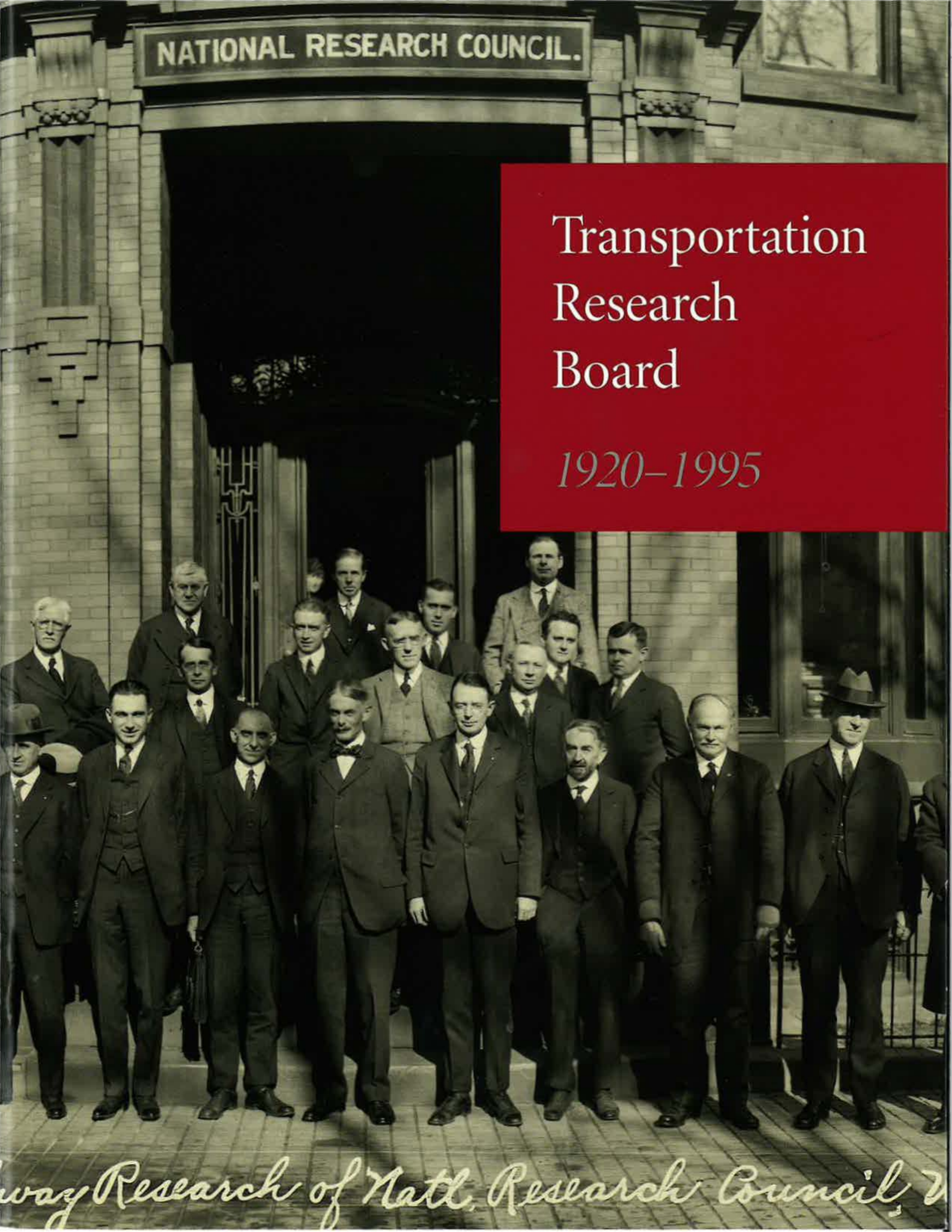
Transportation Research Board

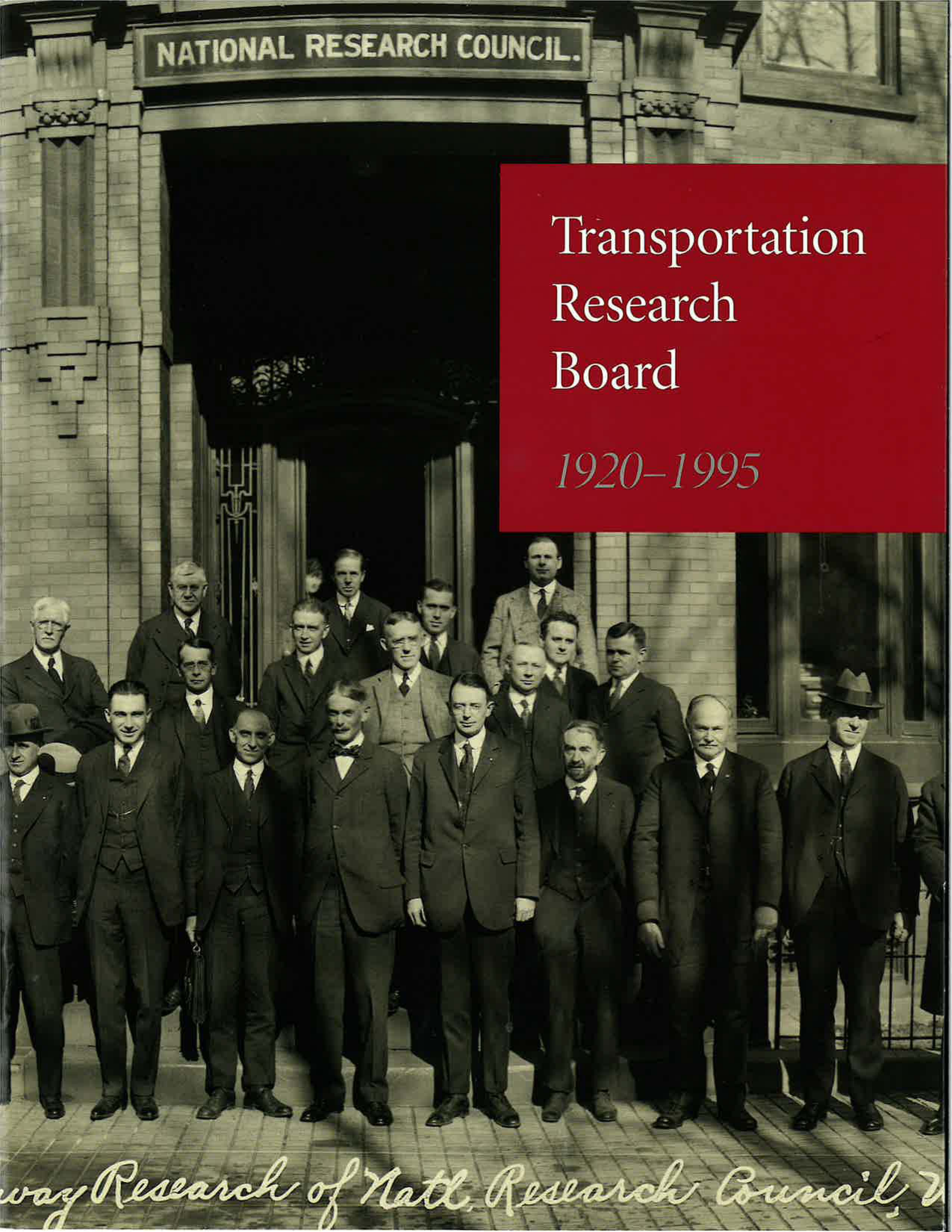
1920–1995

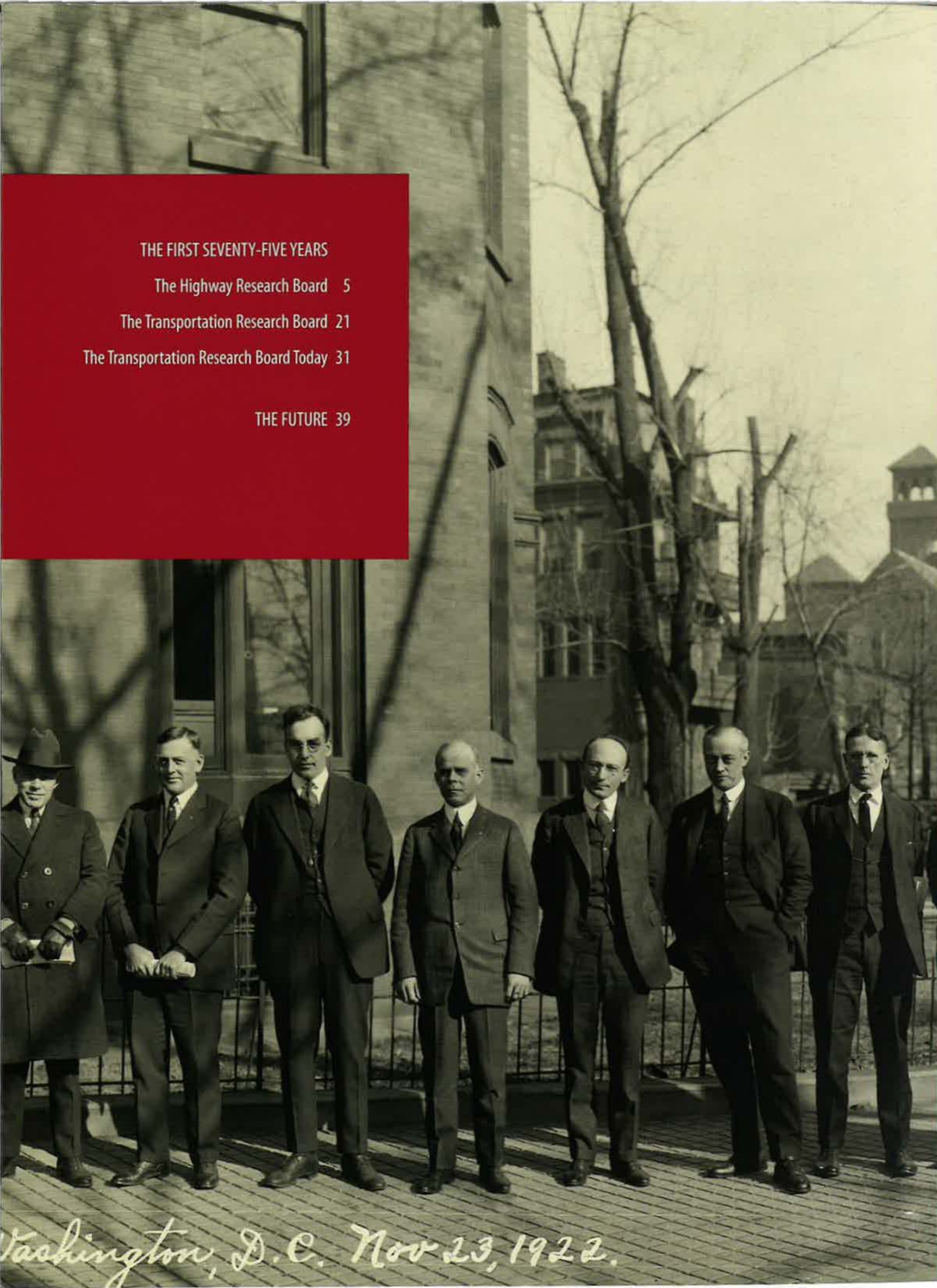



Meeting of Advisory Board on

Transportation Research Board

1920–1995




ashington, D.C. Nov 23, 1922.

Greetings and best wishes to the Transportation Research Board and its many supporters and friends on the occasion of its 75th anniversary!

As Chairman of TRB's parent organization, the National Research Council, I am very much aware of TRB's distinguished history. The National Research Council came into being in 1916, when President Woodrow Wilson asked the National Academy of Sciences to provide the government with broader scientific research services to assist the nation's military preparedness. Shortly thereafter, in response to a need identified by state and federal highway agencies, the Transportation Research Board was organized, becoming one of the earliest units established within the National Research Council. Its creation in 1920 (first as the National Advisory Board on Highway Research, and soon thereafter the Highway Research Board) reflected the states' need for a research clearinghouse at the time that they were setting out on the unprecedented task of designing and constructing a national highway system to accommodate motorized vehicles. From the outset, the Board relied on and benefited from a special partnership with the states and the federal government, which has continued to the present day.

Over the past 75 years, TRB has grown and evolved as the interests of the states and the federal government in transportation have expanded. In the 1970s the Board's scope was broadened to include all modes of transportation, and its name was officially changed to the Transportation Research Board in 1974. At the Board's first Annual Meeting, which took place in January 1922, there were 30 participants and three technical committees. Its 74th Annual Meeting, held in January 1995, included 253 sessions, 200 committee meetings, and more than 7,100 participants.

I am pleased to recognize the Transportation Research Board's extraordinary 75-year record of achievement and proud of the role that the National Research Council has played in supporting the work of the Board. In looking ahead, I fully expect that TRB will continue to play as vital a role in the future as it has in the past—by continuing to foster vigorous innovation in transportation through research.

Sincerely,

Bruce Alberts
President, National Academy of Sciences
Chairman, National Research Council
1995

TR NEWS

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This special issue of *TR News* celebrates the 75th Anniversary of the Transportation Research Board, which began life in 1920 as the National Advisory Board on Highway Research and became the Highway Research Board in 1925, evolving into the Transportation Research Board in 1974.

The Transportation Research Board is a unit of the National Research Council, which serves as an independent advisor to the federal government on scientific and technical questions of national importance. The National Research Council, jointly administered by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, brings the resources of the entire scientific and technical community to bear on national problems through its volunteer advisory committees.

Nancy A. Ackerman, Editor

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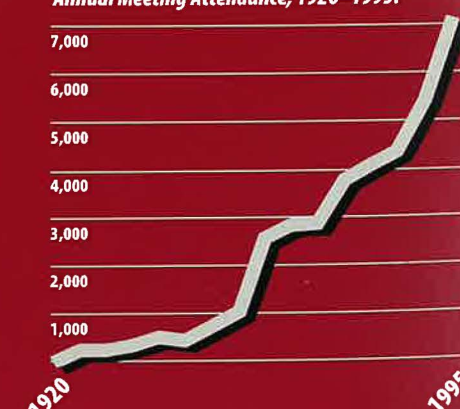
COVER: The Second Annual Meeting of the Transportation Research Board (then the National Advisory Board on Highway Research) was held in November 1922, at the early headquarters of the National Research Council, Washington, D.C. The one-day meeting drew approximately 70 registrants.

Today the Annual Meeting—a primary activity in accomplishing the purpose of the Transportation Research Board to advance knowledge of the nature and performance of transportation systems through the encouragement and dissemination of research—has evolved into the world's largest and most comprehensive gathering for the exchange of transportation information. Each year, over a five-day period, more than 7,000 transportation administrators, researchers, and practitioners from more than 50 countries attend technical sessions, committee meetings, specialty workshops, and other events addressing the latest research findings and current practices in all modes and aspects of transportation.

Annual Meeting Attendance, 1920–1995.



During the past 75 years, the Transportation Research Board has meant many things to the individuals and organizations that are a part of its history. Some of us know TRB primarily through its authoritative publications on diverse transportation topics. These include peer-reviewed papers in the Transportation Research Record series, research and synthesis reports issued by the Cooperative Research Programs that are administered by TRB, policy study reports authored by expert committees convened by TRB, proceedings of special TRB conferences, and a variety of other publications.

Others of us know the Board through its Annual Meeting. With more than 250 sessions and 200 committee meetings, and more than 7,000 attendees, it is the largest gathering of its kind in the world. (Some would say it is also the most hectic transportation meeting because of its "no frills" tradition of technical sessions morning, noon, and night.)

But many of us see the Transportation Research Board not so much in terms of its products and meetings it holds, but as a unique transportation community—a community that ranges across transportation modes, cuts across disciplinary boundaries, and includes everyone from graduate students and young professionals to senior officials with public and private transportation agencies and businesses. Its sponsors have been consistently supportive and loyal, and more than 4,000 individuals volunteer their time to serve on its committees and panels.

No doubt there are many reasons why individuals and organizations choose to participate in the activities of the Transportation Research Board, including individuals seeking career advancement and sponsoring agencies looking to leverage their research resources. But it takes more than self-interest to explain TRB; I believe that sponsors and individual professionals alike generally want to make a contribution for the good of their profession and for the good of transportation by participating in TRB.

Francis Francois, the Executive Director of the American Association of State Highway and Transportation Officials, once stated: "I don't know how the transportation research activity of this nation could operate without TRB. If it didn't exist, we would have to invent it. Fortunately it was invented. Fortunately it is here."

We are indeed fortunate because inventing an organization like TRB today would be difficult. Seeing firsthand the benefits we derive, individually and collectively, from TRB, we can appreciate its value. We owe a debt of gratitude to the farsighted individuals who nurtured the concept of a central "clearinghouse" for technical information about highways 75 years ago. And the debt extends to the many individuals who expanded on that original concept over the years to create the organization we now know.

On the occasion of TRB's 75th Anniversary and its 75th Annual Meeting, this special issue of *TRNews* provides us with an appropriate opportunity to commemorate the Board's history and recognize some of the individuals who played important roles in its development. L.G. (Gary) Byrd recounts highlights of the Board's history, with special emphasis on the past 25 years. Gary Byrd is particularly well suited for this assignment: he has actively participated in TRB in virtually every capacity during his professional career. Recently he completed six years of service as a member of the Executive Committee and chairman of the subcommittee that oversees appointments and report review and provides liaison with the National Research Council's governing body.

The history of the Transportation Research Board is intertwined with the progress that has been made in the past 75 years in improving the safety, efficiency, capacity, and cost-effectiveness of the nation's transportation systems. To illustrate the progress that has been made through research and improved technology, this publication presents a number of brief descriptions of notable success stories. A few are well known to us and to the general public; some are less visible and recognized only by practitioners in a particular area of transportation; but all are important and all affect the lives and well-being of most Americans. And many more successes could have been included.

Finally, we want the 75th Anniversary to be not only a celebration of the past, but also an opportunity to look toward the future—for transportation and for the Board. With an introduction by 1996 Executive Committee Chairman James W. van Loben Sels, four distinguished transportation experts—Thomas B. Deen, Thomas D. Larson, Paul O. Roberts, and Frederick P. Salvucci—speculate about what we can expect in the coming years; and Executive Director Robert E. Skinner, Jr., comments on how TRB will evolve to face the coming challenges.

It has been my special pleasure to chair TRB's Executive Committee during the year of its 75th Anniversary. Those of us involved in the Transportation Research Board—sponsors, volunteer participants, staff, and others—should take pride in what we and our predecessors have accomplished. We must strive to maintain TRB's high standards and its enduring commitment to promoting innovation in transportation by stimulating research, facilitating technology transfer, encouraging the implementation of research results, and broadening our relationships in the international community.

Lillian C. Borrone
Chairman, 1995 Executive Committee
Transportation Research Board

TRANSPORTATION RESEARCH BOARD
THE FIRST SEVENTY-FIVE YEARS

The Highway Research Board

L.G. Byrd

Warren G. Harding was elected the 29th President of the United States. Prohibition was the law of the land. The Treaty of Versailles formally ending World War I was less than one year old. Henry Ford's Model T was just two years old, and 9.2 million motor vehicles were registered in the United States when the National Advisory Board on Highway Research was born in 1920. This fledgling successfully met the needs of a nation on the brink of the automotive age and over the years has broadened its mission—and even its name—in response to new national challenges in transportation. Its history parallels the history of American transportation, and the Board is as vital today as it was 75 years ago.

What prompted this unique organization, now known as the Transportation Research Board, to emerge and prosper? A major share of the credit must go to men and women with vision and a compelling mission. They are the strong threads woven through the fabric of this history.

L.G. (Gary) Byrd is a consulting engineer involved in policy studies for the American Association of State Highway and Transportation Officials, the Federal Highway Administration, the Transportation Research Board, and other organizations. A member of the National Academy of Engineering, Byrd served as Interim Director for the Strategic Highway Research Program.

The Beginning

The impetus for the Board's beginning was passage of the Federal-Aid Road Act of 1916, which provided funding for highway construction by state highway departments on a 50-50 matching basis. This legislation launched an era in which highway transportation technology advanced steadily. That era is still evolving today.

In the years following World War I, the nation was attempting to respond to the explosion of the motor vehicle population and the vast need for rebuilding and construction of many miles of roads. Highway agencies were committed to doing the job right but the questions were extensive. In a dynamic and changing transportation environment, without experience and standards for vehicle operating characteristics, dimensions, loads, speeds, volumes, and other criteria, highway agencies were proceeding on judgment and engineering knowledge, but without a consistent approach. Engineers had neither confirmation nor correction of the fundamental decisions they had to make. The battle cry was "Get the farmers out of the mud," and the nation's energies turned to the task.

Thomas H. MacDonald, Chief of the U.S. Bureau of Public Roads, speaking at a 1919 conference of the Division of Engineering of the National Research Council, summed up the challenges facing the nation:

> *The problems of reconstruction are of such magnitude and so extensive that they call for the greatest possible encouragement and support on the part of the*

Road building in 1915, using a steam shovel for excavation. After World War I, the nation's energies turned to road building, and the benefits of research soon became apparent to highway engineers.

federal government. Yet in the present situation there is every indication that we are to lose, and lose forever, that one most valuable gift, time, in inaugurating and adequately prosecuting the research and investigational studies incident to a solution of these problems. The highway engineer has for the first time had placed in his hands large sums for highway improvement. Let there be a recognition upon the part of both federal and state legislative bodies that expenditure of a reasonable proportion of these funds for highway research and experimental studies will be the best investment that can possibly be made.

New York City's 42nd Street: traffic jams were not far behind America's adoption of the automobile.

Other individuals recognized the same need. Later that year, Anson Marston, Dean and Director of the Engineering Department at Iowa State College, presented a paper entitled "A National Program for Highway Research" at the Fifth Annual Meeting of the American Association of State Highway Officials (AASHO). Marston served on the organizing committee for the Board as did MacDonald, a former student of Marston's, who supported the aims and activities of the Board through Bureau of Public Roads funding until it gained strength and later support from state highway departments and other sources. Others who participated in the organizing process and would be present at the birth of the Board were A. N. Talbot, Professor of Engineering, University of Illinois, and Past President of the American Society of Civil Engineers; Clifford Older, Chief Engineer, Illinois Highway Department, and President, Mississippi Valley Conference of State Highway Departments; and Thomas R. Agg, Chairman, AASHO Committee on Investigations, and Tests and Testing Engineer, Iowa State Highway Commission, who later would become Chairman of the Executive Committee of the new Highway Research Board in 1927.

Nurturing the organizing process from the institutional side was Comfort

A. Adams, Chairman of the Division of Engineering of the National Research Council, the operating arm of the National Academy of Sciences and later the National Academy of Engineering. At the recommendation of civil engineering representatives in the Division, Adams and the Division's Executive Committee established a Highway Research Committee in 1919 to "coordinate and assist the highway research work now being conducted by the United States Bureau of Public Roads, the state highway departments, and manufacturers, research departments, and commercial laboratories."

Birth of the National Advisory Board on Highway Research

The National Advisory Board on Highway Research came into existence at a conference convened in New York City on November 11, 1920, by the Highway Research Committee. The new Board was created as a unit of the National Research Council's Engineering Division. The founding fathers were early giants in the highway community—leaders in the National Research Council, professional societies, state highway departments, the Bureau of Public Roads, academia, and industry.

The objectives enunciated by the committee in 1920 have proven to be timeless in their applicability to the Board's role in highway research and a model for the role it has assumed in transportation research more generally:

- *To identify feasible problems for highway research to serve the highway industry's needs;*
- *To formulate a statement of nationwide highway research needs to serve the public interest;*
- *To stimulate efforts in highway research, education, and application;*
- *To correlate highway research activities to make them more conclusive, efficient, and effective for highway departments, universities, and highway industries;*
- *To present and discuss problems and ideas through group assembly;*
- *To pool and share research resources, data, and new knowledge;*
- *To collect and disseminate highway research findings through information services;*
- *To conduct sponsored research when feasible; and*
- *To administer and mediate—not manage.*

By early 1921 the Board's first Executive Committee was appointed with Anson Marston as Chairman and Alfred D. Flinn as Vice Chairman and Interim Executive Director. Members were Thomas MacDonald, Bureau of Public Roads; George S. Webster, President, American Society of Civil Engineers; and Charles F. Kettering, President, Dayton Engineering Laboratories. Flinn also served as Vice Chairman of the Research Council's Division of Engineering, and in that role provided effective leadership in making a place for the new Board within the National Research Council. He arranged for the initial funding needed to employ a director and begin work. During his brief tenure, the Board's office was in the Engineering Societies Building in New York City.

William Kendrick Hatt, Professor of Civil Engineering and Director of Testing Laboratories, Purdue University, was appointed Executive Director in July 1921. The first year's budget was $14,500. Contributors to that initial fund were the Bureau of Public Roads ($12,000), the Engineering Foundation ($1,000), the Connecticut State Highway Department ($1,000), and the National Research Council ($500).

Hatt is best remembered for organizing the first two annual meetings and establishing the precedent that has grown into today's popular convocations. The First Annual Meeting brought 30 participants—17 of them members of the Executive Committee—together on

A steady stream of new automobiles rolled off production lines, increasing public clamor for better roads. Hudson line, circa 1921.

The George Washington Bridge over the Hudson River, connecting New York and New Jersey, was the world's longest suspension bridge and the first to use steel towers when it opened in 1931.

January 16, 1922, at the Engineering Societies Building. Attendance grew rapidly: there were approximately 70 in attendance at the Second Annual Meeting held 10 months later, with 89 registrants at the Third Annual Meeting in November 1923 and 273 the following year.

The new Board with a minimal staff concentrated its first efforts on charting the field of highway research. In a 1922 survey the Board found that 479 research projects were being conducted by 132 institutions for an annual expenditure of about $300,000. Hatt saw the first six committees organized and active. In 1923 he added a technical assistant, Emil R. Olbrich, to the staff.

It was Hatt who first suggested establishment of a highway research information service, later to become a vital function of the Board in disseminating highway research findings. After two years of service, he returned to Purdue University, from which he had taken a leave of absence.

By this time three forces were in place that shaped the Board into a dynamic and vital organization of service to the transportation community:

- External support and backing of sponsors and other members of the transportation community, which was provided principally by the Bureau of Public Roads. Today financial support derives from BPR's successor, the Federal Highway Administration; other modal administrations of the U.S. Department of Transportation; the U.S. Army Corps of Engineers; the Environmental Protection Agency; state highway and transportation departments; local and regional transit agencies; rail, trucking, and materials industries; universities; consultants; and research institutions.

Linking People and Places

Bridges are vital to transportation, so much so that building bridges is a common metaphor for linking people and places. For many centuries, wood and stone were the materials used for bridge construction; and strong, durable, and picturesque stone arches can be found in Europe dating back to the Roman Empire. But the U.S. surface transportation system—with more than 1 million highway and railroad bridges—could not have been built if bridge engineers had been confined to using ancient materials and technologies.

The first iron bridge was built in 1779. It was only during the last two decades of the 19th century—less than 50 years before the organization that evolved into the Transportation Research Board was established—that structural steel and concrete reinforced with steel were first used in bridges. During the next 75 years, there was a continuous and accelerating series of developments in bridge technology. At each stage of development, new information was made available through research and offered promise for technology advancement. At the time of the Board's first Annual Meeting in 1922, the longest suspension bridge in the world spanned 1,750 feet. Ten years later, the George Washington Bridge doubled that record, and in 1937 the Golden Gate Bridge became the longest span at 4,200 feet. Longer bridges continue to be constructed; the record span now exceeds 1 mile.

An innovative application of existing technology, revealing design sensitivity to aesthetics and its historical site, the Natchez Trace Parkway Bridge in Tennessee was completed in 1994. The first and only segmental arch bridge in North America, its principal arch spans 582 feet.

Long-span bridges capture the imagination, but most of the work of bridge engineers involves more modest structures of the type described by Charles Whitney in 1929 in his book *Bridges, Their Art, Science, and Evolution*:

> *Bridges are among the most ancient and honorable members of society, with a background rich in tradition and culture. For countless generations they have borne the burdens of the world, and many of them have been great works of art. As in most large families, there are numerous poor relatives. The modern bridge too often appears as a workman performing his task for a minimum wage, mechanically efficient but uneducated and ignorant of its own ancestry.*

These honorable members of society increase mobility by spanning obstacles; they enhance safety by separating traffic; and, if they are to be economical and safe, engineers must rely on research to provide better ways of designing, constructing, maintaining, and repairing them.

In 1931 the American Association of State Highway Officials (now the American Association of State Highway and Transportation Officials) initially published its *Standard Specifications for Highway Bridges and Incidental Structures*, the first bridge-design standard used in this country. These specifications were accepted as the most comprehensive document guiding bridge design and put the United States at the forefront of bridge engineering technology. During the next 60 years, the specifications were revised on a near-annual basis to account for refinements in design theories, innovations in construction methods and materials, and heavier and more frequent traffic loads on bridges.

In the past 35 years bridge engineers have used many innovations resulting from research, including prestressed concrete, high-strength steel, weathering steel, box girder construction, modular construction, segmental construction, cable-stayed construction, high-strength bolts, welding, epoxy-coated reinforcement, curved girder construction, bridge management systems, load and resistance factor design, adhesives, elastomeric bearings, and drilled shaft foundations.

By the mid-1980s it was obvious that the AASHTO specifications had become fragmented and there were major gaps in coverage of various bridge elements. In addition, a design approach known as load and resistance factor design (LRFD) had gained prominence; however, the United States, once the leader in bridge engineering and technology, was one of only a few advanced countries not actively working toward adopting the LRFD format for its bridge specifications. In 1987 AASHTO's Highway Subcommittee on Bridges and Structures agreed on the need for a current, comprehensive code and commentary; and the National Cooperative Highway Research Program, administered by the Transportation Research Board, was directed to develop and recommend AASHTO bridge specifications in a form suitable for the 21st century.

A $2 million NCHRP project was carried out over a period of almost 5 years to provide state-of-the-art bridge specifications that once again would place the United States at the forefront of bridge engineering. The project required translating and augmenting years of prior research results into a coherent and practical form suitable for use by designers. A research team, composed of more than 50 leading bridge experts, worked to develop the specifications, and hundreds of state, federal, and industry engineers were involved in monitoring the research effort and reviewing drafts of the specifications. States performed trial designs of bridges using the new specifications, and provided thousands of comments to the researchers.

This research project has helped to ensure that the United States holds a leadership position in the international bridge engineering community. The LRFD bridge specifications, completed in 1993 and approved and published by AASHTO in 1994, are the most comprehensive specifications in the world, and will be used to design new bridges that have a more uniform level of safety as well as improved long-term serviceability and maintainability.

Pavement Design: Improving Where the Rubber Meets the Road

Seventy-five years ago, the states were facing common but unprecedented problems with growing demands for highway travel. The automobile, although just 25 years old, was already a dominant factor as new transportation facilities were planned and built. More than 10 million automobiles and trucks were running on the nation's roads, and the states were seeking better ways to build pavements to serve this new traffic. The nation had experienced heavy truck travel from railheads during World War I just a few years earlier, and the rapid deterioration of the most heavily traveled routes further pointed to the need for pavements that would be more durable under the new traffic.

In the post-World War II era, the number of automobiles in the United States skyrocketed from 28 million 50 years ago to 150 million today, and the volume of trucks grew even faster. Trucks and cars now travel more than 2 trillion miles a year, and almost one-quarter of this unimaginably large volume is concentrated on the Interstate Highway System.

The advent of the automobile age has stirred many social and political discussions, but the pavements that support it draw little public attention. To most drivers, the pavement on one of today's Interstate highways looks just like that on the roadway our grandparents first traveled. But today's pavements—the result of steady and continuous improvement founded on research and technology development—are incredibly more durable, more resistant to traffic and weather, safer, smoother, quieter, and more economical. Fifty years ago, highway pavements were essentially hand-built from native materials of uncertain quality. Pavement construction today is highly mechanized and employs materials that must meet ever higher quality standards.

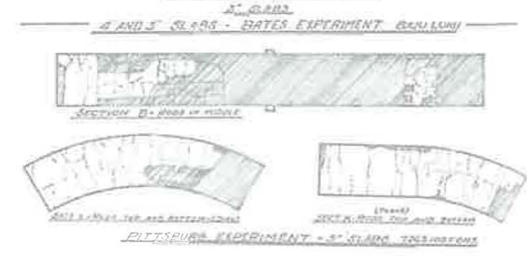
Pavement maintenance has similarly grown in sophistication and effectiveness. Some of the improvements hidden from the highway user include slipform paving, nuclear density gauges for field quality control, drainable bases, surface texturing to improve safety, automated mix plants for both asphalt and concrete, and recycling of both asphalt and concrete pavement materials into new pavements.

As the nation embarked on a program of Interstate highway construction back in the mid-1950s, highway engineers were aware of the need for better techniques to design pavements to withstand sustained heavy truck traffic. The nation's highway organizations joined forces to sponsor the AASHO Road Test to develop advances in pavement design. This huge project, located in Ottawa, Illinois, was managed by the Highway Research Board. Included were more than 800 different pavement test sections—some thin, some thick, some built of asphalt, and some of concrete—arranged in six test loops. Each lane of each loop carried carefully selected traffic, ranging from 2,000-pound single axle loads up to 30,000-pound axle loads. An additional control loop carried no traffic. The test vehicles traveled the loops for more than two years, and the resulting pavement condition was systematically measured and analyzed.

The AASHO Road Test resulted in a set of pavement design equations describing how various pavement structures would deteriorate as they were exposed to increasing traffic. These pavement design equations have been the basis of almost all major pavement designs in the United States, and indeed throughout the world, during the last 30 years. The pavements built for the Interstate Highway System rely on these design relationships, as do hundreds of billions of dollars of other highways.

Today's highway traffic exceeds anything ever imagined 40 years ago when the AASHO Road Test was conceived. In view of the huge amount that the United States spends on pavement construction, and because the economy depends on that investment performing effectively, more exact tools are required for designing pavements. Development of the next generation of pavement design began in 1984, when the Transportation Research Board proposed a new, more ambitious pavement study: the Strategic Highway Research Program. In 1987 SHRP began the largest pavement experiment ever conducted. All 50 states, all 10 Canadian provinces, and a number of cooperating countries built or designated more than 2,000 pavement test sections as part of this experiment. These sections are located on operating highways and span a wide array of pavement types and thicknesses and diverse climate and load conditions. Included are different base treatments, drainage systems, and other special features. The condition of the test sections is being carefully evaluated to unravel the effects of traffic, climate, and time; heavy and light vehicles; and other factors that determine a pavement's life. The improved pavement design equations resulting from this work will allow engineers to design pavements to accommodate the needs of any pavement type or setting.

By the time TRB celebrates its hundredth anniversary, the nation's transportation system may feature such innovations as levitating trains, electric cars, and intelligent vehicles. But no matter what revolutionary transportation discoveries lie ahead, the 4 million miles of existing roads that link our communities and workplaces will still be crucial, and keeping them in good repair is certain to be one of the keys to mobility and economic health. Pavement research will continue to ensure that the place where the rubber meets the road is durable, safe, and economical.



Diagrams of broken pavement from a paper on the economic value of reinforcement in concrete roads, presented at the 1925 Annual Meeting of the Highway Research Board.

• The National Research Council, the operating arm of the National Academy of Sciences and later the National Academy of Engineering, which has provided the institutional home for the Board since its founding.

• Internal voices within the Board through its Executive Committee, technical committees and panels, meeting participants, and staff and professional leadership.

HRB Evolves

The 1920s were years of outreach and growth. Charles Melville Upham succeeded Hatt as Executive Director in early 1924 and served through 1927. He brought experience as a former Chief Engineer of the North Carolina State Highway Department and from previous associations with the highway departments of Massachusetts and Delaware.

During Upham's tenure the Board established relationships with state highway departments and universities through the designation of contact representatives as members of the Board. By the end of 1924, 45 TRB state representatives had been appointed, and the following year 121 university representatives also joined the Board. That same year the National Academy of Sciences moved into its new headquarters on Constitution Avenue in Washington, D. C., and the Board was assigned two rooms.

Programs addressing pavement slab performance and secondary roads were initiated. Four sponsored research studies investigated steel reinforcement of concrete roads, earth roads, culverts, and urban highway finance. C. A. Hogentogler, an eminent soils engineer, joined the professional staff, and S. S. Steinberg came on board as Assistant Director.

By 1925 the National Advisory Board on Highway Research had not only a new home and an active program of seven research committees, but also a new name. At its December 1924 meeting the Executive Committee voted to become the Highway Research Board, effective

A geologist analyzes concrete pavement cores (circa 1950).

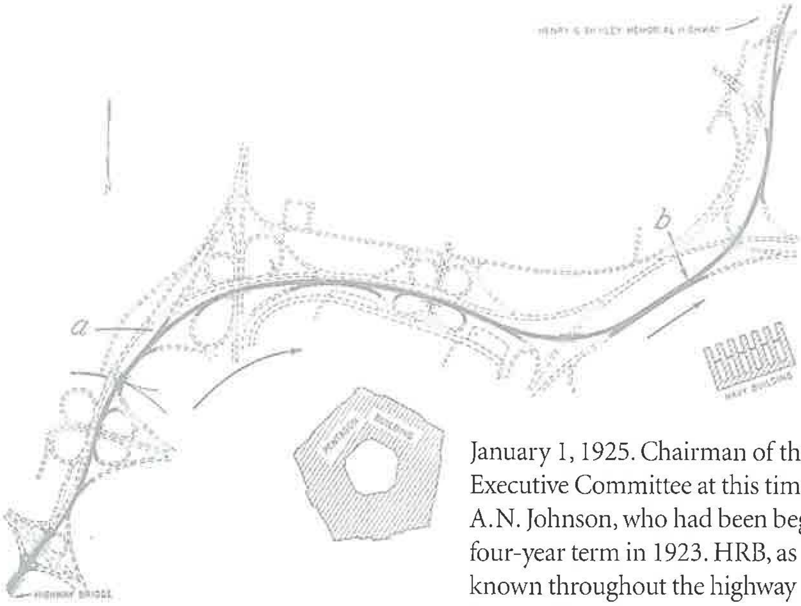


Diagram of the intricate road pattern around the newly opened Pentagon Building in Virginia from a 1942 research paper published in the Highway Research Board's **Proceedings of the Twenty-Second Annual Meeting.**

In 1932 a single police officer with a hand-operated signal was able to control traffic at a busy Washington, D.C., intersection. Today as a result of research in traffic patterns and electronic technology, sophisticated signals monitored and controlled by computers help keep traffic moving on heavily congested streets.

January 1, 1925. Chairman of the Executive Committee at this time was A.N. Johnson, who had been begun a four-year term in 1923. HRB, as it became known throughout the highway community, retained the name and scope of service for almost 50 years.

When Upham resigned in 1928 to accept a position as Engineer-Director of the American Road Builders Association, Roy W. Crum began a 23-year term as Executive Director, serving until his death. He had graduated from Marston's engineering program at Iowa State College in 1907 and served on its faculty, working at the Iowa Engineering Experiment Station and later as Engineer of Materials and Tests for the Iowa State Highway Commission. Crum led the Highway Research Board through the difficult Depression years and the demanding World War II years, seeing the program grow in size and diversity.

Called the "idea man" by his friends, Crum molded HRB into an institution of national stature, with the capabilities to provide leadership, outreach, and service to the highway community. One of his first acts was to request funding for a highway research information clearinghouse. In 1931 the newsletter series *Highway Research Abstracts* was inaugurated; later in the 1960s with the advent of computer technology, the service would expand into the Highway Research Information Service, developing into a valuable national resource.

Throughout the 1920s, the Highway Research Board continued to expand its program to include safety and finance issues as well as design, materials, construction, maintenance, and traffic research. As the decade closed, it was reported that about $500,000 was spent annually on highway research, half by the Bureau of Public Roads and the remainder by 24 states. The number of HRB research projects had reached 11 by 1929, when the Executive Committee decided to reorganize the Board to more efficiently handle future demands. It established a new structure of six departments with provisions for creation of ad hoc committees as needed; 28 were established the first year. The six departments, which endured for 40 years, were Administration and Finance, Transportation, Highway Design, Materials and Construction, Maintenance, and Traffic. Frank H. Eno chaired the Executive Committee in 1928 and 1929.

A variety of new studies were added to the HRB roster in the 1930s, covering such diverse topics as expansion joints, freeze-thaw tests, curing concrete, compacting fills, low-cost highway bridges, driver education, load limitations on highways, and vehicle headlights. As the Depression worsened, economic and operational topics were added. These included the value of travel time savings, motor vehicle operating costs, costs of highways, economy of highway improvements, pavement friction and crack control, highway lighting, alcohol and drivers, and rules of the road.

Staff continued to expand: Fred Burggraf was appointed in 1930 to handle Special Investigations, and later Wilfred Owen was employed as a research assistant to the Department of Finance and Administration. By the end of the 1930s, there were 39 committees at work, and attendance at the annual meeting had increased to 580. Burton W. Marsh chaired the Executive Committee in 1938 and 1939.

World War II and Beyond

After celebrating 20 years of service in 1940, the Board turned full attention to a new selection of studies triggered by World War II. Annual meetings were held away from Washington to avoid transportation and hotel congestion generated

Controlling Traffic

Unpredictable and almost incredible increases in traffic demand over the past 75 years have challenged the traffic engineering profession to make maximum use of highways and streets. While major design changes, such as the introduction of highway interchanges to separate traffic flows and high-occupancy-vehicle lanes to increase occupancy, have played a major role in reducing congestion, the advances in traffic control devices and techniques have allowed the nation to avoid total gridlock.

The introduction of motor vehicles, and the explosive growth in their use, created a critical need for methods and technologies to manage highway traffic. By 1920 engineers and researchers were already at work on traffic control devices, pavement markings and signs, and design methods intended to promote more efficient and safer traffic flow. The first electrically interconnected signal system had been installed in 1917 in Salt Lake City; in the same year traffic towers manned by police had their beginning in Reading, Pennsylvania, spreading to other cities in the 1920s. However, this form of traffic control presented a traffic barrier by its presence in the intersection and was short-lived. The first four-way, three-color signal was installed in Detroit in 1920; and in 1924 in Los Angeles, the words "go," "caution," and "stop" were added to the lenses of signals. The decade of the 1920s involved much experimentation with signals, perhaps more than in any other period. Since that time, there has been a steady stream of improvements in the signal hardware providing better visibility, control, and reliability.

By separating traffic flows, interchanges contribute to safety and increased highway capacity.

The most significant changes in more recent years have been related to the system aspects of traffic control. Interconnection of signals and coordinated progression on arterials and vehicle-actuated signals at lower-volume intersections have become increasingly sophisticated and efficient. Many large cities now have traffic management centers that monitor in real time major intersections covered by their computerized signal systems and have the capability to make immediate changes in response to traffic conditions and incidents and special events.

Such systems can produce significant benefits to motorists. For example, GAO reported (*Transportation Infrastructure: Benefits of Traffic Control Signal Systems Are Not Fully Realized*, 1994) that a new signal system covering 365 intersections in Orlando, Florida, produced $2.2 million in fuel savings per year, 56 percent reduction in both vehicle stops and delays, and 9 to 14 percent reduction in air pollutants. A new traffic control signal system in Los Angeles, also cited in the GAO report, reduced travel time by 18 percent, signal delays by 44 percent, vehicle stops by 41 percent, fuel consumption by 13 percent, and air pollutants by 14 percent.

Significant benefits have also been realized from upgrading or retiming existing traffic control signal systems. For example, recent studies by Washington DOT to quantify the benefits of upgrading and coordinating signal control equipment and retiming existing signals for six signal systems showed annual fuel reductions of nearly 300,000 gallons and annual reductions in vehicle delays of 145,000 vehicle hours. A study by Virginia DOT showed that retiming several signal systems reduced delays by 25.2 percent, stops by 25.5 percent, travel time by 10.2 percent, fuel consumption by 3.7 percent, and air pollution by 16 to 19.5 percent.

Traffic signs and road markings have also made dramatic gains over the past seven decades. Improved nighttime visibility of signs resulted from use of reflectorization and retroreflectorization (which directs the light directly back to the driver). The clarity of sign messages has been upgraded, while the introduction of electronic changeable message signs controlled from central locations has helped to set the stage for a new generation of driver information systems. Pavement markings, unknown before 1920, are now used extensively for a variety of purposes including center lines, edge lines, gore area markings, and channelization. Special temporary markings are used to direct traffic safely through construction and maintenance work areas.

Equal in importance to the advances in traffic control devices and methods have been the benefits resulting from their consistent application by governments at all levels. In 1923 Minnesota published what is considered to be the first state *Manual of Markers and Signs*. A national manual followed in 1927 (published by the American Association of State Highway Officials), and the first version of the *Manual on Uniform Traffic Control Devices* was published in 1935. Updated periodically, the manual continues to serve as the basis for uniformity and consistency in the use of traffic control devices throughout the United States.

The *Highway Capacity Manual*, published by the Transportation Research Board, has had a great impact on improving traffic planning and operations. The manual provides planning and analysis methods to determine the capacity and level of service for different highway designs and operating characteristics. First issued in 1950, the publication has been revised periodically to incorporate the latest research findings.

As motor vehicle use outpaces the construction of new highways, techniques for making the most efficient use of our existing highways are needed. The innovations in traffic control of the past 75 years have laid the foundation for the intelligent highway systems of the future.

A Personal View

A 30-YEAR PERSPECTIVE ON TRB

James A. Scott, Transportation Planner in TRB's Technical Activities Division, joined HRB in 1965. He shares this 30-year term of service with Phyllis D. Barber, Office Manager in the TRB Reports and Editorial Services Office. Betty L. Hawkins, Senior Production Assistant in the Reports and Editorial Services Office, joined the Board in 1963 and currently holds the record for the longest period of service. Jim shared some impressions and experiences from his past years of service during an informal interview with Gary Byrd.

Changes in the transportation industry. The change from an engineering to an administrative, business, or political background by many state transportation leaders, and the rapid turnover in that leadership, has presented a new challenge to TRB in providing appropriate information and service. The increased diversity and complexity of the institutions that govern transportation systems, particularly in urban areas, make the implementation of new technologies such as intelligent vehicle-highway systems difficult. The growing threat of legal liability in our society also challenges our ability to foster innovation.

Biggest internal change. Bill Carey's [Executive Director, 1966-1980] vision and courage in moving HRB into the broader field of transportation was the single most important and valuable change in my years with the Board. Although no easy task with many of the sponsors of HRB firmly fixed in the traditional highway mold, Bill recognized the need, presented the case with conviction, and succeeded.

Best service rendered. The Field Visit Program—annual staff visits to state transportation agencies, universities, and other organizations—enables the Board to serve as a valuable information exchange agent for these organizations, providing an opportunity for others to learn about research activities at TRB and elsewhere as well as national issues affecting transportation. This regular on-site contact with individuals throughout the nation is a source of continuing strength and leadership for TRB.

People who have made a difference. I must start with the founding fathers of the Board, particularly Thomas H. MacDonald and the other leaders from Iowa who had an influence on the Board in its earliest years. As to my years and activities, there are so many people that I cannot name them all here. Some are Don Berry, Doug Carroll, Harold Michael, Grant Mickle, Ted Holmes, Burt Marsh, Charley Wootan, Les Hoel, Tom Larson, Milt Pikarsky. I will never forget the volunteers—those dedicated, talented, remarkable people who have made TRB the vital and effective organization it is today!

Vision of TRB's future. There are opportunities for TRB to play an even greater role in advancing new technologies for transportation. We need to strengthen our service to the modes other than highways. We need to reach out to other agencies that have a vital interest in transportation. We need to strengthen our relationship with and our support from private industry.

by war activities. A new series of publications, *Wartime Bulletins*, was initiated, which discussed highway technologies needing modification because of the war. After the war ended, the series continued under the title of *Current Road Problems*.

By 1947 there were 67 HRB committees addressing many issues, among them repair and restoration of highways neglected during the war; shortage of highway engineers; and increasing use of the highway system by larger, heavier trucks. More professional help was needed, and Crum and Burggraf, now Associate Director, added a staff of engineers for materials and construction, soils and foundations, design, equipment and maintenance, and traffic and operations. Appointed to the new position of Executive Assistant to the Director was William N. Carey, Jr.

The 1950s started on a high point with publication of the landmark reference volume, *Highway Capacity Manual*, a project undertaken jointly with the Bureau of Public Roads. The manual, now in its third edition and published solely by the Transportation Research Board, has made such significant contributions to geometric design and operational knowledge that it has become a veritable bible for the transportation community.

Also launched in the early 1950s was *Highway Research Review*, a series of publications that evolved into *Highway Research in Progress*. The annual meeting had increased in size and importance to become a major national forum for highway research.

Crum died in May 1951. At the 31st Annual Meeting, he was honored posthumously with the Board's Distinguished Service Award, later renamed in his honor.

Fred Burggraf was appointed the next Executive Director and served for 12 years. A graduate of The George Washington University, he had been a member of the HRB staff from 1928 until 1932, and then worked with the Calcium Chloride Association for 8 years before returning to the Board.

The 1950s signaled the start of a series of major "road tests" of pavement performance, and the new executive director was well prepared for these new responsibilities. As a research engineer with the Illinois Division of Highways, Burggraf had participated in the Bates Road Test, the first large-scale test of pavement behavior under controlled traffic loadings.

The Maryland Road Test program, administered by the Board, began in 1950. This project, designed to measure the effects of different truck-axle loads on a concrete pavement, was the catalyst for a series of field tests to study pavements versus loadings. Asriel Tarragin was loaned to HRB by the Bureau of Public Roads to serve as Project Director. The Maryland Road Test was followed in 1952 by the Western Association of State Highway Officials (WASHO) Road Test, and in 1955 by the $27 million American Association of State Highway Officials (AASHO) Road Test.

The road test projects expanded the role and staffing of HRB. William Carey served as project engineer on the WASHO Road Test until its completion in 1954; with the inauguration of the AASHO Road Test in Ottawa, Illinois, in 1955, he supervised the research. William B. McKendrick, Jr., was named Project Director.

While field testing of pavements and structures was under way, the Board was also actively engaged in the emerging problems and challenges of providing highway services in the growing metropolitan areas of the nation. Other new areas for Board study were socioeconomic research as it related to transportation issues and intermodal relationships. By the middle of the 1950s, the Board was also caught up in new challenges presented by the Federal-Aid Highway Act of 1956, which established the Highway Trust Fund and launched the building of the National System of Interstate and Defense Highways.

The AASHO Road Test, initiated in 1955, was managed by the Highway Research Board. Members of the HRB National Advisory Committee inspect the site in Ottawa, Illinois (top); a technician takes a field density sample (bottom).

Trucks have undergone striking changes in size, capacity, and efficiency over the past 75 years and have influenced highway design. The two trucks (right)—one a 1920 model and the other a 1960 model—are in marked contrast to the modern rigs parked at a California truck stop (opposite page).

Elmer Ward was promoted to Assistant Director in 1954 and remained in that position until his death in 1961. By the end of the decade, in addition to the six departments in the HRB organization, there were 10 special committees reporting directly to the Executive Committee and more than 1,000 volunteers filling committee positions in the technical activities of the Board.

Expansion in the 1960s

The decade of the 1960s brought a major new research program to HRB: the highly successful National Cooperative Highway Research Program (NCHRP). Initiated in 1962 by a three-party agreement among the National Research Council, the Bureau of Public Roads, and AASHO, the program convenes panels of experts to advise on contract research projects related to design, construction, maintenance, and other highway activities. M. Earl Campbell was appointed the first Program Engineer for NCHRP. The first NCHRP report was published under the title *Development of Methods To Identify Aggregate Particles Which Undergo Destructive Volume Changes When Frozen in Concrete.* The author of that report, Thomas D. Larson, then at Pennsylvania State University, would chair the TRB Executive Committee in 1981, and serve as Federal Highway Administrator 1989-1993.

The 1960s saw expansion of TRB publishing activities and formal creation of the Highway Research Information

Service (HRIS). Taking advantage of new computer technology, HRIS greatly expanded its activities as a clearinghouse of highway research results, and in 1967 published the second edition of *Highway Research in Progress*, which listed more than 5,000 abstracts of domestic and international highway research. Urban transportation research also was an area of considerable activity during this period.

Significant growth marked the years of the Burggraf administration. Committee membership almost doubled, from 655 in 1951 to 1,255 in 1963, and annual meeting attendance almost tripled, from 850 to 2,443. Burggraf retired in January 1964 after 28 years of service with HRB.

The next Executive Director was D. Grant Mickle, who came from the Bureau of Public Roads where he had served as Deputy Administrator. A graduate of the University of Michigan and the Harvard Bureau of Street Traffic Research, Mickle previously had worked for the Massachusetts Department of Public Works, Michigan Department of State Highways, the City of Detroit, and the Automotive Safety Foundation. During his three years as Executive Director, Mickle concentrated on organizational and administrative matters. One of Mickle's goals was to strengthen ties to private industry; after he conducted a survey of industrial leaders seeking ways to accomplish this, the Executive Committee established an affiliate category for industry representatives.

The Board took an important step toward greater international outreach with creation of a Special Committee on International Cooperative Activities, chaired by Wilbur S. Smith, a consultant with worldwide interests who had chaired the Executive Committee in 1964. Stressing outreach at home as well as abroad, Mickle employed the first full-time public information officer—a need first identified by the Executive Committee in 1945. Mickle later served as Executive Committee Chairman in 1970.

Innovations in Trucking

Among the major trends shaping the trucking industry in the past 75 years have been mechanical innovations in equipment, the changing role of government regulation, and the electronics and information revolutions. In 1921 the tractor-semitrailer was a rare sight on American roads and had an average capacity of 8 tons. Today trucks are ubiquitous and routinely carry 25-ton loads.

Trucking companies have made significant gains in productivity by continually adopting mechanical innovations, including the diesel engine, engine and drive-train refinements, aerodynamic design, improved tire and suspension designs, and enhancements in brake performance. Today's trucks achieve far better fuel economy and enjoy longer equipment life than those of just 20 years ago.

In recent years, large trucks have contributed less pollution to the air and posed fewer dangers on the road. To meet federal engine emissions standards, diesel trucks were equipped with technological advancements that enabled the rate of particulate matter emissions to be reduced by 83 percent between 1990 and 1994. Although truck safety remains a major concern, the fatal crash rate for large trucks has dropped by nearly 40 percent in the last decade as improvements in vehicle and roadway design have been adopted and as training and licensing requirements for drivers have expanded.

The past 75 years have witnessed the transformation of the trucking industry from an unregulated infant industry, through 45 years of tight federal and state control of rates and competition, into the present post-regulatory era. Deregulation has created opportunities for reducing costs, and has stimulated renewed emphasis on marketing and innovative service offerings, with schedules, equipment, and reliability tailored to individual customer requirements.

Trucking companies have adopted new electronic and computer technologies that reduce paperwork and regulatory costs while improving responsiveness to customers. Many trucks are now equipped with automatic communication systems that aid their routing, shipment tracking, dispatching, safety, and regulatory confirmation activities. Researchers predict that in the near future, most systems on board a truck—engine, transmission, brakes, and even tires—will be controlled or monitored electronically.

Interstate highway construction in 1963: interchange linking I-75 and I-4 in Tampa, Florida.

William N. Carey, Jr., Deputy Executive Director, became Executive Director in 1966, following Mickle's resignation. His appointment capped a 20-year career with the Board, marked by progressive advancements in responsibility. A graduate of the University of Minnesota, Carey had experience in cement research and airport construction plus a broad understanding of HRB's evolution.

His administration oversaw significant expansions and additions to programs. The Board renewed a lapsed affiliation with the Permanent International Association of Road Congresses, further strengthening international outreach. The Research Information Service was expanded to include maritime, railroad, and urban mass transportation. Beginning in 1968, summer meetings were conducted as a means of reaching participants who could not attend the annual meetings in Washington, D.C., each January; although in 1976 these meetings were discontinued because the Board was sponsoring so many other seminars, workshops, conferences, and special meetings throughout each year.

Under Carey a new statement of purpose and scope for the Board was drafted for approval by the HRB Executive Committee and the Governing Board of the National Research Council. This action recognized that the interests of HRB committees and sponsors were extending beyond highway transportation, and it signaled the Board's intention to ultimately become a multimodal organization. This was followed by a new organizational structure conceived by the Board's Long Range Planning Committee and refined and endorsed by the delegates to a special conference on reorganization and reorientation held in Warrenton, Virginia, in 1968.

HRB Becomes TRB

The Highway Research Board celebrated its 50th anniversary in 1970 by publishing a history, written largely by Fred Burggraf and completed after his death by M. Earl Campbell. But there was little time to pause for reminiscences of past successes because the Board was rushing into a future filled with challenging new responsibilities. Events were converging within the National Research Council and throughout the transportation community that mandated a reconsideration of the Board's identity and scope of activities. In 1973 the National Research Council reorganized into four commissions. The new Commission on Sociotechnical Systems housed HRB. Discussions revolved around a proposed role for the Highway Research Board in parallel with a Maritime Board and an Air Board, all as units of a transportation research division within the new commission.

The HRB Executive Committee and sponsors were concerned about such narrowing and segregation of transportation activities. For several years they had recognized the increasing multimodal aspects of much of the transportation research the Board was conducting. Committees had been actively investigating problems of land use; new transportation systems; social, economic, and environmental factors in transportation; and passenger and freight transportation. Annual meetings in the early 1970s were also reflecting broader interests with sessions on such topics as "Mass Transportation: Future Research Needs" and "Public Transportation to Airports."

Concurrently, many state highway departments were being transformed into departments of transportation in recognition of the multimodal nature of transportation. AASHO also was examining a reorganization to encompass similar changes. Shortly, the organization would broaden its name to the American Association of State Highway and Transportation Officials (AASHTO).

State and federal sponsors supported a broadening of HRB's mission. Representatives of the Federal Highway Administration, chief administrative officers of state highway and transportation departments, and HRB officers and staff met in November 1973 to explore questions of HRB's name and scope. By unanimous agreement a new name and broadened scope were recommended. With approval by the National Research Council, on March 9, 1974, a momentous change occurred when the Highway Research Board became the Transportation Research Board (TRB)—with a broadened scope to include highway, rail, air, marine, and urban mass transportation activities.

In the late 1950s, construction began on the planned 41,000 miles of the National System of Interstate and Defense Highways, which greatly expanded America's economic and industrial base. Federal funds enabled states to construct multilane, controlled-access highways that bound the nation together.

Americans were introduced to unprecedented flexibility—new choices in where to live, where to work, where to shop, and how to spend leisure time—which had a profound influence on their lifestyles and vision of the future.

Map shows the original Interstate network as planned in 1956.


La Brea
Ave

The Transportation Research Board

1970s: Responding to a Broadened Scope

The Transportation Research Board quickly responded to its new name and expanded role with a wide variety of activities throughout the 1970s. A summer meeting focused on automation systems for highway organizations. A workshop addressed environmental considerations in transportation. New sponsors provided additional financial support, including the Urban Mass Transportation Administration (now the Federal Transit Administration), followed later by the Association of American Railroads and the Federal Railroad Administration. Special committees were formed on rail and air transport. Two full-time rail specialists were added to the staff. In 1978 TRB's Executive Committee simplified the classes of affiliation to provide for Sponsors, Sustaining Associates, Contributing Associates, and Individual Associates, which numbered more than 3,000 that year.

The remainder of Carey's term as Executive Director of the Transportation Research Board was given to successfully consolidating the Board's new responsibilities and reaching a greatly broadened constituency in the transportation community. Carey retired in 1980 after 33 years of service and, in recognition of the leadership he had provided to the transportation research community, was honored with the Roy W. Crum Distinguished Service Award.

1980s: Multimodal Transportation Role Firmly Established

Thomas B. Deen succeeded Carey as Executive Director in 1980. Previously President of Alan M. Voorhees and Associates, a well-known transportation planning and engineering firm, Deen, a graduate of the University of Kentucky and Yale Bureau of Highway Traffic, earlier had been Director of Planning for the National Capital Transportation Agency, which developed the early plans for the metrorail system in the Washington, D.C., metropolitan area. His 14-year tenure was distinguished by strong leadership in times of financial stress, dramatic growth of TRB services, revitalization of transportation research activities, a new role for TRB in the conduct of national transportation policy studies, and reorganization of the National Research Council that included raising the status of TRB as a major unit of this prestigious organization.

In the early 1980s, national double-digit inflation threatened the stability of TRB's programs. Deen instituted a series of management efficiencies that enabled TRB to emerge from this trying period with revitalized strength and efficiency, greater recognition of the value of its services, and renewed commitment by its sponsors and the National Research Council.

Despite financial constraints, this decade established TRB's role in multimodal transportation research. This period was also noteworthy for the Board's successful entrance into the policy arena and for renewal of much-needed investment in some fundamental highway research.

The initiation of highly sensitive policy studies was a significant and challenging addition to the traditional role of the Transportation Research Board and required major administrative and staff changes. A Subcommittee on Policy Review was formed by the Executive Committee to monitor all aspects of policy studies and advise the Special Projects Division (now the Studies and Information Services Division) in which TRB's policy study activity was housed. Panels for each study were appointed under rigorous National Research Council

In the 1980s, highway designers began using computer-aided drafting and design (CADD) systems in place of their drafting boards.

The Highway Safety Success Story

During the past 75 years safety has notably improved in all modes of transportation. Much of this improvement can be directly attributed to research and technological innovation. The advances in highway safety have been dramatic and are particularly important given that nearly 175 million Americans are now licensed drivers. The number of traffic fatalities has declined from more than 20 deaths per 100 million vehicle miles traveled in the early 1920s to less than 2 today. Improvements in vehicles, facilities, and operator performance all have contributed to this significant reduction.

In the early days of automobile transportation, vehicles were much less stable and maneuverable than they are today. Frames and interiors were rigid and unyielding in crashes, thereby transferring crash forces to occupants. Roads designs had limited sight distances on curves and at intersections and opposing traffic lanes were rarely separated. Signs and markings were primitive by today's standards.

Over the decades, research has led to steady progress in improving the safety of both vehicles and roads. Early crash tests pioneered in the 1940s helped automobile manufacturers understand the importance of providing frames and structures that deformed in a crash and the need to provide occupant compartments that limit intrusions during a crash. Many vehicle safety features were subsequently introduced because of federal motor vehicle safety legislation passed in the 1960s and 1970s, but the improvements themselves were dependent on research in areas such as designs for steering wheel columns that would deform safely in a crash, windshield glass that would break without shattering into sharp-edged shards, and air bags that would deploy quickly, safely, and reliably.

Road designs advanced because human factors research defined the amount of time and space drivers need to react to avoid crashes and because highway designers better accounted for these needs in setting specifications for curves, intersections, and lane widths. Many lives have been saved by roadside improvements such as breakaway light and sign posts, and crash barriers, which redirect vehicles that run off the road preventing more serious impacts or rollovers. (The National Cooperative Highway Research Program, administered by the Transportation Research Board, has funded research on roadside barriers leading to improved barrier designs.) Visual cues to drivers have been enhanced through innovations in materials that give signs and markings greater visibility at night while providing good legibility during the day.

In addition to improvements to vehicles and roads, society has become more safety conscious. For example, drug and alcohol-impaired driving is far less acceptable behavior than in earlier years. Motorists are also much more likely to use safety belts. While increased use of safety belts is part of a wider change in social mores, this trend has also been influenced by research that identified the most effective enforcement measures and public information strategies to induce compliance.

Many of the improvements over the years in vehicle and roadway design and traffic safety programs would not have been possible without the development of traffic safety data systems at the federal and state levels. The federal Fatal Accident Reporting System (FARS), initiated in 1975, enabled researchers to evaluate the effectiveness of numerous highway safety measures. FARS and other accident data bases have been critical for establishing a sound basis for safety measures adopted in the 1970s and 1980s, such as child safety seats, occupant restraint standards, high-mounted traffic lights, and for understanding the impact of alcohol-impaired driving.

Safety has been an important success story in the highway community, but much remains to be done. As substantial as the improvements in vehicles, roads, and driver behavior have been, more than 40,000 highway deaths and millions of injuries still occur each year. Moreover, some trends point toward increasing risks from higher speeds, less adherence to traffic safety regulations, a more diverse mix of vehicles on the road, and an aging population that is more vulnerable to injury in crashes. Continued efforts are required to find safer materials, better designs, and effective measures to modify unsafe behaviors.

Federal and state governments have mounted multipronged crusades to improve highway safety. Mandatory use of seat belts is now the law in 49 states and the District of Columbia (top).

The national 55-mph speed limit, adopted in 1974 to conserve fuel, also had safety implications. In its 1984 report, **55: A Decade of Experience**, *the Transportation Research Board found that the reduced speed had important safety benefits, but was difficult to enforce, particularly on rural interstates. (In late 1995, the national maximum speed limit was repealed.)*

procedures. Five new professional staff positions were created, and supplemental support was provided by visiting academicians, borrowed personnel, and consultants.

Five policy studies were mandated by Congress in 1982: design standards for highway rehabilitation projects; use of citizen-band radios on intercity buses; effect of twin-trailer trucks on highway operations; economic, energy, and safety effects of the national 55-mph speed limit; and human resource needs for the future. The completion of these studies established TRB as an important participant in policy development.

In 1982 the TRB Executive Committee, chaired by Darrell V Manning, initiated a series of studies called Strategic Transportation Research Studies. One set of recommendations led to the establishment of the Strategic Highway Research Program (SHRP), a $150 million, 5-year project that produced a number of cost-effective highway innovations. Funded by Congress, the program addressed fundamental needs for improvement in asphalt materials, pavement performance, maintenance, concrete bridge protection, cement and concrete, and control of snow and ice. Another set of recommendations laid the groundwork for a cooperative research

A Personal View

SOME NICE THINGS HAPPENED ON THE WAY TO THE FRONT OFFICE

Jewelene G. Richardson joined the Highway Research Board in 1969 as a secretary in the Highway Research Information Service (HRIS) and advanced to become Committee Appointments Officer in the TRB Executive Office. During an informal interview with Gary Byrd, she shared some insights from her 26 years of service.

Memorable events. The move from HRIS to the front office provided opportunities to grow in the organization. My first job in this office was to compile an HRB Directory on a mainframe computer from voluminous paper records. I was no computer expert when I started but I learned fast.

Winning the Chairman's Award in 1979 was a thrill. That plaque is still shining on my office wall. I was especially pleased to realize that Bill Carey [Executive Director, 1966-1980] knew me and my work!

The name change from HRB to TRB. My first reaction was: what a lot of paper work to change all those records! But I soon realized what a monumental and exciting change in all activities it was to be for the Board and for all of us involved.

When the Board began its policy studies program, I had a sense of personal pride. I remember telling a friend that we were studying the 55 mile-per-hour speed limit—and then I realized how much I felt a part of the team!

Changes. When TRB began its program of quality control over the slides and viewgraphs to be used by presenters at Annual Meeting sessions, Roy Edgerton [Technical Activities Division Director, 1967-1978] and I could do the entire job of reviewing the slides and preparing the subsequent correspondence in one long weekend at the office. Today I have a staff of six to eight working part time on this each November through the Annual Meeting in January. The moratorium on visual aid reviews for the 1995 Annual Meeting was a mixed blessing based on the feedback we received. Although the staff enjoyed the role of benevolent counselor to presenters, the unreviewed visual aids shown at the technical sessions were of mixed quality. Working with the Division A Council, we are currently developing TRB's visual aids policy for future years.

A change of great satisfaction has been the increasing diversity of the people involved in TRB. That early directory I first worked on did not include many women or minorities. Today there is a growing presence of both on the committees, in meeting attendance, and on the staff. And in 1995 we have our first woman, Lillian Borrone, chairing the Executive Committee.

Staff. The first person I think of is Marilou Damon; she was my mentor and friend. She and Bill Gunderman were responsible for giving me the opportunity to move to the front office. Jimmy Allen challenged and inspired me to take on new tasks, and Roy Edgerton taught me how to work under pressure to meet the inevitable deadlines that are a necessary part of the TRB operations and to be responsible, conscientious, and detail-oriented. Bill Carey, even though he was at the top of the staff, made me feel important. I will always be grateful to all of them and to my present associates.

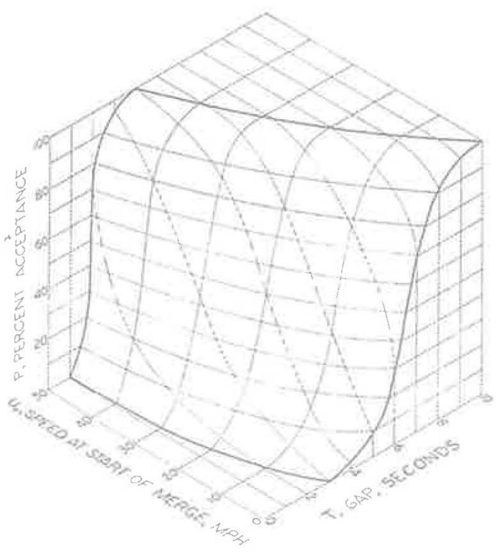
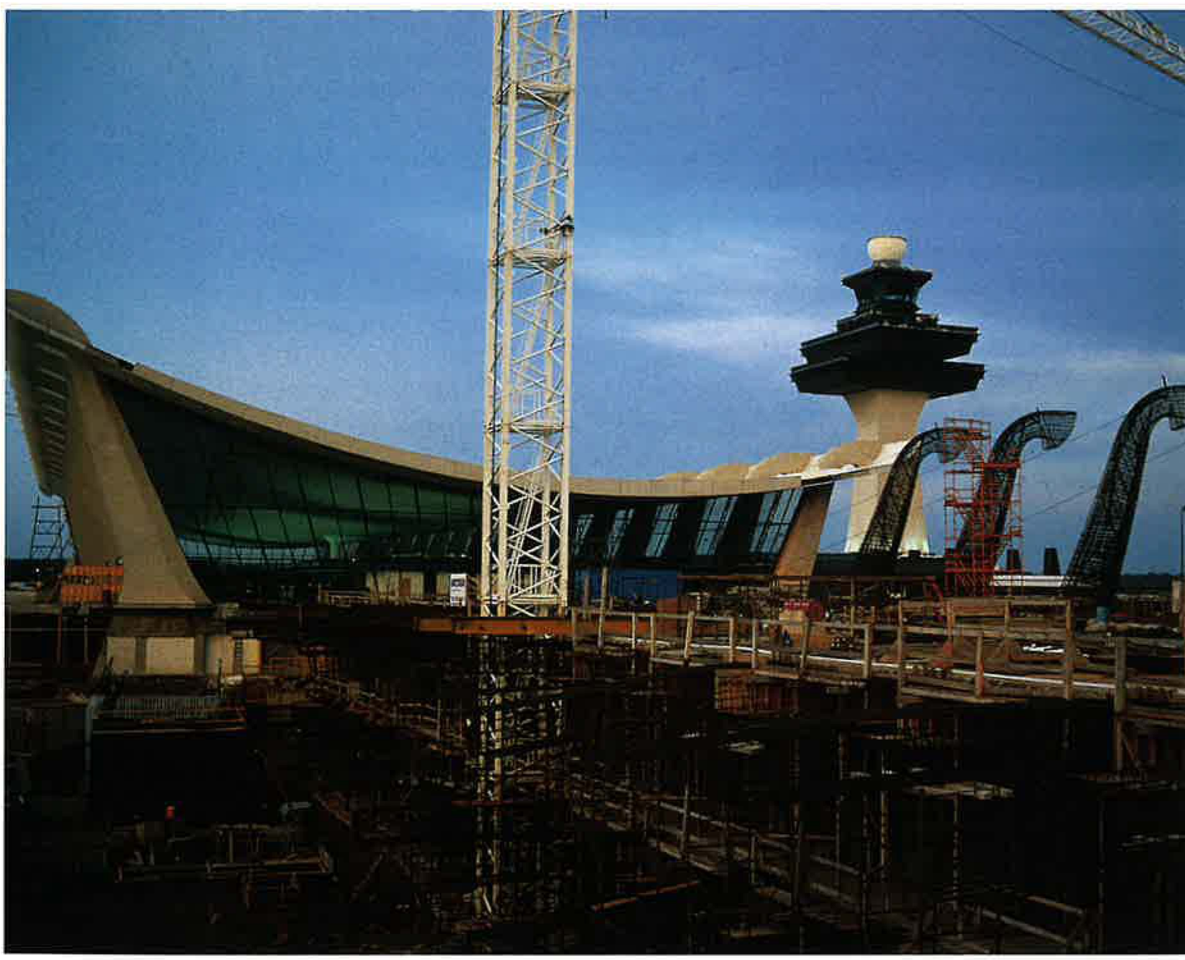


***Illustration from U.S. Bureau of Public Roads study on merging vehicles at a junction of ramp and highway, published in a 1967* Highway Research Record.**

program in transit to be modeled on the National Cooperative Highway Research Program.

As part of a 1982 reorganization of the National Research Council, TRB was designated as one of eight major units reporting directly to the Governing Board. The Executive Committee was now required to include a minimum of five members of the National Academy of Sciences, National Academy of Engineering, or Institute of Medicine. A Subcommittee for NRC Oversight was established by the Executive Committee to provide liaison between TRB and the National Research Council Governing Board.

The National Highway Traffic Safety Administration became a sponsor. The Board began development of an Urban Mass Transportation Research Information Service, and a Special Committee on Aviation was formed to advise on aviation matters. In 1987 TRB, along with other National Research Council units, moved its offices in Washington, D.C., from the Joseph Henry Building on Pennsylvania Avenue to newly refurbished facilities at 2001 Wisconsin Avenue, where it resides today. At the end of the decade,



Dulles International Airport in Virginia, underused for two decades following its 1961 opening, has experienced increases in passenger traffic in recent years, forcing a major expansion program to double its size. The new extended terminal preserves the familiar soaring profile designed by Eero Saarinen.

The Revolution in Passenger Aviation

Since the Wright brothers' first sustained-power flight in 1903, aviation has benefited from a continual injection of technological advances backed by years of aeronautical research and development. By the time of Orville Wright's death in 1948, the aviation industry had experienced unprecedented advances in technology, and Americans were primed to enter a new age of air travel. In the intervening years, many advances in safety and efficiency were required for air travel to be able to compete with, and eventually surpass, rail as the predominant mode of long-distance passenger travel.

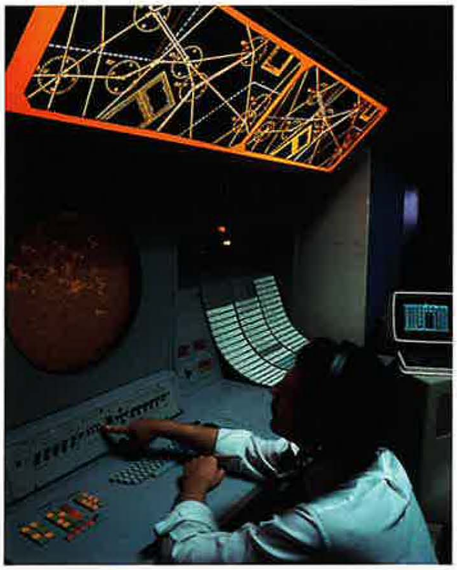
Many of these critical developments occurred during the 1930s and 1940s, when cockpit instruments for "blind" flying, radio and radar, pressurized cabins, lightweight construction materials, and jet engines were developed. Travelers in the 1930s flew on the first modern airliners, including the 21-seat Douglas DC-3, which became the workhorse of the airline industry for the next two decades. Radio beacons were installed across the continental United States during this period, and Newark International Airport was outfitted with the first traffic control tower. By the 1940s pressurized cabins allowed some passenger aircraft to cruise at high altitudes (above 20,000 ft), enabling pilots to avoid turbulent weather and increasing the comfort and safety of air travel.

Dramatic advances in passenger aviation followed the development of the jet engine. First patented in Great Britain in 1930, jet aircraft did not become commonplace in passenger service until 30 years later. Advances in the turbine engine were accelerated by the demands for military use during World War II. The first U.S.-built jet aircraft was tested in 1943, and before the end of the decade, Chuck Yeager would break the sound barrier in U.S. military aircraft. The successful military application of jet propulsion caused commercial aerospace companies to invest heavily in improving the comfort, manufacturing processes, and flight efficiencies of more complex aircraft. This research quickly paid off: by 1952 the first jet airliner was developed in Great Britain, and in 1959 Boeing introduced the 707, capable of seating 180 passengers and flying more than 500 miles per hour.

By the early 1960s all major airlines had regularly scheduled jet service, as the speed, safety, and comfort of the new class of airliners proved extremely popular with travelers. Air safety improved dramatically during this era. Following the widespread introduction of jet service, the fatal accident rate declined sharply. There were half as many fatal accidents per aircraft mile flown during the 1960s than during the previous decade. Travel times between cities also fell sharply. Whereas a typical piston-engine passenger aircraft—predominant in the 1950s—might require 20 hours and refueling stops to complete a flight from New York to Paris, a Boeing 707 could make the trip nonstop in just 7 hours.

During the 1960s and early 1970s, airports across the country were expanded and upgraded. Airside facilities such as runways, aprons, and gates were constructed or improved to accommodate the much larger aircraft. New passenger facilities, such as remote terminals, people movers, and baggage conveyor systems, were developed to handle the increased passenger traffic. These changes coincided with the dawning of the computer age, which enabled the automation of air traffic control systems and enhancements in airline ticketing, operations, and marketing. Between 1955, when most of these revolutionary changes were on the horizon, and 1970, when wide-body "jumbo" jets were introduced, the number of passengers flying on U.S. airlines more than quadrupled, from 40 million per year to nearly 175 million.

After radical reduction of government restrictions on airline fares and services during the late 1970s and 1980s, passenger traffic has continued to grow at a fast pace. Airlines—no longer overly subject to regulations governing their prices and routes—merged and expanded their networks, developing "hub-and-spoke" systems that filled empty seats, increased aircraft departures, and enabled more efficient use of aircraft. These efficiencies have led to dramatically lower fares and increased flight options, making air travel more accessible to millions of Americans who could not previously afford to use this mode. Today, nearly 20 years after deregulation and only 35 years after the widespread introduction of jet aircraft, U.S. airlines carry more than 500 million passengers per year while air travel continues to become safer.



The air traffic control system is being modernized to handle the increases in traffic expected in decades to come. This controller is monitoring flights en route.

Resurgence of Freight Rail

With delivery of the first units in 1994, these new 5,000-horsepower locomotives are providing improved operating efficiencies.

The railroad industry was near its peak 75 years ago: employing more than 2 million, rail was by far the nation's dominant mode of freight transportation, carrying more than three-fourths of all intercity tonnage. However, with the advent of the motor vehicle and the construction of a modern highway system, rail traffic suffered a serious decline (except for a surge during World War II). By 1970 rail's share of freight had fallen to below 40 percent, and some experts were predicting that the railroad industry would not survive as private enterprise except in specialized markets.

Today the rail freight industry shows dramatic expansion. In recent years the industry has experienced a resurgence, handling record levels of traffic for eight consecutive years through 1994; and 1995 is expected to be another record year. Unimaginable even a decade ago, by 1993 some freight railroads were experiencing capacity constraints.

Economic deregulation, most notably the Staggers Act of 1980, has played a large role in this revival by allowing railroads to compete more effectively through pricing flexibility, contracting options, and other mechanisms to improve marketing their services to customers. Major cost-cutting efforts have also boosted railroad profitability, including system rationalizations, employment reductions (to an industry total equal to 10 percent of the 1920 employment level), and restructuring that has led to a dramatic increase in the number of shortline and regional railroads.

Since deregulation there have been significant improvements in railroad safety resulting from the joint efforts of the industry, the Federal Railroad Administration, and suppliers. For example, cooperative programs have led to better understanding of track-train dynamics and improved tank car safety.

The deregulated environment has also bolstered rail carrier incentives to implement new technology and their commitment to support industry-sponsored research through the Association of American Railroads. As a result of AAR research programs, the railroads are incorporating improvements enabling the hauling of larger cars with heavier axle loads without significantly increasing track maintenance costs. Research leading to the development of dynamic simulation models has improved both vehicle design and train operations. The most promising recent advancement—AC traction locomotives—which represents combined research efforts of manufacturers and the rail industry, is starting to generate big payoffs: fewer locomotives are needed to haul trains, they are more fuel-efficient to operate, and they reduce rail wear.

Computerized information and management systems are also generating efficiency in operations (for example, centralized dispatching and operations systems) and providing important information for customers, such as tracking of shipments. A recent mandate by the Association of American Railroads requires automatic equipment identification (AEI) with transponders on all freight cars and locomotives, which will provide even more accurate tracking information.

In recent years intermodal traffic, a product of deregulation measures that gave railroads the institutional flexibility both to own carriers of other modes and to establish partnerships with other rail, truck, and waterborne carriers, has accounted for a large part of freight rail growth. In addition, new developments in equipment—such as specially designed cars for double stack container trains; trailers that operate directly on rail or highway; and most recently train equipment that incorporates a loading platform, eliminating the need for additional track-side loading equipment—have facilitated the growth of the intermodal freight industry.

As implementation of technological improvements generates service improvements, customer service is becoming the driving force in the rail industry and is spurring restructuring actions that continue to change the nation's railroad map.

Interstate 70 in scenic Glenwood Canyon, Colorado, was constructed through rugged terrain with minimal environmental damage. The Hanging Lake Viaduct is one of several viaducts constructed in a steep, narrow area with the aid of an overhead gantry that lowered precast concrete segments in place without scarring the landscape.

the Executive Committee created a Special Task Force to review the role of the Board in marine and intermodal freight transportation.

In 1988 the responsibilities of the Subcommittee on Policy Review were expanded by the Executive Committee, chaired by Herbert H. Richardson, and its name changed accordingly. In addition to oversight of policy studies, the revised responsibilities of the Subcommittee on Planning and Policy Review included identifying major transportation problems and the role of the Board in addressing them; preparing and recommending critical issues for consideration by TRB; and acting for the Executive Committee as required between regular meetings of the committee.

Strengths, Changes, and Challenges in the 1990s

By the beginning of the 1990s, TRB had developed a number of clear responsibilities and continuing activities to meet its goals and objectives:

- **Technical Activities.** Standing committees, task forces, field visit program, annual meeting, conferences, and workshops.
- **Policy Studies.** Investigations by expert panels with staff support on complex national transportation issues, as requested by the states, federal agencies, or Congress, or initiated by the Executive Committee.

During construction of the Channel Tunnel, connecting England and France, approximately 700,000 segments of reinforced concrete and cast iron were moved in to line the walls, and 7.8 million cubic meters of channel "muck" was moved out. The "chunnel" opened in May 1994.

• **Cooperative Research Programs.** Research on highway and transit issues administered by TRB on behalf of state governments and the urban public transportation community.

• **Publications.** Large portfolio including Transportation Research Records (primarily papers presented at the annual meeting), Special Reports (primarily policy study findings), Conference Proceedings, Circulars (workshop proceedings, research statements, and other committee documents), and Cooperative Research Program Reports and Syntheses of Practice (presenting research findings for transportation professionals).

• **Transportation Research Information Services.** Development and management of computerized bibliographic data bases on highways, transit, and other transportation modes.

Along with the development of a comprehensive program of activities, the end of the 1980s and early 1990s reflected the addition of a number of new organizations to the TRB sponsor roster: U. S. Army Corps of Engineers, American Automobile Manufacturers Association, American Trucking Associations, American Public Transit Association, National Asphalt Pavement Association, and Research and Special Programs Administration of the U. S. Department of Transportation, along with the return of the Federal Railroad and National Highway Traffic Safety administrations. In the mid-1990s, the U.S. DOT's Bureau of Transportation Statistics and the Environmental Protection Agency also became sponsors.

In 1991 the Transportation Research Board presented its first Five-Year Strategic Plan to the National Research Council Governing Board. The plan identified TRB's strengths and accomplishments as well as its problems and challenges. In presenting a set of goals and critical issues, it also proposed special initiatives and specific projects. C. Michael Walton chaired the Executive Committee at this time.

The first half of the decade of the 1990s can best be characterized as a period of growth for the Board. In 1990 TRB had 4 divisions, just under 95 staff members, and a budget of $18 million. By 1993 there were 5 divisions and more than 115 staff members, and by 1995 a budget of almost $40 million.

Much of TRB's growth during this period was stimulated by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). This legislation contained research provisions reflecting a renewed focus on the importance of new technology and the role of the federal government as catalyst in providing that technology to address the nation's transportation needs. The legislation also established the Transit

Cooperative Research Program, calling for the National Academy of Sciences, acting through the Transportation Research Board, to administer the program. And it provided funding for TRB to continue selected SHRP activities after that program formally ended.

Deen retired in 1994 after overseeing the addition of new programs and staff to TRB. As an indicator of the growth in interest and participation in the Board, annual meeting attendance surpassed 7,000 in the last year of his administration. At the 1995 Annual Meeting, Deen was honored for his outstanding service to the Board by presentation of the William N. Carey, Jr., Distinguished Service Award.

Robert E. Skinner, Jr., became the ninth Executive Director in September 1994. He brought more than 11 years of valuable experience on the TRB staff, most recently as head of the Studies and Information Services Division. A civil engineering graduate of the University of Virginia, with a graduate degree from the Massachusetts Institute of Technology, he was a vice president with Alan M. Voorhees Associates before joining the Board. Skinner heads the Transportation Research Board during a time when fundamental changes are occurring in transportation as a result of such factors as deregulation, application of advanced information and communication technologies, and reconsideration of the roles of local, state, and federal governments in the delivery and financing of transportation services.

Lillian C. Borrone chairs the 1995 Executive Committee. Under her leadership, in light of the changes and challenges ahead, a process featuring significant outreach to TRB's many constituencies was initiated to revise and update the strategic plan.

Toward Cleaner, More Fuel Efficient Cars

Motor vehicles are a primary source of air pollution and remain the nation's top source of oil consumption. Today's models, however, are far friendlier to our health—and less expensive to operate—than were their predecessors.

Pioneering regulations in California, along with the federal Air Quality Act of 1967 and subsequent amendments, prompted the automotive industry to devote considerable resources to research and development of emission control systems. In the early 1970s the industry began using carbon canisters capable of partially absorbing hydrocarbon emissions from fuel systems. In 1975 automobile manufacturers installed catalytic converters in engine exhaust systems that reduce emissions of the three major pollutants by up to 90 percent before the exhaust enters the atmosphere. While emission reductions from technology improvements were partially offset by growth in motor vehicle travel, between 1970 and 1993 highway vehicle emissions of carbon monoxide were reduced by 32 percent and hydrocarbons by 53 percent. Nitrogen oxides, a more difficult pollutant to control, were reduced only slightly. Highway vehicle emissions of lead were effectively eliminated by the introduction of lead-free gasoline during that period.

Regulatory measures and technology advances have also prompted dramatic improvements in the fuel efficiency of automobiles. After the 1973 oil embargo imposed by the Organization of Petroleum Exporting Countries created gasoline shortages, Congress passed national legislation in 1975 to require manufacturers selling cars in the United States to significantly increase by model year 1985 the corporate average fuel economy (CAFE) of their new-car fleets to 27.5 miles per gallon.

By 1993 passenger cars in the United States averaged 21.6 miles per gallon—a 60 percent improvement since 1970. Innovations such as multipoint fuel injection for improved fuel metering and more efficient engines and transmissions, and the reduced weight of passenger vehicles were largely responsible for this development.

Because of increases in travel, the overall consumption of oil by motor vehicles in the United States continues to grow; but as a result of innovative vehicle and engine technologies, the growth is occurring at a much slower pace than would otherwise be expected.

Gasoline shortages created by the 1973 oil embargo became a major impetus for improvements in automotive fuel efficiency.

The Transportation Research Board Today

Along with the nation's transportation system, the scope and nature of the activities of the Transportation Research Board have changed dramatically since that simple beginning 75 years ago. But TRB's basic mission—to stimulate research and disseminate the findings that help provide safe, efficient, economical, and flexible transportation—has not changed. This mission has been clarified and refined over the years so that today it still serves as an effective guide for the complex and demanding work of the Board.

In its early years, the Board was committed to the advancement of the technologies needed to build and pave the nation's highway network so that it could accommodate the explosive growth of automobile and truck traffic. Over time the emphasis in the Board's activities expanded from design, materials, and construction technologies to include issues related to traffic and operations, planning, and administration. In later years the scope grew to include other modes of transportation and to address the social, economic, and environmental impacts of transportation systems.

What is the Transportation Research Board today? How does this multifaceted organization that has evolved over 75 years carry out this growing and challenging mission?

The Team

The Transportation Research Board is composed of three groups: sponsoring organizations; individual (volunteer) members of committees, panels, and task groups; and employed staff, consultants, and research contractors. This unique mix of paid and volunteer participants, engaged concurrently in many diverse activities, does not lend itself to a quick and easy description; but its complexity has not diminished its outstanding success, durability, and contributions to the transportation community over the years.

Sponsors. Like other units of the National Research Council, TRB depends on others to provide the funds required to carry out its program. The principal portions of its annual budget are provided by the organizations serving as sponsors, which currently include the modal and research administrations of the U.S. Department of Transportation; all of the 50 state, District of Columbia, and Puerto Rico departments of transportation individually (represented on the Executive Committee by AASHTO); the U.S. Army Corps of Engineers; the Environmental Protection Agency; the American Public Transit Association; and private industry groups including the National Asphalt Paving Association, Association of American Railroads, American Automobile Manufacturers Association, and American Trucking Associations.

Members. Activities of the Board are carried out by more than 400 committees, panels, and task groups, involving more than 4,000 individual volunteer members appointed from state and federal transportation agencies, academia, and the private sector. In recent years, there has been substantial growth in international participation on TRB committees.

Staff. Organized into five divisions, the TRB staff provides management for activities and guidance and support for the volunteer committee membership. The staff has grown significantly from its modest beginning; however, the organization has maintained a conservative staffing policy and today TRB operates with a lean but effective team of professional, administrative, and support personnel.

A major activity of the Transportation Research Board is the worldwide dissemination of publications, which present the latest research findings and current practices, address major national policy issues, and analyze research needs in all modes and aspects of transportation. More than 100 reports are issued annually.

Currently under construction, the 7.5-mile Central Artery/Tunnel project in Boston will replace an elevated highway and clear a downtown area for redevelopment (opposite page).

The introduction of modern rapid transit and light rail service has helped to revitalize public transportation in many U.S. cities (above).

Atlanta's Peachtree Center Station is noted for its architectural design (right). The Metropolitan Atlanta Rapid Transit Authority is preparing to carry some 800,000 passengers a day—twice the normal load—during the 1996 Summer Olympics. MARTA has borrowed 2,000 buses and will open three new rail stations to handle the expected crowds.

Executive Committee. TRB policies are determined and directed by its Executive Committee, acting within the overall policies of the National Research Council. Members are appointed to the Executive Committee by the chairman of the NRC Governing Board, with an ex officio member named from each sponsoring organization. Working closely with the committee is the staff leadership, including the executive director, assistant executive director, and five division directors.

The Executive Committee, in addition to its administrative and fiduciary responsibilities, monitors and approves special studies to be carried out by the Board, and reviews and approves conferences and workshops in which TRB is a sponsoring organization. In 1988 the committee added another dimension to its activities with the advent of a comprehensive session at each of its semi-annual meetings on a contemporary critical issue in transportation. Presentations by experts and policy officials, where applicable, are followed by in-depth discussions with presenters and among committee members. These sessions have enabled the committee to define and implement self-directed studies of important issues.

Self-directed studies resulting from this activist thrust by the Executive Committee have included the following:

• *America's Highways: Accelerating the Search for Innovation.* Completed in 1984, this early example of a self-initiated study examined the growing inadequacy of the investment being made in highway research and the potential payoff to be realized by funding research for some basic highway materials and technologies.

Public Transportation

Brought about by both the increasing popularity of automobiles and a reduction in all forms of travel during the Depression years, a decline in public transit ridership began to occur in the late 1920s. Transit use temporarily revived during the gas and rubber rationing of World War II, but resumed the pattern of declining ridership in the 1950s.

The 1964 Urban Mass Transportation Act was a major turning point for the public transportation industry, and reflected renewed commitment to public transportation by government at the federal, state, and local levels. This commitment took the form of new investment in public transportation facilities and the conversion of many systems from private to public management during the 1960s and 1970s. During this period, 12 North American cities initiated light rail systems, 6 cities invested in rapid rail, and numerous bus and paratransit systems were started or expanded. The resurgence of public transportation activity generated new interest in research in this area, with the Transportation Research Board forming new committees to share information about transit technology, planning, and financing; encourage research; and disseminate the research findings.

Today transit agencies also benefit from research sponsored by the Federal Transit Administration and private-sector equipment suppliers, as well as from innovations developed in other countries. New automated fare collection systems, which are more efficient, allow the use of more equitable fares based on trip length. Recording fareboxes on buses provide a wealth of information to aid transit management, planning, and marketing. Current research and experimentation with scannable smart cards promise to further revolutionize fare collection in the next few years.

Automated train control has improved the safety and reliability of the newer rapid rail systems. Continued advances in train control and signaling are expected to lead to increased capacity for the next generation of rail service. Transmission retarders on buses prolong brake life, and the use of alternative fuels reduces harmful particulate emissions. Low-floor buses and light rail vehicles now being put in service in North America provide better public transportation for passengers with disabilities and speed boarding for all passengers.

Improved planning techniques and supporting computer software have made possible more sophisticated analysis of transit options, contributing to the planning of transit systems built in the last 25 years. Current research in intelligent transportation, automatic vehicle location, and geographic information systems is expected to lead to future improvements in operating efficiency and customer service.

The Transit Cooperative Research Program, established in 1992 and administered by the Transportation Research Board, is beginning to make a significant contribution to innovations in public transportation by responding to industry-identified needs for improved methods and technologies. The search for increased efficiency and effectiveness through innovation must continue as all levels of government strive to do more with less.

Buses are an essential component of public transportation in cities of all sizes.

Development of Intermodal Freight

Containerization—the use of standardized, detachable boxes of varying dimensions to hold and transport cargo—is a concept that revolutionized the freight industry. Trucking company owner Malcolm McLean tested the idea in 1956 to complement the operations of a newly acquired steamship line. Although marine containers had been used for military shipments since World War II, McLean's experiments were based on his conviction that using freight containers would simplify the interchange of goods between transportation modes, resulting in more efficient, reliable everyday service.

Since the 1950s, there has been phenomenal growth in the use of containers for a wide range of cargoes. Ships and cranes have been designed to permit efficient loading and unloading of containers, with successive generations of specially designed container ships offering increased cargo capacities. The impressive improvements in productivity that resulted have made containerization the global standard, permitting significant economies of scale, reduced handling time, and improved cargo safety.

Railroad cars carrying double stacks of containers have made intermodal rail service more efficient and economical. Trainloads of containers cross the nation daily carrying products being shipped to foreign markets and imports for American consumers.

The widespread adoption of container technology, along with the growth of information technologies to track shipments and manage freight movement, led directly to another revolutionary change: the development of intermodalism. The ease of interchanging containers and information among modes fostered the integration of water, rail, and truck movements of containerized cargo, often in a continuous or "seamless" movement from shipper to consignee. This trend was accelerated by deregulation of the railroad, shipping, and motor carrier industries in the 1980s and by the increasing globalization of the economy. Institutional changes, together with the innovations in cargo handling and information technologies, cleared the way for further intermodal developments that continue to this day.

In 1984 greater economies of scale were realized when the American President Lines inaugurated regular double-stack container train service between Los Angeles and Chicago-New York—a single carrier operating an integrated intermodal transport system with complete door-to-door service. Since then, there has been significant growth in double-stack services, with weekly eastbound service increasing to 241 train sets in 1993. By that year 18 percent of goods shipped more than 500 miles in the United States moved by more than one mode, and the intermodal market share continues to rise.

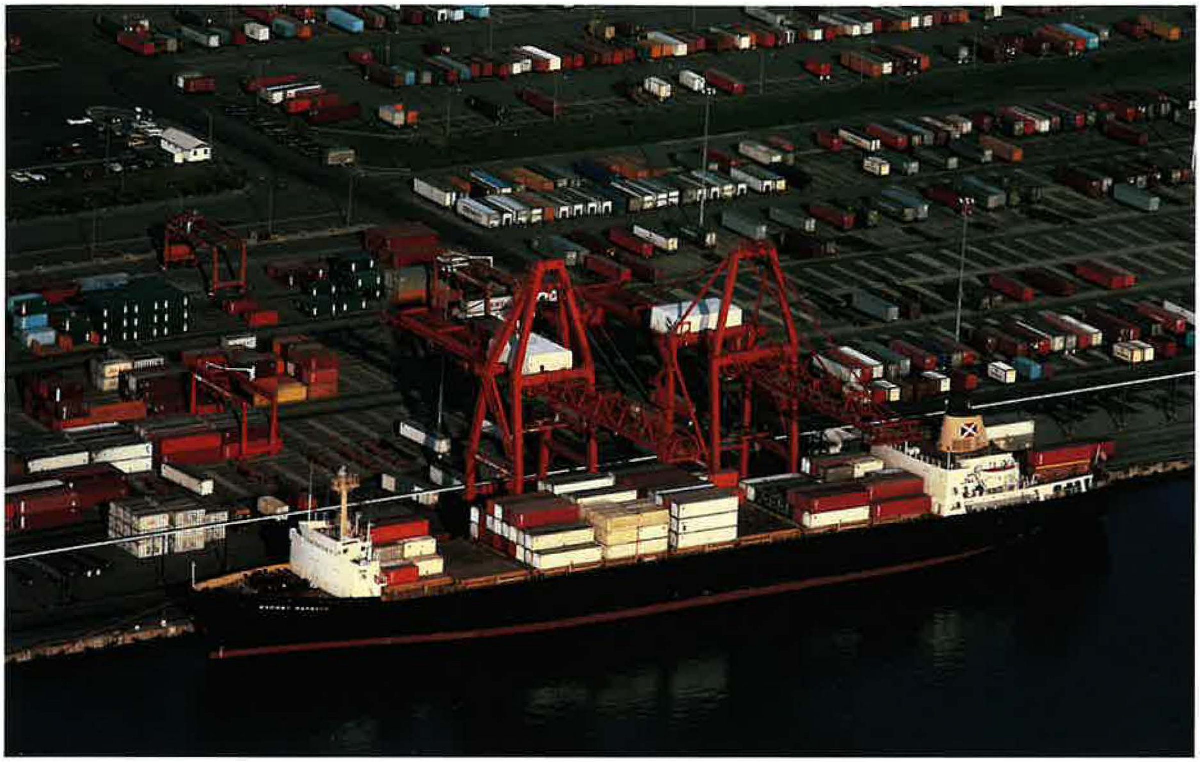
Continuous innovation drives this competitive industry. Today intermodal freight carriers are applying new technologies—including advanced information systems, simulation modeling, and automatic equipment identification—to further improve the efficiency and reliability of their services.

This report recommended the Strategic Highway Research Program, which was subsequently approved by FHWA and AASHTO and funded by federal legislation, and resulted in a $150 million, 5-year research program.

- *Transportation in an Aging Society: Improving Mobility and Safety for Older Persons.* Completed in 1988, this 2-year study recommended a broad range of improvements to the design of vehicles and highways and screening and licensure of drivers.
- *Impacts of Highway Capacity Improvements on Air Quality and Energy Consumption.* This 18-month study examined areas of scientific consensus on the impacts of capacity improvements on traffic flow characteristics and vehicle emissions, travel behavior and trip-making, and land use and regional development.
- *Public Policy for Freight Transportation.* This study, now under way, is examining the feasibility of performing a comprehensive analysis to measure the subsidies received by freight carriers and shippers and the external costs of freight transportation—an attempt to measure the "level playing field" for competing freight modes. Addressed are the conceptual framework, methods, data, scale of subsidies, and external costs involved, along with the approach and resource requirements for any further analysis.
- *Transportation and a Sustainable Environment.* This 2-year study, under way during this 75th anniversary year, seeks to lay out a path toward sustainable transportation, recognizing that transportation is currently a major consumer of fossil fuels and the source of one-third of all greenhouse gases while also essential to the function of modern economies and critical to continued economic growth.

Technical Activities

Technical activities have grown in size and stature over the life of the Transportation Research Board. Today they are housed in a separate division of the Board and are



Container ship docked at Norfolk International Terminal. Container ships are integral components of a modern intermodal transport system; containers are efficiently off-loaded to flatcar or truck for delivery. Containerization and sophisticated inland distribution systems have increased speed and efficiency while lowering costs.

carried out by five groups: Systems Planning and Administration, Design and Construction, Operations Safety and Maintenance, Legal Resources, and Intergroup Resources. Approximately 190 standing committees and task forces involving more than 3,000 volunteers make up these groups.

In addition to the management of these committees, this Division is responsible for planning and administering the annual meeting, which has evolved into one of the largest gatherings of its kind, drawing transportation administrators, researchers, and practitioners from government, industry, and academia worldwide to Washington, D.C., each January. The Division also carries out the Field Visit Program, whereby all state highway and transportation departments, many university transportation centers, transit and other modal agencies, and industry representatives are visited annually with the primary objectives of information exchange and technology transfer. Support for these activities is provided by a skilled team of professional experts in the specific fields.

An example of the significant activities undertaken by the Technical Activities Division is the Forum on Future Directions in Transportation Research and Development, held in March 1995 to assist the President's National Science and Technology Council in its review of the federal transportation research and development program. Other recent examples include major conferences in intermodal transportation, bridge engineering, ISTEA implementation, and low-volume roads, as well as the development of new editions of the *Highway Capacity Manual* and *Landslides: Investigation and Mitigation.*

Studies and Information Services

TRB self-initiated policy studies and those studies requested by Congress or sponsors are the responsibility of the Studies and Information Services Division (formerly the Special Projects

Increased travel demand, high costs of building and maintaining roads and bridges, and innovations in marine technology have led to renewed interest in marine transportation. Alaska's Marine Highway System, along with its important role in state tourism, provides a vital transportation link among Alaskan communities, offering passenger and vehicle ferry service to commuters along the southern coasts and connecting to the continental road system in British Columbia and the lower 48 states.

Division). The studies are conducted by NRC-appointed panels, supported by staff and consultants. The reports are subject to vigorous peer review in accordance with National Research Council policy. In addition to the self-initiated studies of the Executive Committee, in the recent past this Division has successfully undertaken such challenging issues as *Safety Research for a Changing Highway Environment*; *Providing Access for Large Trucks*; *Ensuring Railroad Tank Car Safety*; *Measuring Quality: A Review Process for the University Transportation Centers Program*; *Hazardous Materials Shipment Information for Emergency Response*; *Improving School Bus Safety*; and *Airport System Capacity: Strategic Choices*.

The Division also houses the Information Services team, which includes the Transportation Research Information Services (TRIS); the TRB Library; and the Syntheses Program. The Synthesis of Practice series, a popular product of the Cooperative Research Program, consists of concise reports covering current practices in highway and transit operations, contemporary issues of concern to practitioners, and valuable background information to help transportation administrators determine the need for new research and the direction it should take.

Cooperative Research Programs

The Cooperative Research Programs Division manages two programs with a total budget in fiscal year 1995 of more than $20 million. The National Cooperative Highway Research Program (NCHRP) has a 1995 budget in excess of $15 million. Selected by AASHTO's Standing Committee on Research, NCHRP projects reflect contemporary problems facing the highway community and provide a vital service to the sponsoring state highway agencies. The products of this program are both synthesis and research reports. Recent reports include *Guidelines for Effective Maintenance Budgeting Strategies*; *Public Outreach Handbook for Departments of Transportation*; *Recommended Procedures for the Safety Performance Evaluation of Highway Features*; *Roadway Widths for Low-Traffic-Volume Roads*; and *Adaptation of Geographic Information Systems for Transportation*.

The Transit Cooperative Research Program (TCRP), initiated in 1992, is the newest cooperative program. Budgeted in fiscal year 1995 at more than $8 million, TCRP is supported by annual grants from the Federal Transit Administration. Projects are selected by the TCRP Oversight and Project Selection Committee, which is also the Board of Directors of the Transit Development Corporation, a nonprofit educational and research organization of the American Public Transit Association. The TCRP is operated under a three-way agreement among the National Academy of Sciences, the Federal Transit Administration, and the Transit Development Corporation. Recent products from the TCRP program, which are both synthesis and research reports, include *Low-Floor Transit Buses*; *Employee Incentive Programs to Improve Transit Performance*; *Public Transportation Systems*; *Retrofit of Buses to Meet Clean Air Regulations*; and *Artificial Intelligence for Transit Railcar Diagnostics*.

Special Programs

The catalyst for creation of the Special Programs Division, the newest of TRB divisions, was the Strategic Highway Research Program (SHRP) and the need for follow-up activities at the close of this special five-year research effort. This Division monitors and advises on the continuing operation of the Long-Term Pavement Performance studies initiated by SHRP, and provides advice and assistance to the Federal Highway Administration and state highway agencies on the implementation of SHRP research results. In addition, it manages the Innovations Deserving Exploratory Analysis (IDEA) programs. All of the programs are guided by committees and expert task groups with support from professional staff.

TRB in Brief

This, then, is the Transportation Research Board today—

A NATIONAL INSTITUTION called upon by the White House, the Congress, the U.S. Department of Transportation, and the states to address major transportation policies and issues facing the nation.

A TRANSPORTATION RESEARCH MANAGEMENT AND INFORMATION SERVICE for which the states, transit agencies, federal government, and private sponsors demonstrate their well-founded confidence by committing more than $30 million of their scarce funds annually.

A FORUM in which more than 4,000 members are active volunteers on committees and task forces addressing all aspects of transportation, and to which more than 7,000 participants gather from around the world each year for an annual meeting.

A PROMINENT GENERATOR OF PUBLISHED REPORTS that disseminate transportation research results and technology worldwide, address major national transportation policy issues, and analyze research needs.

A PROFESSIONAL ORGANIZATION of internationally known and respected transportation experts, leaders, and staff, poised to provide even greater service to the nation and the world community as it faces the challenges of transportation in the dawning 21st century.

THE FUTURE

This special issue of *TR News* celebrating TRB's 75th Anniversary would not be complete without a look at what might lie ahead for transportation in the United States in the next century. Alvin Toffler, the futurist author, describes predictions as possible, probable, and preferable. The Transportation Research Board asked four distinguished transportation leaders to predict how transportation will have changed by the year 2020 when the Board celebrates its 100th anniversary. Our authors have surveyed different aspects of transportation and given us a blend of all three views. Understandably, they have not covered all aspects or dealt with all modes of transportation evenly.

Thomas Deen presents probable developments in transportation areas most susceptible to change, noting that the roots of many changes can already be detected. He acknowledges that his views may disappoint some readers and are not necessarily his own preferences.

After judging some scenarios as wishful thinking, Thomas Larson lays out promising possibilities in technology and institutional organization.

Paul Roberts peers into the future of freight-handling operations and forecasts major improvements in efficiency with the development and adoption of advanced electronics technologies.

With the Cold War at an end and the Interstate Highway System virtually completed, transportation policy must reflect new priorities, political realities, and economic changes, observes Frederick Salvucci. He presents his preferred approach to transportation policy in the unstable times that lie ahead.

These essays give us a glimpse of what the future may hold and what choices we face—thought-provoking material to be sure, with which you may or may not agree. But like a time capsule discovered many years after its burial, these essays may tell future readers more about us than about transportation in 2020 and beyond.

James W. van Loben Sels
Chairman, 1996 Executive Committee
Transportation Research Board

SPECULATIONS ABOUT AMERICAN TRANSPORTATION BY 2020

Thomas B. Deen

Stock market analysts are fond of saying that they are willing to forecast either what the market is going to do or when it is going to do it, but never both at the same time. The Transportation Research Board, having specified 2020 as the "when" of this essay, will not permit waffling on the "what." Thus entrapped, I want to stipulate that my comments should be regarded as purely predictive and not prescriptive. Some of my predictions will not be happy ones to many readers; were I to offer my preferred vision, many of these comments would be different.

The year 2020 is but 25 years away—only a heartbeat in history's view. Many expected changes already are rooted in current events and therefore easily predicted. Much, if not most, of the physical transportation system—routes, terminals, bridges, and rights-of-way—is now in place, as are the cities, homes, office buildings, mines, farms, and industrial plants that fix the demand for travel and shipping. My emphasis is on those things most susceptible to change in an otherwise rapidly changing world: operations, financing, institutions, government programs, and technology.

Assumptions

All predictions require dealing with imponderables, and 25-year forecasts of transportation are no exception. I will deal with the imponderables by making three assumptions:

• The U.S. economy will continue to grow by about 2 to 3 percent annually; in other words, there will be no economic collapse.

• No environmental crisis will emerge. However, if a scientific consensus were to develop concluding that carbon dioxide emissions from transportation were making an unacceptable contribution to global warming, causing sea levels to rise and inundate coastal cities, then all bets are off. Such an event would trigger a totally new political climate with tight public controls over many actions now acceptable. I am assuming this or an equivalent crisis will not happen.

• We will begin to find a solution to the blight afflicting our cities. The current trends are so bleak that if extended for 25 more years, conditions would become too grim to contemplate. Crime, drugs, poor education, and welfare inequities have created such a stewpot of problems that many of our cities are depopulating. My assumption is that by 2020, somehow, someway, we will at least have learned how to stabilize the situation. Possibly we will do better, but current trends are not promising.

Emerging Technologies

New technology is a rapidly changing variable that will have an impact on costs, performance, reliability, convenience, and sustainability. Several new technologies will be in place, or at least in the process of gradual deployment by 2020.

Cars of the future will be faster, cleaner, and safer. They will average 60 miles per gallon and will have only a marginally negative effect on air quality. These improvements will have been made possible by a variety of innovations, including lightweight composites, flywheels, fuel

In the 16th century, Michelangelo stated: "A bridge ought to be built as though it were intended to be a cathedral, with the same care and the same materials." The Sunshine Skyway Bridge in Florida stretches 4.1 miles over Tampa Bay, making it the longest cable-stayed, precast concrete segmental bridge in the Western Hemisphere (opposite page).

cells, and microprocessors. Freeway speeds will continue to increase to an average of 75 mph in uncongested areas with no adverse impact on safety as a result of intelligent cruise control and other sensor-based safety devices. By 2020 operational tests will have demonstrated the technical feasibility of automated highways. Serious proposals have been made for development of a privately financed high-speed automated toll road for commercial and other vehicles, but no actual roads will be in service by 2020. These improvements will make car travel even more attractive, making such environmental issues as urban congestion and land use even more critical.

Intelligent transportation systems (ITS) will be deployed less rapidly than currently expected by advocates of these technologies because of a host of institutional problems. Local and, to a lesser extent, state governments lack the incentive, as well as the financial and human resources, to initiate such major projects. Many truckers are suspicious that ITS will be the avenue for adding another layer of taxes. Many other potential applications of ITS require a level of cooperation by a number of entities larger than we are accustomed to; therefore progress will be slow.

Nevertheless, more electronic capability will be employed for more purposes on more vehicles at ever lower prices. Electronic identification tags for vehicles and containers of all types and modes will become increasingly common and be installed as standard equipment. By the end of the first decade of the new century, several large, integrated urban traffic management centers will be in operation to control intersections, ramps, and freeway traffic and provide drivers, carpoolers, and transit passengers with real-time information on optional routes, service interruptions, and other useful travel data. This information also will be communicated directly to vehicles, offices, kiosks, homes, and personal communications devices. By 2020 so many individuals and vehicles will carry communications devices that commercial firms will be providing such information in many locations.

High-speed ground transportation will be employed in a few high-density corridors. The experiment of a national railroad passenger network will have fallen victim to constraints on federal budgets and a lack of incentive on the part of freight railroads to share tracks in the face of insufficient capacity to move more profitable freight. However, the Northeast Corridor will be electrified from Washington to Boston, and high-speed (160 mph) tilt trains will be flourishing, the beneficiaries of overcrowded airports in the ever-more congested Northeast. High-speed rail will also be operating in some corridors in Florida and Southern California.

Aviation

Subsonic aircraft will still dominate aviation, although planes will be quieter, less polluting, and more efficient. On high-density routes, large planes with loads of 700 or more passengers will be in use, and hypersonic aircraft will be emerging for intercontinental routes. Airport capacity still will be a critical issue forcing continued airport expansion, improved traffic control, larger planes, substitution of high-speed ground transportation in selected corridors, and more direct flights with fewer hubs.

Commercial Freight

Commercial freight will be in a state of growth and transition, triggered by the strong economic and financial benefits of even larger and heavier trucks along with capacity limitations on railroads. These needs will generate pressure for 57- and 63-ft trailers, as well as double 48s and triple 40s, on selected parts of the National Highway System. Break-bulk terminals will be built at appropriate points along this network. There also will be serious proposals for a few truck-only commercial highways. Improved wheels, tires, and brakes will permit a lowering of truck floor heights, providing additional capacity in each vehicle.

Intermodal traffic will be expedited by information systems that track not only containers, but also shipped items within the containers. ITS technology will gradually force states to rewrite regulations allowing the use of automation in such procedures as truck safety inspections, driver performance monitoring, registration, and permit issuance. Some states will replace fuel taxes with weight-distance taxes as a more equitable and efficient method of collecting user fees. Intermodal terminals, much like airports, increasingly will be funded by local industrial revenue bonds, secured by long-term contracts with transportation companies.

Urban Transportation

Urban traffic patterns will change as electronic communications and computer-based videoconferencing reduce the need for workers to commute to a central office five days each week. Despite an easing of the current crises in many large metropolitan areas, as stated in my third assumption, people will not flock back to American cities. Technology will provide the impetus for continued urban sprawl, and workers will live even farther out in order to find less expensive land and other desired amenities. The workplace will become less dependent on the city center and will continue the shift to the suburbs. The result will be increases in car and truck travel in metropolitan areas, especially in the low-density exurbs. Although many workers will go to the office fewer days each week, they will travel more miles when they do.

Fixed-route transit service will still be essential in the largest cities. As the cities regain financial health, the old fixed-route rail systems can be restored and revitalized. Commuter rail service will continue to grow, and a number of new lines will be developed. The growing outer suburbs will be served by an array of private jitneys and carpool services, assisted by a growing menu of commercial travel information services spawned by ITS systems.

Roles and Responsibilities

The federal role in transportation infrastructure financing will continue to decline. By 2020 assistance will primarily be restricted to the National Highway System, administered in the next century by the U.S. Department of Economic Development, a merger of the current Departments of Transportation, Commerce, Labor, and Housing and Urban Development. The National Highway System will include connections to major airports, ports, and intermodal terminals. The federal government also will be a partner in the development of a few high-speed ground transportation corridors between major cities.

Most decisions and funding for transportation will fall to state and local governments. States will support strong metropolitan planning organizations as problematic but essential instruments for growing superregions in reaching consensus on an array of divisive regional issues. Financing will be less uniform, combining a mix of federal and state assistance programs with more toll facilities, infrastructure banks, and privatization schemes.

Transportation and the Environment

Population worldwide and in the United States will continue to grow, as will the environmental impact of more people consuming increasing amounts of the earth's resources. Technology can assist in reducing consumption per person while still providing for economic growth, which will partially offset the effects of population increases. However, the difficulties of accommodating both mobility and environmental goals will spread as population and consumption continue to grow.

Transportation is a large consumer of resources and contributes, directly and indirectly, to the degradation of the environment. However, it also provides enormous benefits that consumers and producers would be loath to lose. The desire for sustainable development will bring increasing pressures on both the environmental and the transportation communities to find cost-effective solutions.

Concerns will continue over urban sprawl and the blurring of distinctions between urban and rural areas, reductions in agricultural and open land, threats to wildlife, and other dangers to the environment. Solutions, however, are likely to be quite diverse depending on the differing values of different jurisdictions. Some areas will generate the consensus required to control development through coordinated land use and transportation policies, and some will explore, with varying degrees of success, new pricing policies for road use and parking. Other areas will see stringent development controls as threatening to individual property rights and will elect to continue current policies.

The result will be a more heterogeneous and widely divergent set of policies and prescriptions for transportation development than we see today.

Thomas B. Deen was Executive Director of the Transportation Research Board from 1980 to 1994. He currently serves as Chairman of the Planning Committee for ITS America. Previously he was President of Alan M. Voorhees and Associates.

Successful test runs by the Swedish X2000 tilt train and other foreign equipment preceded Amtrak's plans to acquire new train sets for higher-speed service between Boston and Washington.

THE FUTURE OF TRANSPORTATION

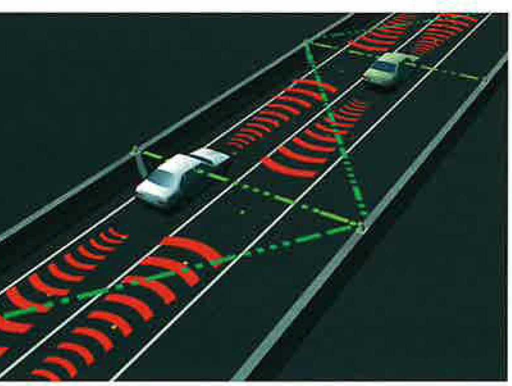
Thomas D. Larson

Marshall McLuhan, author of that remarkably prescient phrase, "the coming global village," speaks to us in other wise words: "We always plunge into the future looking in the rear view mirror. Imagine what would happen if we raised our eyes and looked through the windshield."

Casey Stengel also had practical advice on this subject, reportedly saying: "It's difficult to make predictions—especially about the future."

But despite these and other warnings and exhortations, we ordinary mortals have a compulsion—if not always an immediate need—to share notions about the future of just about everything. Some few may claim special oracular powers, but for the rest, the relentlessness and pace of change only reinforce Stengel's wisdom. This wisdom notwithstanding, we can expect the tendency to predict will intensify as a new century—and a new millennium—rush at us.

Still, making observations about the future of transportation is not hopeless. And since this is a long-cycle business, one increasingly vital to our well-being, there is justification for some amount of prognostication even in the face of known risks.



Automated highways of the future may control vehicles to eliminate collisions, increase road capacity, ease congestion, and reduce fuel consumption and exhaust emissions. For example, an automatic response to avoid collision could be triggered when a vehicle's radar-like beam detects a dangerously close obstacle.

Unlikely Outcomes

Seeking greater validity in this uncertain business, I suggest we might begin to perceive the real future by discarding, or at least pushing back, some unlikely-to-occur outcomes or scenarios—those grounded in an imperfectly recalled, romanticized past, for example, or unfettered by short-term reality. This approach is not without its risks. Since we generally reach for the easy, ready-made solutions, a list like the one I offer could become a crutch, an excuse for avoiding the hard, creative work that perhaps would surmount obstacles only visible to jaded eyes. Still, as Dr. Samuel Johnson said to Boswell, "When a man knows he is to be hanged in a fortnight, it concentrates his mind wonderfully." Perhaps, for those who see long-cherished transportation icons marked, even so tenuously, for the gallows, this will be a "mind-concentrating," re-energizing experience. At the least, stimulating a discourse on probabilities surrounding each scenario's likely future seems to have merit.

Others will bring their own candidates to this elimination game, but I offer the following as a beginning:

The evident land use/transportation nexus will be operationalized soon in integrated planning and decision-making processes. Since land use controls are primarily local, and transportation plans and policies are most often set at higher levels of government, I doubt this desirable outcome can be predicted as occurring on any near-future, widespread basis. But there are some positive examples to be cited.

In Portland, Oregon, and several other metropolitan areas, growth boundaries have been drawn, and development has focused on "in-filling" within these boundaries in coordination with regional transportation plans. State and local governments work with the public to ensure that the plans reflect real commitment across an area large enough to be significant for both land use and transportation. Over time, such a creative, although politically volatile and risky (possibly even unstable) policy could rationalize transportation to land use.

In California, following a different approach, there is a growing, explicit recognition and acceptance of the fact that land use is resolutely under local government control. Here, in a refreshingly realistic response, funding for transportation is being moved to that same level of government; that is, those who make unconnected-to-transportation land use decisions will have to pay for the consequences instead of appealing to some higher authority with deeper pockets.

In the future we will see and utilize transportation as a key component of sustainable *development.* Desirable as the concept may seem, I believe it is elusive. We are a consumption-driven society. Consumer confidence now is reported as a leading economic indicator. Development tied to consumption (perhaps measurable by the almost unbelievable growth in the rental storage-bin business) must, at some level, be unsustainable. Still, transportation is called to serve this consumption-driven society. It has served, and continues to do so, typically with disconcerting fidelity and profit-driven alacrity.

On a larger scale, sustainability persists as a societal goal. Beginning with the 1992 Rio Conference, there has been growing world interest in sustainable development. For the future, we can join ourselves to this interest and help drive it by communicating the inefficiencies of many present transportation systems. We can also work to bring together what Thomas Deen (former Executive Director of the Transportation Research Board) has called "the mobility and environmental political blocks" that impede progress in this area.

The approximately 40,000 annual U.S. highway deaths will be substantially reduced. There are two pivotal problems in realizing this goal. First, the current fatality rate of 1.7 per 100 million miles of travel has been reached via a remarkably stable, seven-decade downward trend, producing a curve that in graphical representation now approaches a zero fatality rate as an asymptote. Therefore, driving it lower, by definition, approaches impossibility. Second, the number of miles driven each year—some 2.5 trillion—is growing, as is the mix of drivers and vehicles. Therefore, instead of looking for some easy relief from this appalling carnage, we must run faster in a statistically handicapped race just to stay even.

As a first and immediate step, there should be a careful review and hard-nosed sorting out of reasonably well defined and effective remedial safety measures. Then a sharp national focus must be placed on those measures that can drive down the rate to perhaps 1.2 per 100 million miles of travel by the turn of the century. We must take this action in order to keep the number of deaths by automobile from climbing inevitably and unacceptably higher.

There will be a resurgence in transit ridership or some other alternative to single-occupant auto usage. Transit's cost structure, the land use problem noted above, the growing number and diversity of workers and workplaces, a general rejection of "Manhattanization," and forces for smaller government and tighter budgets all argue against this outcome. As one example, Harvard University Professor Jose Gomez-Ibanez recently analyzed the Boston MBTA's (Massachusetts Bay Transportation Authority) performance and saw only hard choices following an adjusted-for-inflation deficit growth of 639 percent in 26 years. He stated: "[Boston] will have to learn to make tough choices about controlling unit costs and be more selective in MBTA service and fare offerings ...." Clearly, Boston is not alone in its dilemma.

Freight will move off the roads and back to rails. In fact, it is filling both roads and railroad tracks! Serious congestion points have developed on the freight railroads and for the first time in decades major capital expansions are under way to relieve these constraints. At the same time, we see trucks in increasing numbers each day, and these vehicles, especially those engaged in high-value package delivery not readily transferable to rail, face all the limitations imposed by our increasingly congested, urbanized population. In the face of real physical and demographic constraints, and given the consumption-focused society that is driving growth in freight movements faster than general economic growth, I suggest there must—and will—be more trucks and more trains.

Accentuating the Positive

Prophets of despair are rarely popular—and fortunately not often accurate. While there are many candidates for elimination as unrealistic future transportation scenarios, so are there many promising and exciting ones in the offing. Another quotation, this one from Alfred Lord Tennyson's *Locksley Hall* (1842), helps set a positive stage:

For I dipped into the future far as
The human eye could see,
Saw a vision of the world and all the
Wonders that would be.

And with only the most modest effort, one can come up with some of "the wonders that would be" in our field of transportation.

Real wonders will be available for the next decade. According to a recent report by The Battelle Technology Management Group, the future will bring us super-materials for longer-lasting bridges and pavements and for many other purposes, hybrid-fuel and clean vehicles, the information highway offering more options for interaction with potentially less physical movement, and much more. Unfortunately, too few transportation practitioners seem to realize how many technologies applicable to transportation are waiting on someone's shelf, most (but by no means all) paid for from other-than-transportation R&D sources. As the public sector is squeezed for funds and the private sector comes to play a larger role in providing transportation services, the profit motive will pull an increasing number of high-technology advances into the business of improving transportation service. ITS (intelligent transportation systems) depends, in large part, on just such a process.

The heavy hand of the federal government will lift. Given the developed character of our transportation infrastructure, the growing divergence in future transportation needs and expectations among the states and communities of this country, and the near impossibility of devising politically acceptable national programs with the necessary equitable funding distribution formulas, federal government transportation policy and practice will continue to be changed and minimized. The shift will be toward more flexibility in programs and funding; the minimization will be toward that set of core systems (as yet ill defined) needed to keep us socially united and economically effective as a globally competitive nation in the 21st century.

Opportunities for creative new state-level structures and management approaches will emerge. The monolithic character of the state departments of transportation will continue to erode. The clearly rural states will necessarily be served by the traditional highway-focused programs. The state DOTs in highly urbanized contexts will increasingly become partners and brokers, as well as providers, for a complex basket of transportation services. They will partner with and broker services in collaboration with local governments and the private sector. Of course, there will be a continuum between these extremes.

But in all cases, transportation providers will be challenged to respond to and compete with stringent social, environmental, and economic demands by a public that increasingly is seeing transportation as just one thread in the fabric of society. Successful transportation leaders will study the overall pattern of this fabric to discern how best to leverage their thread to public advantage. While offering real benefits to customers, this scenario, moving away from the long-held, one-size-fits-all mentality, will challenge national institutions like the U.S. Department of Transportation, the American Association of State Highway and Transportation Officials, and the Transportation Research Board.

For urbanized areas, local governments likely will come to play far more dominant transportation service roles. This will be accomplished through enhanced (and hopefully renamed to reflect a broader role) metropolitan planning organizations. Local units will inherit the lead in planning, coordinating, and operating metropolitan transportation systems and will be a principal locus of new opportunity in the field. An evolving model for this can be observed in the San Francisco Bay Area under the name The Bay Area Partnership.

A New Era for Funding

Finally, but by no means least among necessary and appropriate predictions for the future of transportation, there is the matter of money. How can we pay for any future when everywhere we hear of shortfall and cuts? First, I believe that we must recognize that the gas tax/user's fee, a remarkable instrument pumping out predictable billions of dollars over decades, deserves much credit for the past successes in the field of transportation. Second, we must accept that at an unsteady, unpredictable pace, this gas-tax-fueled era is ending. I believe that there must be a shift to more direct user charges to fill shortfalls as they develop. The technology is available, the need is apparent, and we are gathering courage through experimentation.

Leaping beyond limited current and timid experiments, Wilfred Owen has asked when we will consider tolling the Interstate system. I cannot answer that, but I do see in that bold stroke relief to state and federal treasuries, a vast new arena for applying new technologies, economic growth for the construction industry as the system is upgraded for heavier and more frequent commercial vehicles, and a huge new potential market for private finance.

But, more likely, this new era of funding will come like a night visitor, slowly and softly. It will occur across all levels of government, and political courage will build on broad, shared experience and relentless need.

Further along in Tennyson's *Locksley Hall* are lines all leaders might ponder to advantage when they are tempted to make light of "that vision thing":

Not in vain the distant beacons. Forward,
Forward let us range.
Let the great world spin forever
Down the ringing grooves of change.

A Contemporary Vision for Transportation

A contemporary vision for transportation might be, I believe, surprisingly consistent with what our third President charted in an otherwise prosaic budget message. "By these operations," Thomas Jefferson advised the 9th Congress, "new channels of communication will be opened between the states; the lines of separation will disappear, their interests will be identified, and their union cemented by new and indissoluble ties." He continued: "Transportation . . . would knit the Union together, facilitate defense, furnish avenues of trade, break down local prejudices, and consolidate that 'union of sentiment,' so essential to the national polity."

Holding this as our vision, as our polestar, will help us build and manage a secure, value-adding, future role for transportation. We can do this if at the same time we build learning transportation organizations and institutions. These must be capable of being endlessly creative in finding new talents and in devising new structures, processes, and technologies to better serve citizen–customers and their communities, all now pressing relentlessly toward the "global village of the 21st century."

Thomas D. Larson served as Administrator, Federal Highway Administration, from 1989 to 1993, and as Pennsylvania's Secretary of Transportation for eight years. A member of the National Academy of Engineering, Larson chaired the TRB Executive Committee in 1981.

FREIGHT TRANSPORTATION FOR THE NATION'S FUTURE

Paul O. Roberts

The freight transportation system of the United States has changed rapidly over the last 20 years and is likely to change even faster in the future. Transportation has evolved from a highly regulated industry with distinctly separate modes to an industry that is largely deregulated and increasingly integrated. In the past, our transportation system started and ended at the nation's boundaries. Now it spans both the Canadian and Mexican borders and is well on the way to becoming fully integrated by sea and air into the systems of Europe and Asia.

Our view of the transportation system, as distinct from the production process, is also changing. We now realize that transportation and production are both components of the nation's total logistics system. An American company must be able to buy products from wherever the price is lowest and have them delivered on time and at a competitive cost. Efficient, reliable freight transportation is a primary factor in the nation's logistics system and a key to keeping the U.S. economy competitive.

Technology, Public Policy, and Economics

The freight transportation system is shaped by both technology and public policy, operating as boundaries to what is essentially an economic process: management of the nation's production and distribution enterprises. Technology establishes the technical limits of the process. Public policy establishes the rules of the game. Technology provides the tools that determine what our engineering, manufacturing, marketing, and distribution systems can accomplish on a broad scale. Public policy writes the regulations by which the marketplace is forced to play the game. Consequently, these two elements—technology and public policy—both have an impact on system economics in determining whether the U.S. freight transportation and logistics system will remain competitive.

Three fundamental economic relationships are key to understanding what is occurring in the combined system: (a) the cost per unit to transport a shipment drops dramatically as shipment size increases; (b) the cost per unit of acquiring and holding stock rises with lower use rates, larger shipment sizes, and higher product values; and (ç) the cost per unit of holding safety stock to protect against unforeseen events that could deplete supplies drops dramatically as the amount held is spread over more individual users.

Although space limitations do not permit a detailed discussion, these forces work to change the ways producers and distributors go about defining their markets, locating their plants, and selecting their suppliers. In the long run, they actually help to determine the distribution of population and economic activity.

We don't have to look far to find vivid examples in recent transportation history in which a technology or policy change had a major impact on the nation's transportation and logistics system. Since World War II a virtual revolution has taken place in freight transportation and, subsequently, in the distribution of economic activity. Construction of the Interstate Highway System led to trucks replacing railroads as America's primary freight carriers. Development of efficient diesel engines reduced the cost of operating trucks, and the new highways made it possible for goods to be carried from the factory directly to regional distribution centers in urban areas. A series of regulatory reforms gave railroads, shipping lines, airlines, and the trucking industry freedom to reorganize for more profitable operations. The assurance of rapid deliveries and the use of computers to track inventory on a real-time basis opened the way for retailers to streamline logistics procedures, reduce operating costs, and lower prices. All of these developments

Straddle carriers position containers on railcars for inland distribution.

Customer demands for reliability and for special services such as just-in-time delivery schedules mean that today's freight transportation must be an all-weather system. This need provides additional incentive for research in snow and ice control, focusing on efficient use of equipment and materials, forecasting and monitoring of road conditions, and reduction of environmental impacts.

have combined to place us on the threshold of a single worldwide economy, an economy in which freight movements play a major role.

Current Status

As we look to the future it is clear that the nation is on the verge of still further dramatic change. Most of the population currently resides in metropolitan areas around regional distribution centers. These demographics probably will not change much even though computers now make it possible for many people to work in their homes. Traffic congestion over the system as a whole, even on local roads, is the rule rather than the exception. The economy is becoming dominated by the service sector, and manufactured products are increasingly imported. Jobs are beginning to fall into one of two groups: high-tech, including engineering, research, and development; and low-tech, such as food service, building maintenance, and child care. The mood of the country is dominated by a feeling of uncertainty—about jobs and whether U.S. industry can compete successfully with foreign producers in this single-world economy.

The key to staying competitive depends on education, innovation, and the ability both to improve products and services and to deliver them into new markets. Currently, the United States leads in the development and application of computers and information processing. It still has the best transportation and communication systems anywhere in the world. Increasingly, we understand how to use these assets to improve the operation of our economy, but we must be careful not to fall behind in any of these critical areas.

Nevertheless, a warning is in order because we are beginning to let our transportation infrastructure deteriorate. This should be a source of great concern; instead, we frequently argue that we cannot afford to renew the infrastructure. The fact is we cannot afford not to renew it. To be able to use it more intensively, we must manage it more actively; but we should not be lulled into the false expectation that additional capacity can be created without major investment.

On the policy side, with state deregulation of the trucking industry, the last regulatory constraints on the transportation system appear to be lifting. This change will eliminate a great deal of paperwork, but at the same time will reduce the amount of data available for better understanding of the system and for formulating public policies.

Some momentous changes are in the offing. Congestion on the highways has led to the designation of a National Highway System, which supplements the Interstate Highway System with a network of primary highways. The U.S. Department of Transportation is planning on support from Congress to improve and expand this network, with special attention to addressing intermodal connector designations. More dramatic is the prospect of intelligent transportation systems (ITS), new technologies advanced to increase the capacity of existing roadways, improve safety, and make personal travel easier and more enjoyable. Funding to move forward with research and development, although reduced, appears to be adequate.

View of the Future

The prospects for freight transportation in using ITS and other emerging technologies to improve the efficiency of its operations are extremely bright. Currently, the commercial shipping industry in the United States is transforming from voice and other traditional communications to place orders for goods, secure the transportation services of carriers, arrange for pickup and delivery of shipments, trace movements through the system, and pay for the goods and services purchased. Supplier, receiver, carrier, and truck driver need to be in communication with one another to coordinate the many details involved. The number of information transfers associated with transportation and logistics is staggering. About 16 to 20 separate communications are typically required to deliver a single shipment. The goal is to automate operations as in other industries. Automated data interchanges will cut expenses, both in absolute dollars and in dollars per unit.

Attempts to automate the process using electronic data interchange are fraught with complications and have been only marginally successful. New systems are being researched that one day may revolutionize the way parties in the commercial shipping process do business. One could envision systems that could be best described as an advanced version of the Internet specifically designed to serve the transportation and logistics community. This system (let us call it transnet) will be faster and more secure than the widely used Internet. Individual vehicles will actually be nodes on the net. It may work something like this:

A manufacturer needing a specific product will use transnet either to place an order or to query potential vendors about product availability, price, and possible shipping dates. The vendor selected to provide the product will then place a transportation request to the carrier of his choice, listing the loads available and their destinations and soliciting an offer of carriage. The carrier will respond by indicating which loads he will accept. The carrier's dispatcher will then contact a driver connected into transnet by dataphone or satellite and deliver digital instructions for picking up the load from the shipper. If the driver needs to arrange a dock appointment, he will also do this via transnet. When the shipment is loaded and the truck departs, a notice, which could include the manifest of the load, will be transmitted via transnet to the dispatcher in the carrier's home office with a copy to the receiver at the destination.

The truck becomes a node on transnet with the ability to communicate with other nodes that need to know the details of the movement and have approved access to certain trip and load information. When the shipment arrives, the amount and condition of the items unloaded will be electronically recorded and compared against the purchase order and the manifest. If everything is in order, an authorization to release funds will be issued automatically via the transnet. The same process could be followed for rail, air, or intermodal shipments.

Real-time cargo tracking would be maintained throughout the trip by the use of radio frequency tags on individual items in the shipment. Tagged items would be "rolled up" in a list to produce an electronic manifest of the freight on board. When the goods are unloaded, the electronic tags would reestablish contact with their new node—the warehouse, intermodal terminal, rail yard, or other holding point—and again would be "rolled up" to create a manifest for the new location.

Transportation- and logistics-specific communications systems, such as the one described above, are functioning in leading-edge segments of the freight industry. Already most of the components are available, but the cost must be sufficiently reduced and intermodal information connections require further study. These systems will extend across international boundaries. Direct contact with individual vehicles places all inventory in the system under the direct control of the logistics manager from source of supply to final destination. When this system is fully integrated with scanners at the point of sale, all information needed to plan an efficient logistics system will be available to the supply chain manager. The logistics manager will need to understand the tradeoffs between shipment size and cost of transport, shipment size and holding costs, and the role and nature of safety stock. Careful design of the system to select the proper tradeoffs will still be important to success.

Challenges Ahead

Despite the bright promise offered by electronics for assisting the logistics manager in moving goods faster and more efficiently, several constraints appear to threaten the ability of the freight transportation system to meet future needs of the American public particularly in the pick-up and delivery phases. As traffic congestion increases, the impact on truck transportation is increased travel time and decreased reliability, which, in turn, raises costs throughout the transport chain, ending with higher prices to consumers. Also the number of trucks on the roads increases as managers are forced to expand the size of delivery fleets to compensate for the slower movement of traffic.

A second challenge is meeting the continued need for larger capacity in all components of the freight transportation system without facing environmental problems. Currently, any expansion in highway capacity will immediately be filled with more single-occupancy vehicles; and increases in vehicle-miles traveled are typically associated with further degradation of air quality. Similarly, the rail, seaport, and airport industries all face capacity issues. Unless a substantial portion of the added capacity can be preserved for freight movements, the efficiency of the freight delivery system will not be improved.

A third challenge is to overcome the institutional impediments that stand in the way of improving the system, including promoting leveraged public/private sector cooperation. Our philosophy as a nation has been to selectively segregate certain public-sector activities, thereby limiting cooperation with the private sector; yet much could be gained by joint planning and selective investments when they are in the interests of the public as a whole.

Solutions for each of these issues are not yet apparent. However, it is clear that we must experiment with a variety of potential solutions, such as innovative financing of freight facilities, environmentally friendly technologies, congestion pricing, and intelligent transportation systems.

It is also clear that we cannot eliminate problems in the freight transportation system without affecting the passenger system, since the two are inextricably linked. Banishing one from the other is not likely to help us achieve a cost-effective solution.

If the United States is to reap the full advantages of foreign trade, it must remain competitive. To do so, we must pay more attention to the country's freight transportation system. The first step is to understand how the system works and ensure that it gets the attention it deserves and its proper share in the allocation of the nation's resources.

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NEW DIRECTIONS IN TRANSPORTATION

Frederick P. Salvucci

In considering what new directions may be appropriate in transportation as we approach a new century, it is useful to consider where we have been. What has worked well? What has not worked so well? What evolving trends appear robust? What new factors are developing in the political environment that will set the context for transportation policy?

A Brief Retrospective

The central overwhelming achievement of U.S. transportation policy over the past half century is the construction of the Interstate Highway System. This project was not a response to any existing demand so much as the creation of an essentially new infrastructure that introduced tremendous flexibility and redundancy into the transport system. It made possible the development of a highly competitive and customer-oriented trucking industry, thus breaking the monopoly previously held by railroads for the long-distance movement of goods.

The new Interstate system changed the shape of metropolitan areas—with both positive and negative consequences. It allowed the development of extensive suburban low-density housing freed from the necessity of proximity to a transit system. It allowed a dispersal of economic activity throughout the metropolitan area and provided investors with tremendous flexibility and choice. It essentially created a new frontier where housing and economic activity could escape the ties and constraints of old patterns and social responsibilities.

The investment in the Interstate Highway System undoubtedly facilitated the growth of the automobile industry and helped lead to an expansion in basic industrial activity. The international situation, dominated by the Cold War and fear of political instability outside the United States, fostered a powerful motive for nondefense industry to stay within the country. The new flexibility made possible by the Interstate system provided the necessary space for an expanding industrial base.

All of this economic activity was accompanied by a steady increase in real wages and real wealth—the latter largely through home ownership. In many ways the contributions of the National System of Interstate and Defense Highways to the national defense were more related to the strengthening of the automobile-industrial complex, the growth in the economy, and the increase in earning power and wealth of the emerging middle class than to any perceived need to facilitate movement of military troops and defense supplies.

The institutional investments that led to this success seem in retrospect to have been brilliantly farsighted. A federal commitment to fund 90 percent of the construction cost worked extremely well in making the implementation of the Interstate network a top priority for every state. The federal focus of the program, with a committed federal bureaucracy working in partnership with a network of state highway agencies, created a combination of national vision and standards combined with state-level sensitivity to local conditions. The dedicated user funds from gasoline taxes, in combination with a bipartisan political coalition that included every state as well as construction, industrial, suburban real estate, and labor constituencies, made the funding and support for the program extremely reliable.

Interchange design has become more complex as the number of vehicles using Interstate highways has increased. Highway engineers began using the trilevel cloverleaf in the 1970s.

Emerging Trends

Over the years as the system approached completion, priorities began to change. The tremendous success of suburban development undermined the vitality of the urban cores and the transit systems that made living in a densely populated city feasible. This decentralized pattern caused adverse environmental impacts, including the loss of green space and agricultural land near cities. The rail freight system was weakened by the loss of its monopoly position and has regained viability only by downsizing and focusing on lower-value, high-weight commodities and more recently on multimodal transport.

Changeable highway message signs warning of accident or congestion ahead originate in control rooms. Receiving information from a variety of sources, ranging from sophisticated road sensors to calls from drivers, operators at computer terminals alert drivers about traffic and road conditions and suggest alternate routes.

The actual and potential disruption of urban neighborhoods and environmentally sensitive areas led to opposition to the construction of some Interstate links, accompanied by pressures to allow states to receive increased transit funds in lieu of Interstate highway funding. Much stronger environmental protection legislation was enacted, and the federal role in funding both capital and operating costs of transit systems grew.

In the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), a large number of new evolutionary tendencies are apparent, including much stronger emphasis on metropolitan areas; further strengthening of environmental commitment [environmental enhancement and congestion management/air quality (CMAQ) funding are prime examples]; growing emphasis on management systems, operations, and maintenance issues in highway networks; increased emphasis on congestion problems, intermodalism, and the link between the economy and transportation; and continued interest in both highway and rail capital investment.

At the same time that the 1990 Clean Air Act Amendments and the 1991 ISTEA appeared to move in an evolutionary path toward a continued strong role for the federal government in transportation, albeit with greater emphasis on environmental quality, responses and reactions against these trends were visible. These alternative views—more prominent since the 1994 Republican congressional victories—include reaction against environmental regulation and protection; opposition to a dominant federal leadership role; reassertion of a strong state role; reemphasis of private sector leadership in the economy; and a powerful antitax sentiment.

Further examples of these trends include renewed discussions of block grants to states and elimination of categorical programs, along with proposals to expand use of transportation trust funds to offset the federal deficit. While "flexibility" in the use of funds continues to be emphasized, its meaning has become ambiguous, alternatively proposed by environmentalists seeking to use highway funds for transit and by highway interests resisting the categorical program of CMAQ funds and environmental enhancements.

Transportation in a New Economy

In this ambiguous environment, substantially diverse alternative directions are possible for national transportation policy. One direction could make transportation a central engine of economic development—a role similar to that of the Interstate period; an opposite direction could transform transportation into a passive, somewhat marginal activity. Given the history of strong bipartisan support for transportation as a focus of government activity, there is at least the potential for a sustained central role for transportation in national development. This position may be robust and stable for a long period of time if it relates to fundamental problems of society.

I believe that the outlines of the new economy are substantially different from those of the Cold War period that has recently ended. Without the Soviet threat, defense spending is no longer likely to infuse much money into the economy. Industries that may have tended to stay within the United States for security reasons are now finding globalization a practical strategy as they seek to take advantage of lower-cost locations. In this new environment, anxiety over jobs and economic activity is likely to be a major factor for the foreseeable future. Consequently, the role of transportation in the economy—both its potential for attracting stable political support for direct government spending and its links to other economic activity—can be expected to become an even more important factor.

Concern with environmental quality is likely to increase as the consequences of population growth and human aspirations for improved standards of living place new stresses on ecological resources worldwide. I believe that if the role of transportation in the economy is perceived to be in conflict with environmental quality, we are likely to see political instability in the support for transportation. If the socioeconomic and environmental factors can be brought into a convincing synthesis, the potential for a stable bipartisan consensus in support of transportation is very high.

At the more specific level of the transportation network, I believe that we are at a fundamentally different phase in the history of the system. In the 1950s the Interstate program provided a well-conceived and well-executed institutional mechanism to respond to the nation's needs. Today the highway system is substantially completed. I believe that the center of attention now needs to shift to operations and maintenance of the existing system and to the strategic investment required to make intermodal and multimodal improvements a reality.

The capital investments most likely to be useful in the new environment are ITS (intelligent transportation systems) initiatives and improvements to transit. Although large capital investments will be required, they will be meaningless unless a stable funding base is provided for consistent operations and maintenance. If these new initiatives are to be a credible means of eliciting private sector commitment for American investment, the public sector must provide a more credible stable market for the initiative—and this can only happen effectively at the national level.

In addition, if the transportation program is to be relevant to the key issues of the economy and the environment, attention must be paid to the 33 urban areas with populations exceeding 1 million, for these are the primary locations for economic activity and environmental problems associated with transportation and urban development.

If the analysis is correct that there is a societal need for a strong national focus on the major metropolitan transportation systems, what is the prognosis for a political consensus that could generate a public will to put dollars into the system at an adequate level to make a difference? Is it possible to generate such a willingness in the face of national and state fiscal austerity, a reassertion of state roles, and a lack of confidence in the capacity of government?

A New Approach

I believe that the elements for a successful program are available by reinforcing the positive aspects of the evolving shape of the transportation program. The outlines are clear within ISTEA, as previously discussed. There is substantial evidence from political polls that the public is willing to pay higher taxes—if it believes the money will be put to the stated use. The congressional bipartisan effort to take the Transportation Trust Fund "off budget" to establish credible trust funds is central to the success of any sustained government intervention in transportation.

The other element in a successful effort is to revisit the issue of a capital budget at the federal level. A shift to a capital budget would allow transportation funds to be reconfigured to totally remove transportation from the use of general funds, and even to allow some contribution to deficit reduction, while substantially increasing transportation operations and maintenance funding levels and expanding capital renewal and new investment. Of course, utilizing the revenue stream for bonds would mean that increased taxes would be required in the future to continue to fund new infrastructure capital. This is achievable if public credibility in the dedication of certain taxes could be established. In fact, that is how the 50 states structure their capital programs. The continuation of categorical funding for transit, environmental enhancements, and metropolitan areas, and the creation of new strong categories to fund operations and maintenance mandates are essential incentives because they both target resources to the areas of greatest need and secure political support, given an institutional framework based on states that do not naturally focus on the problem of metropolitan areas in a consistent way.

Bureaucratically, this approach suggests that the highest priority facing the U.S. Department of Transportation is not the merger of the federal administrations for highways, transit, and railroads—structures that help to target attention and have made major strides in achieving a more multimodal view of their roles—but instead the integration of the Federal Aviation Administration into the multimodal culture. It is important to recognize that when we talk of intermodalism, the primary intermodal issue facing every metropolitan area is airport access. Every major metropolitan area has at least one airport, and almost all have access problems and opportunities.

The times appear unstable, and they are. But there also appears to be within grasp a set of bipartisan building blocks that could achieve a new stable consensus. ISTEA with its thrust toward multimodal approaches and strengthened environmental commitment was President Bush's initiative. It has been implemented and supported by President Clinton's Department of Transportation team. President Clinton has proposed the privatization of the air traffic control system, and the Republican congressional delegation is supporting that thrust. It is not a great leap of logic to say "let's extend the ISTEA philosophy to incorporate the residual FAA," once the air traffic control function has been spun off.

The combination of the transportation capital budget at the federal level with a rededication of trust funds would implement concepts with which every governor is familiar. It would help deal with the deficit and provide enough money to support a substantial new role for the federal government in operations and maintenance so that the ISTEA management systems do not become unfunded federal mandates. U.S. Department of Transportation Secretary Peña's proposal for state infrastructure banks could become the central mechanism for infrastructure renewal and investment in a federal program reconfigured to focus on operations and maintenance and federal payment of debt service—instead of pay-as-you-go capital.

In short, while these suggestions would result in a substantially changed federal program as a driving force in the national transportation system, I believe that it is politically achievable, given the evolutionary base built by ISTEA and current pressing national needs.

To speculate more expansively beyond current organizational boundaries, it may be useful to explore the combination of the Housing and Urban Development and Transportation departments with substantial parts of the Environmental Protection Agency and the U.S. Army Corps of Engineers into a Department of Transportation, Urban Development, and the Environment. This arrangement would put all the tools for making metropolitan areas work environmentally and economically into one organization.

Finally, it is worth thinking about the intellectual underpinnings of transportation planning methodology. The current elaborate capital investment analytical process has never been the driving force in a system based on fiscal policy and political consensus to create a preconceived network. If the focus should now shift to operations, maintenance, and management of congestion, the current approach will become even less relevant. A new approach centered on operations and maintenance, as well as accessibility, would relate better to the new focus and also be more capable of incorporating other infrastructure and urban development in a broadly multimodal approach. This would position transportation analysis as an activity more centrally relevant to the national program.

In closing, let me restate that these future directions are by no means easy to achieve. They represent fairly major changes in emphasis and institutional relations, but are sufficiently related to existing trends and national needs to be possible. They represent a mechanism for public intervention to assist environmentally sustainable economic growth in a new political-economic situation with precious few such opportunities. They are certainly worth the effort to achieve.

Frederick P. Salvucci served as Secretary of Transportation for Massachusetts from 1983 to 1990, and as transportation advisor to Boston Mayor Kevin White from 1975 to 1978. He is a civil engineer specializing in transportation with particular interest in infrastructure and urban and public transportation.

Threading 16 miles across Oahu's breathtaking landscape, Hawaii's Route H-3 was designed to lessen adverse environmental impacts while providing a convenient commuting corridor. In the North Halawa Valley, traffic was rerouted to avoid an archeological and cultural site.

When the Transportation Research Board celebrates its 100th Anniversary, will it play the same role in transportation research that it does today? Will its Annual Meeting still be the largest event of its kind in the world? How will the issues addressed by TRB committees differ from those today, and how will the committees do their work? These are just a few of the questions that come to mind about TRB's future.

If past is prologue, we can be certain that the Transportation Research Board will continue to evolve and change, even if we are uncertain about the specific changes in store for us. The Board has come a long way since 30 leaders of the highway industry, mostly from state and federal agencies and universities, met at the first Annual Meeting in 1922. As needs arose in the highway field, TRB often met those challenges when innovation and information were part of the solution. As the interests of the states and the federal government expanded and highway organizations became transportation organizations, the Board's scope expanded as well. And equally important, as intercity travel became easier and more commonplace, TRB attracted participation from not only industry leaders but also transportation professionals at every step on the career ladder.

Although it is difficult to speculate with confidence about future changes at TRB, it is less difficult to identify the two principal areas in which change is likely and to suggest some of the possibilities. The first involves participation: who participates in TRB now, and how will that be different? The Board's constituencies have steadily expanded, especially over the past 25 years as TRB made the transition from primarily a highway organization to a multimodal organization. I expect this trend to continue for several reasons.

The interdependencies among transportation providers and users, fostered by deregulation and information technology, will continue to increase and become more complex. This means that parts of the transportation community that were once of peripheral interest to public-sector transportation agencies, for example, are now viewed in a different light. In addition, new players are entering the field seeking to capitalize on the potential for integrating transportation, communication, and computing technologies.

Another reason supporting future expansion of TRB's constituencies is that we as a nation are more aware than ever of the interactions among transportation and economic growth, lifestyle, and environmental quality. As a result, groups and individuals concerned with these issues will continue to become more involved in transportation planning and policy. And finally, the emerging "global" economy, coupled with the realization that the United States can benefit from the experience and technologies of other countries, creates a strong motivation for greater international involvement at TRB.

The second area in which change is likely concerns the services TRB provides. The Board's core mission—promoting innovation by encouraging research and facilitating information exchange—will remain the same, and its technical committees will be just as critical to fulfilling this mission in the future as they are today. However, we can expect some evolution, and probably growth, in the issues addressed by committees in response to changes in transportation, the addition of new constituencies, and the changing needs of sponsors.

We can also expect changes in the products committees produce and in the ways they do their work. Certainly, TRB will use new information and communication media for disseminating technical papers, reports, and other research information, a change that is already under way. But more significantly, these technologies will ultimately change the way committees do business. Although we will not eliminate the need for face-to-face meetings, "electronic dialogues" will allow committees and subcommittees to work more effectively between meetings and no doubt will reduce the need for meetings. Participating in TRB committees will be easier and more time efficient.

TRB's technical committees and information dissemination activities have provided the solid foundation on which TRB sponsors have undertaken added responsibilities over the years: administering cooperative research programs, conducting special studies of transportation policy issues, and handling other specialized program needs. Today these activities are an important and large part of TRB. We can expect that the Board will be called upon to perform new or expanded activities of this type in the future; however, experience indicates that serendipity plays a part in these programs, making it difficult to anticipate how and when they will develop. Almost surely, there will be opportunities and we must be prepared to accommodate them.

As the Transportation Research Board enters the fourth quarter-century of its life, the principal challenge will be to manage change, and we should not underestimate the difficulty of the challenge. When organizations become larger and more complex, and undertake increased responsibilities and serve wider constituencies, change becomes more difficult. Nevertheless, the Board has managed change effectively in the past, and I am optimistic that we will continue to do so—not because of the inspired leadership of a single individual or master plan, but because TRB draws upon the talent and good judgment of thousands of dedicated volunteers and staff and the support of transportation organizations throughout the nation.

Robert E. Skinner, Jr.
Executive Director
Transportation Research Board
1995

TRANSPORTATION RESEARCH BOARD 1995 EXECUTIVE COMMITTEE

TRANSPORTATION RESEARCH BOARD

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The Transportation Research Board is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. The Board's mission is to stimulate research concerning the nature and performance of transportation systems, to disseminate the information produced by the research, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 400 committees, task forces, and panels composed of 4,000 volunteer administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purpose of furthering knowledge and advising the federal government. The Council is the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities.