For more than 70 years the Transportation Research Board of the National Research Council has undertaken a variety of activities aimed at stimulating transportation research and coordinating and disseminating research findings. As part of this mission, the TRB Executive Committee has periodically developed and published a list of critical issues in transportation. We have undertaken this activity in the belief that to keep transportation research relevant and timely, the transportation research community must be alerted to the changing expectations and constraints that affect our transportation systems. We are pleased to present the current list of critical issues, which has been updated during the past two years by the Executive Committee in conjunction with the development of TRB's first Strategic Plan.

C. Michael Walton
Chairman, Executive Committee
Transportation Research Board

Critical Issues in Transportation

for the 1990s

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THE 1990S WILL BRING GREAT CHALLENGES and opportunities for the providers and users of the nation's transportation systems. The benefits of transportation, along with some of the problems it causes, have become intertwined with national concerns about international competitiveness, environmental protection, energy conservation, and the federal budget deficit. Although the increased complexity of the issues makes the resolution of problems more difficult, it heightens the need for research to identify solutions to transportation problems that will also contribute to the broader national interest.

The decisions made in the next few years about building and rebuilding transportation facilities, a clean air policy, and fuel efficiency will directly affect the level of investment and the kind of transportation systems that will serve future generations. Research can improve the quality of decisions about the major transportation policy issues facing the nation. To challenge the researchers and managers who participate in the many functions of the Transportation Research Board to respond to the broad implications of transportation, the TRB Executive Committee regularly outlines the critical issues.

DALLAS AREA RAPID TRANSIT 1989 ANNUAL REPORT/RITCHIE McHAM. (Inserts, *top to bottom*): TRANSRAPID INTERNATIONAL. IBM

Critical issues are defined as those unresolved aspects of transportation, national in scope, on which there is a wide variety of viewpoints, for which the impacts of possible actions are not well defined, and for which decisions will be made at the policy level. The committee has adopted the following list of issues, in no particular order, as the most critical for transportation in the 1990s:

- Economic competitiveness and productivity,
- Congestion,
- New investment,
- Maintenance,
- Environmental protection,
- Energy conservation,
- Intergovernmental and public-private cooperation
- Safety, and
- Human resources.

TRANSRAPID INTERNATIONAL

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Economic Competitiveness and Productivity

Concerns

American companies are competing increasingly in global markets just as American consumers are buying more imported goods. During the last 20 years imports and exports have grown to equal 21 percent of the gross national product. Since the early 1980s, most of this growth has come from imports as U.S. exports have faced fierce competition and dependence on imported oil has increased.

Several aspects of transportation can contribute to increasing the competitiveness of U.S. goods: the extent, connectivity, and reliability of transportation infrastructure; the efficiency of infrastructure investments; innovation; and regulations affecting the use and operation of the system. As examples of the latter, regulations governing vehicle and container size and weight, labor regulations, and policies promoting fair competition directly affect the costs and productivity of private carriers. (Congestion-caused delay, which also directly affects efficiency and productivity, is discussed under the next topic.)

Innovation in management has also proven to be a key to competitiveness and productivity. In response to competitive pressure at home and abroad, many U.S. firms are restructuring—eliminating managerial layers and relying more on information technologies—to foster innovation and solve problems; their experience may be instructive. In addition, many transportation firms are evolving from single-mode into multimodal organizations to better serve customer demands for fast and reliable freight service. These organizational adaptations have facilitated the efficiencies made possible by such technological innovations as containerization and double-stack trains.

Key Questions

Systemwide Investment Policy

Recent econometric research suggests a strong positive correlation between higher investment rates in public capital (highways, transit, ports, and airports) and higher growth rates in the productivity of nations with which U.S. firms must compete. This research also suggests that the U.S. competitive position will continue to erode unless infrastructure-investment policy is changed. This conclusion involves complex and controversial issues, and the findings are by no means accepted by all economists; but the debate is a healthy one. It probes to the heart of a critical policy question: Is the United States investing appropriate amounts to ensure sufficient, efficient infrastructure to support improved productivity? Continued research to examine the relationship between infrastructure investments and economic productivity may shed more light on the appropriate scale of public investment. (Questions about appropriate types, as opposed to level, of investment are discussed in the section on new investment.) Much research has been conducted on a mode-by-mode basis, which overlooks the increased interdependency of the modes. A multimodal perspective must be integrated into institutional arrangements, research funding mechanisms, and research methodologies.

Technological Leadership

Since the industrial revolution, the United States has been a world leader in technological innovations, which, in turn, have driven productivity gains. Whereas the United States once led the world in the development of new transportation technology in most modes, it presently enjoys a commanding lead in aviation only, and even that lead is threatened by growing international competition. Germany and Japan are ahead of the United States in developing the state of the art in high-speed magnetically levitated (maglev) trains, a technology that was invented in the United States. Traditional rail technologies ("steel wheel on steel rail") have been advanced to high levels of speed and reliability in these and other countries.

In highway transportation, international competitors have formed consortia to develop hardware and software for intelligent vehicle-highway systems (IVHS) and appear to be ahead of the United States in developing major research and development programs. In the past, the federal government took a strong role in developing and nurturing the railroad, aviation, and maritime industries. What is the appropriate role for government today in nurturing such new technologies as "smart" highways and maglev?

Technological innovation is also a major concern in infrastructure design and preservation. The design and construction of facilities need improved materials, procedures, and technologies to ensure that they are cost-effective, long lasting, and maintainable. What new methods can be used to reduce costs in rehabilitation? How can designs be altered to incorporate better life-cycle cost efficiency? Which new technologies, such as remote sensing and visual imaging, can be improved through research to reduce the cost and improve the performance of the nation's infrastructure?

Competition

Adequate competition between the modes helps ensure that carriers control cost and shippers receive competitive prices. Competition between trucking and rail has intensified in recent years as the two modes have been partly deregulated, truck size and weight policies have been liberalized, and rail firms have invested in double-stack technology. Rail managers contend that the industry is hobbled by federal labor protection laws that predate deregulation and impose greater costs on their operations than is experienced by trucking. Is there a level playing field in truck-rail competition, and what part do labor protection provisions play?

The deregulation of aviation, although not without problems, is largely viewed as making air carriers more cost-conscious and competitive. How well has the partial deregulation of trucking and rail worked? How do state regulations affect federal efforts to deregulate interstate commerce?

Management Innovation

The managerial innovations occurring in industry worldwide can also have productivity benefits. How well do corporate strategies reduce managerial layers? Are corporations relying more heavily on information technologies? Can their experience assist public-sector managers in identifying ways to bolster innovation and reduce unnecessary management layers?

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Congestion

Concerns

The demand for travel exceeds the supply of infrastructure in some parts of the country. In aviation, for example, delays increase the operating costs (for fuel and labor) of commercial air carriers by more than $2 billion a year. The cost to passengers of delayed flights is even larger. Congestion on urban highway facilities, as anyone living in or near a major urban area can attest, is increasing. The U.S. Department of Transportation estimates that delays caused by congestion cost $35 billion annually. Ports in the United States are experiencing landside congestion on highways and rail corridors that could reduce the efficiency gains made possible by containerization. Congestion problems should be viewed from a multimodal perspective, because some solutions for existing problems in one mode may be most efficiently solved by shifting passenger and freight movements to alternative modes and by improving the connections between modes.

Key Questions

New transportation technologies on the horizon, such as "smart" highways, maglev, and advanced air traffic control systems, may have the potential to reduce congestion. How much can these new technologies alleviate congestion or absorb growth from already congested facilities, and at what price? Other, existing technologies, such as "steel-wheel-on-steel-rail" systems, may also have appeal. Can high-speed rail substitute for short-haul air travel in some markets? What role can the existing intercity passenger rail system play in reducing congestion? Can it alleviate congestion on other intercity modes in a cost-effective manner? Can IVHS improve throughput in existing corridors at an affordable cost? How much can the new air traffic control technology—including automated decision aids for controllers, new radar, and computerized data links—reduce airspace congestion and delay?

To guide future investment, better estimates are needed of congestion relief from existing options (traffic management, transit, toll roads, and passenger rail). As federal policy shifts toward emphasis on the most effective use of existing assets, procedures will be needed for evaluating whether existing capacity is being used efficiently.

Although experimentation with peak-period pricing of congested facilities has been limited to peak surcharges in transit and increased fees for runway use, the short-term experience is promising; for example, pricing runway use at Boston-Logan airport reduced delay. Better estimates are needed of the potential effectiveness of pricing strategies for the various modes, the extent to which peak period pricing would relieve the need for new investment, and how it could be implemented equitably. (Pricing strategies are also being discussed as ways of reducing vehicular emissions.)

The federal government is increasingly interested in bringing the principles of market competition, and the expertise of private-sector managers, to bear in all governmental transportation services, and in the face of the federal deficit, continues to reduce federal subsidies in aviation, highways, public transit, and waterways. Given the current low level of new investment, the need for strategies for transportation managers to control costs yet maintain adequate levels of service with the existing infrastructure continues.

Congestion also reduces the efficiency of freight movements, and reduced efficiency at intermodal connections has a direct effect on the cost of U.S. exports. Are there bottlenecks in the movements of goods at intermodal points that are high priorities for public investment or action?

AMERICAN SEGMENTAL BRIDGE INSTITUTE

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New Investment

Concerns

Previous generations of Americans made long-term investments in the physical infrastructure that undergirds the U.S. economy. The system of highways, bridges, airports,

ports, waterways, transit systems, pipelines, and railroads that move goods and people is enormous—the public share alone is valued at $800 billion. New investment, however, as a share of GNP is declining. During the last 20 years public works investment has fallen from 2.5 percent of GNP to just 1 percent. Part of this decline is attributable to strapped finances at the federal level, but the increased competition for funds for other needs at all levels of government is also leading to reduced investment in public capital. In its 1988 report to the President and the Congress, the National Council on Public Works Improvement warned that the nation's infrastructure is "barely adequate to fulfill current requirements, and insufficient to meet the demand of future economic growth and development" (*1*).

Key Questions

Research is needed to identify new investments that will yield the greatest net benefit for mobility, efficiency, land use, energy efficiency, environmental effects, and economic development. Too many investments—some representing substantial financial costs—have been made without a full assessment of their contribution, or cost, to both national and local economies. Many of these costs and benefits are difficult to quantify, but continued research is needed on ways to better incorporate these issues in cost-benefit analyses. Research is needed to evaluate the full range of costs and benefits of transportation investments, including the trade-off between modes.

Emphasis on innovation in design, construction, and materials will continue to be important to reduce cost and extend service. The Strategic Highway Research Program is addressing many of these needs in highway research, but work is also needed in transit and vehicular safety.

As available land near metropolitan areas becomes increasingly scarce, land-banking sites for future airports and corridors for rail lines and highways could ensure that future facility development will not be foreclosed. Rail abandonments and the potential closing of some military bases offer unique opportunities to preserve land for future transportation use. Policies and plans for land banking need to be developed at the federal and state levels.

COLIN/CALTRANS

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Maintenance

Concerns

Much of the extensive infrastructure that has been built by federal, state, and local governments and the private sector during the last few decades is reaching the end of its service life, a situation that has been accelerated by inadequate maintenance and repair. As noted by the National Council on Public Works Improvement, "Maintenance is perhaps the single most important element of governments' stewardship obligation. It also is the element that is easiest to defer, and the one most likely to be cut from the current expense budget" (*1*).

Key Questions

Federal policy is shifting toward developing incentives and criteria for federal highway programs that would encourage use of federal funds for preservation of existing facilities. What kinds of incentives and criteria would be effective? Are maintenance standards needed? If so, how would they be developed and applied? Maintenance practices and management plans for bridges, pavements, and other facilities need to be refined to assist state and local governments in the development of effective strategies.

Many state and local governments have developed inventories of pavement conditions and are working on strategies to obtain optimal funding for the necessary expenditures. Similar strategies need to be developed for routine maintenance and applied to other major capital assets.

Maintenance is also a key concern for public transportation system managers. Research topics include recruitment and training of maintenance personnel, effective supervisory programs, and simplified vehicle subsystems and diagnostic equipment.

Planning and budgeting for maintenance and capital replacement must become more effective. What financing mechanisms used in the private sector (e.g., sinking funds for capital maintenance) can be adopted by public agencies to ensure adequate funds for maintaining and repairing infrastructure?

ALASKA DEPARTMENT OF FISH AND GAME/HYDE

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Environmental Protection

Concerns

The environmental consequences of transportation have probably become more central to national, state, and local policy debates than any other transportation issue. Examples abound. Government officials at all levels, particularly at state highway agencies, are debating the federal policy of "no net loss" of wetlands. Concern about global warming and the contribution of automotive exhausts to excess carbon dioxide and other greenhouse gases is shaping legislative proposals and debate. Many municipalities are failing to meet Clean Air Act ambient air quality standards; more than 100 million Americans live in areas where ozone levels exceed federal standards. Oil spills from ocean-going vessels and their adverse effects on wildlife and recreational areas receive extensive national news coverage. A growing number of transportation improvements are delayed or canceled when hazardous materials are found in the right-of-way. Local restrictions on airport

noise to reduce adverse effects on residential areas are frequently cited as the major impediment to expanding much-needed airport capacity. Communities are also reconsidering zoning and land-use decisions and the provision of transportation improvements in response to the energy intensiveness of low-density settlement patterns.

Key Questions

Projections of global warming are full of uncertainties, but most models show a gradual warming trend over the next few decades. Transportation accounts for about one-quarter of the greenhouse gases contributing to global warming. Research in three general areas is needed to find solutions to the growing environmental problems: technology to reduce automobile emissions, alternative fuels to reduce the adverse by-products of combustion, and policies aimed at changing driving behavior. Better estimates of the potential gains from these solutions along with their costs are needed to provide clearer guidance for policy decisions.

In the technology arena, research is needed on design of engines to use alternative fuels and on both engine and vehicle design to improve fuel efficiency. (Research on alternative fuels is also discussed under the next topic.) What public policies would be most effective in stimulating additional research and action?

Policies aimed at changing driver behavior include a wide array of possible measures: equal tax treatment for employer-provided automobile parking and public transportation passes; pricing of the alternative passenger transportation modes to reflect environmental costs; stricter inspections of vehicles to improve maintenance and reduce emissions; strategies to reduce congestion (e.g., high-occupancy vehicle lanes, transit improvements, "smart highways"); and strategies to increase vehicle occupancy (e.g., carpools, vanpools, paratransit, and flexible work schedules). Southern California, through the South Coast Air Quality Management District, is ahead of the rest of the country in developing approaches, but with so many major urban areas failing to meet air quality standards, others may soon embark on strategies of their own. How can air-quality monitoring (data collection and the models estimating areawide air quality) be improved? Which strategies aimed at reducing reliance on the automobile are likely to reduce single-person vehicle occupancy, and which are most cost-effective? Can pricing policies be designed that are responsive to political opposition and concerns about equity? How can the environmental costs associated with transportation be estimated and incorporated into pricing strategies?

The issues are exceedingly complex. For example, policies that reduce congestion and ease access to major employment centers may further contribute to low-density development patterns in which service by public transit is expensive and, for individuals, not competitive with the flexibility offered by the private automobile. How can regional development, land use, and transit policies shape development patterns to reduce energy consumption?

Transportation noise is another growing environmental problem. The development of a national policy on airport noise has long proven elusive, in large part because of the understandable unwillingness of the federal government to intrude on land-use policy traditionally handled by local government. Similarly, the noise caused by seaport operations also results in efforts by surrounding neighborhoods to restrict port operations. Restrictions on noise that meet local interests, however, may not serve the national interest; hence, strategies are needed for better balancing national transportation needs with local concerns about noise.

U.S. DEPARTMENT OF ENERGY

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Energy

Concerns

Although most forecasts indicate an abundant supply of fuel for the next few decades, the United States depends increasingly on foreign petroleum sources. The vulnerability of this dependence is illustrated by the recent fuel price increases as a result of the Persian Gulf War. By 2010 about two-thirds of domestic consumption is likely to be imported compared with about half today. Oil prices (in constant dollars) are expected to double during this same period. Transportation consumes about one-quarter of all refined petroleum products, and highway transportation accounts for three-quarters of transportation's share. Transportation in the United States alone consumes more petroleum than the nation produces.

Although automotive fuel economy has made dramatic strides and continues to improve, demand for travel is outracing energy conservation; hence total demand for petroleum continues to grow. Heavy reliance on imported fuels raises national security concerns, increases the balance of payments deficit, and raises fears of inflation caused by future price shocks. As already discussed, continued reliance on fossil fuel sources and the resulting emissions is also harmful to the environment.

Key Questions

Many alternative fuels can be developed to reduce energy dependency. Oil shale, of which the United States has an abundant supply, can be converted into gasoline. Liquefied natural gas, biomass, and coal can be converted into methanol. Ethanol can be made from biomass. Vehicles can also be

adapted to operate on compressed natural gas, which may prove to be a realistic option for truck and bus fleets. Each alternative fuel, however, has some disadvantage relative to gasoline, such as higher production and distribution costs, additional adverse environmental effects, or reduced safety. For example, oil shale and coal and potential feedstocks for alternative fuels can reduce dependency on imported fuel. Like petroleum, however, they are fossil fuels with similar environmental effects. Methanol, proposed as an alternative clean-burning fuel, is attracting much attention but is more toxic than gasoline. The disadvantages of some alternatives, however, may be surmountable given sufficient lead time for research. In addition, increases in petroleum fuel prices are likely to make some alternatives cost competitive. More information is needed on the full range of alternate fuels and how they compare in terms of reducing dependence on foreign sources, total emissions, efficiency, and cost.

The importance of the answers to these questions raises general questions about federal policy on research and implementation. Should the federal government have a more ambitious research program? Can it rely on the private sector to conduct the basic research? Will prices in the marketplace reflect the true cost (in terms of energy dependence and environmental consequences) of the current national energy policy?

Increased fuel economy for internal combustion engines can also reduce energy dependence. Proven technologies—fuel injection, engine friction reduction, aerodynamic design, and reduced tire-rolling resistance—offer additional gains in fuel efficiency, perhaps as much as 25 percent. Additional research will be needed to find the technological breakthroughs that will lead to substantially greater fuel economy than these. Research breakthroughs in batteries or fuel cells will be needed to make electric vehicles competitive with internal combustion engines.

As already mentioned, fuel economy can also be achieved by reducing reliance on the automobile. Many existing public transportation systems are underused, and improved ridership could reduce energy consumption. What is the scale of potential energy conservation benefits from increased transit ridership? What are the prospects of getting more Americans out of their cars? What benefits can be obtained through ride-sharing and other efforts? How much do federal and state tax and land-use policies affect mode choice? How can these policies be shifted to encourage greater reliance on less energy-intensive transportation?

DALLAS/FORT WORTH INTERNATIONAL AIRPORT

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Intergovernmental and Public-Private Cooperation

Concerns

Intergovernmental issues are at the heart of many transportation problems because of the decentralized decision making across levels of government and the complex, sometimes conflicting, responsibilities of different units of government. For example, one of the major impediments to implementing IVHS and other high-speed land transportation technologies is likely to come from overlapping and sometimes conflicting jurisdictional regulations and standards.

The continuing federal budget crisis is hamstringing traditional approaches to the resolution of many problems and raising alternative forms of financing to the forefront of policy debates. State and local governments are willing to become more proactive in many cases but are confronted by some barriers imposed by the federal government. For example, local efforts to boost transit use run up against federal tax policies that treat employer-provided reduced-cost transit fares as a taxable employee benefit but do not treat employer-provided free parking as a taxable benefit. The continuing shift of the financial responsibility to state and local government may be hastened by the changes proposed for federal categorical programs in the Administration's 1991 proposed highway reauthorization bill. In exchange for increased federal funding and fewer federal restrictions, states will be expected to increase their total spending.

Even at the local level, problems bridging organizational boundaries in metropolitan areas call for new solutions from the states or better intergovernmental coordination through regional planning agencies.

Given limited public funds, there is a growing need for more public-private cooperation in financing new capacity through the use of toll roads and value-capture financing, and linkage of public investments with private initiatives in intermodal projects.

Key Questions

The most significant transportation issue in the shifting roles of levels of government is the search for a different balance of federal, state, local, and private responsibility. What regulatory and policy changes are needed to achieve this different balance? Several federal funding and tax policies impose restrictions on state and local financing of infrastructure, such as limits on private development bonds and prohibition of the use of federal funds on toll facilities. Which of these federal policies can be better balanced with state needs for financing mechanisms? How much funding would be freed for state and local investment? Transportation projects that rely on user-fee financing must consider and account for the social inequities that may arise. What kinds of income transfers or subsidies can best reduce inequities?

The private sector has shown initiative in airport development, an arena traditionally handled by public agencies. The privatization of airports, as recently proposed by Albany, New York, however, raises complex issues. On one hand, it would place airport management in the hands of the private sector, with promise of more efficient management. On the other, it gives local monopoly power to private investors. Can airport privatization pro-

posals be structured to protect the public interest?

Regional and metropolitan planning organizations (MPOs) can play a useful role in identifying transportation priorities that transcend jurisdictional boundaries. The federal government, after a period of some neglect, has reasserted the importance of strengthening MPOs. How can MPOs bring together parties at the local and regional levels with conflicting goals to achieve greater agreement on complex issues such as air pollution, noise, and congestion?

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Safety

Concerns

Roughly 49,000 Americans died in 1989 as a result of injuries incurred in transportation. Millions more were seriously injured. The majority of injuries, accidents, and fatalities—nearly 93 percent— occurred on the highway system. Although the rate of fatalities and injuries per unit of distance traveled is declining, the number of deaths and injuries is appalling. Trends indicate that highway travel is increasing faster than fatality and injury rates are declining; thus, the number of deaths and injuries may increase beyond an already unacceptable number. Safety could also be further impaired if freight movements continue to be shifted away from the railroads to trucks, leading to a greater increase in truck travel. Despite the magnitude of the problem, federal funding for highway safety research has declined substantially during the last 15 years.

Although aviation catastrophes that involve commercial airlines are infrequent and the rate of fatal crashes is declining, public fear of such events is great and support for safety measures in commercial aviation is strong. More effective procedures and technology for improving security at airports are being demanded. Actually, the majority of deaths in aviation occurs in general aviation (two-thirds), instead of in commercial travel. However, it has long been difficult to estimate the severity of the safety risk in general aviation because good estimates of the exposure to risk have been lacking.

The risk of crashes involving vehicles transporting hazardous materials is also an important safety problem.

Key Questions

Many measures to improve highway safety have been adopted since the 1960s. Such improvements continue to be phased into the motor vehicle fleet and are beginning to influence driver behavior. The most obvious, cost-effective improvements to vehicles, regulations, and behavior have been identified and many have been put in place. The identification of further improvements will require creativity, innovation, and a better understanding of some basic relationships. For example, what are the mechanisms of crash trauma? How do they vary by age? How can vehicle designs be better adjusted to protect the growing population of older, more vulnerable drivers? How can side-crash severities be reduced? Continued developments in automotive fuel economy will help reduce energy consumption, but smaller automobiles may pose more risk to occupants when they are involved in a crash. What are the trade-offs between energy conservation and safety? Can cost-effective occupant protection technologies be developed to reduce these risks? Would greater safety gains be achieved by efforts to encourage motorists to shift to transit?

As the proven occupant-protection technologies are phased into the automotive fleet, research is shifting toward the more difficult area of understanding and reducing driver error, which is the major contributing factor in highway crashes. New technologies are being developed and are approaching introduction, some of which may help reduce driver error. In the longer run, IVHS—being considered by many a way of increasing highway capacity—may have equally large, if not larger, safety benefits. Some emerging in-vehicle devices, however, could actually distract drivers as much as they assist them. A better understanding of driver performance is needed, and the role that new technologies can play in reducing driver error merits close evaluation.

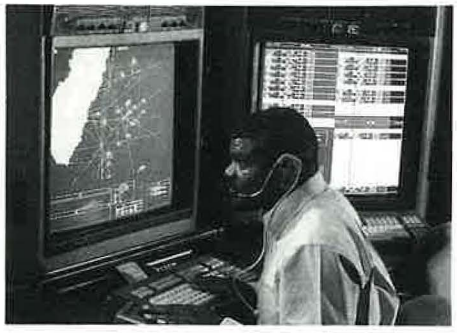
Research continues to be needed to better understand behavior that has long plagued highway safety: drug-impaired driving, excessive speed, and failure to wear safety belts. Improved countermeasures depend on a better understanding of these behaviors.

The development of technology and procedures to ensure security at airports and for other modes rates high on the public agenda. Possible studies might include security technologies with multimodal applicability, human factors issues, and avenues for cost control in transportation security systems.

Improvements in general aviation safety may well need to focus on reducing pilot error, which accounts for two-thirds of fatalities in general aviation. Policy options for improvement include more stringent licensing and training standards, greater support for air traffic services and navigation aides at reliever airports, and requirements for more sophisticated avionics in general aviation aircraft. What policies are most likely to be effective?

Accident reporting and measurement of risk exposure in many transportation modes are not as good as they should be. Although considerable advances have been made in accident data and information systems for highways and commercial aviation, estimates for truck travel are lacking. Also needed are better estimates of exposure to risk and information on trends and patterns leading to accidents in recreational boating and general aviation, the modes with the second and third largest number of annual deaths. Although additional data are needed in these areas, it is important to first define the application of the data and then to develop system management, data collection, and storage approaches that are cost-effective.

Similarly, the hazardous materials being hauled and piped across the nation include many ingredients essential to modern life. Research should address some basic questions to guide policy: What modes are the safest for moving hazardous materials? What are the costs and benefits of national policy mandating transport by the safest modes? What types of local and state restrictions are compatible with national transportation needs?



IBM

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Human Resources

Concerns

Transportation industries, along with others, may face a labor shortage in future years. All modes of travel are becoming more complex technologically as automobiles, buses, trains, ships, and aircraft become more dependent on high-tech propulsion and monitoring systems, but skilled technicians are expected to be in short supply at the turn of the century. Transportation workers will need to be better educated to catch up with the changing technology. Many state and federal transportation agencies are beginning to feel the effect of the retirement of their most senior workers, particularly engineers, who were hired during the expansion of the highway and aviation system that began following World War II. Finding entry-level employees to move up the ladder will be more difficult. The number of students enrolling in the civil engineering programs that have supplied transportation agencies and firms in the past has declined, and fewer students are pursuing advanced degrees. The past surplus of entry-level civil engineers has diminished, if not evaporated, such that public agencies will have to recruit more aggressively and from a wider segment of the potential work force. They will also have to develop and support education and training programs to prepare this work force, and will probably have to raise salaries to be more cost competitive with the private sector.

Already aware of this problem, state transportation agencies have begun recruiting more heavily and expanding training programs, as has the Federal Aviation Administration. The U.S. DOT is also addressing the problem by providing more financial support for university transportation programs. Increased funding for personnel and salaries, however, is hard to obtain from legislatures.

Key Questions

As transportation agencies shift emphasis toward system management and rely more on technology, their personnel needs will change. Some state and federal agencies, however, are finding that rigid job classifications and pay levels are impeding their ability to recruit the best personnel. Can civil service systems be reformed to provide more flexibility? What kinds of training programs will be needed to prepare a less skilled work force for technical jobs? Better marketing of transportation industry careers would help recruiting. How can the various transportation professional associations fill this role? As an alternative to expanding the work force of public agencies, how much can technology reduce the reliance on personnel, for example, through computer-aided design and other productivity-enhancing technologies? What segments of the work can be effectively and more efficiently provided for by private suppliers?

Reference

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