the development and realization of many pavement-related procedures, tests, and training programs. He is an advocate for hot-mix asphalt (HMA) pavements. From 1979 to 1982 he participated in the development and implementation of in-place strength measurements of pavement layers for use in the American Association of State Highway and Transportation Officials' (AASHTO's) modified pavement design for flexible pavement rehabilitation projects.

"Sharing my expertise and learning from others helps to improve the science, technology, and practice of what we do as engineers."

Page has participated in developing specifications, procedures, and practices for milling and for reuse of reclaimed asphalt pavement into quality HMA. He participated in development and implementation of binder and mix specifications for higher performance in Superpave®, an improved system for specifying the components of asphalt concrete, asphalt mix design and analysis, and performance prediction. He continues to work to improve those specifications.

From 1998 to 2001, Page was involved in the creation of a comprehensive, five-part HMA training program for construction technicians. The training materials developed for the program have assisted many other state DOTs.

Looking back on his years of service in the transportation industry, Page considers his greatest accomplishment to be his role in the hiring and professional mentoring of seven engineering graduates at Florida DOT. Five of the engineers are still working in asphalt materials and pavements at the department.

"If I look back at what I've accomplished and the contributions I've made to the transportation industry, that is history—in today's what-have-you-done-for-me-lately environment, the past is not of interest to many," Page observes. "What is important is who you have hired or mentored to take on the challenges of the future."

Page's involvement with TRB began in 1982, and he has chaired or served on many TRB committees and National Cooperative Highway Research Program (NCHRP) panels. He served as the vice chair of the Asphalt Advisory Committee during the Strategic Highway Research Program, and he has chaired several NCHRP Project Panels, overseeing practical research on Laboratory Determination of Resilient Modulus for Flexible Pavement Design; Investigation of the Restricted Zone in the Superpave Aggregate Graduation Specification; Quality Control and Quality Assurance Procedures for Superpave Mixes; and Superpave and Its Implementation.

For the Technical Activities Division, he has chaired the Characteristics of Nonbituminous Components of Bituminous Paving Mixtures Committee, the Bituminous Materials Section, and the Design and Construction Group, and was a member of the Technical Activities Council.

"My participation in TRB and my work with the Design and Construction Group has been personally and professionally rewarding," Page comments. "I believe that the Design and Construction Group is the 'heart' of TRB, and as long as that heart thrives and beats, TRB will continue to fulfill the mission started by its predecessor, the Highway Research Board."

In 2001, Page was the recipient of the Secretary's Award for Sustained Superior Achievement—the highest award presented by the Florida DOT. He is a registered professional engineer in Florida and Wisconsin, and has published widely on topics related to pavement testing, materials, design, and evaluation.

Page graduated from the University of Wisconsin with a bachelor's degree in civil engineering in 1965, and a master's degree in engineering in 1975. He is a member of the American Society of Civil Engineers, served as a member on the ASTM (American Society for Testing and Materials) Board of Directors, chaired the ASTM Committee on Road Paving Materials, and served as president of the Association of Asphalt Paving Technologists.

"I look at participation in technical and professional organizations as being integral to my job," Page notes. "Sharing my expertise and learning from others helps to improve the science, technology, and practice of what we do as engineers."

Guiding Research on Rail Network Performance

ELAINE KING
Rail Transport Specialist, TRB

In the past 2–3 years, the freight railroad industry has been transformed. The tremendous increase in international trade—primarily in intermodal containers arriving by sea from China and continuing by rail domestically—has driven much of the industry change. In addition, three of the Class 1 freight railroads have new leadership.

The increased freight traffic is straining the capacity of freight railroads. Congestion in other modes of transportation has led to increased demand for commuter and intercity passenger rail services. Many of these services, however, must share tracks and other facilities owned by freight railroads, adding to the pressure on rail system capacity.

The TRB Workshop on Research to Enhance Rail Network Performance, April 5–6, 2006, at the National Academies' Keck Center, Washington, D.C., examined the dramatic changes in the railroad business under three major themes: capacity, safety, and efficiency. The workshop, sponsored by the Federal Railroad Administration (FRA), asked the TRB Committee for Review of FRA's Research, Development, and Demonstration Programs to provide assistance in developing input for a new *Five-Year Strategic Plan for Railroad Research and Development* by engaging the stakeholders and customers of the programs in a discussion about needed research. Railroad industry and government leaders shared their perspectives from the freight and passenger sectors on issues related to the core themes.

Robert E. Gallamore, workshop chair, gives opening remarks at the plenary session of the Rail Workshop.

Charles "Wick" Moorman, President and CEO of Norfolk Southern, stated that research could assist in improving all the components of system capacity, including workforce, locomotives, rolling stock, and infrastructure. He emphasized development of positive train control (PTC) technology, noting its potential for increasing capacity, safety, and efficiency. Moorman also urged the application of more resources for research on rail networks and systems.

Representing commuter rail, Philip Pagano, Executive Director of Chicago's Metra, echoed many of Moorman's concerns about capacity on shared rail lines and seconded the need for research and development on PTC.

Jo Strang, FRA Associate Administrator for Safety, provided an overview of safety issues, calling for a more proactive approach supported by research. This will require more attention to risk assessment and

Tracking the Trends in Light Rail Transit

TRB, the American Public Transportation Association, and the International Association of Public Transport (UITP) sponsored the 10th National Light Rail Transit (LRT) Conference: Light Rail—A World of Applications and Opportunities, April 9–11, 2006, in St. Louis, Missouri. More than 400 participants from North America and Europe attended, and the program presented the latest research and experience in key LRT areas such as

- Planning and urban integration;
- Use of infrastructure and design of new infrastructure;
- The case for contracting;
- Financing and controlling capital costs;
- Streetcar applications worldwide;
- Regulations and standards;
- Security issues;
- Light rail vehicle design;
- LRT or bus rapid transit—letting the market decide;
- Accessibility; and
- Remote monitoring for control and information.

The conference papers and presentations will be published as a TRB e-circular on the TRB website later this year.

For more information contact Pete Shaw, TRB (telephone 202-334-2966, e-mail pshaw@nas.edu).

A work crew welds plates before driving them into the ground during LRT construction in Phoenix, December 2005.

management, development of close-call data to increase understanding of incident causes, and behavior-based safety perception studies. The U.S. Department of Transportation and FRA strategic goals will shape research and development for the next 5 years—including a department goal of reducing congestion while improving safety.

Addressing efficiency, Matt Rose, President and CEO, BNSF, provided details of the dramatic growth in rail industry traffic since deregulation in 1980 while the industry was cutting costs and streamlining operations through reductions in infrastructure, equipment, and workforce. Rose identified critical elements for efficient growth, including improvement in the velocity of traffic on the network, in the physical infrastructure reliability, in intermodal hub technology, in mechanical and equipment reliability, and in performance-based safety.

According to Conrad Ruppert, Jr., Division Engineer (Northeast), National Railroad Passenger Corporation (Amtrak), the efficiency of passenger rail depends on the productivity of the workforce combined with improvements in technology and equipment.

Amtrak's Northeast Corridor experiences unique capacity, operational, and safety issues because of the heavy volume of intercity passenger and commuter rail in major urban areas, as well as freight movements.

The workshop concluded with remarks by Congressman Steve LaTourette (R–Ohio), who chairs the Railroad Subcommittee of the House Transportation and Infrastructure Committee. LaTourette stressed that railroads are important to the nation's economy and provide environmental benefits. He underscored the need for increased investment in rail capacity and described the types of public–private partnerships and funding sources that can meet the investment needs.

Breakout discussion groups offered opportunities for all workshop participants to express their views on research and development priorities. The breakout groups generated more than 150 research-needs statements, which will be sorted and prioritized by the sponsoring TRB committee for publication in workshop proceedings by year's end. Reports from the breakout discussion groups, along with background materials, are available on the workshop website at www. trb.org/Conferences/RailWorkshop/.

Participating in breakout discussion are workshop group attendees (*left to right*) Reilly McCarren, Arkansas and Missouri Railroad; Brendan Hickman, Teradata; and Bruce Horowitz, ESH Consult.

Charles "Wick" Moorman, president and CEO of Norfolk Southern, presents the freight-rail perspective on rail-system capacity issues.

EXPLORING THE OPTIONS— Speaking at a meeting of the TRB Committee on the St. Lawrence Seaway, Anthony Earl, a partner with the Quarles and Brady Law Firm, Madison, Wisconsin, discusses the natural resources of the Great Lakes region. The Committee on the St. Lawrence Seaway is studying ways to enhance the potential for global trade in the Great Lakes region, and eliminate further introductions of non-indigenous aquatic species by vessels transiting the St. Lawrence Seaway.

SHARING GEOSPATIAL INFORMATION— Speaker Leni Oman, Director of Transportation Research, Washington State Department of Transportation, takes questions from attendees at the Environmental Geospatial Information for Transportation Workshop in Washington, D.C. The May 3–4 workshop focused on issues in Geographic Information System (GIS) applications and GIS use by transportation organizations to communicate planning and project information among diverse agencies. Attendees included representatives from state and federal transportation and natural resource agencies, local government, and nongovernmental organizations with expertise in natural resource planning, transportation planning and project development, and geographic information specialists from the Mid-Atlantic Region.

COOPERATIVE RESEARCH PROGRAMS NEWS

Transit Passenger Safety Inspections: Guidebook in Development

In response to worldwide terrorist activities and growing concerns about transit security, many transit agencies are assessing their security measures and acting to reduce the risk of attacks. One of the more notable measures under consideration is the introduction of passenger safety inspections. In addition to navigating the policy and logistical issues inherent in implementing inspections, many public transportation agencies need guidance on how to determine whether inspections should be implemented.

The Transit Cooperative Research Program has awarded a $100,000, 9-month contract to Countermeasures Assessment & Security Experts, LLC, to develop a guidebook, *Public Transportation Passenger Safety Inspections: A Guide for Decision Makers*, to assist public transportation agencies in evaluating the feasibility of passenger security inspection programs and in introducing the programs.

Questions asked by transportation agencies about the introduction of passenger security inspections include the following:

- When are passenger security inspections warranted?
- What are the legal bases for conducting passenger security inspections?
- What are the liability issues associated with implementing or not implementing passenger security inspections?
- How can measures be implemented with minimal impact on operations?
- What are the precedents in the public transportation environment? What are the lessons learned?
- How will the public respond to implementing such measures?
- What public outreach or stakeholder input should be considered?
- What types of passenger security inspections are possible, and what technologies are available to support the inspections?
- What human resources are required?
- What financial implications and cost considerations are involved?
- How effective are passenger security inspections expected to be? What are the metrics?
- What other challenges must be addressed in implementing passenger security inspections?

Research for the guidebook will be completed in November 2006. A draft report documenting the research is planned for October 2006.

For further information, contact S. A. Parker, TRB, 202-334-2554, saparker@nas.edu.

Increasing Concrete Girder Shear Strength

Fiber-reinforced polymer (FRP) —usually externally bonded laminates or near-surface mounted bars— are gaining wide acceptance for strengthening concrete structures. Research has shown that using FRP systems to strengthen concrete girders improves both long- and short-term flexural behavior.

Lesser known are the effects of FRP systems on girder shear strength. Although experimental data have shown that FRP systems can be effective for increasing concrete girder shear strength, the design of the FRP strengthening systems has been based largely on system- or project-specific research.

The University of Missouri–Rolla has been awarded a $400,000, 30-month contract [National Cooperative Highway Research Program (NCHRP) 12-75, FY 2006] to develop design methods, specifications, and examples for the design of FRP systems for strengthening concrete girders in shear. The proposed specifications will be prepared in a format compatible with the American Association of State Highway and Transportation Official's (AASHTO's) Load and Resistance Factor Design Bridge Design Specifications and will be recommended for adoption by the AASHTO Highway Subcommittee on Bridges and Structures.

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

FOCUS ON POLICY AND PRIORITIES—Tyler Duvall, Assistant Secretary for Transportation Policy, United States Department of Transportation, accompanied by Christina Casgar, Office of Freight and Logistics, Office of the Under Secretary for Transportation Policy, describes departmental policy and research priorities at the spring 2006 meeting of the TRB Executive Committee's Subcommittee on Planning and Policy Review, Washington, D.C.

IN MEMORIAM

Carl J. Seiberlich 1922–2006

SOURCE: USS HORNET MUSEUM

Carl J. Seiberlich, retired Navy rear admiral, World War II veteran, U.S. representative to the International Standards Organization, and longtime affiliate of TRB, died in Haymarket, Virginia, on March 24.

Born in Jenkinstown, Pennsylvania, Seiberlich graduated with a bachelor of science degree in marine transportation from the Merchant Marine Academy in 1943. He served in the Merchant Marine and the U.S. Navy for more than 40 years; saw action during World War II in the Atlantic and Pacific Theaters as a navigator aboard the USS *Mayo*; and witnessed the September 2, 1945, surrender of the Japanese high command at Tokyo Bay.

In 1952, Seiberlich earned his pilot's wings flying lighter-than-air craft or blimps, and made the first successful blimp night landing on an aircraft carrier. That same year, he received the Harmon International Trophy for achievement in aeronautics from President Harry S Truman for his work in the development and the fleet introduction of the world's first operational, variable depth-tone, towed sonar.

During the mid-1960s Seiberlich qualified to land multiengine airplanes on aircraft carrier flight decks. He was the only aviator in U.S. Navy history qualified to land blimps, helicopters, and airplanes on an aircraft carrier. In 1967 Seiberlich became commanding officer of the fleet oiler USS *Salmonie*. In command of the USS *Hornet* in 1969, he participated in the recovery of NASA's first lunar landing craft, *Apollo 11*, seen by more than 500 million television viewers live on July 24, 1969. Seiberlich repeated his performance four months later by recovering the *Apollo 12* crew.

After retiring from the U.S. Navy in 1980, Seiberlich worked for several defense contractors in the transportation industry, including American President Lines, a global container shipping company, and TranSystems, a maritime consulting corporation. In his transportation career, Seiberlich worked tirelessly to bring an intermodal perspective to transportation decision making, and he was a leader in the field of supply chain management long before it became popular.

Active in TRB for 14 years, Seiberlich cochaired the Task Force on Intermodal Transportation from August 1993 to January 1998. He was a member of the Ports and Channels Committee, the steering committees for the Conference on Setting an Intermodal Transportation Research Framework and the Conference on Education and Intermodal Transportation, the Intermodal Freight Transport Committee, and the Military Transportation Committee.

The Rear Admiral Carl J. Seiberlich Fund for Youth Education has been established in his honor. For more information, go to www.uss-hornet.org/seiberlich/index.html.

Red-light camera at Northwest Highway and I-65, Garland, Texas.

Red-Light Cameras Reduce Crash Costs

Red-light running in the United States is estimated to cause more than 95,000 crashes and about 1,000 deaths per year. According to a new study by FHWA, red-light cameras at intersections can reduce the costs to society from crashes that result from red-light running.

The study examined crash-related results at 132 sites in multiple U.S. jurisdictions to determine the safety and effectiveness of red-light camera systems. The frequency of different crash types, including right-angle (side impact), left-turn, and rear-end crashes at signalized sites with and without cameras, was examined.

Data taken from camera-monitored sites indicated that right-angle or side-impact collisions typically decreased under camera enforcement, but rear-end collisions increased. The study also found that red-light camera systems would be most beneficial at intersections with relatively few rear-end crashes but many right-angle crashes.

Data were analyzed from intersections in El Cajon, San Diego, and San Francisco, California; Howard County, Montgomery County, and Baltimore, Maryland; and Charlotte, North Carolina. Because of the observational, retrospective nature of the study, the authors note that additional research is necessary.

For more information view the complete report at www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE//14270.htm.

Bay Area Study Endorses Pedestrian-Friendly Zones

A new study by the Metropolitan Transportation Commission showcases the most promising techniques for making the Bay Area cities pedestrian friendly. *The Bay Area Pedestrian Districts Study* provides city, county, and regional agency planners with 10 case studies of Bay Area pedestrian-friendly zone models that examine pedestrian master plans from cities such as San Francisco, Oakland, and Berkeley.

The driving study identifies 10 models or typologies of pedestrian districts: urban residential, pedestrian-oriented suburban residential, major mixed-use district, transit village, large neighborhood corridor, major city downtown, medium-sized city downtown, small downtown, urban institutional, and suburban employment center.

The study provides practical information for traffic engineers and public works staff, with guidance on how to identify appropriate streetscape and district improvement projects. The study's cost estimates can assist in determining funding needs for similar projects by local and regional planning agencies.

For more information, view the complete report at www.mtc.ca.gov/ planning/bicyclepedestrians/index.htm.

Crash Study Targets Driver Behavior

A report released in April by the U.S. Department of Transportation estimated that 43,200 people died in car crashes last year, an increase from 42,636 in 2004. Released at the same time, the 100-Car Naturalistic Driving Study, conducted by the National Highway Traffic Safety Administration (NHTSA) and Virginia Tech's Transportation Institute, cites inattentiveness and risky behavior as key factors in crashes and near-crashes.

The study was conducted by equipping 100 vehicles with sensor devices and video cameras, and tracking vehicle drivers for more than 1 year as they drove nearly 2 million miles on U.S. public roads. Drivers were involved in 82 crashes and 761 near-crashes, with 15 incidents serious enough to be reported to police.

Findings showed that drowsiness, cell phone use, and reaching for a moving object were forms of risky behavior that increased the likelihood of a crash. Risky driver behavior was noted in 80 percent of crashes and near-crashes.

Highway crashes are estimated to cost society $230.6 billion, or about $820 per American. Additional statistics released by FHWA include an increase in pedestrian deaths from 4,641 to 4,674, and an increase in alcohol-related fatalities, from 16,694 to 16,792. A follow-up analysis of the 100-car study results also has been released.

For more information, view the study results and analysis at www-nrd. nhtsa.dot.gov/departments/nrd-13/driver-distraction/PDF/100CarMain.pdf.

Safety Campaign Aims at Seatbelt Nonusers

Although seat belt use has reached record levels nationwide, approximately 48 million Americans do not use seat belts when driving, according to a report from the National Highway Traffic Safety Administration (NHTSA). Young males living in rural areas comprise the largest demographic among those who drive unbelted.

The report also notes that men account for 65 percent of the more than 31,000 people killed each year in passenger vehicle accidents. Other statistics indicate that of those killed while unbelted, 58 percent were killed along rural roads; in crashes involving pickup trucks, approximately 7 out of 10 killed were unbelted; and approximately 6 in 10 of those aged 8–44 years killed in passenger vehicles were not wearing safety belts.

As a countermeasure, NHTSA is spending $31 million this year in state and federal grants for advertising aimed at drivers in the target demographic. The ad campaign, "Click It or Ticket," ran from May 22–June 4, and was backed with increased enforcement of seat-belt laws nationwide.

For more information, visit www.nhtsa.gov.

CALENDAR

TRB Meetings 2006

July

8 — Challenges of Data for Performance Measures (by invitation)
La Jolla, California
Thomas Palmerlee

9–11 — TRB 2006 Summer Conference
La Jolla, California

9–11 — 31st Annual Summer Ports, Waterways, Freight, and International Trade Conference
La Jolla, California

10–12 — Traffic Signal Systems Committee Summer Meeting
Woods Hole, Massachusetts

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

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

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

23–26 — Geospatial Data Acquisition Technologies in Design and Construction Committee Summer Meeting
Port Angeles, Washington
Thomas Palmerlee

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

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

August

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

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

13–16 — 7th National Access Management Conference
Park City, Utah

13–16 — 9th International Conference on Applications of Advanced Technology in Transportation*
Chicago, Illinois
Thomas Palmerlee

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

27–29 — The Metropolitan Planning Organization: Present and Future—A Conference
Washington, D.C.
Kimberly Fisher

September

13–15 — 10th National Conference on Transportation Planning for Small and Medium-Sized Communities: Tools of the Trade
Nashville, Tennessee

18–19 — Aviation Forecast Assumption Workshops: Airports (by invitation)
Washington, D.C.
Christine Gerencher

18–20 — 5th National Seismic Conference on Bridges and Highways*
San Mateo, California

25–26 — National Security, Natural Disasters, Logistics, and Transportation: Assessing the Risks and Responses
Kingston, Rhode Island

25–27 — Freight Demand Modeling: A Conference on Improving Analysis and Forecasting Tools for Public-Sector Decision Making
Washington, D.C.
Elaine King

26 — Symposium on Applications of Geophysics for Geotechnical Projects
Breckenridge, Colorado

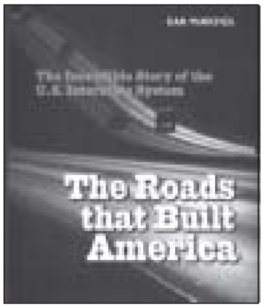
October

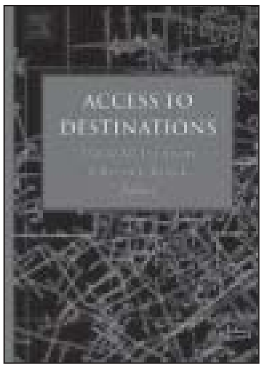
2–5 — Plastic Pipes XIII Conference*
Washington, D.C.

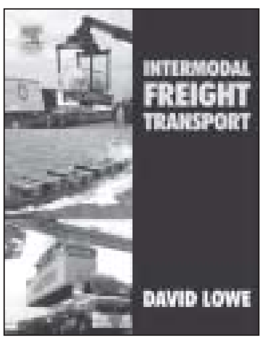
5–6 — Aviation Forecast Assumption Workshops: Business Aviation (by invitation)
Washington, D.C.
Christine Gerencher

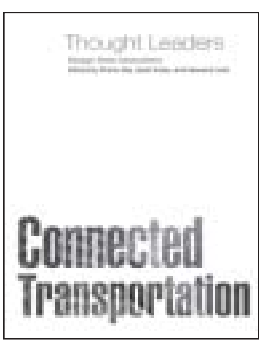
Additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, is available at www.TRB.org/calendar). To reach the TRB staff contacts, telephone 202-334-2934, fax 202-334-2003, or e-mail lkarson@nas.edu. Meetings listed without a TRB staff contact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

*TRB is cosponsor of the meeting.









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

The Roads That Built America
Dan McNichol. Sterling, 2006; 255 pp.; $14.95; 1-4027-3468-9.
Author and former Department of Transportation appointee Dan McNichol chronicles the creation and development of the U.S. Interstate system and describes the visionaries who were responsible for bringing the "world's greatest engineering project" to fruition. The ideas and intents that shaped the system are examined in detail, including how the 67 highways, 54,663 bridges, and 104 tunnels of the system were created with the goals of improving commerce, reducing travel times, and protecting the nation from military aggression. The system's effects on the lifestyle, culture, and economy of the nation also are examined.

Mathematical and Economic Theory of Road Pricing
Hai Yang and Hai-Jun Huang. Elsevier, 2005; 486 pp.; $135; 0-08-044487-3.
This book presents the most recent advances in the application of advanced modeling techniques to road pricing. Moving beyond the empirical, the studies are carried out in the context of a general equilibrium model, with rigorous optimization and application of economic theories.

Topics of discussion include fundamentals of traffic equilibrium problems; the principle of marginal-cost road pricing; models and algorithms for the general second-best road pricing problems; discriminatory and anonymous road pricing; social and spatial equities; Pareto pricing and revenue refunding schemes; pricing, capacity choice, and financing; simultaneous determination of toll levels and locations; sequential pricing experiments with limited information; bounding the efficiency of road pricing; and dynamic road pricing.

Access to Destinations
Edited by David M. Levinson and Kevin J. Krizek. Elsevier, 2005; 422 pp.; $94.95; 0-08-044678-7.
Efficient land use and planning is a key strategy for reducing traffic congestion. Currently measures of traffic congestion, however, rarely provide more than a snapshot of a city's transportation system and often fail to indicate how quickly a destination can be reached.

Editors Levinson and Krizek focus on the science and policy surrounding the multimodal concept of accessibility with a collection of 17 research papers from the Access to Destinations conference sponsored by the University of Minnesota Center for Transportation Studies in November 2004. Papers explore many aspects of accessibility, the loss of accessibility, and how mobility and accessibility relate to one another.

This book should be of interest to planners, engineers, and urbanists of all backgrounds. Krizek is chair of the TRB Telecommunications and Travel Committee and secretary of the Transportation and Land Development Committee, and Levinson is a member of the TRB Transportation Demand Forecasting Committee.

Intermodal Freight Transport
David Lowe. Butterworth Heinemann, 2005; 304 pp.; $79.95; 0-7506-5935-1.
Lowe examines the concept of intermodal freight transport, placing European experiences, developments in the United Kingdom, and political influences on intermodal freight in the context of developments in North America and Asia. Topics include rail freight operations, environmental and economic issues, grant aid and government support, intermodal road and rail vehicles, maritime vessels, customs procedures, and safety.

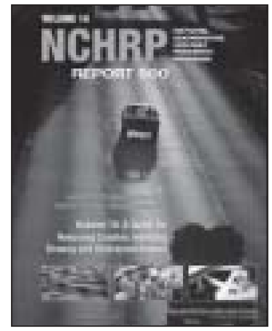
A comprehensive review of intermodal freight transportation, this book should be of interest to shippers, intermodal road haulers, terminal operators, equipment manufacturers, ancillary suppliers, students, and others who follow the industry's trends and developments.

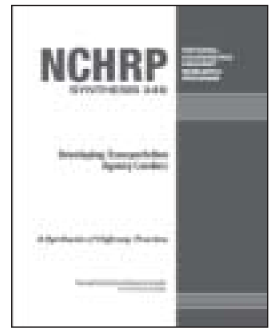
Connected Transportation
Edited by Pravin Raj, Sved Hoda, and Howard Lock. Cisco Systems, 2006; 140 pp.; 0-9551959-0-X.
The editors from the Cisco International Business Solutions Group have assembled a collection of essays by business executives and leaders in government and transportation organizations highlighting issues in the U.S. transportation industry. The focus is on viable strategies to meet the demand for transportation services and to deal with the challenges that threaten to strain the transportation infrastructure. Topics include the role of government in transportation; the use of pricing as a means of controlling congestion; improving security; and the social, economic, and political factors involved in providing an efficient transportation system.

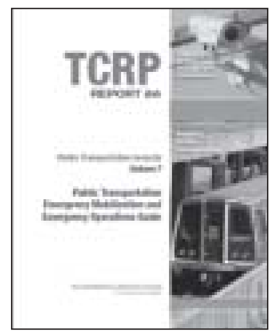
Adding FAST Lanes to Milwaukee's Freeways: Congestion Relief, Improved Transit, and Help with Funding Reconstruction
Robert W. Poole, Jr., and Kevin Soucie. Reason, 2006; 40 pp.
Variable-price toll, or FAST, lanes should become the core of southeastern Wisconsin's $6.2 billion freeway modernization plan, according to the proposals in this study. The FAST lanes would ease traffic congestion and fund road reconstruction in the Milwaukee region.

The authors examine traffic's impact on public transportation efficiency and motorist commute times; projected toll revenues; toll lane effects on emergency vehicle response times; FAST lane locations; and real-time variable pricing modeled after in-place systems in San Diego, California, and Minneapolis, Minnesota. Poole is a member of the TRB Congestion Pricing Committee.

TRB PUBLICATIONS







Guidance for Implementation of the AASHTO Strategic Highway Safety Plan: A Guide for Enhancing Rural Emergency Medical Services
NCHRP Report 500, Volume 14
This volume of *NCHRP Report 500* provides strategies to reduce the number of crashes involving drowsy and distracted drivers by decreasing the occurrence of distracted or fatigued driving and by making the consequences of lapses of attention less severe.

2005; 96 pp.; TRB affiliates, $16.50; TRB nonaffiliates, $22.

Environmentally Sensitive Channel and Bank Protection Measures
NCHRP Report 544 (with supporting material on CD-ROM)
Useful, environmentally sensitive channel- and bank-protection measures are described, along with design guidelines for their application and a system for selecting the most appropriate measure for channel and bank protection.

2005; 50 pp.; TRB affiliates, $22.50; nonaffiliates, $30. Subscriber categories: energy and environment (IB); bridges, other structures, hydraulics and hydrology (IIC); soils, geology, and foundations (IIIA).

Developing Transportation Agency Leaders
NCHRP Synthesis 349
Practices and innovative approaches for developing transportation leadership within state department of transportation (DOT) management and operations are presented. Four key subtopics are examined: demographics, recruitment and retention, leadership training, and succession management. This synthesis will be of interest to state DOT personnel, as well as to other professionals in the public and private sectors who are dealing with the issues of leadership training and succession management.

2005; 51 pp.; TRB affiliates, $12; nonaffiliates, $16. Subscriber category: planning and administration (IA).

Crash Records Systems
NCHRP Synthesis 350
This synthesis examines current practices in applying crash records systems to the improvement of highway and traffic safety. No single system offers the best approaches to data collection, data processing and management, and data linkages for reporting and analysis, but systems are identified with components that successfully address one or two of these areas. Improvements are suggested for expanding the use and capabilities of crash records systems.

2005; 35 pp.; TRB affiliates, $12; nonaffiliates, $16. Subscriber categories: planning and administration (IA); highway operations, capacity, and traffic control (IVA); safety and human performance (IVB).

Public Transportation Security: Public Transportation Emergency Mobilization and Emergency Operations Guide
TCRP Report 86, Volume 7
Key considerations are highlighted for public transportation agencies in working with local communities to enhance mobilization. The recommendations and tools derive from extensive research conducted with public transportation systems; local, state, and federal emergency planning agencies; and first responders around the country.

2005; 124 pp.; TRB affiliates, $18.75; nonaffiliates, $25. Subscriber categories: planning and administration (IA); safety and human performance (IVB); public transit (VI); rail (VII).

Public Transportation Security: Hazard and Security Plan Workshop: Instructor Guide
TCRP Report 86, Volume 10 (with supporting material on CD-ROM)
This instructor guide is designed to assist rural, small urban, and community-based passenger transportation agencies in creating hazard and security plans or in evaluating and modifying plans, policies, and procedures consistent with the National Incident Management System. The guide includes a lesson plan, a PowerPoint presentation with notes, a guide for workshop participants, and a CD-ROM that contains a template adaptable for participants' organizations, along with sample policies and procedures.

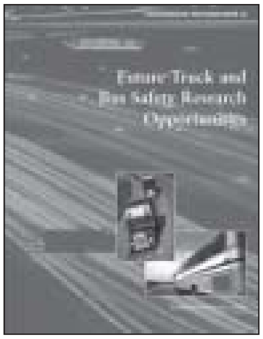
2006; 195 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber categories: planning and administration (IA); public transit (VI); security (X).

Traveler Response to Transportation System Changes: Vanpools and Buspools
TCRP Report 95, Chapter 5
The TCRP Report 95 series comprehensively documents transportation system changes, policy actions, and alternative land use and site development design approaches. This third edition covers 18 topic areas, each to be published as a stand-alone chapter.

Chapter 5 examines the effects of travel times, pricing, and related tangibles and intangibles on the decision to vanpool; quantifies vanpooling and buspooling; examines vanpooling trends; presents information from rider surveys; identifies indicators of market potential; and explores the cost implications.

2005; 55 pp.; TRB affiliates, $15; nonaffiliates, $20.

TRB PUBLICATIONS *(continued)*



Subscriber categories: planning and administration (IA); highway operations, capacity, and traffic control (IVA); public transit (VI).

Future Truck and Bus Safety Research Opportunities
Conference Proceedings 38
The conference on Future Truck and Bus Safety Research Opportunities, held in March 2005 in Arlington, Virginia, considered the directions of the commercial vehicle industry and explored the types of research needed to meet the upcoming challenges. The proceedings include research papers along with summaries of the issues, comments, future scenarios, and other information addressed at the conference. Also presented are the results of a follow-up meeting of the conference committee, which synthesized the information and deliberated on findings and recommendations for future research.

2006; 107 pp.; TRB affiliates, $30; nonaffiliates, $40. Subscriber category: safety and human performance (IVB).

Pavement Rehabilitation, Strength and Deformation Characteristics, and Surface Properties 2005
Transportation Research Record 1905
This multifaceted selection of papers presents information on asphalt pavement rehabilitation treatments, Wisconsin's experiences with reflective crack relief projects, the interpretation of transverse profiles to determine the source of rutting within an asphalt pavement system, assessments of pavement layer condition with use of multiload-level falling weight deflectometer deflections, a methodology for the detection of defect locations in pavement profiles, and modeling hydroplaning and the effects of pavement microtexture.

2005; 176 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber category: pavement design, management and performance (IIB).

Freight Analysis, Evaluation, and Modeling 2005
Transportation Research Record 1906
The first section of this two-part volume contains the 2005 Thomas B. Deen Distinguished Lecture by Lillian C. Borrone, "Sparking the Globalized Trade and Transportation Connection: Supplying Freight System Responses to Global Trade Demands." The second part includes information on the technical efficiency of road haulage firms; urban freight in Dublin City Center, Ireland; the impact of pickup- and delivery-related illegal parking activities on traffic; multiobjective optimization for hazardous materials transportation; and measurement tools for assessing a motor vehicle division's port-of-entry performance.

2005; 128 pp.; TRB affiliates, $37.50; nonaffiliates, $50. Subscriber category: freight transportation (multimodal) (VIII).

Construction 2005
Transportation Research Record 1907
Authors assess topics in construction management, quality assurance, bridges and structures, portland cement concrete pavement, and hot-mix asphalt pavement. Specific subjects include improving construction communication; the computerized system for efficient scheduling of highway construction; development of the Florida Department of Transportation's percent-within-limits hot-mix asphalt specification; design and construction of a full-width, full-depth, precast concrete deck slab on a steel girder bridge; changing the shape and location of pavement load transfer devices; and the initial ride quality of hot-mix asphalt pavements.

2005; 144 pp.; TRB affiliates, $37.50; nonaffiliates, $50. Subscriber category: materials and construction (IIIB).

Statistical Methods; Highway Safety Data, Analysis, and Evaluation; Occupant Protection; Systematic Reviews and Meta-Analysis
Transportation Research Record 1908
Safety studies presented in this volume cover use of a linear optimization model to maximize the safety benefits from highway improvements under specific budget constraints and the analysis of types of crashes at signalized intersections with complete crash data. Other investigations examine the events leading to a sport utility vehicle rollover, as well as countermeasures for deer–vehicle crashes.

2005; 235 pp.; TRB affiliates, $44.25; nonaffiliates, $59. Subscriber category: safety and human performance (IVB).

Inland Waterways; Ports and Channels; and the Marine Environment
Transportation Research Record 1909
The research topics examined in this volume include the study of short-run grain movements of the inland waterway system, long-term forecasting of world grain trade by gulf exports, measuring the nontraditional benefits and costs of inland navigation, European transport policy and the Danube River, rural water transport and development, geographical characterization of ship traffic and emissions, and oil spills in maritime transit.

2005; 107 pp.; TRB affiliates, $34.50; nonaffiliates, $46. Subscriber category: marine transportation (IX).

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

INFORMATION FOR CONTRIBUTORS TO

TR NEWS

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

FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 to 4,000 words (12 to 16 double-spaced, typed pages). Authors 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.

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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.
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- 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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Yesterday, Today, and Tomorrow

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Highway Capacity Manual 2000
Transportation Research Board, ISBN 0-309-06746-4, 1134 pages, 8.5 x 11, binder, $110.00 (2000)

The Fuel Tax and Alternatives for Transportation Funding
TRB Special Report 285, ISBN 0-309-09419-4, 235 pages, 6 x 9, paperback, $30.00 (2006)

Guidelines for Early-Opening-to-Traffic Portland Cement Concrete for Pavement Rehabilitation
NCHRP Report 540, ISBN 0-309-08835-6, 28 pages, 8.5 x 11, paperback, $20.00 (2005)

A Guide for Reducing Work Zone Collisions
NCHRP Report 500, Vol. 17, ISBN 0-309-08847-X, 165 pages, 8.5 x 11, paperback, $28.00 (2005)

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NCHRP Report 517, ISBN 0-309-08787-2, 555 pages, 8.5 x 11, paperback, $35.00 (2004)

Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles
TRB Special Report 267, ISBN 0-309-07701-X, 270 pages, 6 x 9, paperback, $24.00 (2002)

Surface Transportation Environmental Research: A Long-Term Strategy
TRB Special Report 268, ISBN 0-309-07702-8, 219 pages, 6 x 9, paperback, $23.00 (2002)

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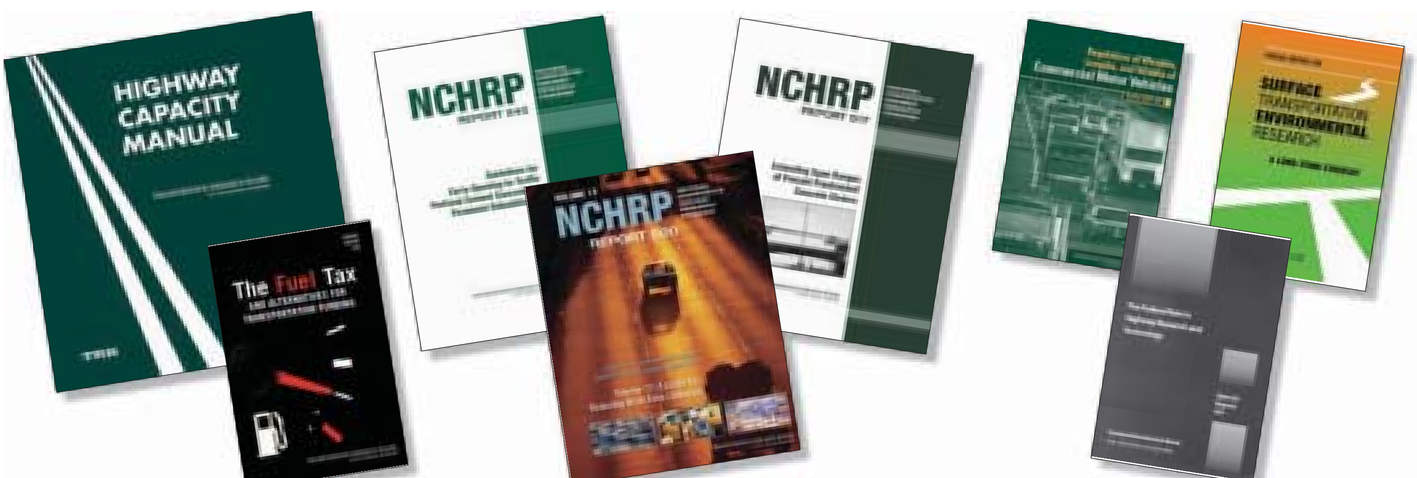
TRB Special Report 261; ISBN 0-309-07246-8, 146 pages, 8.5 x 11, paperback, $21.00 (2001)



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