SPECIAL REPORT 220

A LOOK AHEAD

YEAR 2020

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Special Report 220

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YEAR 2020

Proceedings of the Conference on Long-Range Trends and Requirements for the Nation's Highway and Public Transit Systems

Conducted by

Transportation Research Board

Sponsored by

Federal Highway Administration
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National Association of Regional Councils

Transportation Alternatives Group

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EDWARD WEINER, U.S. Department of Transportation

Transportation Research Board Staff

JAMES A. SCOTT, Senior Program Officer
NAOMI KASSABIAN, Associate Editor

Preface

What are the implications of the globalization of the U.S. economy for the nation's transportation network? What demographic changes are taking place in cities, suburbs, and nonmetropolitan areas? What is the probability that current suburban growth patterns will continue? Will the United States have to make a transition to alternative fuels by 2020? What advances in technology are anticipated by 2020, and what will their impacts be on transportation?

These and other issues were discussed at the Conference on Long-Range Trends and Requirements for the Nation's Highway and Public Transit Systems, held by the Transportation Research Board on June 22–24, 1988, at the Washington Hilton Hotel in Washington, D.C.

The objective of the conference was to identify the nature and level of demand for future highway and public transit services and their role in the nation's future transportation system. Expert views were presented on the potential impacts on the nation's future surface transportation system of a variety of factors, including future demographics and life-style, urbanization and suburbanization, new technologies, international business competition and economics, energy demand, technology, commercial freight transportation, personal mobility, and institutional arrangements.

A highlight of the conference was the keynote address by Robert M. White, President of the National Academy of Engineering and Vice-Chairman of the National Research Council. White's address, "Beyond the Millennium: Transportation and the Economy," is included in this report.

This conference is one element in the information-gathering phase of the TRANSPORTATION 2020 program that is currently under way in the United States. Other efforts include a series of public hearings throughout the states, conducted by the American Association of State Highway and Transportation Officials (AASHTO) 2020 Task Force Advisory Committee on Highway Policy. A total of 65 such public hearings have been held in the 50 states. Also, various AASHTO standing committees are involved in a complex process of determining state and local roadway requirements, transit needs, and intermodal links through the year 2020.

Information gathered through these efforts will be transmitted to the Transportation Alternatives Group, a broad-based organization that has been formed as a part of the 2020 program to reach agreement on the shape and direction of the new national surface transportation program. Support for this conference came from the American Association of State Highway and Transportation Officials, the Federal Highway Administration, the National Association of Regional Councils, and the Transportation Alternatives Group.

This report begins with a general overview of the conference, including background information on its purpose and development, summaries of the primary discussion topics in each of the eight sessions, the perspectives of three conference observers, and Robert M. White's keynote address. The resource papers and respondents' comments follow.

I would like to recognize in particular the steering committee for their advice as to the nature of the conference and its output, as well as the TRB staff, Thomas B. Deen, and James A. Scott for their advice and counsel.

Theodore C. Lutz
The Washington Post
Washington, D.C.

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Conference Overview

Introduction

THE TRANSPORTATION 2020 PROGRAM was initiated by the American Association of State Highway and Transportation Officials (AASHTO) to develop interest nationwide in formulating a new surface transportation program for the 1990s and beyond. The program is being coordinated by an AASHTO task force chaired by Charles L. Miller, Secretary of the Arizona Department of Transportation. As part of this effort, the Transportation Research Board (TRB) was asked to conduct the Conference on Long-Range Trends and Requirements for the Nation's Highway and Public Transit Systems (also called the Transportation 2020 Futures Conference) with support from AASHTO, the Federal Highway Administration, the National Association of Regional Councils, and the Transportation Alternatives Group.

The objective of the conference was "to identify the nature and level of demand for future highway and public transit services and their role in the nation's future transportation system." The conference, one of the first steps in the 2020 program effort, provided essential background information on the factors influencing transportation requirements for consideration in other 2020 activities. A steering committee chaired by Theodore C. Lutz, Vice President and Business Manager of the *Washington Post*, developed the conference program, reviewed resource papers, and produced the conference report.

To provide background material for the conference and to stimulate discussion, resource papers were prepared on the following topics:

- Economic growth and vitality,
- Demographics and life-style,
- Energy and environment,
- Patterns of future development,
- Commercial freight transportation,
- Personal mobility,
- New technology and communications, and
- Resources and institutional arrangements.

Each paper was presented at the conference, critiqued by a panel of experts, and discussed in an open forum for greater interaction with conference attendees. Nineteen authors, 32 panelists, and a total of 225 attendees participated.

Summaries of the primary discussion topics in each of the eight sessions follow. These summaries were abstracted from the resource papers and the open discussions at the conference.

The conference covered subject areas and points of view too numerous to be captured in a concise summary representing a consensus of the participants. The conference was not intended to produce such a consensus. Instead, each resource paper stands on its own as an insightful background statement on each topic, and the panel comments serve to identify areas of agreement, differing viewpoints, and additional aspects that should be considered.

Therefore, in place of one summary of the conference findings, this overview section offers several perspectives. First, the comments of three conference observers are provided. Lester A. Hoel and Daniel Brand were asked to observe the conference deliberations and to report at the concluding plenary session. Hoel identifies 23 major issues discussed by the participants, and Brand comments on unresolved issues that are candidates for TRB's agenda. Following the conference, Alan E. Pisarski was asked to reflect and comment on the conference discussions and written materials. His description of the conference's two dominant themes—characterizing future demand and serving that demand—provides useful insights for consideration as the 2020 effort continues.

Robert M. White identifies three concepts in his keynote address that need to be central elements of a national technology strategy for economic growth:

- A greater focus on the processes of manufacturing and service industries to achieve quality and customer satisfaction in U.S. products and services at low cost,
- Investment in U.S. research infrastructure in new ways to ensure the creation of new technology and to foster transfer from scientific discovery to commercialization, and
- Steps to strengthen education systems to ensure the future science and engineering talent pool.

The conference and this report will inform and complement other TRANSPORTATION 2020 program activities, including the following:

- Various AASHTO task forces and standing committees, along with the other organizations, are involved in a complex process of determining state and local roadway requirements, transit needs, and intermodal links through the year 2020. The work of the AASHTO Task Force Advisory Committee on Highway Policy (ACHP) has been published in the report *Keeping America Moving: The Bottom Line.*

• A series of 65 hearings was conducted throughout the states by ACHP with the cooperation of the state transportation agencies. The hearings were designed to obtain from the users of the highway system their perspectives on transportation needs and problems. This activity was chaired by Lester P. Lamm of the Highway Users Federation for Safety and Mobility. The Federation has published a report of the 65 forums entitled *Beyond Gridlock: The Future of Mobility as the Public Sees It.*

• The Transportation Alternatives Group (TAG) has been formed as a part of the 2020 program to develop a consensus on the shape and direction of the new national surface transportation program. This effort is chaired by Thomas W. Bradshaw, Jr., of the First Boston Corporation. The major public and private groups that sponsor TAG include

National Governors Association
National Association of Counties
National League of Cities
American Association of State Highway and Transportation Officials
Highway Users Federation for Safety and Mobility
American Automobile Association
American Public Transit Association
National Conference of State Legislatures
U.S. Conference of Mayors
National Association of Regional Councils
American Public Works Association
American Trucking Associations

TAG will develop alternative proposals for a national transportation program by mid-1989. A consensus conference will be convened in 1989 to reach as much agreement as possible on the TRANSPORTATION 2020 program. The results of this conference will flow through the policy-setting processes of the sponsoring organizations to Congress, the new administration, and state and local governments.

Session Summaries

SUMMARIES OF THE EIGHT conference sessions based on the resource papers, the respondents' comments, and the open discussions are presented below. Some key challenges that face transportation providers as they prepare for the future and that, in some cases, transcend individual session topics were identified at the conference:

- The increased relevance of productivity gains from infrastructure investment to the maintenance of living standards and global competitiveness as the labor force grows more slowly than in the past.
- The new and more complex patterns of interaction associated with the postindustrial global economy, dispersed service-based economic activity, extended urbanization, and emerging centers of growth and redevelopment.
- Future travel demand increases beyond mere population growth caused by a proliferation of households and life-styles that generate a diversity of mobility needs and desires.
- A blurring of traditional boundaries among transportation providers, modes, and institutions fostered by deregulation and service innovation and enhanced by recent applications of computer and communications technology.
- Heightened awareness of the interdependence of increasing vehicle travel, community quality, natural resources, and the environment.
- Changing views of appropriate public and private-sector responsibilities and of intergovernmental roles as affected by evolving institutional traditions, relative technical and financial capabilities, and competing priorities for available resources.

Economic Growth and Vitality

Investment in infrastructure should be related to the overall economy. A 2.6 percent growth rate in the gross national product (GNP) is forecast for 2020 in terms of labor force and productivity. However, to sustain the current U.S. standard of living, the level of economic activity needs to be 3.5 percent. In order to close the gap, increased rates of capital investment are needed by both the public and private sectors.

Higher rates of capital investment are key to future growth of productivity and income for the nation. Investment in transportation has certainly contributed to this country's growth during the first three-fourths of the 20th century. Such investment has declined as a portion of the GNP and as related to the increase in vehicle miles traveled. Additional transportation investment is necessary, in a form that will yield improved productivity from more efficient technology.

Other ways to stimulate productivity of transportation facilities include more rational use of assets. These facilities should be financed primarily from user charges, which help ensure their efficient use and serve as a check on the demand for additional capacity. To ensure more rational investment, a plan should be developed in which goals and objectives are clearly identified and integrated into a design process that encompasses mobility, economic development, conservation of resources, and community and land use considerations.

Benefits and costs over the lifetime of the project should be identified and evaluated. The issue of maintaining the existing infrastructure was not covered specifically at the conference, but all states and local governments, regardless of their growth and development potential, share the same interest in when, where, and how best to reinvest in existing systems while continuing to provide high levels of transportation service.

Increased investment in transportation facilities of whatever type should be a stable long-term commitment to ensure that private-sector productivity is not constrained and to encourage innovation and development of new technologies, systems, and methods.

Demographics and Life-Style

The nation's population is projected to grow by 58 million between 1985 and 2020. Of this increase, 70 percent will result from the growth in the number of Hispanic, black, and Asian residents. The population under age 45 will increase by 3.3 million (5.7 percent), whereas the number of those 45 to 64 is projected to increase by 31.8 million (71 percent) and of those 65 and over by 22.8 million (80 percent). The number of households will increase faster than the total population, and the size of the average household will continue to decline. More than 90 percent of all national growth is expected to occur in the

South and the West and in the suburban rings of metropolitan areas in all regions.

The majority of employment increases will be in the same areas, with service industries projected to grow the most. Accessibility by national and international airlines is seen to be of increasing importance to an area's future employment growth.

Central cities will continue to change functionally from goods processing to information processing, raising the education requirements needed for employment in future urban growth industries. As jobs requiring less education continue to become decentralized in the suburbs and exurbs of metropolitan areas, the growing number of inner-city minorities will face increased spatial separation from their traditional sources of employment. Unless these greater distances are overcome by more efficiently planned communities or by suburban relocation of minorities, a growing surplus of lower-skilled labor will occur in the cities, whereas suburban businesses will experience severe shortages of such labor.

These trends have many and varied implications for transportation:

- Transportation alternatives for meeting these diverse demand patterns while satisfying environmental constraints are unclear and will depend both on the specific situation and on the values and resource allocations within the regions themselves.
- The growing transportation needs of the inner-city work force employed in suburban areas must be considered in long-range planning.
- The aging (or "graying") of America will mean that more of the elderly will possess driver's licenses. This will affect many aspects of the system, including licensing, highway design and operation, and vehicle design.

More real income, a shorter work day, and new consumer technology all contribute to the evolving life-style of urban area residents. Consumer demands help generate new products and services, industries and institutions, and urban forms.

To understand current life-styles and to be able to predict how they will change, it is necessary to examine the continuing activities and behavior patterns associated with different parts of the life-cycle and different roles in society that are measurable and potentially predictable. These patterns have implications for both transportation policy makers and planners. Life-styles will become more diverse and nontraditional. A variety of living and working arrangements will exist. Single-parent families and two-worker families create special needs. Transportation for children is a major demand and may require special treatment. These conditions imply different travel patterns, which in the aggregate may not show major changes. Research is needed to assess how these trends will affect the future.

Energy and Environment

A growing challenge to transportation is posed by increasing petroleum costs and decreasing security of oil supplies. The U.S. transportation sector is nearly totally dependent on petroleum today, and the existing capability for use of alternative energy sources is negligible. In 1987 transportation alone consumed more petroleum than the United States produced. This dependence on foreign sources raises the question of whether the United States will continue to enjoy an uninterrupted and adequate supply of petroleum. The challenge can be met, however, without serious changes in the nature of the transportation system by a combination of dramatically increased energy efficiency and the beginning of a transition to alternative fuels. It is possible that before 2020, air quality improvement and other concerns will motivate the transition to alternative fuels. Government policy will be important with respect to both automobile and light-truck fuel efficiency and the conditions under which alternative and petroleum-based fuels compete in the market.

Environmental considerations are often viewed as constraints on the planning and delivery of transportation projects. However, environmental enhancement should be a central objective of transportation planning and project development on its own merits and because sustained economic growth and prosperity rely on good environmental quality.

Inadequacies of the existing Environmental Impact Statement (EIS) process in large part reflect broader limitations imposed by the current structure of transportation planning and finance. The EIS is often perfunctory, reactive, and too late in the project development process to offer any substantial guidance to decision makers. Regulatory reforms could help focus the EIS on the serious issues at hand, encourage meaningful program-level environmental analysis, speed up the overall process, provide better information, and allow for more constructive community involvement.

Transportation continues to be an important source of air pollution, and requirements for transportation air quality planning and action will continue. Many of the measures that are needed for clean air also serve other important objectives, such as congestion relief.

Related to energy and environmental considerations is the renewed attention to the interrelationships between transportation, land use, and economic development. For example, local governments are increasingly active in requiring developer-provided transportation facilities and services, in managing land use with an eye to transportation impacts, and in mandating traffic mitigation activities.

To respond effectively to social, economic, and environmental objectives rather than being constrained by them, it may be necessary to restructure transportation planning and project development activities.

DEVELOPMENT PATTERNS AND PERSONAL MOBILITY

The nation is emerging from a period of rapid population growth and entering a period of much slower growth. Most of the growth during the next few decades will be in the South and the West. Although the North Central and northeastern regions may have serious problems with decaying transportation infrastructure, system expansion will be confined mostly to the South and West.

Personal vehicle travel is expected to grow 1.3 to 1.7 percent annually between 1988 and 2020. Rates of growth will be higher than the foregoing range in the near term and lower in the latter part of the forecast period.

Within urbanized areas, the classical concentric pattern of both residences and work places is changing to a sprawling low-density arrangement that contains a number of local work-place clusters but even more unclustered employment. More urban roadways are becoming congested each year, and a larger proportion of urban travel is taking place under congested conditions. Increasing congestion levels are occurring at a time when there is preliminary evidence that the increased proportion of jobs in the suburbs is adding work trips that are shorter on average than existing work trips and that these trips may be on facilities with better travel speeds than the average for urban-area facilities. The shift of housing and jobs to the suburbs has had an equilibrating effect to keep average commuting time amazingly constant at about 30 minutes for decades. However, there is not likely to be much more capacity for growth in suburb-to-suburb travel before volumes on these roads render travel speeds as slow as those for other types of travel.

Nearly all work trips are now, and will continue to be, in private vehicles. Nonwork travel accounts for three-fourths of all trips and also depends heavily on use of private vehicles.

The use of averages and aggregates to set national policy has caused some concern. As an example, because transit has a 2.5 percent mode share, it may not be considered important in solving congestion problems. However, transit will remain important in certain circumstances—in high-density congested corridors and in those areas where highway improvements are prohibitive or where it is necessary to provide mobility for those who cannot or who choose not to drive.

The automobile will almost certainly be the predominant form of transportation in 2020. The private consumer has shown great willingness to pay for personal mobility of a high quality. However, private consumers make only a portion of the expenditures necessary to preserve and enhance mobility. Public agencies must make decisions on infrastructure improvements and maintenance programs that will support private mobility demands. The importance of transit cannot be underestimated in serving trips under very congested conditions and in areas where there may be few or no options to improve the capacity of existing highways.

Commercial Freight Transportation

Between now and the year 2020, the GNP will grow more slowly than in the recent past, but because industrial production is expected to increase, demand for rail and motor carrier transportation services should expand as well. A major unknown is understanding how rail-truck competition will be resolved during this period. Changes in governmental policies may influence the competitive environment. Policy areas in which such changes have occurred or may occur include regulation, abolition of the Interstate Commerce Commission, truck access to the Interstate system, size and weight laws, use of twin trailer trucks, urban truck bans, new sections of the Interstate, and the quality of the highway system.

The rail and trucking industries have changed dramatically, especially during the last 7 years because of the deregulated environment. In the 1950s rail carload was the standard mode for transporting manufactured products. The construction of the Interstate highway system and deregulation underlie the shift from rail to truck, which is the major competitive change affecting the freight industry. Intermodal transportation represents the cutting edge of rail-truck competition and consequently the hope for future growth of earnings for the rail industry. New intermodal technology such as the RoadRailer could revitalize a portion of the rail market. Although the past has seen slow growth in the industry and movement has been from rail to truck, these trends could be reversed as demand increases and competition grows.

New business organizations that may evolve to handle freight constitute a separate issue, and changes are already taking place. For example, short-line railroads have emerged since deregulation. The larger railroads have spun off low-density lines into separate businesses that have reduced their labor costs and adjusted their overall cost structures. "Total" transportation companies that might arise to utilize both rail and motor carrier modes are certainly on the horizon, but even these will have to decide how intensively to use each mode.

NEW TECHNOLOGY AND COMMUNICATIONS

Because the computer-control revolution is just beginning, one can only guess at its effects, but the pace of such change will quicken. Industrial plants can be much smaller. Factories can be located wherever there is good transportation, even in places that are not yet cities. Freight movements will be diverse and time-sensitive. Although these changes appear to favor trucking, new technology, such as the "carless piggyback" or RoadRailer, and logistics control systems will help the railroads to compete.

It is unlikely that many more expressways will be built to reduce congestion. There will be a trend toward working at home, but transportation will not be affected significantly by this trend in the near future. Half-width vehicles have been developed that could increase the throughput on existing highways, and electronic guidance systems will help drivers locate new destinations. In the discussion of automatic vehicle control (AVC) and similar vehicle guidance systems, it was concluded that obstacles to their development are more institutional than technological. Improved traffic signal systems have been developed to increase speed of traffic flow and reduce the time and fuel involved in travel.

Improvements in vehicle technology are also anticipated. Fuel economy gains will continue and new materials that reduce the weight of the car may be used, although this could increase the price of the car by more than the savings in fuel costs. However, the cost of these materials will decrease with time and experience, and new materials will be widely used by 2020.

The internal combustion engine is approaching theoretical propulsion efficiency limits, and it will be difficult to obtain further improvements. Fuel cells, a potential replacement for the battery, use an electrochemical process, but low-cost catalysts are needed to make them economically feasible.

RESOURCES AND INSTITUTIONAL ARRANGEMENTS

The importance of having national goals and national policy for transportation around the theme of economic competitiveness was stressed. Further, it was emphasized that federal-aid programs should be redesigned with less intervention by the federal government, leaving to states and localities a greater role in funding and planning. However, these relative roles need to be defined. The need for vision was expressed as well as greater involvement with the public to ensure active and effective political support for transportation needs.

Among other themes articulated both in resource papers and in discussions were (a) the need for more research and development in technology and the management of public works and transportation systems, (b) the need for strengthening regional planning and the metropolitan planning organization (MPO) in urban areas while perhaps expanding the MPO concept to rural areas, (c) continued emphasis on deriving transportation funds from user charges, and (d) use of local mobility block grants as an alternative to federal funding of urban projects.

Observers' Comments

Lester A. Hoel

This has been an extraordinary conference and may well mark a new watershed in transportation planning history; it represents the convening of a most distinguished group of transportation professionals to discuss and debate the direction of transportation in this nation with a time horizon of 30 years, well into the 21st century.

This is a timely event, for the 20th century has seen a legacy of transportation achievements perhaps unmatched in the history of mankind. In this century, the United States has evolved from primarily a rural country with a backward transportation system to one that has afforded such unlimited mobility for its citizens that it has become overwhelmed by its success.

Moving into the 1990s and preparing for the 21st century, Americans can look with pride at the completion of a major project, the Interstate highway system, but also recognize that this system is aging and that new demands are being placed on this system and on other streets and highways. Transit systems have been built in many metropolitan areas and a variety of transit services have been provided in recognition that in many urban areas, both public transportation and the automobile are essential.

The question is, where does the country go from here? What strategies can we follow? What are the trends and how should we react to transportation needs of the future?

During the past 2½ days, from early morning to late at night, well-written, thoughtfully presented papers have been heard on many aspects, and panelists have presented additional insight. There have been open discussions, and many ideas and viewpoints have been expressed. No doubt the record of this conference will reflect the best in a variety of ideas and viewpoints that will be useful for the 2020 committee in developing a proposal for action to anticipate the next 30 years.

My role is to act as an observer and to present what appear to be the major points from the discussions. I must admit that this assignment is a daunting one, because of the complexity of the topic, the many nuances that each area and issue represent, and the extensive amount of material that was presented. These remarks should not be viewed as a summary of the papers and discussions, because that would simply not do justice to the excellent work presented by the authors.

The overall objective of this conference is to identify the nature and level of demand for future highway and public transit services and their role in the nation's future transportation system. This conference was specifically designed to examine the demand side of transportation's future, although one session was devoted to technological change.

It was not the intent of this conference to come up with definitive conclusions and recommendations. At best, major trends, issues, and other factors are presented that should be considered by the transportation community as they begin the process of addressing future needs and requirements. To accomplish these objectives, some of the best minds on a variety of topics have presented their judgments and comments on issues including the relationship among economic development, growth, and transportation; the influence of demographic trends and changes in life-style on transportation demand; the effect of energy availability and environmental concerns on the ability to implement highway and transit alternatives; the pattern of future urban development and its influence on transportation planning; commercial freight transportation and its impact on the highway system; new technology and communications and their relationship to future demand; and, finally, resources and institutional relationships that will be required if transportation, land use, and finance are to be linked with the innovation and development of improved technology and transportation supply.

Making predictions about the future is a hazardous occupation, and one is more likely to be incorrect in such estimates than not. Each speaker here has commented on the inability to take current or past data trends or observations and to extrapolate them into the future. Those in the so-called hard sciences can measure a phenomenon like the elasticity of a beam and be relatively assured that the parameter will remain the same 20 years hence, but that luxury is not afforded in predicting trends in the future. Also, what exists now will not be repeated in the future. Any 30-year period of transportation history shows that extensive changes have occurred that were not anticipated by those who were making transportation decisions for the future. For example, the Erie Canal was completed in 1825 and sparked a building boom in which 3,000 mi of these waterways were built by 1840. Yet, 30 years after the Erie, which is 1855, canals were all but extinct, having been replaced by the railroads.

Similarly, in this century, the past 30 years has witnessed technology changes in air transportation, computers, highways, and rail transit that could not have been anticipated 30 years earlier. Throughout this conference participants reiterated that they were not able to anticipate the impacts of the Interstate system, could not predict what actually would happen, have to do a better job in anticipating what these effects will be.

Finally, a caution about basing trends on average values. These numbers hide variations and may distort the actual conditions. Everyone has heard of the person who drowned in a lake that had an average depth of 4 in. Many speakers here have warned that the use of averages will distort or hide actual variations that are occurring within any area.

Thus, the trends that are observed are not the country's destiny; that is created, and the results of the creative genius and energy of U.S. industries and governments will be to supply transportation services that people want and can afford.

The speakers at this conference have posed a number of issues on which there appears to be some consensus. The following 23 points summarize the major issues discussed.

1. Higher rates of capital investment are the key to future growth of productivity and income for a nation. In this nation, the investment in transportation has contributed to our growth, certainly during the first three-fourths of the 20th century.

2. Investment in transportation facilities, particularly highways, has declined as a portion of the gross national product (GNP) and as related to the increases in vehicle miles of travel. Additional transportation investment is necessary, but it must be a better form that results in improved productivity coming from efficient and better technology. Better technology includes both hard science inputs and improved management. Experience from the past proves this point. New systems like railroads and later airline networks were added because they created improvements in productivity, that is, higher levels of service at lower cost.

3. To develop a plan, goals and objectives must be identified. These goals should be functionally defined, such as "improve urban mobility," rather than based on programs or specific standards. Goals should be integrated into a design process to encompass mobility, economic development, conservation of natural resources, and community and land use considerations.

4. Options should be identified and evaluated that identify all benefits and costs over the lifetime of the project, using appropriate discount rates.

5. Transportation facilities should be financed primarily from user charges to ensure efficient use of facilities and to manage capacity. The market mechanism serves as an efficient measure of the demand for additional capacity and for the allocation of energy resources.

6. The investment in transportation facilities of whatever type should be based on a stable long-term commitment to increased investment so that private-sector productivity is not constrained and innovation and the development of new technologies, systems, and methods are encouraged. This approach will ensure that we are not left behind by obsolete technology.

7. The political process and the governmental system must be taken as givens. To replace them with a "rational system of decision-making" would remove that decision-making role of elected officials. Our system of government was designed for a purpose, and although it may appear cumbersome and inefficient, it is the mechanism by which public resources are allocated. Rather than decry this situation, transportation planners must work within its boundaries and develop the strong rationale necessary to secure scarce public funds for transportation solutions.

8. Planning is driven by demographics. Examination of trends in cohort groups will tell a great deal about the general nature of society. Thus, the Baby Boom and the "scarce generation" give a broad picture of conditions within a decade and should help to tell something about conditions in 2020.

9. Migration and population forecasts indicate that the preponderance of growth by 2010 will occur in the South and the West, and in suburban agglomerations. Although eastern and midwestern cities may experience increased traffic demand, partly because of smaller household formation and some growth, the major growth will be in these sunbelt areas. Growth will occur in both suburbs and central cities, but the largest percentage increase will be in the suburbs. The transportation alternatives identified for meeting these diverse demand patterns and satisfying environmental constraints are unclear and will depend both on the specific situation and on the values and resource allocations within regions themselves.

10. The majority of population growth by 2020 will be in the Hispanic, black, and Asian population groups. Non-Hispanic whites are expected to decline in population by 2020. This phenomenon has special implications for transportation and should be included in 2020 planning. For example, the increase in minority populations in the inner city while most of their job opportunities occur in the suburbs will create a reverse commuting pattern that needs to be addressed.

11. The population of the United States will have a larger proportion of older persons. The most dramatic changes will occur after 2010 as the Baby Boom moves into the Graying Boom. Most of these older persons will have driver's licenses, a contrast to the situation that exists now or did in earlier years. This will have a major effect on the transportation system as well.

12. Life-styles of U.S. residents will become more diverse. A variety of living and working arrangements will exist. These imply different travel patterns, which in the aggregate may or may not show major changes. Little is

known about how travel attributes change in response to travel environment, and research is needed to assess how these trends will affect the future.

13. Nontraditional life-styles are becoming more prevalent. Single-parent families and two-worker families create special needs. Transportation for children is a major demand generator and may require special treatment.

14. The availability of petroleum should not be a constraint in transportation. Adequate supplies exist worldwide, although most of it is found in other countries. Accordingly, the market will control demand, and this is a self-correcting phenomenon. Alternative fuels are available, and these may be required if policy or environmental issues dictate. Oil prices will rise and the transportation system will adapt.

15. Long-range planning should seek to identify and preserve major transportation corridors. Railroad rights-of-way, for example, are a resource in this category and should be held for other transportation uses such as fiber-optic cable rights-of-way, bike paths, and road-rail vehicles.

16. There is no evidence to suggest that the automobile will not be the predominant form of transportation in 2020. This hardy little beast is characterized by flexibility for the user, permitting him to go wherever he wants and whenever he wants. It has a remarkable capacity to survive, changing its color, size, and shape to conform to the current environment. Although the vehicle may be technologically unrecognizable as it adapts to the computer age, its essential features will remain. Research into advanced automotive technology and new forms of guideways is justified because this represents opportunities for increased productivity and efficiency of the automobile.

17. Travel demand in urban corridors should grow in some areas, suggesting that in those areas where rail transit lines exist, these systems will provide a service. However, little evidence exists for extensive building of fixed-guideway rail systems within or between cities, although system extensions may be required.

18. Externalities that are now unforeseen could influence transportation technology and demand. Indicators exist that may prove to overtake trends. The seeds of changes that will be commonplace by 2020 have probably already sprouted and are growing quietly among us. Examples are resource shortages, land development schemes, trends to higher densities, increases in family costs for housing, and the greenhouse effect.

19. Commercial freight transportation will undergo major changes that will influence regional transportation development. Freight is a derived demand, and the user is becoming more and more indifferent to modes. Innovation within the railroad and the trucking industries will result in productivity gains. Intermodalism will flourish and competition will ensure the user the best service at lowest cost. Industrial growth is expected to recur, with positive implications for both truck and rail. New technology such as the RoadRailer

could revitalize a portion of the rail market. The future of the industry will depend partly on changes in governmental policies that will influence the competitive environment. These include abolition of the Interstate Commerce Commission, access to the Interstate system, size and weight laws, use of tandem trailers, urban truck bans, new sections of the Interstate, the quality of the highway system, and regulation. Although the past has seen slow growth in industry and movement has been from rail to truck, these trends could be reversed as demand increases and competition grows.

20. Labor shortages will be a problem in the transportation industry. Demand will exist for truck drivers and other service-sector employees. Transportation professionals will also be required in order to replace the labor pool that is retiring.

21. Advanced technology for transportation is abundant. There is no dearth of ideas and proposals for moving people and goods. The problem is in identifying markets and implementing systems in politically hostile environments.

22. The many political jurisdictions within a region create problems in implementing long-range transportation plans. These units compete for the tax base and often act in their own best interests. Coordination and cooperation among these units will be essential if meaningful transportation land use plans are to be implemented.

23. There is a role in developing transportation plans for federal, state, and local governments. First, the program must be justified and a continuing source of funding must be ensured. Decision making is best at the local and state level, where the problems are known and understood. Selections of alternative courses of action are best handled by the states and the regions themselves.

Some comments at this conference have indicated that the results were rather mundane. No prescriptions for the future were heard and no great new ideas seemed to emerge. Emphasis was placed on the status quo, on what we should be doing now, and on extrapolation.

The question was asked, Where are the real leaders? Where are the thinkers? Where is the vision? Well, a look at the assembled group suggests that many here have been around for a while, and perhaps we are older and wiser. Perhaps there is a need to extend our circle to include other interest groups representing a greater diversity of ideas.

On the other hand, I heard it said a number of times that "the more things change, the more they stay the same." Perhaps that is true. But I am guessing that if we could be here in 2020, we would discover that things are quite different. Of course, only time will tell.

DANIEL BRAND

Some of the following unresolved issues from this conference are clearly candidates for the Transportation Research Board's agenda.

First, management by objectives. The overall objective of the conference as stated in the conference brochure was "to identify the nature and level of demand for future highway and public transit services and their role in the nation's future transportation system." Ted Lutz's charge at the beginning of the opening session went even further. He asked for "some logical transportation responses to these future demands."

How well were these two objectives achieved? With regard to the first, this conference has presented comprehensive and authoritative forecasts of future economic and demographic activity nationally and in urban regions. The papers presented here represent a landmark effort to bring together what is known on the social and economic factors that determine the future demand for transportation. However, as comprehensive as the forecasts in these papers are, they do not vary in accordance with transportation responses to these future demands. There is a need eventually to analyze transportation options for their impacts, in turn, on these determinants of long-run demand for transportation.

With regard to the second objective, there was time only to scratch the surface in identifying logical transportation responses to the future demand for highway and transit services presented here. This will have to be the subject of the next conference.

Two of the high points of this conference for me were the first resource paper, by Lewis et al., and the comments of Fred Miller, the last formal respondent at the conference. Both dealt with one of the two imperatives to come out of this conference for me, namely, the issue of economic growth. "We must establish a linkage with economic growth if we want to justify future investments in the nation's transportation system," in the challenging words of Fred Miller. The other imperative identified at this conference is the issue of suburban highway congestion in our major cities. Indeed, a third possible imperative, the greenhouse effect, was mentioned briefly. Much more will be heard about that and its effect on atmospheric heating in the coming months and years.

In their paper on economic growth and the public infrastructure, Lewis et al. challenged the conference with the imperative that labor productivity must be increased if the standard of living is to be preserved. Transportation options must be identified and evaluated in terms that link them with economic growth through productivity growth.

There should be no pork barrel projects that spread federal money around to local projects with no net economic effects. Lewis reduced the problem to its simplest terms. He said that a 2.5 percent per year real GNP growth rate is forecast over the next 25 years, but that a 3.5 percent growth rate is needed to keep up the standard of living.

The key to that growth, he said, is growth in labor productivity. An increase of 0.8 percent per year in productivity would produce the needed growth, and the right kinds of infrastructure investment would help. This is because 85 percent of the past real GNP growth has been due to labor productivity growth, not growth in the number of workers.

The big question, therefore, is which transportation investments lead to productivity increases and how to evaluate alternative transportation policies appropriately with respect to economic growth.

In presenting his challenging comments, Miller said that a vision is needed to get the excitement back into the transportation mission—the sense of purpose, the tremendous degree of professionalism and pride, even "virility," that characterized the early days of the Interstate highway program. Miller postulated the link to economic growth as the best candidate for the source of that vision. He even suggested that transportation operates as the engine of economic growth in 40- to 50-year cycles—the railroads in the 1850s to 1870s, the largest industry in the country, and the mobility that they brought; the automobile industry in the twenties and the mobility that it brought; and the Interstate highway system and aviation in the 1950s and 1960s, and the mobility that they brought. What will the engine of economic growth be in the year 2000?

This is hardly an idle question, because if something momentous is to occur in the year 2000, there clearly should be some ideas about it now, in 1988, and in this audience especially. Industries driving the national economy do not spring up overnight. What, then, is the vision? I suggest that it clearly has to do with computers and microprocessors. What should we have them doing for us? I suggest the obvious answer, which is to have them increase the productivity of the existing transportation rights-of-way, the archetype of which is the limited-access highway, which does not have cross traffic to interfere with closer vehicle spacings and higher speeds.

Obviously, research is needed into how much and at what cost transportation performance can be increased through automation. In terms of the two imperatives identified, will there be a net economic benefit translatable into productivity growth and will suburban highway congestion be alleviated too? The answers are not certain, but it is clearly worth some research money to find out.

I also have an innovation theory argument in support of this vision of the transportation engine driving the economy in the year 2000. At its most basic level, the function of transportation in cities is to overcome urban space, and the function of cities in turn is to reduce the need for transportation. As long as transportation costs are less than the benefits, transportation helps cities maintain the economic and social interdependence that distinguishes them from more isolated rural areas.

During the last half-century, the perceived unit cost of transportation to urban consumers has declined and cities have spread out, resulting in increased space and privacy for most urban residents and increased land availability for more efficient horizontal manufacturing processes.

Cities are definitely in what Bill Garrison calls "the third stage of innovation" as regards the private car. The first stage of innovation typically occurs when an invention performs an existing function better than before. The early motor car was faster and pulled more weight on dry roads than the horse, but its function was the same as that of the horse.

In the second stage of innovation, the invention has been improved and new uses have been found for it. In the case of the motor car, self-starters were developed, vehicles were adapted to move goods as well as people, and chauffeurs were added to create the motor bus.

In the third stage of innovation, the structure of the surrounding system, in this case the city, adapts so that the innovation can perform at still lower costs and increasing gain to individuals. Urban regions have been changing rapidly to meet the motor car's needs. In U.S. urban areas, privately owned vehicles are used for about 95 percent of all vehicle person trips. The structure of cities has changed to allow the automobile to operate more effectively and fixed-route and scheduled public transit services, less effectively.

The suburbanization of the national population and the intrametropolitan shifts have been stressed repeatedly at this conference. "The strongest competitive effects are in the suburbs," in the words of John Kasarda.

What does this mean to the application of computers in transportation? An entrenched third stage of innovation cannot fight with another third stage. The structure of the system in which the motor car operates has adapted to the motor car. There must be a return to first-stage innovation: to perform an existing function better than before.

Computers are well suited to enhance or take over part or all of the existing guidance and control functions now performed by humans. Automated highways, or more logically, automated guideways of an intermediate-stage dual-mode system, could well be the next transportation engine that drives the economy. Transportation speeds and throughput could be markedly increased. The market for microprocessors in this application would certainly dwarf the few million personal computers now in use.

Are we on track for developing the transportation engine for economic growth in the year 2000? I think we probably are. Transportation should get on board and try to drive this development in the public interest. (I'm sorry for the metaphors—they show the pervasiveness of transportation in our society.)

We can only wonder and speculate on what the second and third stages of innovation would or will be—the new uses for the innovation, and how the structure of the surrounding system would adapt—but I will not speculate further. I have carried you this far in the argument only to suggest that automation as a research direction is an eminently logical response to the nature and level of demand for future highway and public transit services, to quote the charge of the conference.

Having put a not-so-concrete transportation option on your plate, let me return to the issue of economic growth as "the horse we have to ride" if, as Miller suggests, the 2020 effort hopes to demonstrate the worthiness of increased or even continuing major investment in transportation infrastructure.

I would suggest that TRB needs to put squarely on its research agenda the question of how to link transportation investments and economic growth, particularly labor productivity increases. I think TRB already has this on its calendar, but this conference just confirms the importance of this question.

The question is, indeed, nontrivial, and although there have been many studies, the question is far from answered. How are the usual quantified benefits from highway and transit investments translated into economic growth? How do travel time savings and cost per new transit rider translate into productivity increases? If money to build highways and subways does not result in net benefits, it is merely being transferred from one region to another for no economic purpose.

The problem of mapping benefit measures on labor productivity growth may be easier to solve for air transportation. Lewis et al. cite Congress' 1985 authorization of $8 billion in air traffic control improvements, including "authorizing the FAA to begin in earnest on a program of R&D in advanced automation. This was because air traffic control automation is expected to create $36 billion worth of productivity improvements for the FAA, for airlines, and for airline passengers in the form of fewer delays and thus more time for productive work." Because airlines are a private industry, and so many air passengers fly on business, the argument is easily made that much of these time savings can be translated into productivity increases.

For highways and transit, economic benefit measures are not so easily linked to labor productivity. In trucking, the links are clearer, but for highway person trips, do time savings translate into more leisure or more productive hours? Or do they translate into longer trips seeking lower-cost housing or higher-amenity living?

In the 1940s Campbell Gibson said that 20 percent of a person's income went for housing. Now it is 40 percent. Will the housing cost increase be slowed by consuming more transportation in the future? Has this really happened in the past? How does trading transportation for location translate into labor productivity? How does location itself lead to increased productivity, especially location at a high transportation cost? Is amenity a factor in labor productivity?

Friends of mine live on a mountain top in Vermont near an Interstate, two exits from a major cultural center and hospital. They consult out of their home. Federal Express does their traveling for them, although that increasingly is being replaced by a fax machine. It is a high-amenity life made possible by the Interstate, but is it more productive? Admittedly, this is an extreme example of the transportation-amenity trade-off, but just as we need increased productivity to preserve our standard of living, amenities are important, too, in any standard-of-living determination.

In public transportation, Congress mandated in the 1987 transportation assistance act that all major transit projects be cost-effective to receive federal funds. The criterion in the proposed regulation implementing that act is cost per new rider. How does a new transit rider translate into economic benefit?

There are many different ways of asking the question of how well our transportation investment evaluation measures map on labor productivity. Is net economic output in our economy really measured by our conventional evaluation measures, the items that go into our net present value calculations? And if not, how do we improve our evaluations?

Let me for a moment turn our attention to the very touchy and related subject of road pricing to promote the efficient use of transportation facilities. Given the hostility towards congestion pricing expressed at this conference, it seems unlikely to happen in the short term outside of some price adjustments at existing toll facilities. Highway automation could of course make congestion pricing technically quite feasible in the long run. In the case of highway automation, it may be quite acceptable to charge different fares for each trip on the system, just as we charge zonal and peak-period fares for transit.

The theoretical arguments for road pricing and a low-cost means of promoting efficient use of facilities and thus net economic benefits are quite strong. Efficient pricing generally means setting prices equal to the cost of providing the facility at any given time. If people are not willing to pay that price, the investment does not have benefits equal to its costs, much less greater than its costs. If prices are less than cost, this leads to overconsumption of that transportation service, which lowers efficiency and economic output.

For example, heavily discounted monthly pass fares for commuter rail users in a large city encourage consumption of expensive-to-produce, long-distance, peak-period commuter rail. This also causes people to move further out into the suburbs, which may increase costs in nontransportation sectors as well.

But there clearly has been something of a stand-off at this conference on the pricing issue. Robert White, President of the National Academy of Engineering, called this conference very timely because "we have a crisis of undercapacity." On the other hand, John Meyer, the eminent transportation economist, loves to say, "We don't have a capacity problem on our highways; we just manage to throw it away twice a day." And at this conference we have as thoughtful a commentator as Peter Koltnow viewing congestion pricing as "a way to improve mobility by taking the wheels off the wagon." I suggest that TRB has a lively issue here and that it won't go away as long as there are economists at these conferences.

Let me turn briefly to the battle of the demographers at this conference, which was another highlight. John Kasarda, in a very impressive paper, had us convinced there are powerful demographic forces fueling the demand for continuing investments in surface transportation facilities. These forces are the spatially uneven development of our regions, the intrametropolitan shifts, and the "unique competitive effects of the suburbs."

He went on to say that "metropolitan areas have a strong hold on the externalities that promote population growth. Suburbanites want control over the temporal and spatial dimensions of their travel and will pay large sums of money for these." These are all wonderful and insightful descriptions of the suburbanization phenomenon.

However, we were rocked back on our heels by Ira Lowry, who said, "The need for highways follows aggregate population growth," and that our population growth is slowing dramatically because we are below replacement and coasting on the Baby Boom. Lowry's paper elicited some rather strong responses, and he appeared to temper his strong statements, which were based on aggregates.

Among his respondents, Richard Forstall said, "Central business districts (CBDs) are growing in employment despite decreases in central city population, which makes net in-commuting to the central city CBD even greater." A good transit market here, I would add, and growing, as shown by Forstall's statement that "we should anticipate further CBD growth and commuting growth." Ron Kirby, another respondent, said that some areas are growing and some declining. They may net out in the aggregate, but there is still a big transportation problem out there.

The Lowry session and controversy pointed up an area of considerable research interest for TRB: there is considerable uncertainty in the demographic forecasts that have been presented. And, as I said at the beginning of these comments, the forecasts do not take into account our transportation responses to these future demands either.

Another way of saying this is that there is a supply-demand equilibrium operating here that needs TRB's attention. Lowry says, "Congestion is nature's way of limiting travel demand." Mel Weber has said, "Congestion is the price we pay for free movement." Any way we say it, if we reduce congestion, we are likely to get more travel and more dispersed land uses, although not necessarily a smaller CBD.

Indeed, one of the reasons CBDs may be growing in the larger cities is that they are well served by transit. Transit to the CBD provides a very important additional travel choice in the equilibration of space, time, and mode (in this case) that is the individual's way of solving the congestion problem in terms of his or her own values. We need, therefore, to analyze transportation options in a way that ensures that the future development patterns to which our transportation proposals respond are consistent with the development patterns that would result from their implementation (after everyone's supply-demand equilibration takes place).

We can also link land use and transportation more directly by policy, as Florida and Vermont are doing. Florida has comprehensive growth management legislation, meaning that building permits cannot be issued if the development cannot be accommodated by the existing or planned infrastructure. This new legislation should certainly be monitored to determine its practical effectiveness.

Finally, I direct your attention to the recommendations on transportation institutions and funding organizations by Stowers and McDowell. These were two excellent papers and presentations, with detailed and far-ranging recommendations on transportation institutions that bypassed the controversy on specific transportation responses to the long-range needs and projections presented at this conference.

Of course, these institutional recommendations can lock in certain points of view. McDowell went even further and suggested a new national highway system of high-priority roads that would be considerably longer than the current Interstate system. For this, he received some serious objections, indicating how early we are in the process of formulating logical transportation responses to potential future transportation demands.

McDowell did receive a lot of agreement with his comment that the reality of the American federal system is that responsibility for getting things done tends to sink to the local level, whereas the ability to raise funds tends to rise to the state and federal levels.

I would add that controversial projects like building highways are difficult to do at the local level, where costs and negative impacts are concentrated, whereas benefits are dispersed widely over the region. This is why the federal-state partnership was so effective in building the Interstate system until neighborhood groups and communities banded together to stop the highway in many cities, although clearly not in all cities.

This is the obverse of (Charlie) Lave's Law: "When benefits are concentrated and costs widely spread out, Congress will pass lots of bad laws." In the highway case, when costs are concentrated and benefits are spread out, it is hard to build freeways these days in many, but not all regions.

In the session on new technology, as a respondent, I warned of capital shortages and difficulties in building new freeways. The session chairman was the Secretary of Transportation in the state that probably has the most active freeway construction program in the country. My apologies to Charles Miller of Arizona. I was giving the perspective of some other places in the country.

It certainly does show the diversity in this country and the fallacy of prescribing uniform solutions to our transportation problems out to the year 2020.

Alan E. Pisarski

The TRANSPORTATION 2020 program is a great challenge to all in the transportation profession. When the future of transportation after the Interstate program is considered, it is easy to lapse into clichés and speak of "crossroads" and "watersheds." In this case such prosaic phrases may be accurate—deciding on the kind of surface transportation program the nation needs after the Interstate program may well be an important crossroads. It is certainly the end of an era. Whether it is the beginning of a new era will depend on all who participate in the TRANSPORTATION 2020 process.

For most of those in the transportation profession, the building of the Interstate system, spanning as it has their entire working life, has been the dominant career force, even though they personally may never have planned an Interstate facility or turned a spade of earth for an Interstate route. The Interstate program defined the engineering, planning, and institutional realities of the transportation universe.

The Interstate program has become so pervasive a part of the intellectual landscape of these professionals that to be challenged now, as the Interstate effort concludes, to fashion a new centerpiece for the nation's surface transportation program is a daunting task. A task in which perhaps the first need, and the most difficult, is to throw off the conceptual constraints accumulated over three decades, not because the Interstate effort has not worked well, but because it has. For to be a worthy successor to the daring spirit that conceived and attempted the Interstate program, one would want not simply to prove an efficient custodian of the system but to emulate in 1988 the same kind of "creative leap" represented by the Interstate program 32 years ago.

The Interstate program represented a great departure, not just in terms of design and engineering concepts, but also in terms of the institutions to plan, finance, and build the system. The very strength of the Interstate model of "how it is done" diminishes the ability to visualize new ways to approach the necessary tasks. It is so embedded in the experience of today's professionals, and has worked so well, that it makes thinking about new approaches and new departures a great challenge.

The Transportation Research Board (TRB) has responded to that challenge. It accepted the role offered by the organizations responsible for the TRANSPORTATION 2020 program to foster broad and deep thinking about the future in an effort to define the demographic, economic, and technological context for a vision of transportation's future. This conference on the future was developed as part of its response to that task.

TRANSPORTATION 2020 PROGRAM

The TRANSPORTATION 2020 program was initiated by the American Association of State Highway and Transportation Officials to chart a course for the future surface transportation policy of the United States. The immediate stimulus for the 2020 effort was the coming end of the Interstate program; however, the objective of the program has grown to encompass the development of a new surface transportation program built on a broad spectrum of support that will identify and address the varying surface transportation needs of the nation in the 21st century.

The organizations forming and guiding the TRANSPORTATION 2020 program have put in place a far-reaching and complex process involving literally hundreds of organizations and associations and dozens of separate planning and policy efforts. All this is necessary to ensure the participation of the many groups at interest and the examination from all points of view of the many program elements. Such an approach, crucial as it is, is unlikely to produce the intellectual underpinning that will give the TRANSPORTATION 2020 program a coherent base on which to build. That task that has been identified for TRB.

CONFERENCE THEMES

In 3 days not all the questions on the agenda could be resolved. Great success was achieved in the following areas:

- A review of each major area in which there were significant questions about the prospective character of transportation demand and the form of services responsive to that demand;
- An examination of all facets of those questions with some of the available experts in a completely open discussion format; and
- Differentiation between questions on which there was reasonable consensus and those on which professional opinion was unresolved and the topic was in need of intensive further consideration.

In brief, the best of current information was synthesized to identify what was important and what needed to be studied further in order to respond effectively to the transport needs of tomorrow.

The conference produced a broad and impressive array of findings, conclusions, and observations in the main topics considered. It may be fruitful here to identify some of the themes that dominated the 3 days of intensive interaction. These themes should define the major elements of the work programs supporting the 2020 effort during the next year or more. They identify the major directions for research resources. The major themes can be assembled under two headings—characterizing future demand and serving future demand.

Characterizing Future Demand

There was considerable debate and question about fundamental attributes of transportation demand. This was noteworthy, not just because differences of opinion occurred but because the questions raised went to the heart of the quality, coverage, and sensitivity of the tools employed in demand analysis. Specifically, the data and the projections provided by government agencies were the focus of major concern.

Lack of appropriate data, a problem frequently raised, is a subject amenable to intensive consideration. In particular, many pointed out the critical need to go beyond using broad national statistical averages when new policy and programs are structured. It was noted that there are times when such statistics obscure information. This issue arose often in discussions about transit and its future importance and prospective role.

Even more critical were the questions caused by weaknesses in the data that concerned the level of future demand. Evidence can be construed to indicate that future travel demand should be leveling off and that continuation of current growth into the 1990s is most unlikely. The key question is whether recent demand is a distortion of the long-term demand trend and is already abating, or whether it is a true shift in the character and quantity of demand that will persist into the next century. Current data and analyses are inadequate to full understanding of that problem, yet the answer is central to program planning.

In parallel with these concerns, substantial suspicion arose about the usefulness of currently available demographic projections. The key issue raised was whether simple demographic projections are workable tools at this time for understanding and forecasting demand. These suspicions stem from several unresolved concerns.

First, current projections by different agencies using different perspectives yield inconsistent results, particularly with regard to prospective employment, obviously a critical transportation demand variable. The prospective role of immigration in the labor force is a crucial connected issue about which little is known.

Second, the projections of current trends appear extreme in the long term, specifically with respect to continued population shifts to the South and West in general and to Florida, Texas, and California in particular. Current projections would place 50 percent of future growth in those three states.

Both of these concerns bear on the question raised earlier of whether current patterns are a distortion of past trends or the basis of a new trend. It is clear that patterns of demand have currently changed, sometimes dramatically, and that, as a profession, transportation planners for the most part failed to foresee these pattern shifts, and therefore failed to respond effectively to the new demands with facilities and services. The profession's failure to meet the challenge of these new patterns tends to be excused on the grounds that these charges are "unprecedented." Is one to be prepared only for the precedented? Is the unprecedented aspect an adequate excuse for the failure to anticipate and respond by a profession that is inherently oriented toward the future?

Clearly this is an area in which improvement is necessary, and improvement generates the need to know more. Past failures do not suggest better forecasts than those being made now. The error of failing to have foreseen the current distortion in demand patterns could be compounded by using these distorted patterns as bases for future trends. In fact, when demographic patterns are as distorted as they are now, serious questions may be raised about the utility of projections, because a distortion is a bad basis for projection and such a distortion is by definition a failure to have captured a trend. Current government projections need to be evaluated and made consistent.

Serving Future Demand

Two areas were central to understanding future demand and better serving it. The first was the broad subject of the relationship between transportation and economic development and productivity. The second concerned the role of technology in responding to demand.

Transportation and Economic Development The theme of the interrelationship of economic development and transportation was reiterated in different forms throughout the conference. Among the elements of the discussion that had great bearing on the future were these:

- Throughout history, transportation has periodically been a major driver of national economic productivity through dramatic decreases in travel time and cost for transporting goods and people. Has transportation lost that ability? If not, what areas of transportation will be the likely sources of future major productivity improvements?

• The United States is moving into a new economic world characterized by a high proportion of foreign trade and by intensive international economic competition. The role of transportation in contributing to the nation's new needs in this area is unclear. Can transportation make a major difference in the nation's trade posture? How? What investments and decisions are most supportive of national competitiveness?

• As the nation's economy continues to shift to a greater orientation toward services, how do transportation's roles change? Is it more or less crucial to economic well-being? Will there be a two-tiered freight system in which large ton-mile commodity shipments use traditional means and high-value goods move in increasingly responsive, just-in-time truck-air systems? What about demand for tourism and recreational travel? When will tourism no longer be taken for granted and seriously incorporated into the economic demand picture?

Discussions at the conference revealed that all these questions are interrelated and together demonstrate a lack of knowledge of the importance of accessibility and mobility to the economy and society. These relationships must be better understood so that transportation plans can serve the national economy better and make stronger the case for cost-effective transportation investment.

Role of Technology A topic that took on increasing strength and importance as the conference progressed was the role of technology in serving and perhaps modifying demand in the future. There were sessions dealing explicitly with technology in many of its aspects, but the subject of technology arose often in all sessions and in various forms. There were three variations on the technology theme:

• Technology to expand the carrying capacity of current facilities, which includes new techniques to manage the capacity of roads on a real-time basis, better signalization systems, and other new operational tools;

• Technology to mitigate the indirect effects of travel activity, particularly those involving energy and the environment (pending urban air-quality sanctions and concerns for the greenhouse effect were high on the list of concerns);

• Technology to improve future responses to travel demand, such as smart cars and smart streets (these portend opportunities for more rapid, safe movement of vehicles, people, and goods; also included in this area are systems such as telecommuting and automated route planning and guidance, which can reduce the amount of travel).

Each of these aspects of technology held great promise in the view of most participants, and together they represented the major focus for the thinking on the future of transport.

CONCLUSIONS

It is safe to say that although many topics were covered and many important issues were addressed, three dominant areas for focus of the 2020 effort were identified at the conference:

- Better bases for demand forecasts,
- Better understanding of the relationship between economic development and transportation, and
- Better development and utilization of technology.

These three areas correspond closely to the questions What? Why? and How? to be answered by transport policy as part of the 2020 effort. What is needed, because of the inextricable link between transportation and economic development, is an understanding of the needs of the new century and a response based on that understanding. How to do it is by harnessing the potential of new technologies to meet these needs.

Important strides have already been made by TRB in forming new groups and task forces to respond to TRANSPORTATION 2020 program needs, and beyond, in both economic development and technology. Possible TRB actions to address problems in the first area, better data and forecasts specific to the needs of the 2020 process, remain to be considered.

Having this conference performed a valuable service in that it effectively focused the broad subject matter under consideration so that these significant areas of concern could be identified and responsive programs prepared to address them. They are the key elements in establishing the intellectual underpinning, the "creative leap," that will make the TRANSPORTATION 2020 program a success.

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Beyond the Millennium—Transportation and the Economy

Robert M. White

IT IS A PLEASURE to join you on the occasion of this conference on transportation futures. It is timely to surface ideas that will shape transportation policies to serve the interests of our nation—timely because it is self-evident to the traveller and the shipper that we have a system in a crisis of undercapacity and increasingly unable to accommodate a burgeoning travelling population and a dynamic and growing national and world economy.

Transportation plays a special role in advancing our economic welfare. It is central to our ability to achieve our national economic and social goals. Fortunately, our transportation systems on land, sea, and air stand on the threshold of new technological opportunities impeded only by our social will to grasp them.

In this conference you seek to predict the future, and that is a hazardous undertaking at best. It calls for both boldness and humility. Recall that you are considering a period some 30 years hence. Reflect that 30 years ago the United States sat astride the world economic scene as a colossus. Jet engines were only then entering aviation as the main propulsion system. The space age had just been launched with the Soviet Sputnik in 1957. Computers were just emerging from the vacuum tube generation and the personal computer was but a distant dream. Biotechnology as a discipline and an industry was nonexistent and the dominance of the U.S. automobile industry was unchallenged.

Robert M. White is President of the National Academy of Engineering. Before joining the National Research Council, Dr. White was Chief of the U.S. Weather Bureau and served as the first President of the National Oceanic and Atmospheric Administration.

In this era of almost infinite technological possibility, one is struck by the fact that pervasive effects on society of specific technological developments were not understood or predicted at the time of their introduction. The invention of the steam engine, for example, and the age of steam power started from very modest beginnings. The steam engine was invented in Britain to pump water from coal mines. Only much later did steam power become the basis for railroad transportation systems. When railroads were first put into operation, they were visualized only as overland ways to connect canal transportation systems. In many cases transportation innovations developed outside the industry that was providing services with the old technology. Few surface or maritime transportation companies foresaw or participated in the air transport revolution. Carriage makers did not participate significantly in the development of the automobile. Stagecoach companies did not participate in the development of the modern railroads that supplanted them.

The predictions of even the best experts can be subverted by unpredictable economic and political events and our transportation industry has been particularly subject to these uncertainties. We need look no further than the consequences of the 1973 oil shock. It was believed by oil experts that by 1985 we would be paying $2.00 a gallon for gasoline at the pump. The present glut of oil was unforeseen by virtually all the experts.

The uncertainties of predicting our technological future are paralleled by our present self-doubts about our ability to compete industrially in a global economy. One of the keys to being competitive in a global economy lies in our ability to provide safe, efficient, and low-cost transportation for goods and services.

For some years we have become inured to news about the deterioration of the U.S. competitive position in the global economy. Our television and newspapers assault us each month with news of the state of the trade deficit. We learn that we have become the greatest debtor nation in the world. Our concerns are reinforced every day as the U.S. dollar bounces around historic lows against currencies of our trading partners. We are unbelieving as we note that the trade balance in agriculture products has turned negative. Even in key technology industries our trade balance is not to our advantage. Toward the end of last year, however, a little-noticed but significant milestone was added to the lengthening list. In the third quarter of 1987, the trade balance in services turned negative for the first time in memory.

To fully understand the importance of transportation in rectifying this situation, we need to step back and place the transportation industry in perspective. It is common to structure the debate about U.S. competitiveness in the global economy principally in terms of the competitiveness of U.S. manufacturing industries. In this case the manufacture of aircraft, especially large passenger aircraft, has been one of the few bright spots in an otherwise grim picture. We continue to enjoy a trade surplus in aircraft. Unfortunately, we are all aware of the dismal situation in surface transportation, especially in automobiles, subway cars, and the moribund maritime industry.

Transportation, however, plays a special role because it is both a manufacturing and service industry. Seventy-five percent of the U.S. workforce is engaged in service industries, and employment growth in the United States during the past decade has been almost totally in the service sector. Services are the circulatory structure of the entire productive system. Service industries do such diverse things as provide and distribute energy, control and move information through communications networks, and generate new knowledge and new technology through research and development. Service industries allow the management and financing of the nation's entire productive system and are the way we organize ourselves to meet essential needs such as health care. Transportation services are the bloodstream of the circulatory structure.

We need to recognize that the U.S. economy consists of interdependent productive systems that include not only manufacturing but also services. Although each of these sectors exhibits considerable internal diversity, there is a technological-ecological principle at work that renders each sector dependent on all other sectors for the level of its productivity. In this industrial ecology the service industry and the service dimension of transportation occupy a central role because they hold an important key to costs of the entire national productive system.

The most important feature of modern economic reality is the now-universal understanding that the harnessing of science and technology for economic growth is the way to change the rules of the game. We see this in the burgeoning economies of Japan and Germany; we see it also in the newly industrialized countries of the Pacific Rim and in the growing economic power of Brazil and India among the developing nations of the world.

The future of the transportation industry, like other industries, clearly rests with the application of science and technology. The transportation industry's role in our national response to competition from abroad is complex, reflecting the complexity of the competitive issue itself. Competitiveness is determined by economic policy. It is a product of tax policy. It is dependent on political relationships. It is affected by the regulatory environment. It responds to financial relationships and, last but not least, it depends on the invigorating contributions of science and technology. The transportation industry is affected by and in turn affects the competitiveness of all other U.S. industry in a global economy.

The cost of capital translates to the cost of aircraft or manufacturing plants and the ability to install a subway system; the dollar/yen ratio translates to competitive costs of equipment and access to foreign markets and competitiveness of the engineering workforce.

Issues related to environmental regulation and public acceptance of new large infrastructure needs of transportation for roads and airports translate to delays in construction, increased costs, and further deterioration of transportation capacity. The political dimensions of competitiveness translate to favorable financing by governments to companies abroad and penetration and servicing of markets in developing countries. The large passenger aircraft industry is particularly subject to this phenomenon.

The transportation industry is both a technological driving and a driven force. It is one of the major markets for high-technology products. It is a user of materials, propulsion, energy, and computer and information technologies. Whether it is the application of information, electronics, and computer technology to increasing the capacity of highways; the introduction of new tracking, monitoring, and information systems for control of air traffic; or new superconducting propulsion systems for railroads, the transportation industry is both developer and user of key technologies.

Your conference can play an important role in laying the basis for a national strategy to advance the development of safe, efficient, and low-cost transportation systems. However, whatever strategy emerges, it will be only part of the broader issue of developing a national strategy for harnessing science and technology for economic growth and ensuring the competitiveness of all U.S. industry, whether in manufacturing or services. Such a national strategy needs to be shaped around three major thrusts.

First, we need to regain lost competitiveness. Our national strategy must encourage manufacturing and service industries to adopt the goal of sustained improvement in products and services. We need to conceive and actually treat these activities as integrated systems from design through engineering, production, and marketing. The aircraft manufacturing industry has done this well. Our automobile manufacturing industry is doing much better. Marshall McLuhan some years ago observed that "the medium is the message" in an information society. We need to become more aware that "the process is the product." This simple concept needs to be embraced by the management of American corporations large and small.

The evidence is growing that solid progress is now being made in U.S. manufacturing industries. But such concepts are applicable to service industries as well. If services are to be competitive in the world marketplace, and this is particularly true of transportation, the quality, speed, and customer satisfaction of services will need the closest attention.

The second major thrust needs to be a drive to capitalize on technology in the economic marathon set in motion by the globalization of the economy. It will be essential that we look to the long-term health of the engineering and scientific research and development enterprise and its connections to both manufacturing and service industries. The research infrastructure must be able to produce and capitalize on the technology on which our future economic growth and competitiveness will depend.

What is wrong with the current system? By some measures we are doing fine. We invest more money in research and development than any other nation by far. In 1987 we will have spent about $125 billion on R&D. Our system remains the most innovative in the world. Our most severe problem lies in our inability to reap the economic benefits of translating fundamental discoveries into commercial products as rapidly as some of our competitors do.

We have begun to do useful things. The National Science Foundation has put into place its Engineering Research Centers and will soon augment them with Science and Technology Centers. Industry has pioneered new alliances with the universities, and universities themselves are exploring new ways of linking with industry. Much of what still needs to be done by government is to create an environment favorable for the commercialization of technology, and many of the necessary actions lie outside the realm of engineering and technology. Economic, tax, regulatory, health, and environmental policies directly affect the ways in which and the degree to which technology advances in industrial applications.

We need to be bolder still in our thinking about how government and industry can respond to these challenges by fostering research and development on commercially useful technologies. What is the logic? Simply that the nature of competition in a global economy has changed. We now confront the world in which other countries have structured their technological policies and programs to achieve global competitiveness while we have been content that our present structure can meet the new challenge. Like it or not, other countries as a matter of policy have now developed government-industry relationships able to focus resources in key technological areas with a view to increasing market share, whether in aircraft, automobiles, machine tools, or transportation systems. They have adopted policies that enable them to invest in key technologies for the long term and have insulated these activities from the vagaries of short-term market forces.

If we are to play in this game successfully, we need mechanisms appropriate to our system that permit long-term investments that individual companies cannot make. One focus of these efforts must be on technological development activities that bridge the gap between scientific discovery and commercialization. The government is already actively pursuing such a course, but in an ad hoc and largely opportunistic way. There has been no broad policy recognition that there should be a government obligation and therefore no consistent approach to the problem.

This is what we need to do.

- Recognize that certain strategic, commercial, and defense industrial research and development needs warrant special attention and government support when the private sector is unable to marshal the resources to meet these needs.
- Increase long-term government investment in research on technological problems whose solution is essential to the industrial health of this nation and focus on strengthening the processes that lead from discovery to commercialization.
- Develop institutional mechanisms to respond to private-sector initiatives from industries prepared to shoulder a significant part of the financial burden for important R&D on industrial strategic technologies and be prepared to capitalize on discoveries to encourage engineering development such as in high-temperature superconducting materials.
- Involve industry directly in the decisions about resource allocation and modes of achieving results.

The third major thrust involves the need to strengthen our educational systems across the board. If our R&D infrastructure has a weakness, so too does our educational infrastructure. Why is this so important? Simply, unless the United States is a place where value is added to products, then we cannot be competitive in a broad range of economic activities with other nations with low wage rates and growing technical and scientific capabilities.

Mathematics and science education from kindergarten to the 12th grade must be strengthened. Math and science attainments of these students in the United States lag seriously behind those of our industrial allies. Problems also exist at the university level. The simple fact is that there has been decreased interest in careers in science and engineering among our own citizens. We have become dependent on foreign students in our graduate schools of engineering. We need to increase the numbers of American citizens seeking university degrees in engineering and science.

To sum up, three concepts need to be central elements of a national technology strategy for economic growth and competitiveness. First, we must focus on the processes of manufacturing and service industries to achieve quality and customer satisfaction in U.S. products and services at low cost. Our objective is to regain competitiveness where it has been lost.

Second, we must invest in our research infrastructure in new ways. The objective is to ensure the creation of new technology and to foster transfer from scientific discovery to commercialization.

Third, we must take steps to strengthen education systems. The objective is to ensure the future science and engineering talent pool.

Either we can face a dynamic future with competitive U.S. industries and continued rapid economic growth, with attendant improvements in standards of living, environmental quality, and health care, or we can face a future of gradual deterioration of the industrial productive capacity of this country relative to other countries, with all of the unfortunate consequences that would flow from that situation. The choice is ours.

SESSION 1

Economic Growth and Vitality

The Role of Public Infrastructure in the 21st Century

DAVID LEWIS, DANIEL HARA, AND JOSEPH REVIS

IMMEDIATE PROSPECTS FOR THE U.S. economy appear optimistic. There has been an extended period of expansion since the recession of the early 1980s. In its 1988 Annual Report, the Congressional Budget Office (CBO) reports a 2.9 percent growth of real output in 1987, the third consecutive year for this level of growth (*1*). The year 1987 also saw a sharp decline in the unemployment rate (Figure 1, *top*) and an acceleration of the growth rate during the year. This output growth was led by growth in exports and business inventories, indicating an improved trade position and growing business confidence. Recent statistics have continued the good news. The seasonally adjusted trade deficit has moved lower, and the total number of employed in the economy continues to rise. Although the unemployment rate has moved upward recently, this is due to the increased labor-force participation rate. More people are seeking jobs now that employment opportunities are expanding. The stock market crash of last fall has apparently had little impact on the economy.

On the inflation front, the trend appears to be for slightly higher but stable prices. A lower U.S. dollar, rising food and energy prices, and the increased

David L. Lewis is currently Partner-in-Charge, Division of Economics and Policy, J. F. Hickling Management Consultants, Limited, Toronto, Canada. Previously he was a principal with the Congressional Budget Office. He is the current TRB chairman of the Committee on Transportation for the Transportation Disadvantaged. Daniel Hara is Senior Consultant at J. F. Hickling Management Consultants and is completing his Ph.D. in economics at Carleton University in Ottawa, where he received an award as most outstanding doctoral candidate in economics. Joseph Revis has been Director of Transportation Planning with Louis Berger Inc. since 1987. Before that, he headed his own consulting firm, which specialized in transportation management and planning.

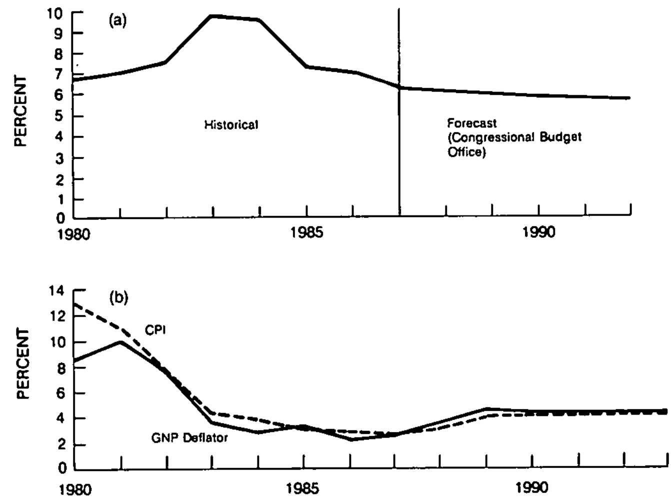

FIGURE 1 Unemployment and inflation: historical and projected trends (*1*). (*a*) Civilian unemployment rate, 1980–1987, with forecasts to 1993; (*b*) inflation 1980–1987 with forecasts to 1993.

demand of a growing economy have put pressure on prices, leading to recent moves upward. Inflation increased in 1987 (see Figure 1, *bottom*). However, monetary authorities are expected to continued a policy of firmness. Recently, interest rates have been allowed to rise slightly, dampening demand. Most short- to medium-term forecasts indicate a steady fall in the rate of unemployment and a stable rate of inflation. For example, Wharton Econometrics forecasts an average inflation rate of 4.3 percent as its baseline case to the year 2011. This is roughly in line with the CBO forecast in Figure 1.

However, a sanguine short-term outlook must not obscure persistent structural problems in the U.S. economy that, if uncorrected, could dampen prospects for long-term growth and vitality. The huge federal deficit, an adverse balance of payments, and America's dubious standing as the world's leading debtor create adverse conditions for strong and stable long-term economic growth. To this list must be added problems in the nation's transportation infrastructure, the subject of this conference. The purpose of this paper is to examine infrastructure requirements within the context of the nation's outlook for long-term growth and vitality.

The following section surveys the macroeconomic landscape and highlights some of the major structural impediments to long-term economic growth. Next long-term targets and forecasts for the U.S. economy are compared to determine what might represent a reasonable goal for U.S. economic growth. Finally, the transportation infrastructure is discussed in the context of long-term macroeconomic goals. The role of highways, transit, and other public works infrastructure in helping to diminish the risk of economic decline and to foster the macroeconomic conditions for long-term growth and stability is addressed.

The Long-Term Macroeconomic Landscape

Short-term expectations in fiscal and monetary policy and the near-term prospects for economic growth can blur one's perception of the economy's underlying ability to support long-term growth and vitality. An examination of "structural" aspects of the economy can shed light on fortunes that lie ahead on the more distant economic horizon. First the outlook for the federal deficit as a source of structural barriers to long-term economic growth is reviewed. Then the economic outlook for the United States is examined and the question is posed: Is the current forecast for economic growth one with which Americans should be satisfied?

Outlook for the Federal Deficit

At $150 billion, the federal government's budget deficit in fiscal year 1987 was actually well below the projections of most analysts (*1*, p. 49). But according to CBO and Wharton Econometric Forecasting Associates, the good news is already past. They project that if current policies are continued, the deficit will likely rebound to $157 billion in 1988 and $176 billion in 1989, and fall below $170 billion only slowly thereafter.

If a deficit of this magnitude were caused by a deep recession, the deficit itself would not be reason for long-term concern. It would serve to cushion the recession and would dwindle as the economy recovered (2). But the current deficits have persisted in an economy substantially recovered from recession. They are "structural," not temporary. As shown in Figure 2, the structural deficit (the deficit that occurs with full, noninflationary employment and output) stands well above that of major foreign competitors.[1] Both in their own right and in relation to international competitiveness, high structural deficits pose a serious threat to the long-term growth and vitality of the United States.

If an economy is to grow, it must have a high level of investment in plant, equipment, and other forms of capital. To maintain a given level of investment, a nation must either save an equivalent amount from its current income or obtain capital from abroad (2). Now national saving is the sum of private and government saving. When the government runs a budget deficit, it

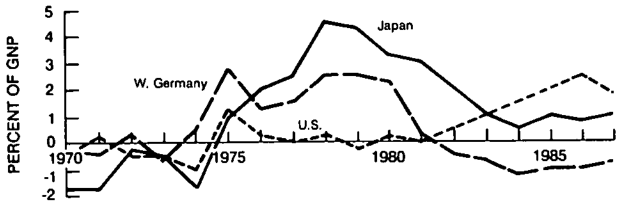

FIGURE 2 International comparison of structural deficits (*1*).

"dissaves," and national saving goes down commensurately unless private businesses or individuals increase their saving to make up for it. Between 1972 and 1981, net national saving in the United States was about 7 percent of the gross national product (GNP). Between 1982 and 1985 it was only about 3 percent. The difference is attributable to the large rise in the budget deficit on top of a slight fall in private saving.

The impact of the deficit on domestic saving is compounded by a shortage of private saving. The United States has had one of the lowest savings rates among industrial nations both from 1960 through 1985 and from 1979 through 1985.[2]

What has been the impact of this savings shortage? Analysis offered by The Brookings Institution is compelling. The Brookings analysts argue (*3*) that this dearth of national saving put upward pressure on interest rates and would have cut U.S. investment drastically had it not been for a substantial inflow of capital from abroad. This inflow of foreign funds has kept U.S. interest rates from rising higher, thereby preventing additional decline in investment levels—but also has exacted a heavy cost. Capital inflow means high foreign demand for dollars and, hence, a high value for the dollar in foreign exchange markets. An expensive dollar, in turn, impairs the competitiveness of U.S. firms in international markets. Both export industries, including agriculture, and industries competing with imports found their markets shrinking. The result has been injury to both labor and capital in industries affected by international competition, as well as slower growth of the economy as a whole.

More recently, exchange rates have moved lower, but the impact of a large structural deficit remains the same. If continued over the long run, large budget deficits will either reduce domestic investment or be financed by increasingly uncertain, and potentially reversible, capital inflow from abroad. In either case, living standards of U.S. citizens would fall: a reduced level of investment would retard the growth of the economy, and continued heavy foreign investment would send a larger share of U.S. output abroad in payment of debt service or other returns to foreign investors.

Therefore the continuing deficit is an ever-present structural handicap to future growth and vitality. This theme will be discussed again later.

Long-Term Economic Outlook

Real output (GNP) may be viewed as the product of the number of workers times the production per worker. Potential future growth in output will come from one of these two sources—more workers and greater productivity per worker—or from both.

The Labor Force The labor force is expected to grow more slowly in the future than it did in the past. Long-term projections developed by Wharton Econometric Forecasting Associates and Informetrica Ltd. (*4*, *5*) indicate average annual growth in the labor force of 1.3 percent in 1988 falling to 1.0 percent between 1998 and 2011. In contrast, labor-force growth was as high as 2.9 percent per year between 1976 and 1980. This slowdown reflects both lower population growth and smaller increases in labor-force participation. An aging population implies fewer younger workers entering the work force.

Productivity If current policies are continued, most forecasters foresee total productivity in the United States growing on average by about 1.4 percent over the next quarter century, reflecting about 3.4 percent growth in manufacturing productivity [see Table 1 (*4*)]. The low level of growth in overall

TABLE 1 Long-Term Outlook for the U.S. Economy: Percentage of Average Annual Growth of Key Economic Indicators, 1987–2011 (*4*)

	Baseline	High-Case	Low-Case
Inflation	4.3	3.8	4.7
Productivity			
Total	1.4	1.5	1.1
Manufacturing	3.4	3.5	3.3
Imported oil	5.6	4.4	6.6
Employment	1.2	1.7	0.6
Real disposable income	2.3	3.2	1.5
Real GNP	2.6	3.2	1.8
Consumption	2.3	3.2	1.2
Investment			
Nonresidential	3.6	4.5	2.4
Residential	1.2	2.0	0.3
Government expenditures	1.8	2.4	1.1
Exports	4.4	4.2	4.2
Imports	2.3	3.3	1.1

productivity reflects, among other things, the poor measured performance of productivity in many of the service sectors.

Real Output When the forecasts of labor-force and productivity growth are combined, the 25-year baseline outlook for overall economic growth is 2.6 percent a year, with rates above or below this level implying a falling or rising rate of unemployment, respectively. A more detailed picture of the baseline outlook is summarized in Table 2.[3]

TABLE 2 Long-Term Outlook for U.S. Economy: Baseline Outlook

	1988	1989	1990	1988-1992	1993-1997	1998-2005
GNP (current dollars)	6.1	6.6	5.8	6.3	7.1	7.5
GNP (constant dollars)	2.3	2.4	1.7	2.5	2.9	2.6
Automobile consumption	0.7	1.6	−3.2	1.4	1.2	1.7
Construction output	−0.7	−1.1	−5.3	−0.2	1.9	3.4
GNP deflator	3.7	4.0	4.0	3.7	4.1	4.8
Personal consumption deflator	4.6	4.7	4.4	4.2	4.6	4.7
Commercial paper rate (%)	7.4	8.7	7.6	7.5	7.3	7.6
Bond rate (%)	11.1	12.2	11.0	10.5	9.5	9.7

What Is a Satisfactory Growth Goal?

Does 2.6 percent represent an "adequate" rate of economic growth? Ralph Landau, a consulting professor of economics at Stanford University and a fellow of the faculty at Harvard's Kennedy School of Government, argues (see Figure 3) that if the long-term rate of U.S. economic growth is not increased to its historic level of some 3.5 percent (in gross domestic product, which is the

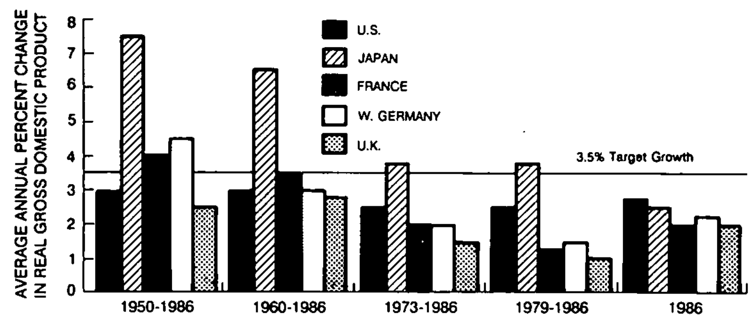

FIGURE 3 International comparison of economic growth (*3*). (© 1988 by Scientific American, Inc. All rights reserved.)

value of all goods and services produced within a country's borders, differing from GNP in that it excludes net international transactions) (*3*, p. 44), "the ever greater employment opportunities and ever higher levels of material well-being to which most Americans have grown accustomed will no longer be possible." Landau then goes on to pose the following question (*3*, p. 44): Is there a way for the U.S. to maintain a high growth rate and thereby ensure for itself both the benefits of growth and a more prominent position of global economic leadership?

The authors agree that higher-than-forecast rates of economic growth are indeed necessary to sustain U.S. competitiveness and living standards; they also believe that there is a way to bring about the conditions for accelerated growth and that the nation's transportation infrastructure has an important role to play in that process.

The key lies in the nation's productivity. Diminished productivity poses what is perhaps the greatest risk to the nation's long-term economic competitiveness and standard of living. Productivity growth, on the other hand, offers enormous rewards. For the individual and the nation as a whole, higher productivity allows U.S. industry to maintain and increase wage levels while remaining cost-competitive with foreign industry.

An increase in the projected growth rate in overall productivity of 0.8 percent a year would be sufficient to bring overall economic growth to the target level of about 3.5 percent over the long term (Figure 4). Although the amount may seem small on an annual basis, the compound effect over many years is substantial.

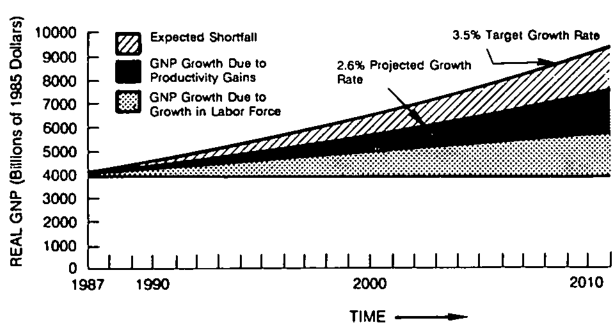

FIGURE 4 Productivity and labor contributions to real GNP growth (*4*).

The long-term forecast for real output growth can be thought of as a combination of the labor-force growth and productivity growth. Some adjustment can be made for further reductions in the unemployment rate as well by substituting employment growth for labor-force growth. Labor-force growth rates of 1.3 percent per year from 1987 through 1997 and 1.0 percent from 1998 to 2011 are forecast. This reflects both a slowing of source population growth and much slower increases in participation rates compared with the 1960s, 1970s, and early 1980s. Productivity growth of 1.4 percent per year is the current baseline forecast for the U.S. economy, with 3.4 percent in manufacturing. This low level reflects to some extent the poor measured performance of productivity in many of the service sectors. When combined, the measure of potential growth is about 2.6 percent per year. Rates below this level imply a rising unemployment rate; above, a declining one.

Of course, the productivity problem cannot be viewed in isolation. Productivity growth is linked to the funds available for private and public investment in new technologies and other productivity enhancements for services, manufacturing, and public infrastructure. This in turn is linked to the size of the deficit and other considerations. In the following section the determinants of productivity and productivity's role in shaping the nation's long-term economic future are discussed in more detail.

PRODUCTIVITY, NATIONAL ECONOMIC GROWTH, AND IMPORTANCE OF CAPITAL INVESTMENT

A nation's economy can produce more goods and services either by employing more factors of production, principally labor and capital, or by increasing the productivity of those factors—the amount of output per unit of resource input.

Historically, it has been productivity growth that has been crucial to U.S. economic growth. Landau reports work by Solow and others attributing up to 85 percent of past growth to productivity increases, as opposed to increases in the quantity of labor or capital (*3*, p. 46).

Recent U.S. productivity growth has been poor. Landau reports that whereas the factor productivity of the U.S. economy had increased by an average of 1.19 percent per year between 1913 and 1950 it actually declined by about 0.27 percent per year between 1973 and 1984.

Capital Investment as a Catalyst of Productivity

What lies behind this collapse in productivity? One may separate this question into labor productivity and capital productivity. It is well known that the productivity of labor, in addition to relying on the quality of labor, depends on the total quantity of capital per worker. The greater the capital intensity per worker, the more leverage the worker has on production.

Low U.S. savings rates have led to low investment and low growth in capital investment per worker. The result has been a low labor productivity growth and low growth in national output per worker. Landau illustrates this effect through comparison with other industrialized nations; Figures 5 and 6 show that, in comparison with other industrial nations, U.S. savings rate, investment in capital per worker, productivity growth, and per-capita national output growth are all low. West Germany and France, which have investment rates roughly twice the U.S. rate, also enjoy about twice the growth rate in productivity.[4,5]

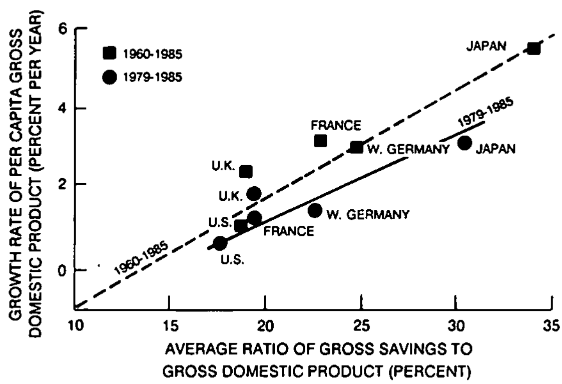

FIGURE 5 International comparison of savings rates (3). (© 1988 by Scientific American, Inc. All rights reserved.)

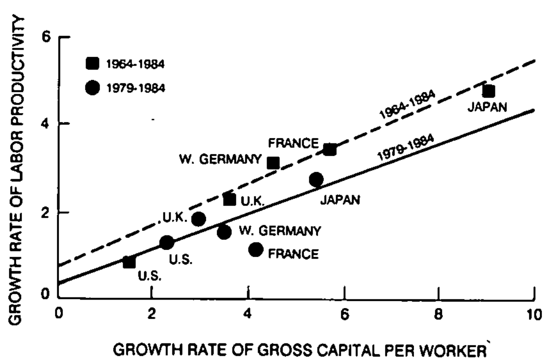

FIGURE 6 International comparison of growth rates of capital per worker (3). (© 1988 by Scientific American, Inc. All rights reserved.)

The importance of capital investment to productivity has been confirmed by work attributed to Dale Jorgenson of Harvard, which suggests that the productivity of labor is significantly affected by the per-worker rate of capital investment—the amount of money spent in building up the nation's capital stock. Jorgenson has also shown that the growth rate in Japan's factor productivity has been heavily influenced by the high rate of capital investment in a number of industrial sectors. Landau points out that the high rate of Japanese investment was at least twice as high as the rate in many U.S. industries (see Figure 6).

A Virtuous Circle

Less well documented, but of enormous potential importance, is the effect of the rate of capital investment on the productivity of capital.

Because new capital embodies the latest technology, it is clear that the more rapidly new capital is added to the capital stock, the faster the average productivity will grow. The significant, though less obvious, point is that the rate of technological progress itself is dependent on the rate of capital investment. The more quickly new capital is added to the capital stock, the better the quality of that capital will be in terms of embodied technology. This in turn means higher productivity and higher growth.

How is it that capital investment stimulates technological advances and productivity growth? According to Landau (*3*, p. 47), the answer is to be found in the way technological change is incorporated into capital (Figure 7). He argues that except for a small part devoted to basic science, research and development is seldom undertaken unless its results are expected to be applied in new facilities and superior operating modes that can increase productivity, reduce costs, or raise the quality of goods and services. Therefore a larger rate of investment creates a market for technological improvements, spurring technological advance.

Landau goes a step further and suggests that the faster technological advance in turn spurs further investment. This can establish a "virtuous circle" that drives further high rates of growth (Figure 7). Capital investment leads to research and development to improve technology, which in turn creates further incentive for capital investment.

The effect of this proposition is shown in Figure 8. Rate of economic growth is constant (Curve *1*) as long as capital formation (the construction of infrastructure, new factories, and production equipment), labor-force improvements (the training of workers), and technological change (the development of new inventions) take place at a constant rate. When capital formation is encouraged by changes in a nation's economic policy, the growth rate

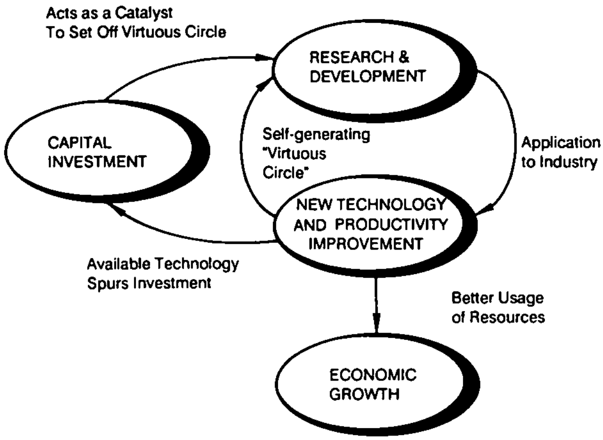

FIGURE 7 Economic growth through capital investment (*3*).

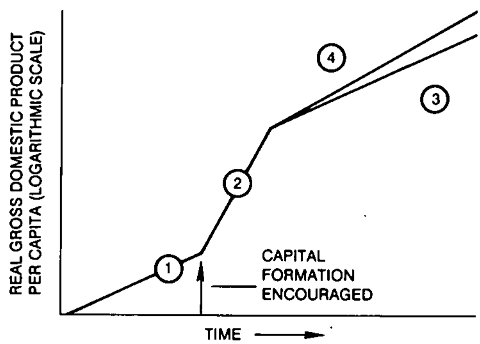

FIGURE 8 Effect of capital formation on the economy (*3*). (© 1988 by Scientific American, Inc. All rights reserved.)

increases (Curve 2), because the nation acquires a greater capacity to supply goods and services. If there are no interactions among the rate of capital formation, the quality of the labor force, and the pace of technological change, the economy returns to its original rate of growth in the long term (Curve *3*). But if increasing the rate of capital formation accelerates the rate of labor-force movements and stimulates technological innovation, there may be a longer-term increase in the rate of growth (Curve *4*). Otherwise, growth will tend to fall back to its original rate after the initial increase in investment rates is past.

Statistics on U.S. research and development are consistent with Landau's proposition: As was the case with the rate of capital investment, the rate of U.S. R&D has fallen behind that of international competitors. U.S. research and development expenditures as a percentage of GNP are compared with those of Japan and West Germany in Figure 9. Total U.S. research and development expenditures have traditionally been higher than those of Japan and West Germany. Since the mid-1970s the other industrialized nations have caught up with the United States. Although total R&D spending is currently on a par with that in Japan and West Germany (Figure 9), the increase in defense research beginning in 1980 (Figure 10) has choked off nondefense spending, which is currently below that of Japan and West Germany (Figure 11) and the gap is widening.

Although much of Landau's analysis relates to private investment, there are certain obvious equivalents in the case of public capital formation. Not until 1985, when Congress authorized $8 billion in federal investment in the nation's air traffic control system, did it also authorize the Federal Aviation Administration (FAA) to begin in earnest a program of research and development in advanced automation. This was because air traffic control automation is expected to create $36 billion worth of productivity improvements for the FAA, for airlines, and for airline passengers in the form of fewer delays and thus more time for productive work *(6)*.

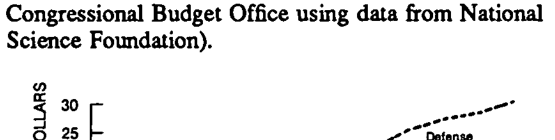

FIGURE 9 Research and development expenditures in selected countries as percentage of GNP (Source: Congressional Budget Office using data from National Science Foundation).

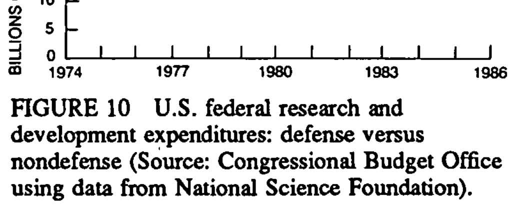

FIGURE 10 U.S. federal research and development expenditures: defense versus nondefense (Source: Congressional Budget Office using data from National Science Foundation).

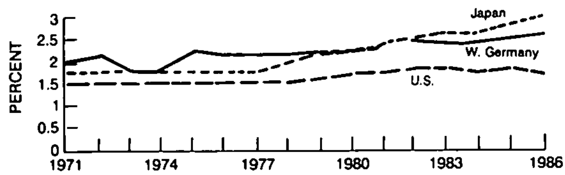

FIGURE 11 Nondefense research and development expenditures in selected countries as percentage of GNP (Source: Congressional Budget Office using data from National Science Foundation).

A similar example is apparent in the case of federal highway investment; Congress has authorized, in association with a large increase in level of federal highway spending, the Strategic Highway Research Program, a $150 million, 5-year program of research and development into more efficient and productive highway maintenance and construction methods.

From all of this it may be concluded that the rate of saving and capital investment is crucial to achieving higher productivity for the United States. In addition, it appears that increased quantity of capital investment has significant additional benefits in increased quality of capital investment through stimulation of technological advance.

The complementary relationship between quantity and quality of investment is one that should be preserved. For private investment, market forces will naturally ensure that greater investment calls forth greater innovation. For public investment, market forces are weak, and a deliberate effort must be made by infrastructure managers to take advantage of the opportunities for innovation afforded by increased investment. This issue is explored in the next section.

Public Works Infrastructure and National Economic Growth

It has been established that higher rates of capital investment are key to the future growth of productivity and income for the nation. What, then, is the role for investment in public works infrastructure in particular?

Public works are a fundamental and necessary part of the nation's total capital stock. The decline in the national rates of investment and productivity growth are reflected in the decline in investment in public works. Figure 12 shows that the percentage of GNP spent on public works has declined consistently since the 1960s. If one excludes operations and maintenance and considers capital investments alone, capital expenditures have fallen to half

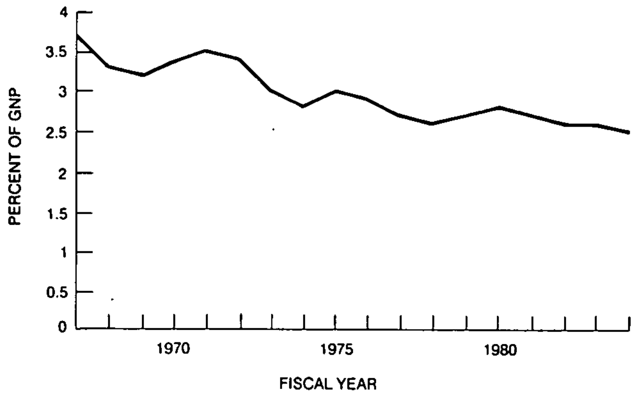

FIGURE 12 Public works outlays as percentage of GNP (Source: Office of Management and Budget, Bureau of the Census, and Economic Report of the President).

their previous rates, from 2.5 percent of GNP in the 1960s to approximately half that rate today.

The decline in public works investment has, in fact, been more severe than the decline in investment as a whole. In the 1960s public works capital investment was \$14 to \$15 for every \$100 of private sector investment. In more recent years it has been a ratio of \$6 to \$8 for every \$100 of private investment (7, p. 9). This declining ratio indicates that inadequate infrastructure may act as a significant constraint on private-sector productivity growth.

Any strategy to boost productivity and achieve higher economic growth for the United States must include a renewed commitment to the maintenance and enhancement of the public works infrastructure. Key is the economic infrastructure, such as all modes of transportation, which serve the industries.

To say that more infrastructure investment is necessary, however, is to partly miss the point. Not only more public works investment is needed, but better investment. As with other forms of capital, the chief hope for increased economic growth comes not solely from the quantity of capital, but from improved productivity through more efficient and better-suited technology.

The achievement of better public investment will require attention and concerted action. In the case of private-sector investment, more investment will lead to better investment. The "virtuous circle" of capital expansion and technological advance will be naturally driven by profit-seeking market forces. In the case of public investment, where market forces are weak, an effort must be made to ensure that innovation in the public sector matches and enhances productivity gains in the private sector.

Better public investment is indeed possible. It should be borne in mind that the word "technology" applies not only to the hard science and engineering of bridges and airports, but also to the means of organization and investment. An airport or harbor built in the wrong place and managed poorly will not increase productivity. Directing investment dollars to their most effective points of impact and ensuring that facilities are efficiently used will enhance the nation's total productivity and increase the worth of each additional dollar invested.

Federal infrastructure investment serves a useful example. CBO argued that federal infrastructure management practices could be substantially improved (*8*). Many federally aided public works programs fail to identify and evaluate in consistent terms the proper mix of new construction, rehabilitation, and operational improvements needed to provide the infrastructure base that a sound economy requires. These failures can lead to overinvestment in inefficient systems, disregard for national rather than local needs, inability to achieve the best and most productive use of facilities through pricing, and lack of appropriate and timely information for decision making. A reversal in these trends would translate directly into stronger national productivity and economic growth.

Three types of improvements can be identified:

- Better identification of infrastructure options,
- Better evaluation of options, and
- Improved use of incentives for infrastructure users and managers.

Identification of Options

A key problem here is actually goal identification. Many federal programs have tended to be oriented on specific physical standards rather than performance goals. For example, during the 1960s and 1970s there were substantial programs to assist and improve existing urban mass transit systems. These were undertaken during a period in which increased reliance on the automobile was making mass transit less important and the growing pattern of daily traffic was between suburbs and urban centers. A more effective program of investment might have been directed at roads or at developing frequent and reliable new transit services between suburbs and urban centers. Had the goals of the program been more functionally defined, such as for "urban mobility," the broader range of possible options could have been identified and evaluated.

Typical features of programs that artificially limit consideration of options are as follows:

1. *Use of design standards over performance standards*: Because of apparent ease of administration, programs are often defined in terms of physical

standards rather than policy objectives. For example, consider a program to modernize bus fleets rather than improve urban transit or a program that maintains road condition regardless of the usefulness or traffic volume on the road. Similar concerns will arise over regulatory programs as well as spending programs. To ensure efficient use of resources, regulations should be sensitive to the possibilities of emerging technology. For example, it is likely that the productivity of some airport runways will be enhanced by the availability of microwave landing systems, provided the FAA reduces the distance between planes during takeoff and landing.

2. *Restriction of assistance to physical capital costs*: Capacity improvements may come from sources other than the expansion or construction of additional facilities. Improvements in management, in traffic-handling technology, and so on, might meet needs more efficiently but be ineligible for funding.

3. *Restriction of assistance to specific jurisdictions*: If a program offers assistance only to mass transit authorities, alternative solutions such as carpool lanes and improved parking regulations may be overlooked.

In general, programs that restrict local choice as to how to best meet intended goals will result in efficiency loss. Improved federal infrastructure programs will allow state and municipal authorities the opportunity to define the best means of achieving program goals in their communities. A positive example of this is the current ability of cities to reallocate Interstate highway funds to other roads, highways, or mass transit. Permitting these transfers has allowed states to opt out of constructing the most expensive segments of the planned Interstate system and to substitute projects that bring better transit improvements per dollar invested.

The theme of defining program goals functionally and of decentralizing the choice of methods of execution to the local level is especially important given future trends in industrial organization and transport. Increased computer capacity and satellite communications are having the long-run impact of decentralizing production. Physical proximity of firm units is becoming less important, and proximity to local markets is becoming of greater importance. Complementary developments can be seen in the growth of just-in-time inventory control and of networked truck dispatching. As production moves out of the urban centers to the suburbs and disperses to local manufacturing and service sites across the country, local authorities will have an increasingly better grasp than central authorities of the transport needs in their areas. The federal role will be most effective in defining broad program goals and in setting such macroeconomic targets as the overall level of investment in transportation infrastructure.

Evaluation of Options

Once options have been identified, the next logical step is evaluation and comparison. Procedures in this area have historically suffered from several problems, discussed in the following paragraphs.

Use of Comparable Values In order to compare options, a common unit or method of evaluation must be applied between them. All costs and benefits should be identified. For example, consider the objective of increasing the capacity of a waterway to handle larger ships. Two choices may exist—raising the level of a bridge or dredging a channel. Raising the bridge may seem cheaper until the cost of delaying traffic is considered. In a broader context, comparison of projects between modes also requires common units. Different transport modes should be placed in competition for the same budget dollar.

Risk and Sensitivity Analyses Major points of vulnerability of programs should be identified and, if possible, programs should be altered or protected to minimize their effect. A positive example of this would be the FAA's 1982 proposal to modernize the nation's air traffic control system. The program benefits depended in part on the closing and consolidation of some air facilities and on air traffic projections. Risk analysis discovered that the benefits of this program were not too sensitive to the accuracy of the air traffic forecasts but were quite sensitive to the prospect of closing certain air facilities. A 5-year delay of these consolidations would cut the benefits of the program in half. Maintaining the pace of consolidation was thus identified as a key factor in ensuring the plan's success. In addition, some portions of the program were found to be marginal in their impact.

The introduction of microwave landing systems was somewhat premature for the costs involved. Net present values were positive for only some airports, and selective implementation of this option was pursued. Note that this is an excellent example of the importance of technological innovation at the management level. The use of advanced evaluation techniques revealed that an apparent advance in science and engineering technology was not a net contribution to productivity for many airports. Just as not all investment is good investment, not all apparent productivity gains are in fact gains to the economy.

Life-Cycle Costing Federally sponsored appraisals of projects are commonly based on the costs and benefits anticipated for a single year in the middle of the life of a project. This assessment technique disregards the timing of costs and benefits. Projects with large up-front costs and delayed benefits will be less worthwhile than projects with more favorable timing. A preferable alternative would be to assess the cost-and-benefit profile of a project over its entire life cycle.

Use of Discount Rates To evaluate the worth of costs and benefits over different periods, the appropriate discount rate should be used. The use of discount rates gives a heavier priority to projects that offer earlier payoffs or postpone costs to later dates. Discount rates should also account for risk. Projects that are riskier for society should offer higher rates of return before they are undertaken.

Incentives for Users

Charging users for the use of services can have several valuable functions that improve the productivity of transport facilities:

1. *More efficient use of facilities*: Fees will help users account for the cost burden that they place on the taxpayer and other users. For example, higher landing fees at airports during peak-hour periods will help ensure that the users during the peak are those who place the highest value on that time slot. Air traffic that does not require landing at a given time will shift to cheaper time periods. Thus a scarce resource, runway time, is allocated to those who can make the greatest use of it.
2. *Savings on capacity requirements*: When users are required to pay the costs they impose on transport systems, any increases in capacity required to meet that demand will be known to be justified. Alternatively, if users do not pay the full cost, there will be an increase in demand for capacity stemming from reasons not justified by the cost.
3. *Reductions in costs*: If users are asked to pay the additional costs imposed by their use of facilities, they will take better account of how the manner of their use affects costs. For example, if trucking licenses were tied to the impact of vehicles on road maintenance, this would affect the nature of trucking technology employed.
4. *Demand signals*: The willingness of users to pay for the cost of their services provides a signal to the provider of the need for the service. If people are unwilling to pay, the service may not be worthwhile. If an excess of people are willing to meet the cost, more of a facility may be called for.

It should be noted that user fees should not be used as exclusive criteria for public investment. It must be remembered that user populations usually spring up after the infrastructure investment is undertaken. From time to time, public investment requires a leap of faith in the vitality and future growth of the economy in order to bring that future into reality.

Incentives for Public Managers

Current funding systems have many incentives that distort management decision making and direct projects away from efficient solutions. For example, trust fund revenues that are restricted to specific uses encourage either overinvestment in selected areas or the postponement of needed projects so that they may be financed out of these restricted funds at a later date. Similarly, matching federal grants create the incentive for state and local managers to undertake investment projects whose return exceeds only the local government's share of the cost rather than the whole cost.

Preferable are grant programs that allow flexibility at the local level while requiring final proposed plans to meet program objectives on a cost-effective basis.

Indicative Macroeconomic Planning

The foregoing discussion has given some examples of how public infrastructure productivity could be increased. The combination of innovations in this area would eliminate substantial waste and promote more efficient use of current resources, with the net effect of greater productivity for each infrastructure dollar invested.

To the previous suggestions one more can be added: a national commitment to attain the higher levels of productivity and growth must include a national plan for infrastructure investment. In particular, an aggregate goal for total investment expenditure should be set that is consistent with the increased investment required for increased growth.

A stable long-term commitment to increased investment in infrastructure is necessary to

- Prevent the current levels of infrastructure investment from constraining private-sector productivity growth,
- Sustain and enhance a national effort to increase private-sector productivity growth,
- Encourage infrastructure innovation at the science and engineering level, and
- Motivate innovation in the allocation, evaluation, and management of infrastructure investment.

Naturally, infrastructure investment alone will not bring about the desired level of economic growth. However, it is a necessary part of any national plan. Japan and West Germany, two countries of special interest because of their high economic growth rates, both use 5-year infrastructure plans (9). These plans set aggregate spending levels and include breakdowns by geographic area, mode, and "targeted" industries. In Germany's case, the 5-year plan is on a rolling basis. It is recast annually to look 5 years into the future. These infrastructure plans are part of a larger plan for growth. Target industries are identified as having the greatest potential for growth, and infrastructure investment is used to promote them as growth centers. Typically these industries are export oriented.

In the context of lower exchange rates and an increased need to earn foreign exchange to pay for foreign borrowing, the United States must face the requirement for a concerted national effort to promote its industries and enhance its productivity. A plan to promote infrastructure growth would require local governments and industry to provide the details when applying for funds and through direct consultation. Nevertheless, there is a federal responsibility to establish and maintain the macroeconomic indicators necessary for such planning. These include both aggregate investment levels for public investment and a restrained fiscal policy (deficit) to ensure an adequate supply of savings for private investment.

FINANCING INFRASTRUCTURE EXPANSION

A related planning concern is how an increased level of public infrastructure investment should be financed. There are three essential sources of funds: user fees, general tax revenue, and borrowing. Some specific comments are relevant on each of these.

User Fees

The virtues of charging fees equal to the costs that users impose on a system have been outlined. As such, user fees are and will be an important source of funds. It is important, however, not to confuse the efficiency rationale of setting user fees equal to the marginal cost imposed by the user with obtaining 100 percent financing through user fees. There are many potential reasons why efficient user fees may not add up to 100 percent financing. The classic example is mass transit. Those who take the subway are not crowding the streets with their cars during rush hour. Thus it is in the interest of automobile drivers to subsidize mass transit through their taxes to ensure that the roads are less crowded. In general, if it were possible to set user fees that accurately covered total cost, there would be little reason for government involvement in the first place. The private market could provide the service. Government involvement in infrastructure exists precisely because 100 percent financing through user fees is inefficient.

Tax Revenue

Given that there will be some inevitable portion of infrastructure financing that must be covered through taxes or borrowing, taxation is preferable from a growth perspective. The government's power to tax and then invest the proceeds in the economy is a collective means of forcing a higher savings rate in the economy and achieving the common goal of higher growth.

Borrowing

If there is a constraint on tax revenue, borrowing will be necessary to finance infrastructure investment. By definition, borrowing increases the deficit. The concern raised in this paper is that the high deficit has raised interest rates and reduced private investment in the economy. However, a distinction must be made between deficit borrowing that is used to finance tax cuts, implicitly increasing consumption, and borrowing that itself is used to finance public investment in the economy. If the public investments are undertaken wisely, the latter form of deficit pays for itself by generating future income for the nation. The decision is one of a relative preference between public and private investment as a source of growth. Because both are necessary, the concern over the size of the structural deficit should not be used to inhibit or prevent the necessary expansion of public infrastructure investment.

Conclusion

There is a need for a national commitment to economic growth. If the United States is to experience an increasing standard of living and preserve its world leadership role, higher growth rates than those currently forecast must be achieved.

Higher growth rates require increased rates of capital investment, both private and public. Increased investment will promote growth by increasing the productivity of labor and accelerating the rate of technological advance.

To achieve these higher levels of investment, national government must establish firm macroeconomic goals. The deficit must be controlled to liberate savings for private investment, and a target for increased investment in public infrastructure must be established and maintained.

Investment in transportation infrastructure must play a key and necessary role in any plan to achieve higher productivity and growth. Increased productivity in the private sector can be matched by technological innovation in public-sector investment. Technology must be perceived to include the way investments are identified and undertaken. There exists great room for improvement in the identification of investment options, their assessment, and the regulation of their use. These include

- Freeing of local governments from non-goal-oriented funding criteria,
- Comprehensive assessment of alternative mode options to meet given transport needs,
- Use of practical cost measures that account for life-cycle costs and the timing of benefits, and
- Use of user charges to ensure more efficient use of existing facilities and to guide the establishment of additional facilities.

These innovations, combined with an overall commitment to higher investment levels, will bring the U.S. greater economic growth, productivity, and international competitiveness.

ACKNOWLEDGMENT

The authors are indebted to Michael J. McCracken, President of Informetrica, Ltd., for many important suggestions. The authors would also like to thank Mark Haney and Kevin Smyth for their excellent suggestions and assistance in the preparation of this paper. Responsibility for any errors and omissions is, of course, the authors' alone.

NOTES

1. Alice Rivlin has argued that the structural deficits in the federal budget are the result of actions taken by the President and Congress in 1981, when Congress enacted the Reagan program of cutting taxes, increasing defense spending, and reducing domestic spending.
2. Citing Boskin, Landau (*3*) reports that the savings rate of Japan is from two to nearly three times that of the United States, depending on how it is measured. A high savings rate allows the Japanese to make heavy long-term domestic and international investments while still financing government spending on infrastructure and other public priorities. It also explains why the effective cost of Japanese capital has been from one-half to one-third as great as that of American capital.

3. The U.S. outlook is drawn from current projections of Wharton Econometric Forecasting Associates. It suggests no significant effect of the 1987 stock market crash on consumer or investor behavior in the United States, although housing starts level off at 1987 levels to slow the growth of construction activity. Emerging inflation from wages in 1988 and from import prices late in the year lead the Federal Reserve to increase interest rates. This raises real interest rates, measured as the commercial paper rate less the percentage change in the GNP deflator, to 4.7 percent in 1989 and 3.6 percent in 1990. This rate does not fall below 3 percent until the year 2000. The near-term monetary action is supplemented by a $40 billion tax increase following U.S. elections, and growth and steady labor force slows to less than 2 percent for four quarters beginning in May 1989. After this event, growth is steady but at decelerating rates, reflecting slowing labor-force growth and steady labor-force productivity gains of 1.5 percent overall and 3.8 percent in manufacturing through the late 1990s. The deficit of the U.S. federal government falls significantly below $170 billion only after 1990, and the current account deficit exceeds $100 billion throughout the outlook. This implies continuing pressure on the U.S. exchange rate.
4. National savings rates correlate with per-capita growth rate, because a country's aggregate savings account represents a pool of money on which companies can draw for capital formation. As can be seen in Figure 5, the United States had one of the lowest savings rates among industrial nations, both from 1960 through 1985 and from 1979 through 1985. The flatter scope of the line through the more recent data indicates that growth rates in general have declined throughout the world since 1979.
5. Growth rate of capital per worker determines how quickly the productivity of labor rises. Because the United States has not increased its investment in capital per worker as fast as Japan has, labor productivity has grown at a lower rate in the United States than in Japan over the periods from 1964 through 1984 and from 1979 through 1984. The steeper slope of the line for the data from 1964 through 1984 (Figure 6) is a result of the fact that Japan and other countries were then "catching up" to the United States by constructing more new plants that incorporated the latest technology.

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Respondents' Comments

DAVID J. FORKENBROCK I am a planner with a background in microeconomics in a session that is fundamentally related to macro- or national-level topics. Yet I feel very comfortable with my charge of responding to the resource paper written by Lewis et al. I am comfortable because the exogenous macrolevel trends they are concerned with will establish the context within which all transportation policy choices must be made. I am interested in how these policy choices can best build on or at least cope with the major forces acting on state and regional economies.

The resource paper represents an articulate expression of what cannot be emphasized too strongly, that increased productivity and capital investment are the keys to a prosperous future. To be sure, productivity is a complex topic that is worthy of an entire conference at least.

What we need to do here, though, is to consider which transportation policy directions are most likely to foster productivity increases. Likewise, capital investment becomes more attractive when the prospect of a favorable return is enhanced, and wise transportation policy most definitely can help make an area attractive.

This suggests that maybe we ought to spend a lot more on transportation in an attempt to make all parts of our nation attractive to capital investment. But, as Lewis suggests, the rub is that transportation investments must be efficient. Efficient transportation choices are those that move society closer to attaining specified goals. The key here is that, at least in a general way, the goals must be agreed on. Without a consensus, coherent strategies cannot be formulated.

As transportation professionals, we are going to have to become increasingly interested and involved in economic development strategy formulation. Not all good goals are compatible. And what is relatively good in the short run may be less than good in the long run. Don't you get the feeling

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David J. Forkenbrock is Director of the Public Policy Center at the University of Iowa. He is also a professor of urban and regional planning and civic and environmental engineering. In 1987, he coauthored Iowa's strategic plan for economic development.

that U.S. transportation policy needs to be a little less myopic? We need to try harder to balance short-term benefits with longer-term objectives.

Let me illustrate how transportation policy needs to be formulated in the context of longer-term social and economic goals, in this case, at the state level. Two years ago, two colleagues and I were commissioned to write a strategic economic development plan for the state of Iowa. That state, like others, is undergoing a major economic transformation. It is trying to cope with macro forces beyond its control.

Our objective was to assess the state's strengths and weaknesses and to suggest policy directions in a variety of areas, including infrastructure. We spent a fair bit of time examining macro trends and their implications for the state.

One trend that is affecting much of the Midwest is the emerging decentralization of manufacturing. Major corporations like General Motors are purchasing more of their components from other suppliers and taking delivery just in time to assemble their products. This outsourcing strategy has led suppliers to look for low-cost arrangements to be competitive. Some are locating plants in small to medium-sized communities where labor and other costs tend to be relatively low.

With agriculture becoming less viable, part-time farming is becoming more pervasive. Farmers from the surrounding areas represent prospective employees for these scattered plants. As new patterns of commuting emerge, rural areas with declining populations are generating increased vehicle miles on what remain fairly low-volume roads.

So, here is the long-term policy question: Should the state invest more extensively in secondary roads to serve these oftentimes long rural commuting trips? One one hand, badly needed jobs are being created, jobs that appear to rely on subsidized roads. On the other hand, part-time farming and the longer rural commutes may not be a lasting economic phenomenon. They may just be a transitional adjustment to a changing macroeconomic structure.

If that really is the case, the best public policy might be to maintain certain roads so that they last just long enough to ensure service to this generation. Upgraded, higher-quality, more expensive facilities would be inefficient. The same resources could be placed to better use over the long run.

To be sure, using transportation to help guide and accommodate economic transition is good public policy. But this implies that choices can and will be made—such as sustaining rural areas versus maximizing overall state growth. How many states do you know of where long-run economic development strategies are actually guiding decisions regarding the allocation of transportation resources? My state certainly hasn't progressed this far.

Lewis et al. mention that bad decisions regarding transportation investment can adversely affect economic growth. And well they can. Given the chance, economists and planners can produce impact analyses that quite accurately tell decision makers the long-run consequences of alternative transportation investment choices. These analyses can tell us how well specific actions would support developmental strategies.

Between now and the year 2020, strategic economic development planning should be a major part of all capital facilities planning, including transit and highways. Not being sensitive to macro forces, not basing transportation investments on impact analyses, and not taking a strategic view can lead to inefficient projects. Speculative construction of highways to assist lagging regions well may prove inefficient if the desired capital investment by businesses doesn't follow.

This being the case, a cross-subsidy from users of other facilities and taxpayers generally is likely to result. The higher taxes and user charges lead to a less competitive environment for new growth. In this case, the policy followed would have exactly the opposite effect of that intended.

Likewise, not building facilities that would make society better off results in opportunities lost. Lewis et al. are right when they say that we need to redirect transportation investments to make them more goal oriented. Doing so favors productivity growth and invites capital formation.

I was a bit surprised that the authors didn't say more about the rather uniform practice of underpricing the use of transportation facilities. It really can't continue all the way to the year 2020. States that allow facilities to deteriorate and then pass the cost of their reclamation on to the next generation may find that the next generation will invest its capital elsewhere. Capital, you know, is highly mobile.

Efficiency-based transportation policy, the authors correctly argue, is capable of keeping the overall cost of business lower. Charging vehicles for the damage they impose leads to efficient facility use, not overuse. Technological adjustments are likely to follow the economic signals that well-reasoned, consistent policy sends.

I am not so sanguine about the likelihood of the federal government's establishing the macroeconomic goals that the authors call for. Most of the key policy decisions, I think, will end up being handled by the states. Life-cycle costing, more carefully reasoned resource distribution criteria, and innovative user taxation are examples of emerging policy directions being taken by some of the more progressive states.

In the last few pages of their paper, the authors lay out a lot of the right issues. They take an appropriately hard stand on the need for transportation policy to become more focused, more goal-oriented. We need to ask how transportation investment, pricing, and technology can play a more active role in making the states and the nation more competitive in a changing world.

ROBERT W. CRANDALL Transportation infrastructure or even macroeconomics is not my field. I am a microeconomist who spends most of his time looking at things like government regulations and specific industries like automobiles and steel where investment decisions haven't always been very efficient.

I made up my mind very early, looking at the paper by Lewis et al., that I did not want to talk about long-range economic forecasts. The reasons for that are clear. Go back to 1973 and 1974 and take a look at the forecasts that were being made then and ask yourself whether you would like to try to forecast the next 14 years.

The one consideration that is very difficult to predict, of course, is the political one. In 1974, the world's developed economies were in the hands of liberal governments that accommodated a substantial amount of inflation. Look at how the world has changed since then. More conservative governments have taken a much more aggressive stance toward inflation. That has a lot to do with why the growth rates have slowed down.

It was unthinkable in the early 1970s that you would have a German government saying that we really can't reduce the unemployment rate much below 10 percent for fear of creating inflation. The whole policy environment has changed. Now it could change back; I don't claim to be a political forecaster any more than an economic forecaster.

The thrust of this paper is that we need more infrastructure because we have had a slowdown of economic growth and productivity growth. We need to increase productivity growth, which, after all, is the only way in which we can increase the real standard of living.

What I think is missing from the paper, however, is any evidence that there is an infrastructure slowdown, a slowdown, by the way, that has occurred in most developed countries. The irony of this is that we had a reduction in the share of investment of societal resources going to infrastructure and an increase going to social spending just at the time that the size of governments was increasing. Obviously, the reason for that is political. That is, particular interest groups are forming to use government to generate large increases in transfer payments at the expense of other uses of government tax monies. So we have had in many, if not all, western developed countries an increase in the ratio of transfer payment spending to total real spending in government.

Second, I am not sure that you can show that much of the decline in productivity growth is due to infrastructure spending. In fact, perhaps I could make the argument the other way: one of the reasons we have had a slowdown

Robert W. Crandall is a Senior Fellow in Economics at The Brookings Institution. He joined Brookings in 1977 after spending 11 years with the Economics Department of the Massachusetts Institute of Technology.

in infrastructure spending is that we have had a slowdown in economic growth caused by a decline in productivity growth, which came some time in the late 1960s or early 1970s.

Third, keep in mind that in the goods-producing sectors of the economy (not in mining because oil dominates mining), productivity growth has actually rebounded. It is in the service sectors of the economy where productivity growth continues to be dreadful, as low as one-half a percentage point per year. In manufacturing, productivity growth is back to pre-1973 levels at the present time, surprisingly enough.

But I don't know and I didn't see cited in the paper any evidence or studies that suggest that infrastructure is really the problem. There is the Jorgensen analysis, which, of course, has changed over the years but which attributes a lot of the decline in productivity and growth to a slowdown in the rate of capital formation relative to the size of the labor force but also to a sharp rise in energy prices. The learning, at least the thinking, on the effects of energy prices is changing now because we have obviously had a sharp downturn in real energy prices since 1981, and overall there has not been that remarkable a turnaround overall in productivity growth in the U.S. economy. There has been in manufacturing, but as I mentioned before, not in other areas.

Now, the problem with the call for increased spending in infrastructure is that obviously infrastructure expenditures are guided by politicians. They are guided by the political process. They are not market-based decisions. If we want to look at what the federal government has recently been doing in infrastructure spending, we aren't likely to be very reassured.

There has been a continuing expenditure of $2 billion to $3 billion a year on municipal sewage treatment plants through municipal sewage treatment grants allocated by the Environmental Protection Agency. We have had repeated studies by the General Accounting Office saying that they don't know whether these are doing any good in terms of the quality of the water because there are no systems for measuring whether these plants are working very well. Moreover, there is considerable evidence that these investments have been gold plated and that they are excessively capital intensive.

We also have a solid waste problem in this country, even though there is a very simple solution to that problem, namely, to build incinerators. In a developed society, and particularly in the densely populated areas of that developed society, land disposal becomes more difficult. It becomes a cause for some concern on safety and health grounds, but high-temperature incineration is the obvious solution, and yet we don't build the incinerators.

In recent years, we have had an enormous increase in Superfund expenditures. This is in a government program that underwrites the excavation of sites around the country to remove toxic chemicals buried there, even though for most of these sites there is very little evidence that they have caused any harm yet. Nor is there any evidence that we are putting into place mechanisms that will measure whether these excavations, or "clean-ups," are reducing the threat of contamination of the groundwater.

Another example, of course, is the diversion of monies from highways to mass transit, particularly to rail-based mass transit, in cities like Los Angeles and Dallas. It is very hard to believe that those investments are likely to be efficient, but of course, they appeal very much to congressmen and senators from those areas.

The part of the paper by Lewis et al. that I like the most (of course, it appeals to me as a microeconomist) is the part that deals with the efficiency of the use of infrastructure. It is in this area that I think we have enormous room for improvement. The political pressures are all against using the price system to allocate the use of infrastructure of transportation facilities, of water facilities, or whatever.

I was in New York last night, and at an intermission of the New York City Ballet, I noticed a sign in the refreshment stand area that said "Save water." Now, there were no signs that said "Save copper, save iron ore, save wool, save clothing," The sign said "Save water." The reason is obvious—the City of New York has never found a way to price water effectively and as a result, people are drawing it at a zero price even though its cost is substantial.

Another example is obviously airport landing fees. I was late in getting to this meeting in no small part because of the queue at La Guardia and National airports. That queue exists because we don't ration airport space very efficiently. Instead, we talk about the need for more airports despite the fact that we don't use them very efficiently.

Right now, I am working on a study of the breakup of AT&T. For years politicians have opposed the pricing of telephone services according to their cost. We have had a remarkable decline in the cost of providing long-distance telephone service, and yet the politicians have been very resistant to the idea that we ought to reflect these cost reductions in long-distance rates. The reason is obvious; they like to cross-subsidize from long-distance calls, which are paid for principally by businesses, to local service, so that local citizens will not have to bear the full brunt of the cost of local connections to the network. Of course, the large businesses have the alternative of going to private networks and avoiding overpriced common carriage rates—just as they did with trucking services before deregulation.

I could go on and on—you know the examples. So it seems to me before we talk about necessarily increasing infrastructure, we have to talk about using it more efficiently. I also like the discussion about designing it more efficiently. Again, I'm not sure politicians are much disposed to arguments for efficiency.

Let me, in this part of my comments, refer to an article by a colleague of mine. Clifford Winston and Kenneth Small, from the University of California at Irvine, in this month's *American Economic Review*, argue that the decisions that have been made in building the Interstate highway system—the engineering decisions—have been all wrong. As a result, we have built our highways too thin, they are wearing out much sooner than they should have, and we could save countless billions of dollars a year if only we were to build those highways much thicker. Even though the capital charges would be higher, the annual maintenance would be a lot lower.

There are lots of examples like that. The Rural Electrification Administration subsidizes electrical systems and telephone systems, so we build telephone systems in rural areas the same way we build them in a large city. That doesn't make any sense, either.

Let me close by saying that I think the plea for more infrastructure, whether justified or not, whether supported by the evidence that infrastructure would generate increases in economic activity, economic product in productivity or whatever, is going to have a very difficult time in this town over the next few years for the obvious reasons. Government has put itself in a position of making it very difficult to propose direct increases in spending.

The next administration is likely to try to figure out all sorts of ways to increase off-budget types of expenditures. The push is on now for all sorts of mandated benefits to be provided by employers, not to be provided by the government through direct expenditures, but rather to be provided by private employers as mandated by the government.

For example, we have had a huge rise in spending on health, environment, and safety in just this fashion. These mandated regulatory expenditures increased in real terms during the Reagan Administration after actually declining during the Carter Administration.

I think you are going to have to find ways to bring these expenditures off budget, and for that I think you need considerable political ingenuity.

RICHARD R. MUDGE The key questions that are discussed in this paper concern what the level of spending should be on infrastructure, transportation, and public works, and how that relates to more efficient spending.

The first half of the paper focuses on the relationship between future U.S. growth and international competitiveness as a direct function of the productivity with which we use our labor resources, our capital resources, and so forth.

Richard R. Mudge is cofounder and principal at Apogee Research, Inc. He is an economist and regional scientist and has served as chief of the Public Investment Unit with the Congressional Budget Office.

It is a very strong plea that increased capital investment implies improved technology and improved R&D, and results in that very nice "virtuous circle."

The one question that is not directly addressed and is very hard to address is, What is the role of public investment versus private investment in general in terms of reaching that virtuous circle? Classically, you should look at what the economic returns are from the marginal investment in public works and compare that with the returns from private-sector investments or the returns from other public expenditures.

Now, it is very hard to do this even on a project-by-project basis. It is clearly impossible to do it in general on a macro basis—all the public works versus all the private investments. However, let me quote someone else who has tried to take a look at this. There is an interesting piece of work that has been done by David Ashour at the Federal Reserve Board of Chicago, who looks at the link between the level of nondefense public investment and private rate of return on private capital.

If you plot these two curves over 30 years, you find an amazing similarity. When public investment peaked in the 1960s, so did the private rate of return on capital. In turn, both these lines hit bottom—at least I hope they hit bottom—in the 1980s. In fact, Ashour shows that if you increase public investment by, for example, a billion dollars a year, there will be more than a billion-dollar decrease in private investment.

Now, at first glance, you would think that that's a crowding-out phenomenon. His data imply or show, however, that if you have a 10 percent increase in the public capital stock, the private returns on capital will increase from 9.9 percent to 12.6 percent. Again, all this stuff is done with econometrics, so it is subject to some skepticism, but at least it is interesting that it does imply a direct interaction between the level of public investment and the level of private investment. If the level of public investment is too low, you may end up with inefficient private investments as well.

In fact, let me quote what Ashour considers, I think, a summary: "To the extent that the marginal product of public capital may very well exceed that of private capital and private technologies, therefore, further public capital accumulation is required to drive down its productivity on the margin to equal that of private capital." So, his conclusion is that more public spending is better.

Let me look at this in another, somewhat simpler way. Lewis showed a graph from work that was done for the National Council on Public Works Improvement showing that total public investment in public works had been trending downward for the last 25 years.

If you focus on the components of that spending, the change is even more dramatic. For example, if you look only at operations and maintenance across the last 25 years, you will find that as a percent of gross national product (GNP), there's been very little change. In fact, we are spending slightly more as a percent of GNP to operate and maintain our public works than we did 25 years ago—about 1.3 to 1.5 percent.

If, however, you look at the capital spending, which is the key for looking at the investment levels, in 1960 the nation was spending roughly 2.5 percent of the GNP on public works capital investment. Today, it is about 1.1 percent. Now, that doesn't help policy people much because there is no way of saying, Is 1.1 percent or 2.5 percent the right level or something in between? But, clearly, the nation has made a conscious or unconscious decision to shift resources elsewhere.

If you look at capital investment by mode area, you see certain differences. For example, with highways there is a tremendous drop in capital investment. In fact, the drop is so sharp that it almost looks as though we had discovered a new technology for moving people around. And, if someone had appeared from Mars and looked at the charts and said, "Here's our level of spending in the 1960s, here's what we are spending in the late 1970s and early 1980s, we're spending roughly half of what we did before," it looks again as though a new way of moving people had been discovered. But, I think the new way is just to move them more slowly.

If you look at areas like mass transit, we are clearly spending more on capital than we were in the past, and that presumably is partly to make up for previous decades of underinvestment. You can also take these trends of capital spending and convert them into asset values. In fact, if you do that and make some general assumptions, you can say that the nation's total investment in public works is roughly one $1 trillion.

Again, if you look category by category, you'll see in certain places, with highways being the most dramatic, that we are actually disinvesting. Our net assets invested in highways are slightly lower than they were 10 years ago. More useful, perhaps, is to compare the spending level with how we use these facilities. After all, unless you are a major contractor, you do not invest in public works for the sake of pouring more concrete, but because of the services that they provide.

In a comparison of highway investment (which peaks and then comes down again), in constant dollars, with the use of the highway system, that is, the vehicle miles traveled, there is a tremendous gap, like jaws opening up, after 20 or 30 years, where the lines have been roughly comparable in terms of rate of growth. Since the late 1960s, there has been roughly a 50 percent decline in annual capital investment in highways at the same time that vehicle miles of travel has gone up by more than 50 percent.

I call this type of graph—if you believe those numbers—the end of the Western World as we know it. Obviously, that hasn't happened. I guess it could happen, but it makes you want to search for some possible explanations, and I have four.

One is that we have become much more productive in our investment in highways and that we are building highways better, we are placing them in better places, and we are getting better use out of them. A corollary to that is that in the past, we invested pretty poorly, we overinvested, and we invested in the wrong locations. Personally, I think it is hard to imagine that there was that dramatic a change in productivity in that short a period of time.

Second, you can argue that the economy is becoming less infrastructure intensive. Certainly the shift from manufacturing services argues that we may not necessarily have to have as much investment in infrastructure in general and highways as well per dollar of output or per use. One factor that offsets this trend a little is that there have been modal shifts away from railroads and toward trucks. Thus, highways have gotten a larger market share. That certainly accounts for some of that change.

Another explanation, which is more of a political one, is that we have found other national investments that have given us a greater return. That basically means that the politicians have decided to spend the money someplace else. Presumably, if they keep getting reelected, they must be reflecting the people's values.

Indeed, if you look at that chart, the major downturn occurred mostly in the 1960s when the Great Society program started, and there was change at least in national investment toward more health and welfare programs.

The fourth possible explanation is, of course, that the data are wrong. That may be true to a certain extent too. I think that there is a tremendous investment going on in what may be called public-private partnerships. It is very hard to measure that, even though these are all official numbers, and therefore they must be right; there are a lot of informal investments in public works that are just not picked up.

In order to close that whole gap, you would have to be spending, say, $35 billion a year on highways in public-private investment if it was a public-private partnership and that probably accounts for a lot, but not all of it.

Again, my personal conclusion is that more spending is better. But you have to be careful about how you phrase that. A very nice study was done several years ago called Highways in the Economy by the Transportation Systems Center, which found that if you spend a little more on highways, you end up with lower unemployment, higher economic growth, lower-growth consumer price index, and all sorts of good things.

However, they also looked at the situation in which highway spending was increased. If you got rid of all the deficiencies in the national system, the economy was lower, the GNP was lower, and unemployment was higher. So you have to remember that even if you think more spending is good, at some point you can always spend too much. You can end up getting into marginal investments that aren't that good.

In this regard, I was a little troubled by the plea in Lewis' paper that a key federal role is to set the overall level of transportation investment. It is not clear to me, first, how you determine what the right level is and, second, even if you did, especially in the U.S. economy, how do you enforce it, how do you make sure that it happens?

In conclusion, let me talk about two alternatives for using economic tools to help determine how much investment should be. The classic economic approach, which is described and summarized very nicely in the Lewis paper, places an emphasis on cost-benefit analysis, rates of return, and efficient pricing, and certainly we could always use more of that.

But I think these types of tools work best on a short-term basis, and they make implicit assumptions that there is no significant change in the production function, that is, how we produce our goods and services or that there is no real significant change in the technology that we use. In a sense, you can argue that if you rely solely on those tools, there may be a tendency to underinvest or perhaps invest too late in public works.

The second approach, and one that is much harder to analyze but, I think, is very much in tune with the first half of the Lewis paper, is to emphasize the role that investment plays in stimulating change and economic growth. In fact, this has been a classic role for transportation, not only in this country but all over the world. I think of examples such as the Erie Canal, which, of course, as we all know, made New York City what it is today.

There are other examples, for instance, the transcontinental railroads, which were clearly built before the demand was there. The Interstate highway system is probably a classic recent example. It is a 40,000-mi system built without a lot of detailed analysis, and I suspect that if you went back and looked at it at that time, you could argue persuasively that a lot of it was overbuilt in terms of the extent of the system. However, it has had a tremendous impact on the way in which we live and on how the overall economy operates. As a whole, it has probably been a financial success.

Again, my conclusion from this, both from the comments that are in the Lewis paper as well as the other areas that I mentioned, is that more is probably better. That doesn't tell you how much is enough, and it doesn't tell you how much is too much. It also begs what I think is probably the most important question, and that is, whether you believe that more is better or whether you believe that spending it more efficiently is better or whether you believe both are, what are the institutions that we need to get this done? How do we change our current programs to encourage more effective overall public investment in public works? I have many opinions but no answers on that.

ARTHUR L. WEBSTER I agree very much with what Robert Crandall said and also, to a substantial extent, with Dick Mudge's comments.

With that introduction, I will say that there are two main processes by which resources are distributed in the United States. One is the economic process, which involves dollars, and the other is the voting, or governmental, process, which involves votes.

I have always viewed the governmental process as probably the major form of market imperfection in the country. By a set of political decisions it takes money from one group at one time and allocates those resources to another group at another time, with practically no provision for the remuneration of the losers by the gainers. And, thus, it transfers vast amounts of wealth both geographically and between groups and very often on a fairly arbitrary basis.

On the other hand, economic theory has shown that competitive market forces tend to lead to efficient solutions and provide high degrees of incentive, productivity, and other desirable attributes. Thus, I have developed a set of recommendations having to do with greater reliance on market forces.

In essence, I'm saying that the distinction between public and private investment is a political decision. One of the respondents has already pointed out that the decisions have become more and more murky because we are getting more and more private-public co-investment in various types of projects.

In my opinion, the analytic mechanisms for governmental allocation of resources are seriously flawed. They are politically unacceptable and almost unused. Many studies have shown that a substantial part of the benefits of transportation investment are in the form of time or lives saved. Yet standard values do not exist for time or life to be used to assess the benefits of transportation. Determining such values may be impossible, because there is little unanimity as to the desirability of such standards or what they should be.

The squabble over something that is much less critical, "discount rates," I think indicates this. We still have different discount rates for different modes, even though we are still talking about the same economy.

Moreover, even if we had perfect sets of analytic parameters and could do total benefit-cost analyses, I'm not sure that we would use that analysis to make resource allocations. Market forces may be a far more efficient way of allocating resources, mainly because with competitive market forces, the beneficiaries of transactions have to pay back those who are contributing the funds for a particular investment.

Arthur L. Webster is President of EXP Associates, Inc., a consulting firm. He spent many years with the U.S. Department of Transportation, serving as Director of the Office of National Transportation Planning and in various positions with the Office of the Assistant Secretary for Policy and International Affairs.

I would like to make a series of fairly conservative recommendations. Consideration should be given to replacing the Highway Trust Fund with a National Highway Bank fed by user-charge revenues, much as the Trust Fund is today, with each contributing state having a separate account containing the user revenue from that state.

As with other banks in the United States, states with accounts could borrow from others' accounts. However, they would bid in terms of interest rates for the available cash, and the interest would be credited to the loaning state's account. That, in essence, would allow those who want to delay projects to leave the money in the bank, drawing the highest interest rates available. It would also allow those who have projects with a very high benefit-cost ratio to invest in those projects, and as a result of getting the benefits, pay back those who lent them money.

In such a scheme, nobody would be hurt and everybody should gain. That is much different from the mechanism by which we now arbitrarily transfer funds from one locality to another. Sometimes those who procrastinate in investment may get more federal funds simply because they have a poorer system or a higher benefit-cost ratio or because the monies are allocated on the basis of an arbitrary formula.

The bank could initially be funded with the balance from the Highway Trust Fund. If the bank were outside the federal government, the federal budget would be reduced by the annual expenditures from the Trust Fund. The arbitrary and probably economically wasteful federal allocation formulas, expenditure categories, and matching ratios would no longer exist.

That is my major recommendation for highways, but one shouldn't consider highways in isolation. My recommendations for the rest of the modes of transportation, briefly, are as follows.

- Place the inland waterway system under a quasi-governmental, self-supporting corporation that charges for its services, and do away with federal user charges. Federal legal liabilities and the federal budget deficit would thus be reduced, and waterway rates would be forced to more accurately reflect the costs of the provision of the service.
- Place the Federal Aviation Administration, air traffic control, navigation, and flight services under a similar quasi-governmental, self-supporting corporation charging for their services. Federal liabilities and the federal budget deficit would again be reduced, and users would have to more nearly pay for the services they receive. Place the FAA airport program and the balance of the Aviation Trust Fund in bank accounts similar to that recommended for highways; perhaps the same bank could be used but with separate aviation accounts by state.
- Abolish the federal urban mass transportation program, but allow states to use the highway monies in their national bank account for mass

transportation. Change the role of the U.S. Department of Transportation to that of safety and environmental regulation and transportation research and development in areas where economies of scale prevail and increase transportation information and analysis programs so as to advise the President and the Congress how well the nation's transportation system is performing.

The above recommendations would have the following benefits. They would

1. Reduce the federal budget substantially,
2. Force transportation prices to more nearly reflect marginal costs,
3. Tend to standardize and internalize safety and environmental costs across modes,
4. Force a more efficient balance between private and public expenditures in transportation and provide for research and development and public knowledge of the transportation system,
5. Reduce the federal transportation responsibilities and the associated bureaucracy and taxpayer liabilities,
6. Force a more efficient balance between competing modes of transportation and between transportation and other sectors of the economy governed by market forces, and
7. Provide states with more flexibility in the expenditure of transportation user-charge revenues from their states and minimize cross-subsidizations between states.

The foregoing would increase competition within transportation and increase incentives for productivity and encourage more return per unit expenditure. In summary, the foregoing transportation recommendations would promote the national economic growth and development discussed in this session.

SESSION 2

Demographics and Life-Style

Population and Employment Change in the United States: Past, Present, and Future

John D. Kasarda

SINCE ITS FOUNDING, THE United States has experienced continuous changes in the size, composition, and territorial distribution of its demographic and employment bases. There is scant evidence suggesting that these changes will cease in the coming three decades. Indeed, indications are that many such changes will accelerate.

In this paper is a broad-brush overview of the demographic and employment dynamics that shaped America in the latter half of the 1980s as well as statistics and projections to give an idea of what that shape will likely be during the first quarter of the 21st century. The paper begins with a post-World War II appraisal of interregional employment shifts and corresponding migration adjustments. Then a discussion of why certain areas have been particularly competitive for demographic and employment growth during the past 15 years and the prospects for the continuation of spatially uneven growth is presented, followed by a series of demographic and employment projections for the census regions, divisions, states, and 100 largest metropolitan areas into the 21st century. The paper concludes with a consideration of the ongoing economic transformation of America's cities from centers of goods processing to centers of information processing and the implications of these transformations for employment opportunity and transportation policy for their resident populations.

John D. Kasarda is Director of the Center for Competitiveness and Employment Growth, University of North Carolina at Chapel Hill. He is Professsor of Sociology and past chairman of the Sociology Department.

Because of the availability of an immense amount of rich data on population and employment trends and projections, only the most germane will be discussed in the text that follows. Additional data, which typically provide greater geographic or temporal details, are presented in tabular form.

REGIONAL REDISTRIBUTION TRENDS

A central feature of U.S. demographic and employment growth has been spatially uneven development. As more efficient transportation and communication technologies evolve, modes of production organization and services transform, labor and natural resource requirements of industry change, and new locations of economic opportunity rise whereas others decline. America's people, in turn, have tended to follow opportunity, leading to marked temporal disparities in the growth of cities, suburbs, nonmetropolitan areas, and even entire regions.

Before World War II, the metropolitan areas of the Northeast and Midwest contained the majority of the nation's industrial locational advantages (excellent deep-water ports, extensive railroad and inland waterway systems, well-developed inter- and intrametropolitan highways, proximity to rich coal deposits, ubiquitous public utilities, a diverse and relatively better educated labor force, and strong local markets). Such externalities provided competitive cost and market advantages to firms locating in metropolitan areas of the North, which allowed them to expand much faster than their counterparts in more isolated, less developed regions of the South and West. In fact, as late as 1950, more than 70 percent of all manufacturing jobs were in the Northeast and Midwest, mostly concentrated in and around the largest cities of the regions.

Since World War II, a number of economic, political, and technological forces have combined to accelerate industrial restructuring and shift the nation's employment growth pole—first to the West and then to the South. The rapid postwar growth of aerospace, defense, solid-state electronics, and other advanced technology industries, together with expanding construction and services, fueled the economies of the far West, especially California. Growth of these industries was instrumental in attracting over 3 million migrants to California alone between 1945 and 1960 (*1*).

With diversified economic expansion continuing in the West, the region's total employment doubled from 1960 to 1985. Nevertheless, the South emerged in the 1960s as the nation's leader in absolute employment gains. Between 1960 and 1985, the South added 17 million jobs to its economy compared with a growth of just over 11 million in the West. During the same period, the

Midwest added 7.3 million and the Northeast just over 5 million jobs (*2*; Current Population Survey machine-readable files, March 1985).

The South's economic surge has been attributed to its improved accessibility to national and international markets via new Interstate highways and expanded airports, shifting energy sources, upgraded public schools and universities, more modern physical plants, sunny and benign climate, air conditioning, and relatively lower taxes and wage rates (*3*, *4*). To these technological and financial considerations were added healthy doses of pro-growth attitudes and industrial solicitation on the part of southern states and communities (*5*, *6*). Thus, although manufacturing employment in the Frostbelt (Northeast and Midwest regions) declined by over a million jobs between 1960 and 1985, manufacturing employment in the South grew by over 2 million. Yet employment growth in southern manufacturing was far overshadowed by substantial increases in construction, trade, and services, which added more than 15 million jobs to the South's economy between 1960 and 1985 (*2*; Current Population Survey machine-readable files, March 1985).

Since the 1980–1982 recession, the Northeast and Midwest have experienced substantial economic recoveries, and overall employment growth in the South has slowed. Nonetheless, as will be documented later, demographic and employment growth in the Northeast and Midwest over the next three decades will likely be far exceeded by that of the South and West.

Migration Patterns

The expanding post-World War II economies of the West and the South sequentially attracted major streams of migrants. Net interregional migration exchanges for the past three decades (Table 1) reflect the shift in the nation's demographic growth poles from the West to the South. Before 1970 the West was the net beneficiary of migration streams from all census regions. These streams were especially large during the 1950s. During the 1970s, the Current Population Survey indicates that more persons from the West began moving to the South than the other way around, and net flows from the Northeast and Midwest to the South rose dramatically. Between 1975 and 1980, overall net migration to the South was twice that to the West. Spurred by a marked increase in net flows from the Midwest, net migration to the South was nearly three times that to the West between 1980 and 1985 (1.9 million versus 649,000). During the period from 1970 to 1985, the Northeast and Midwest experienced combined net migration losses of 8 million people, with the South becoming their predominant destination. Between 1980 and 1985, the Midwest experienced a net migration loss of 1.5 million, of which 1.1 million may be attributed to this region's negative exchange with the South.

TABLE 1 Net Interregional Migration Flows, 1955 to 1985

Regional Migration Exchanges	Net Migration in Thousands				
	1955-1960[a]	1965-1970[b]	1970-1975[c]	1975-1980[d]	1980-1985[d]
South (net exchange with)					
Northeast	+314	+438	+964	+945	+737
Midwest	+122	+275	+790	+813	+1,100
West	−380	−56	+75	+176	+60
Total other regions	+56	+657	+1,829	+1,935	+1,897
West (net exchange with)					
Northeast	+285	+224	+311	+518	+234
Midwest	+760	+415	+472	+634	+475
South	+380	+56	−75	−176	−60
Total other regions	+1,425	+695	+708	+976	+649
Midwest (net exchange with)					
Northeast	+40	+53	+67	+146	+50
South	−122	−275	−790	−813	−1,100
West	−760	−415	−472	−634	−475
Total other regions	−842	−637	−1,195	−1,302	−1,525
Northeast (net exchange with)					
Midwest	−40	−53	−67	−146	−50
South	−314	−438	−964	−945	−737
West	−285	−224	−311	−518	−234
Total other regions	−639	−715	−1,342	−1,609	−1,022

[a] *Census of Population and Housing* (*2*, Vol. 1, U.S. Summary, Table 237).
[b] *Census of Population and Housing* (*7*, Vol. 1, U.S. Summary, Table 274).
[c] Current Population Reports, No. 285 (*8*).
[d] Current Population Survey machine-readable files, 1980, 1985.

What about the demographic composition of the migrants? Table 2 presents the net interregional migration exchanges between 1975 and 1980 and 1980 and 1985 by race and ethnicity. These exchanges, computed from the Current Population Survey machine-readable files, show that non-Hispanic whites account for nearly 90 percent of the net southern migration gains from other regions. Indeed, in the South both the absolute number and percentage of net migrants who are non-Hispanic whites rose from the 1975–1980 period to the 1980–1985 period. In the West, in contrast, the number and percentage of net migration accounted for by non-Hispanic whites declined substantially. Much of this decline is due to a dramatic decrease in non-Hispanic white migration from the Northeast from the 1975–1980 period to the 1980–1985 period.

Of related interest, the net return of non-Hispanic blacks to the South from other regions declined from 194,000 between 1975 and 1980 to 87,000 between 1980 and 1985, with most of this decrease due to a drop in black

TABLE 2 **Interregional Net Migration Flows, 1975 to 1980 and 1980 to 1985**

Regional Migration Exchanges	Net Migration (thousands)							
	Non-Hispanic White		Non-Hispanic Black		Hispanic		Asian and Other	
	1975-1980	1980-1985	1975-1980	1980-1985	1975-1980	1980-1985	1975-1980	1980-1985
South (net exchange with)								
Northeast	731	630	139	30	64	51	12	28
Midwest	762	981	30	67	21	51	2	0
West	145	84	26	−10	20	6	−15	−20
Total	1,638	1,695	195	87	105	108	−1	8
West (net exchange with)								
Northeast	432	166	32	13	26	34	26	21
Midwest	596	416	28	8	−3	12	13	39
South	−145	−84	−26	10	−20	−6	15	20
Total	883	498	34	31	3	40	54	80
Midwest (net exchange with)								
Northeast	141	38	3	6	−1	−11	3	16
South	−762	−981	−30	−67	−21	−51	−2	0
West	−596	−416	−26	−8	−3	−12	−13	−39
Total	−1,217	−1,359	−52	−69	−25	−74	−12	−23
Northeast (net exchange with)								
Midwest	−141	−38	−3	−6	−1	11	−3	−16
South	−731	−630	−139	−30	−64	−51	−12	−28
West	−432	−166	−32	−13	−26	−34	−26	−21
Total	−1,304	−834	−174	−49	−92	−74	−42	−65

SOURCE: Current Population Survey machine-readable files, 1980, 1985.

migrants (59,000) from the economically rebounding Northeast. Furthermore, the non-Hispanic black migration stream (absolute flow) from the South to the Northeast increased by 50,000 between 1975–1980 and 1980–1985.

Table 2 also reveals the accelerating loss of non-Hispanic whites from the Midwest. Between 1980 and 1985, the Midwest experienced a negative net migration exchange of nearly 1.4 million non-Hispanic whites with other regions of the country, up from a net loss of 1.2 million between 1975 and 1980. The accelerated outmigration of non-Hispanic whites from the Midwest was due entirely to an increase in this region's negative net exchange with the South.

More detailed analysis of these data by race and ethnicity shows that during the last 10 years the West has received approximately 1 million Asian immigrants, more than all other regions combined. The majority of these immigrants have settled in California. The West has also been the largest receiving region of Hispanic immigrants, gaining more than 900,000 between 1975 and 1985. The South has exhibited major increases in Hispanic immigrants during the 1980s, following closely behind the West. The South registered increases in Asian immigrants, but still trails the West substantially as the regional destination of this group. Between the 1975–1980 and 1980–1985 periods, Hispanic immigrants to both the Northeast and Midwest regions increased modestly, and Asian immigrants to these regions declined slightly.

The shift in the regional residence of those who enter this country from abroad during the past three decades reflects a major geographic change in principal sending nations. Until the late 1950s, the origin of most U.S. immigrants was Europe, geographically to the east and north of the United States. The majority of these immigrants therefore found their closest port of entry in New York and other northern states. During the past two decades, the territorial focus of origin nations has increasingly shifted to the west and south of the United States (principally Mexico, Latin America, and Asia). As a result, the primary ports of immigrant entry have become Los Angeles, San Francisco, Miami, and Houston. Between 1970 and 1984, more than 1 million Hispanics, Asians, and other foreign-born persons settled in Los Angeles County (9), lending empirical credence to anecdotal reports that Los Angeles has replaced New York City as the exemplary "melting pot" of the nation.

Most Recent Data

The machine-readable files of the 1986 and 1987 Current Population Surveys allow the updating of figures on interregional migration exchanges and movers from abroad for March 1985 to March 1987. These more current data are as follows:

Region	*Net Migration Exchange (thousands)*	*Movers from Abroad (thousands)*
Northeast	–585	412
Midwest	–94	351
South	+315	619
West	+366	960

It may be observed that between March 1985 and March 1987 the Northeast continued to be a major net exporter of population to other regions. Of its net loss of 585,000 migrants to other regions, 394,000 resulted from a negative net exchange with the South, 103,000 with the West, and 90,000 with the Midwest. The economic recovery of the Midwest helped stem its demographic hemorrhage to other regions, with the Midwest losing a net of only 94,000 migrants between 1985 and 1987 compared with a net migration loss of over 1.5 million between 1980 and 1985. Moreover, all net migration loss in the Midwest between 1985 and 1987 resulted from its negative migration exchange with the West. Net migration losses to the South ceased, at least temporarily. The South remained a net importer of people from other regions only because of the continuing substantial flows to this region from the Northeast. The West, on the other hand, regained its position as a net importer of people from all other regions between 1985 and 1987.

The data on movers from abroad to each region show a continuation of post-1970 trends. Over two-thirds of those from abroad settled in the South and West between 1985 and 1987 and 41 percent in the West. As should be expected, Asians and Hispanics dominated immigrant flows to the West and Hispanics those to the South.

With larger international population flows supplementing the positive net interregional migration exchanges of the West and South, population growth of these regions dwarfed that of the Northeast and Midwest throughout the 1980s. Table 3 reveals that between April 1, 1980, and July 1, 1986, the population of the South increased by 7,616,900, the West by 5,512,500, the Northeast by 882,100, and the Midwest by 456,200. In other words, the South and the West accounted for over 90 percent of the nation's 14.5 million population increase between 1980 and 1986. Of this total increase, more than 11 million can be attributed to just three of the nation's nine census divisions: the South Atlantic, the West South Central, and the Pacific.

Tables 4–7 provide longitudinal data on population changes since 1960 for each census region, census division, and state. These data illustrate nicely the

TABLE 3 Region and Division Population, 1980 to 1986 (in thousands) (*10, 11*)

	1986	1980	Change 1980-86 Absolute	Change 1980-86 Percent
United States	241,010	226,542	14,467.7	6.4%
Regions				
Northeast	50,019	49,137	882.1	1.8%
Midwest	59,323	58,867	456.2	0.8%
South	82,984	75,367	7,616.9	10.1%
West	48,684	43,172	5,512.5	12.8%
Divisions				
New England	12,738	12,349	389.0	3.2%
Middle Atlantic	37,281	36,788	493.1	1.3%
East North Central	41,744	41,683	61.2	0.1%
West North Central	17,579	17,184	395.0	2.3%
South Atlantic	40,916	36,958	3,958.5	10.7%
East South Central	15,208	14,666	541.9	3.7%
West South Central	26,860	23,744	3,116.5	13.1%
Mountain	12,946	11,372	1,574.5	13.8%
Pacific	35,738	31,800	3,938.0	12.4%

dramatic tilt of population growth away from the Northeast and Midwest during the 1970s and its continuation through the mid-1980s, with the South expanding the most on an absolute basis and the West on a percentage basis. Comparing census division growth during the 1980s with that of the 1970s, the Middle Atlantic states are faring better and the East South Central and Mountain divisions worse (Table 5). Tables 6 and 7 show that during the 1980s all of the top 10 states in population growth were either in the South or in the West.

COMPETITIVE FACTORS UNDERLYING UNEVEN GROWTH

One major reason for the substantial growth of the South and West during the past two decades has been the ability of their economies to weather recessions.

TABLE 4 Region and Division Population, 1960 to 1986 (in thousands) (*10, 11*)

AREA	1986	1980	1970	1960
United States	241,010	226,542	203,302	179,323
Regions				
Northeast	50,019	49,137	49,061	44,678
Midwest	59,323	58,867	56,590	51,619
South	82,984	75,367	62,813	54,973
West	48,684	43,172	34,838	28,053
Divisions				
New England	12,738	12,349	11,847	10,509
Middle Atlantic	37,281	36,788	37,213	34,169
East North Central	41,744	41,683	40,263	36,225
West North Central	17,579	17,184	16,328	15,394
South Atlantic	40,916	36,958	30,679	25,972
East South Central	15,208	14,666	12,808	12,050
West South Central	26,860	23,744	19,326	16,951
Mountain	12,946	11,372	8,290	6,855
Pacific	35,738	31,800	26,548	21,198

better than those of the Northeast and Midwest. To account for differential local and regional employment performance during economic downturns, industry mix has received a good deal of attention. It is argued that areas in which the economic base is dominated by firms whose products are disproportionately concentrated in cyclically sensitive industries (such as consumer durable goods manufacturing) will experience more severe declines in their local employment during recessions than those areas in which employment mix is less sensitive to recessions, such as those in which higher-order producer service industries predominate (*12–14*).

Conversely, areas with especially advantageous industrial mixes often experience employment gains in the face of recessions and expand much faster than national growth rates during periods of economic prosperity (*14*). These areas have high proportions of young, vibrant industries that are

TABLE 5 Relative Change in State Population, 1960 to 1986 (in thousands) (*10, 11*)

AREA	1980-86 Absolute	%	1970-80 Absolute	%	1960-70 Absolute	%
United States	14,467.7	6.4%	23,240.5	11.4%	23,978.5	13.4%
Regions						
Northeast	882.1	1.8%	76.4	0.2%	4,382.6	9.8%
Midwest	456.2	0.8%	2,276.5	4.0%	4,971.2	9.6%
South	7,616.9	10.1%	12,554.3	20.0%	7,839.7	14.3%
West	5,512.5	12.8%	8,333.3	23.9%	6,785.0	24.2%
Divisions						
New England	389.0	3.2%	501.8	4.2%	1,337.8	12.7%
Middle Atlantic	493.1	1.3%	-425.4	-1.1%	3,044.8	8.9%
East North Central	61.2	0.1%	1,420.1	3.5%	4,037.6	11.1%
West North Central	395.0	2.3%	856.4	5.2%	933.6	6.1%
South Atlantic	3,958.5	10.7%	6,278.8	20.5%	4,707.0	18.1%
East South Central	541.9	3.7%	1,858.1	14.5%	757.9	6.3%
West South Central	3,116.5	13.1%	4,417.4	22.9%	2,374.8	14.0%
Mountain	1,574.5	13.8%	3,081.6	37.2%	1,434.8	20.9%
Pacific	3,938.0	12.4%	5,251.7	19.8%	5,350.2	25.2%

adapted to macrostructural transformations in the broader economy (*15*; *16*, pp. 11–40).

Yet the industrial structure of localities and regions is not always predictive of how their employment bases will respond to business cycles. In the South, for example, substantial employment was added during the most recent recession (1980–1982), despite an overall industrial mix not nearly as favorable as that in the Northeast (*17*). Analysis of employment change among all 3,100 U.S. counties further reveals numerous counties with unfavorable industrial mixes that exhibit marked employment gains during recent national recessions, whereas other counties with favorable industrial mixes experience considerable employment decline, even during periods of national economic prosperity (*17*). Such localities possess competitive advantages or disadvantages that overcome both the effects of national business cycles and their industrial composition in affecting employment growth.

To measure these competitive effects and assess their role in regional job growth and decline, shift-share techniques were applied to analyze employment changes in all counties within each region during the last two recessions (1974–1976 and 1980–1982) and the business cycle upswings following

TABLE 6 State Population, 1960 to 1986 (in thousands) (*10, 11*)

AREA	1986	1980	1970	1960
Alabama	4,053.0	3,894.0	3,444.4	3,266.7
Alaska	534.0	401.9	302.6	226.2
Arizona	3,242.0	2,716.6	1,775.4	1,302.2
Arkansas	2,372.0	2,286.4	1,923.3	1,786.3
California	26,981.0	23,667.8	19,971.1	15,717.2
Colorado	3,267.0	2,889.7	2,209.6	1,753.9
Connecticut	3,189.0	3,107.6	3,032.2	2,535.2
Delaware	633.0	594.3	548.1	446.3
Dist. of Columbia	626.0	638.4	756.7	763.9
Florida	11,675.0	9,746.9	6,791.4	4,951.6
Georgia	6,104.0	5,462.9	4,587.9	3,943.1
Hawaii	1,062.0	964.7	769.9	632.8
Idaho	1,003.0	944.1	713.0	667.2
Illinois	11,548.0	11,427.4	11,110.3	10,081.2
Indiana	5,504.0	5,490.2	5,195.4	4,662.5
Iowa	2,851.0	2,913.8	2,825.4	2,757.5
Kansas	2,461.0	2,364.2	2,249.1	2,178.6
Kentucky	3,727.0	3,660.3	3,220.7	3,038.2
Louisiana	4,501.0	4,206.1	3,644.6	3,257.0
Maine	1,174.0	1,125.0	993.7	969.3
Maryland	4,463.0	4,216.9	3,923.9	3,100.7
Massachusetts	5,832.0	5,737.1	5,689.2	5,148.6
Michigan	9,155.0	9,262.0	8,881.8	7,823.2
Minnesota	4,216.0	4,075.9	3,806.1	3,413.9
Mississippi	2,625.0	2,520.8	2,216.9	2,178.1
Missouri	5,066.0	4,916.8	4,677.6	4,319.8
Montana	819.0	786.7	694.4	674.8
Nebraska	1,598.0	1,569.8	1,485.3	1,411.3
Nevada	964.0	800.5	488.7	285.3
New Hampshire	1,027.0	920.6	737.7	606.9
New Jersey	7,620.0	7,365.0	7,171.1	6,066.8
New Mexico	1,479.0	1,303.3	1,017.1	951.0
New York	17,772.0	17,558.2	18,241.4	16,782.3
North Carolina	6,331.0	5,880.4	5,084.4	4,556.2
North Dakota	680.0	652.7	617.8	632.4
Ohio	10,752.0	10,797.6	10,657.4	9,706.4
Oklahoma	3,305.0	3,025.5	2,559.5	2,328.3
Oregon	2,698.0	2,633.2	2,091.5	1,768.7
Pennsylvia	11,889.0	11,864.7	11,800.8	11,319.4
Rhode Island	975.0	947.2	949.7	859.5
South Carolina	3,378.0	3,120.7	2,590.7	2,382.6
South Dakota	707.0	690.8	666.3	680.5
Tennessee	4,803.0	4,591.0	3,926.0	3,567.1
Texas	16,682.0	14,225.5	11,198.7	9,579.7
Utah	1,665.0	1,461.0	1,059.3	890.6
Vermont	541.0	511.5	444.7	389.9
Virginia	5,787.0	5,346.8	4,651.4	3,966.9
Washington	4,463.0	4,132.4	3,413.2	2,853.2
West Virginia	1,919.0	1,950.2	1,744.2	1,860.4
Wisconsin	4,785.0	4,705.6	4,417.8	3,951.8
Wyoming	507.0	469.6	332.4	330.1

TABLE 7 Relative Change in State Population, 1960 to 1986 (in thousands) (*10, 11*)

AREA	1980-86 Absolute	%	1970-80 Absolute	%	1960-70 Absolute	%
Alabama	159	4.1%	449.6	13.1%	177.7	5.4%
Alaska	132.1	32.9%	99.3	32.8%	76.4	33.8%
Arizona	525.4	19.3%	941.2	53.0%	473.2	36.3%
Arkansas	85.6	3.7%	363.1	18.9%	137	7.7%
California	3313.2	14.0%	3696.7	18.5%	4253.9	27.1%
Colorado	377.3	13.1%	680.1	30.8%	455.7	26.0%
Connecticut	81.4	2.6%	75.4	2.5%	497	19.6%
Delaware	38.7	6.5%	46.2	8.4%	101.8	22.8%
Dist. of Columbia	-12.4	-1.9%	-118.3	-15.6%	-7.2	-0.9%
Florida	1928.1	19.8%	2955.5	43.5%	1839.8	37.2%
Georgia	641.1	11.7%	875	19.1%	644.8	16.4%
Hawaii	97.3	10.1%	194.8	25.3%	137.1	21.7%
Idaho	58.9	6.2%	231.1	32.4%	45.8	6.9%
Illinois	120.6	1.1%	317.1	2.9%	1029.1	10.2%
Indiana	13.8	0.3%	294.8	5.7%	532.9	11.4%
Iowa	-62.8	-2.2%	88.4	3.1%	67.9	2.5%
Kansas	96.8	4.1%	115.1	5.1%	70.5	3.2%
Kentucky	66.7	1.8%	439.6	13.6%	182.5	6.0%
Louisiana	294.9	7.0%	561.5	15.4%	387.6	11.9%
Maine	49	4.4%	131.3	13.2%	24.4	2.5%
Maryland	246.1	5.8%	293	7.5%	823.2	26.5%
Massachusetts	94.9	1.7%	47.9	0.8%	540.6	10.5%
Michigan	-107	-1.2%	380.2	4.3%	1058.6	13.5%
Minnesota	140.1	3.4%	269.8	7.1%	392.2	11.5%
Mississippi	104.2	4.1%	303.9	13.7%	38.8	1.8%
Missouri	149.2	3.0%	239.2	5.1%	357.8	8.3%
Montana	32.3	4.1%	92.3	13.3%	19.6	2.9%
Nebraska	28.2	1.8%	84.5	5.7%	74	5.2%
Nevada	163.5	20.4%	311.8	63.8%	203.4	71.3%
New Hampshire	106.4	11.6%	182.9	24.8%	130.8	21.6%
New Jersey	255	3.5%	193.9	2.7%	1104.3	18.2%
New Mexico	175.7	13.5%	286.2	28.1%	66.1	7.0%
New York	213.8	1.2%	-683.2	-3.7%	1459.1	8.7%
North Carolina	450.6	7.7%	796	15.7%	528.2	11.6%
North Dakota	27.3	4.2%	34.9	5.6%	-14.6	-2.3%
Ohio	-45.6	-0.4%	140.2	1.3%	951	9.8%
Oklahoma	279.5	9.2%	466	18.2%	231.2	9.9%
Oregon	64.8	2.5%	541.7	25.9%	322.8	18.3%
Pennsylvia	24.3	0.2%	63.9	0.5%	481.4	4.3%
Rhode Island	27.8	2.9%	-2.5	-0.3%	90.2	10.5%
South Carolina	257.3	8.2%	530	20.5%	208.1	8.7%
South Dakota	16.2	2.3%	24.5	3.7%	-14.2	-2.1%
Tennessee	212	4.6%	665	16.9%	358.9	10.1%
Texas	2456.5	17.3%	3026.8	27.0%	1619	16.9%
Utah	204	14.0%	401.7	37.9%	168.7	18.9%
Vermont	29.5	5.8%	66.8	15.0%	54.8	14.1%
Virginia	440.2	8.2%	695.4	15.0%	684.5	17.3%
Washington	330.6	8.0%	719.2	21.1%	560	19.6%
West Virginia	-31.2	-1.6%	206	11.8%	-116.2	-6.2%
Wisconsin	79.4	1.7%	287.8	6.5%	466	11.8%
Wyoming	37.4	8.0%	137.2	41.3%	2.3	0.7%

them. Very briefly, shift-share analysis decomposes an area's employment change between any two points in time into that accounted for by national employment change, that due to the area's industrial mix, and that due to unique local features (*18–20*). The third term, known as the "shift" or "competitive" component, is the amount of an area's employment change above or below that expected on the basis of national economic conditions and its local industry mix. It is an outcome of factors such as transportation access, land availability and cost, wage rates, taxes, labor-force skills, union strength, federal investment, business regulations, physical climate, and local attitudes toward growth. As these competitive factors come into play, some localities and regions fall behind, and others surge ahead.

Before assessing these competitive effects, it is informative to describe the actual employment changes of the nation's 3,100 counties during each phase of the two most recent business cycles. Table 8 [derived from Census Bureau County Business Patterns (CBP) data] presents these figures, aggregated by region and metropolitan status, for 2-year intervals that correspond to different phases of the business cycle.

The shift-share analysis was based on industry-specific employment obtained for 3,100 U.S. counties from the 1974, 1976, 1978, 1980, 1982, and 1984 CBP machine-readable files. Since 1977, CBP employment has been the count of employees during the pay period including March 12 for each year as reported on Treasury Form 941, Schedule A. The form is used to indicate all employment covered by Social Security or other retirement systems. Before 1977, coverage included only employment covered by Social Security. This change affected employment coverage in industries where private retirement systems are prevalent, such as health and educational services. CBP covers approximately 88 percent of total civilian nongovernment employment. Kasarda and Irwin (*17*) have discussed the industrial categories used in the shift-share analysis and related methodological issues. In Table 8, metropolitan core counties are those in which the metropolitan central city is located. Metropolitan ring counties are those counties not containing the central city in multiple-county metropolitan areas.

The 1974–1976 and 1980–1982 recessions and the strong recovery following them are clearly manifest in the national totals in Table 8. Between March 1974 and March 1976, the nation lost 872,000 jobs and another 634,000 during 1980–1982. During the 1976–1980 economic upswing, nearly 12 million jobs were gained; two-thirds of these were added between 1976 and 1978. During the first phase of the post-1982 recovery (1982–1984), the national economy added nearly 3.7 million jobs. For the entire 10-year span (1974–1984), the economy grew by slightly more than 14 million jobs, which represents a 22.3 percent increase from an employment base of approximately 63 million in 1974.

TABLE 8 Base-Year County Employment Totals and Employment Changes Aggregated by Region and Metropolitan Status, 1974-1984

Region and County Type	N	Total 1974 Employment (thousands)	Change (thousands) R,[a] 1974-1976	E,[b] 1976-1978	E,[b] 1978-1980	R,[a] 1980-1982	E,[b] 1982-1984	Span, 1974-1984	Percent Change, 1974-1984	Absolute Deviation From Expected
Northeast										
Metropolitan core	45	10,060	−619	526	455	−92	436	706	7.0	−1,539
Metropolitan ring	42	3,455	−87	402	226	56	326	923	26.7	152
Nonmetropolitan	130	2,198	−54	223	163	−28	96	399	18.2	−91
Total	217	15,713	−762	1,150	844	−64	859	2,028	12.9	−1,479
Midwest										
Metropolitan core	67	9,695	−276	873	181	−768	244	256	2.6	−1,908
Metropolitan ring	101	2,327	−18	424	94	−99	199	600	25.8	80
Nonmetropolitan	885	4,159	37	458	76	−291	123	403	9.7	−525
Total	1,053	16,180	−256	1,755	351	−1,158	566	1,258	7.8	−2,352
South										
Metropolitan core	88	10,178	−99	1,187	901	412	521	2,923	28.7	652
Metropolitan ring	169	3,726	65	625	434	202	452	1,780	47.8	948
Nonmetropolitan	1,162	6,866	−64	793	427	−55	305	1,407	20.5	−128
Total	1,419	20,771	−97	2,606	1,763	559	1,278	6,109	29.4	1,472
West										
Metropolitan core	42	7,829	75	1,445	1,183	−24	764	3,444	44.0	1,697
Metropolitan ring	21	1,085	31	236	160	62	112	601	55.4	358
Nonmetropolitan	349	1,441	138	293	128	−8	79	631	43.8	304
Total	412	10,355	243	1,975	1,472	29	955	4,675	45.1	2,359
National total	3,101	63,019	−872	7,487	4,430	−634	3,659	14,070	22.3	0

[a] R = recession.

[b] E = expansion.

SOURCE: County Business Patterns data from Bureau of the Census.

Of special interest are the striking spatial disparities in county employment change during the recession periods. During the 1974–1976 recession, all county types in the West added employment, whereas all county types in the Northeast lost jobs. The 45 northeastern metropolitan core counties lost 619,000 jobs alone during the 1974–1976 recession. Metropolitan core counties in the Midwest were also hit hard, losing 276,000 jobs.

Spatial disparities in employment change became magnified during the 1980–1982 recession. Although the Northeast (especially its metropolitan core counties) weathered this recession much better than the previous one, midwestern counties were economically devastated, experiencing a net loss of 1.2 million jobs. Both the region's metropolitan core counties and the nonmetropolitan counties suffered particularly severe employment losses. Even suburban ring counties in the Midwest declined in employment.

Conversely, led by remarkable employment gains in its metropolitan core counties, the South added more than 600,000 jobs during the 1980–1982 recession. Only rural counties in this region failed to hold their own.

The last two columns in Table 8 provide descriptive results instrumental in comparing spatial disparities in employment performance and the computations of the shift-share effects. The first entry in the Percent Change column shows that employment in metropolitan core counties in the Northeast expanded by 7.0 percent between 1974 and 1984. If these counties had grown at the national rate (22.3 percent, shown at the bottom of the column), they would have added 1,539,000 more jobs than they did (expected growth = 0.223 × 10,060,000). This is the aggregate deviation of these counties from national performance, which is further decomposed into that due to their industrial mix and that due to competitive advantages or disadvantages.

In contrast, metropolitan core counties in the West added 1,697,000 more jobs than would have been expected had they grown at national rates (22.3 versus 44.0). Not that the national total of all deviations (last row) is zero, which reflects the standardization of all county employment changes around the aggregate growth norm.

Table 9 provides the competitive effects of the counties classified by the same spatial criteria as in Table 8. These effects were actually computed for 10 categories of counties within each region along an urban-rural continuum (from counties containing very large metropolitan central cities to nonmetropolitan counties containing no place larger than 2,500 residents), as were corresponding local industrial mix ("share") effects. Although space constraints preclude tabular presentation of these finer-grained results, they will be noted where pertinent. For example, before 1978, the employment growth of the Northeast was hampered by exceptionally weak competitive effects of the region's large and medium-sized metropolitan core counties. After 1978, however, the competitive position of these larger urban counties

TABLE 9 **County Competitive Effects during National Business Cycle Stages Aggregated by Region and Metropolitan Status, 1974-1984**

Region and County Type	N	Change (thousands) R,[a] 1974-1976	E,[b] 1976-1978	E,[b] 1978-1980	R,[a] 1980-1982	E,[b] 1982-1984	Span, 1974-1984
Northeast							
Metropolitan core	45	−541	−620	−192	−86	−112	−1,770
Metropolitan ring	42	−35	−10	−12	90	131	165
Nonmetropolitan	130	−9	−26	26	15	−5	−3
Total	217	−585	−655	−176	19	14	−1,608
Midwest							
Metropolitan core	67	−135	−273	−457	−685	−198	−1,852
Metropolitan ring	101	34	141	−70	−55	77	151
Nonmetropolitan	885	121	−39	−202	−211	−71	−380
Total	1,053	20	−170	−729	−951	−192	−2,081
South							
Metropolitan core	88	−2	−63	131	445	−160	361
Metropolitan ring	169	132	158	156	258	191	960
Nonmetropolitan	1,162	112	79	15	130	−14	360
Total	1,419	242	174	302	833	17	1,681
West							
Metropolitan core	42	132	452	541	17	184	1,405
Metropolitan ring	21	43	95	69	77	28	329
Nonmetropolitan	349	148	103	−5	5	−5	273
Total	412	323	651	605	99	161	2,007

[a] R = recession.

[b] E = expansion.

SOURCE: County Business Patterns data from Bureau of the Census.

and the region improved. By the 1980–1982 recession, Table 9 shows that the Northeast's overall competitive effect was positive. Led by a remarkable transformation of the Northeast's largest cities to white-collar services, industrial mix effects in the Northeast became much more favorable to growth during the 1980s.

Trends in competitive effects in the Midwest were counter to those of the Northeast, with the midwestern situation steadily deteriorating between 1974 and 1982. This deterioration occurred in most types of counties, but was especially severe in metropolitan core counties. Even during the post-1982 recovery, the positive competitive effects of midwestern metropolitan ring counties did not compensate for the competitive disadvantages of midwestern metropolitan core counties and nonmetropolitan counties. Thus, the regional totals in Table 9 reveal that all other regions continued to grow after 1982 at the competitive expense of the Midwest.

The South's competitive edge increased sharply between 1978 and 1982, then atrophied. During the 1980–1982 recession, all types of counties—from the most rural to the most urbanized—gained substantially more jobs than can be accounted for by either national growth trends or county industrial structures. Smaller metropolitan central-city counties showed particularly strong competitive effects during the 1980–1982 recession, as did the central-city and suburban counties in the region's largest metropolitan areas. The highly unfavorable industry mix of the South's nonmetropolitan counties was not entirely compensated for by these counties' positive competitive effects, so southern nonmetropolitan counties experienced modest employment declines during each of the last two recessions (see Table 8).

With agricultural problems, falling oil prices, and foreign competition striking particularly hard at the South's rural manufacturing industries, negative multipliers rippled through the region's nonmetropolitan areas while problems with previous overbuilding and the energy industry severely dampened a number of large metropolitan core counties such as Harris County (Houston) in Texas. During the 1982–1984 period, the combined competitive effects of metropolitan core counties in the South were less than those in the Northeast and almost as weak as those in the Midwest—a dramatic reversal from the strong competitive position of the South's metropolitan core counties during the 1980–1982 recession.

The competitive components of growth in the West were strongest during the 1976–1980 economic upswing. Whereas the region maintained a consistently positive advantage throughout the business cycle, its competitive edge weakened during the 1980–1982 recession. The West's industrial mix, however, remained highly conducive to employment growth during both national economic booms and busts. Thus, the western regional economy, led by its spatially expansive metropolitan core counties [e.g., Los Angeles, Maricopa (Phoenix), San Diego], was particularly vibrant during periods of national economic growth and only mildly affected by economic downturns.

Overall, the shift-share analysis of county-level employment change shows that the competitive effects of nonmetropolitan counties have weakened; nonmetropolitan counties in all regions exhibited negative effects during the 1982–1984 interval. The analysis also indicates that the marked expansion of jobs in the South during the past decade was due largely to its strong competitive features. These features (which did deteriorate after 1982) more than compensated for the poor industrial mixes of the South's nonmetropolitan counties. The large employment declines in the Midwest resulted from a disadvantaged industrial mix highly sensitive to economic downturns coupled with real competitive effects relative to other regions. However, it should be noted that the industrial mix of the Midwest is conducive to employment growth during business cycle upswings, and the nation is currently in the midst of one of the longest sustained upswings ever recorded. The Northeast has improved its competitive features and its industrial mix in recent years, increasing its ability to hold and attract jobs. Finally, the West has been blessed with a favorable industrial mix and with competitive features that have resulted in that region's steady employment growth throughout all phases of the business cycle.

If the shift-share results are predictive of what should be happening during the current postrecession period, the West should continue to be the nation's leader in employment growth, the South's position should slip, and the Northeast and the Midwest should catch up. Table 10 presents data on the change in nonagricultural employees across the four regions by major industry groupings for 2-year intervals between January 1980 to January 1988. The industry groupings are production (mining, construction, and manufacturing), trade (retail and wholesale), and services (finance, insurance, and real estate; civilian government employees; and other service industries).

Comparing total nonagricultural employment changes during the 1980s (column 1 for each region) reveals interesting cross-regional dynamics. Whereas the South clearly dominated all regions in employment growth (both absolute and percent) during the 1980–1982 and 1982–1984 intervals, it lost its percentage growth rate lead to the West between 1984 and 1986. During the 1986–1988 period, the South maintained its absolute growth advantage but proportionally expanded less than the other three regions. With its depressed oil and mining industries, production employment actually declined in the South between 1986 and 1988 (most of this loss was in Texas). The Northeast exhibited a strong turnaround (from employment loss to employment gain) from 1982 to 1984, and the Midwest improved dramatically. The economies of both regions further strengthened between January 1984 and January 1986, with the Midwest actually surpassing the Northeast in absolute

TABLE 10 Change in Nonagricultural Employees by Region and Major Industry Group, January 1980 to January 1988 (in thousands) (*21, 22*)

	Northeast				Midwest			
Year	Total	Production	Trade	Service	Total	Production	Trade	Service
1980-82	-64.2 -0.3%	-336.5 -5.8%	-9.5 -0.2%	282.0 2.8%	-1006.0 -4.3%	-959.0 -13.0%	-211.0 -3.9%	164.0 1.5%
1982-84	535.7 2.7%	-221.2 -4.0%	281.2 6.6%	475.5 4.6%	-37.8 -0.2%	-242.2 -3.8%	133.7 2.6%	70.7 0.6%
1984-86	1091.3 5.3%	-12.4 -0.2%	368.3 8.1%	745.9 6.9%	1195.6 5.3%	151.4 2.5%	337.1 6.3%	707.2 6.4%
1986-88	1108.0 5.1%	13.0 0.2%	272.4 5.6%	821.5 7.1%	1148.5 4.8%	90.7 1.4%	396.7 7.0%	661.2 5.6%
1980-88	2670.8 13.2%	-557.1 -9.5%	912.4 21.4%	2315.5 22.9%	1300.3 5.5%	-959.3 -13.0%	656.5 12.1%	1603.1 14.8%
	South				West			
1980-82	843.7 3.0%	-120.6 -1.4%	264.2 4.1%	700.1 5.3%	277.6 1.6%	-168.0 -4.0%	90.6 2.2%	355.0 3.9%
1982-84	859.7 3.0%	-202.8 -2.5%	341.9 5.1%	720.6 5.2%	468.4 2.7%	-7.7 -0.2%	169.8 4.1%	306.3 3.3%
1984-86	2065.7 6.9%	231.7 2.9%	644.9 9.2%	1189.4 8.1%	1361.4 7.5%	196.3 4.8%	363.6 8.4%	801.3 8.3%
1986-88	1467.0 4.6%	-92.3 -1.1%	450.2 5.9%	1108.8 7.0%	1179.0 6.1%	148.8 3.5%	283.6 6.0%	739.6 7.0%
1980-88	5236.1 18.7%	-184.0 -2.2%	1701.2 26.4%	3718.9 28.1%	3286.4 18.9%	169.4 4.0%	907.6 22.2%	2202.2 24.3%

(though not proportional) job growth. The recent improvement of the Midwest was due primarily to the significant economic recovery of Ohio, Michigan, Illinois, and Indiana, whose cyclically sensitive industrial bases responded dramatically to the business cycle upswing. Table 11 shows that between 1984 and 1988, these four states have added more than 1.5 million nonagricultural jobs to the Midwest's employment base.

Facilitated by an improved competitive situation and industrial mix, employment growth rates of the Northeast during 1986–1988 were higher than those of the South and nearly as high as those of the West. In fact, between January 1986 and January 1988, the employment growth rate in the service industries of the Northeast led the nation.

Employment changes within the three industry groups illustrate major economic restructuring taking place in the regions. Again, nowhere is this more apparent than in the Northeast. Although this region added 2,670,800 jobs to its employment base between 1980 and 1988, it lost over half a million production-sector jobs. Service industries alone added 2,315,500 employees. By January 1986, more than half of all employment in the Northeast was in the service sector.

Also remarkable was the loss in the Midwest of more than 1.2 million production-sector jobs during the 1980–1984 period. Despite modest recovery of this sector following the recession, overall employment gains in the Midwest since 1982 were largely due to expansion of services and trade—industries in which average wages are generally lower than those in the production-sector jobs they replaced. The lead of the West in percent increase of employment between 1980 and 1988 resulted from strong growth in trade and services as well as a resilient production sector.

Space constraints preclude detailed discussion of the employment dynamics for the individual states during the most recent years. Tables 11–15 rank the 50 states in terms of change in total nonagricultural employment, manufacturing employment, overall production-sector employment, retail- and wholesale-trade employment, and service-industry employment from January 1984 to January 1988.

Table 11 shows the effects of the oil bust on the economies of Alaska, Louisiana, Oklahoma, and Wyoming, with all states suffering overall employment losses during the past 4 years. Conversely, California has added nearly 1.6 million jobs and Florida nearly 1 million jobs during the past 4 years. On the basis of percentage of employment growth, Nevada led the nation in recent years, closely followed by Arizona, Florida, and New Hampshire. Delaware, Vermont, and Virginia also increased their employment base by over 20 percent between January 1984 and January 1988.

TABLE 11 Change in Total Nonagricultural Employment, January 1984 to January 1988: Ranked by Absolute and Percent Change (in thousands)

	Area	Employment Change Absolute	Employment Change Percent		Area	Employment Change Absolute	Employment Change Percent
1	CALIFORNIA	1584.8	15.5%	1	NEVADA	102.1	25.1%
2	FLORIDA	928.2	22.7%	2	ARIZONA	276.0	24.5%
3	NEW YORK	691.6	9.4%	3	NEW HAMPSHIRE	100.0	23.8%
4	VIRGINIA	468.2	20.9%	4	FLORIDA	928.2	22.7%
5	OHIO	458.0	11.1%	5	VIRGINIA	468.2	20.9%
6	MICHIGAN	422.5	12.9%	6	DELAWARE	55.4	20.9%
7	GEORGIA	419.0	17.9%	7	VERMONT	41.6	20.0%
8	PENNSYLVANIA	395.7	8.8%	8	MAINE	81.7	19.4%
9	NORTH CAROLINA	395.4	15.9%	9	GEORGIA	419.0	17.9%
10	NEW JERSEY	374.0	11.7%	10	MARYLAND	278.5	16.1%
11	ILLINOIS	356.6	7.8%	11	WASHINGTON	256.4	16.1%
12	MASSACHUSETTS	293.4	10.7%	12	NORTH CAROLINA	395.4	15.9%
13	MARYLAND	278.5	16.1%	13	TENNESSEE	277.0	15.9%
14	TENNESSEE	277.0	15.9%	14	CALIFORNIA	1584.8	15.5%
15	ARIZONA	276.0	24.5%	15	SOUTH CAROLINA	179.0	14.7%
16	INDIANA	263.8	12.9%	16	HAWAII	56.9	14.0%
17	WASHINGTON	256.4	16.1%	17	OREGON	129.2	13.4%
18	MINNESOTA	216.5	12.5%	18	KENTUCKY	155.9	13.3%
19	MISSOURI	213.0	10.9%	19	MICHIGAN	422.5	12.9%
20	TEXAS	210.8	3.4%	20	INDIANA	263.8	12.9%
21	WISCONSIN	205.5	11.0%	21	MINNESOTA	216.5	12.5%
22	SOUTH CAROLINA	179.0	14.7%	22	ALABAMA	161.4	12.0%
23	CONNECTICUT	175.5	11.9%	23	CONNECTICUT	175.5	11.9%
24	ALABAMA	161.4	12.0%	24	NEW JERSEY	374.0	11.7%
25	KENTUCKY	155.9	13.3%	25	RHODE ISLAND	45.8	11.4%
26	OREGON	129.2	13.4%	26	ARKANSAS	83.7	11.2%
27	NEVADA	102.1	25.1%	27	OHIO	458.0	11.1%
28	NEW HAMPSHIRE	100.0	23.8%	28	WISCONSIN	205.5	11.0%
29	ARKANSAS	83.7	11.2%	29	MISSOURI	213.0	10.9%
30	MAINE	81.7	19.4%	30	MASSACHUSETTS	293.4	10.7%
31	MISSISSIPPI	74.2	9.3%	31	UTAH	59.4	10.3%
32	IOWA	69.1	6.6%	32	NEW YORK	691.6	9.4%
33	KANSAS	68.4	7.4%	33	MISSISSIPPI	74.2	9.3%
34	UTAH	59.4	10.3%	34	PENNSYLVANIA	395.7	8.8%
35	HAWAII	56.9	14.0%	35	NEBRASKA	52.4	8.7%
36	DELAWARE	55.4	20.9%	36	NEW MEXICO	41.3	8.5%
37	NEBRASKA	52.4	8.7%	37	ILLINOIS	356.6	7.8%
38	COLORADO	47.3	3.5%	38	KANSAS	68.4	7.4%
39	RHODE ISLAND	45.8	11.4%	39	IOWA	69.1	6.6%
40	VERMONT	41.6	20.0%	40	SOUTH DAKOTA	15.4	6.6%
41	NEW MEXICO	41.3	8.5%	41	IDAHO	16.7	5.3%
42	IDAHO	16.7	5.3%	42	COLORADO	47.3	3.5%
43	SOUTH DAKOTA	15.4	6.6%	43	TEXAS	210.8	3.4%
44	WEST VIRGINIA	13.0	2.2%	44	WEST VIRGINIA	13.0	2.2%
45	NORTH DAKOTA	2.9	1.2%	45	NORTH DAKOTA	2.9	1.2%
46	MONTANA	-0.4	-0.1%	46	MONTANA	-0.4	-0.1%
47	ALASKA	-8.3	-4.1%	47	ALASKA	-8.3	-4.1%
48	WYOMING	-21.0	-10.8%	48	LOUISIANA	-75.5	-4.8%
49	LOUISIANA	-75.5	-4.8%	49	OKLAHOMA	-91.5	-7.8%
50	OKLAHOMA	-91.5	-7.8%	50	WYOMING	-21.0	-10.8%

Source: Dept. of Labor, Bureau of Labor Statistics, machine-readable files 1988

Table 12, which presents data on employment change in manufacturing, reveals some interesting statistics. Most striking is the dismal performance of Massachusetts during the past 4 years. Massachusetts comes in dead last in percentage of change in manufacturing employment (−10.2) and next to last in absolute change, losing nearly 67,000 manufacturing jobs between January 1984 and January 1988. Conversely, during this same period, California added 119,400 manufacturing jobs to lead the nation in the growth of this sector. Three states particularly strong in both absolute and percentage growth in manufacturing are Arizona, Florida, and Washington.

Regarding absolute change in production, trade, and services employment, California and Florida dominate; New York is strong in employment growth in trade and services. On a percentage change basis, three New England states (Maine, New Hampshire, and Vermont) led the nation in expansion of retail and wholesale trade employment, whereas Delaware and New Hampshire expanded the most in the service sector. New Hampshire comes in a close third in proportional growth of service-sector employment.

Employment is only one side of the regional job outlook, however. The other is unemployment, which reflects growth in the labor force as well as number of jobs. Table 16 presents labor-force size, number employed, number unemployed, and unemployment rate for the four regions biennially from January 1976 to January 1988.

Once again one observes the uneven regional effects of the most recent recession, with marked declines in the number employed in the Northeast and the Midwest between 1980 and 1982 in contrast to growth in the South and the West. After the recession, however, the number unemployed in the Northeast and the Midwest fell more sharply than it did in the West and the South.

The slight rise in the number of unemployed in the South between 1982 and 1986 reflects not only such factors as agricultural distress, falling oil prices, and foreign competition for many southern manufacturing industries, but also the substantial immigration of labor to the region. Although the South added more jobs than any other region since 1982 (more than 5 million), it also added the largest numbers to its labor force.

The Northeast and the Midwest, however, had much slower growth in the size of their labor force, bringing it into better balance with employment opportunities. This is no better witnessed than in the New England census division, where, between January 1983 and January 1988, job growth substantially exceeded labor-force growth, depressing that division's unemployment rate to just 3.9 percent in January 1988, less than half of what it was in March 1983. Much of New England today is experiencing a labor-force squeeze, in dramatic contrast to 1983 when the division had a huge surplus of labor (see Appendix).

TABLE 12 Change in Manufacturing Employment, January 1984 to January 1988: Ranked by Absolute and Percent Change (in thousands)

	Area	Employment Change Absolute	Employment Change Percent		Area	Employment Change Absolute	Employment Change Percent
1	CALIFORNIA	119.4	6.0%	1	ALASKA	3.9	55.7%
2	FLORIDA	52.0	10.6%	2	NEVADA	3.8	18.9%
3	WASHINGTON	46.2	16.8%	3	WASHINGTON	46.2	16.8%
4	GEORGIA	41.4	7.8%	4	ARIZONA	24.2	14.8%
5	NORTH CAROLINA	39.9	4.8%	5	NEW MEXICO	4.4	12.7%
6	WISCONSIN	29.1	5.8%	6	FLORIDA	52.0	10.6%
7	ARIZONA	24.2	14.8%	7	MISSISSIPPI	18.1	8.5%
8	MINNESOTA	22.1	6.2%	8	OREGON	15.3	8.1%
9	ALABAMA	20.9	6.0%	9	GEORGIA	41.4	7.8%
10	INDIANA	18.4	3.0%	10	SOUTH DAKOTA	2.1	7.6%
11	MISSISSIPPI	18.1	8.5%	11	ARKANSAS	15.6	7.5%
12	KENTUCKY	16.0	6.4%	12	KENTUCKY	16.0	6.4%
13	VIRGINIA	16.0	3.9%	13	MINNESOTA	22.1	6.2%
14	ARKANSAS	15.6	7.5%	14	CALIFORNIA	119.4	6.0%
15	OREGON	15.3	8.1%	15	ALABAMA	20.9	6.0%
16	TENNESSEE	14.8	3.1%	16	WISCONSIN	29.1	5.8%
17	IOWA	11.9	5.7%	17	IOWA	11.9	5.7%
18	MICHIGAN	8.5	0.9%	18	NEBRASKA	4.5	5.2%
19	KANSAS	7.1	4.2%	19	WYOMING	0.4	5.2%
20	NEBRASKA	4.5	5.2%	20	NORTH CAROLINA	39.9	4.8%
21	NEW MEXICO	4.4	12.7%	21	IDAHO	2.4	4.6%
22	UTAH	4.0	4.5%	22	UTAH	4.0	4.5%
23	ALASKA	3.9	55.7%	23	KANSAS	7.1	4.2%
24	NEVADA	3.8	18.9%	24	NORTH DAKOTA	0.6	3.9%
25	SOUTH CAROLINA	3.0	0.8%	25	VIRGINIA	16.0	3.9%
26	NEW HAMPSHIRE	2.8	2.4%	26	TENNESSEE	14.8	3.1%
27	IDAHO	2.4	4.6%	27	INDIANA	18.4	3.0%
28	SOUTH DAKOTA	2.1	7.6%	28	NEW HAMPSHIRE	2.8	2.4%
29	VERMONT	1.0	2.1%	29	VERMONT	1.0	2.1%
30	NORTH DAKOTA	0.6	3.9%	30	HAWAII	0.3	1.4%
31	WYOMING	0.4	5.2%	31	MICHIGAN	8.5	0.9%
32	HAWAII	0.3	1.4%	32	SOUTH CAROLINA	3.0	0.8%
33	MONTANA	-1.0	-4.6%	33	OHIO	-2.4	-0.2%
34	DELAWARE	-2.0	-2.9%	34	MISSOURI	-4.7	-1.1%
35	OHIO	-2.4	-0.2%	35	COLORADO	-2.8	-1.5%
36	COLORADO	-2.8	-1.5%	36	DELAWARE	-2.0	-2.9%
37	MAINE	-3.7	-3.4%	37	MAINE	-3.7	-3.4%
38	RHODE ISLAND	-4.2	-3.6%	38	RHODE ISLAND	-4.2	-3.6%
39	WEST VIRGINIA	-4.2	-4.7%	39	TEXAS	-35.2	-3.6%
40	MISSOURI	-4.7	-1.1%	40	ILLINOIS	-42.3	-4.3%
41	LOUISIANA	-9.8	-5.6%	41	MONTANA	-1.0	-4.6%
42	MARYLAND	-10.8	-5.0%	42	WEST VIRGINIA	-4.2	-4.7%
43	OKLAHOMA	-14.1	-8.4%	43	MARYLAND	-10.8	-5.0%
44	CONNECTICUT	-28.4	-6.9%	44	PENNSYLVANIA	-58.5	-5.3%
45	TEXAS	-35.2	-3.6%	45	LOUISIANA	-9.8	-5.6%
46	ILLINOIS	-42.3	-4.3%	46	CONNECTICUT	-28.4	-6.9%
47	NEW JERSEY	-51.7	-7.3%	47	NEW JERSEY	-51.7	-7.3%
48	PENNSYLVANIA	-58.5	-5.3%	48	NEW YORK	-97.8	-7.5%
49	MASSACHUSETTS	-66.8	-10.2%	49	OKLAHOMA	-14.1	-8.4%
50	NEW YORK	-97.8	-7.5%	50	MASSACHUSETTS	-66.8	-10.2%

Source: Dept. of Labor, Bureau of Labor Statistics, machine-readable files 1988

TABLE 13 Change in Production Employment, January 1984 to January 1988: Ranked by Absolute and Percent Change (in thousands)

	Area	Employment Change Absolute	Employment Change Percent		Area	Employment Change Absolute	Employment Change Percent
1	CALIFORNIA	292.3	12.0%	1	NEVADA	17.6	39.6%
2	FLORIDA	105.2	13.3%	2	WASHINGTON	60.6	17.5%
3	NORTH CAROLINA	76.8	8.1%	3	VERMONT	8.4	14.5%
4	VIRGINIA	75.0	13.8%	4	VIRGINIA	75.0	13.8%
5	GEORGIA	72.7	11.2%	5	FLORIDA	105.2	13.3%
6	WASHINGTON	60.6	17.5%	6	CALIFORNIA	292.3	12.0%
7	MICHIGAN	45.7	4.5%	7	ARIZONA	31.5	11.9%
8	INDIANA	44.8	6.6%	8	MARYLAND	37.7	11.9%
9	WISCONSIN	41.7	7.5%	9	GEORGIA	72.7	11.2%
10	TENNESSEE	39.8	7.1%	10	NEW HAMPSHIRE	14.3	10.0%
11	MARYLAND	37.7	11.9%	11	OREGON	20.8	9.7%
12	OHIO	36.2	2.9%	12	HAWAII	3.4	8.8%
13	MINNESOTA	35.1	8.5%	13	MINNESOTA	35.1	8.5%
14	ALABAMA	31.7	7.5%	14	KENTUCKY	27.7	8.3%
15	ARIZONA	31.5	11.9%	15	NORTH CAROLINA	76.8	8.1%
16	KENTUCKY	27.7	8.3%	16	SOUTH DAKOTA	2.9	7.8%
17	OREGON	20.8	9.7%	17	MAINE	9.5	7.6%
18	NEVADA	17.6	39.6%	18	WISCONSIN	41.7	7.5%
19	MISSOURI	16.8	3.4%	19	ALABAMA	31.7	7.5%
20	ARKANSAS	16.6	6.9%	20	TENNESSEE	39.8	7.1%
21	MISSISSIPPI	15.0	5.9%	21	ARKANSAS	16.6	6.9%
22	NEW HAMPSHIRE	14.3	10.0%	22	INDIANA	44.8	6.6%
23	IOWA	11.4	4.8%	23	MISSISSIPPI	15.0	5.9%
24	SOUTH CAROLINA	10.8	2.4%	24	NEBRASKA	6.1	5.7%
25	MAINE	9.5	7.6%	25	IOWA	11.4	4.8%
26	VERMONT	8.4	14.5%	26	MICHIGAN	45.7	4.5%
27	ILLINOIS	6.2	0.5%	27	MISSOURI	16.8	3.4%
28	NEBRASKA	6.1	5.7%	28	OHIO	36.2	2.9%
29	HAWAII	3.4	8.8%	29	DELAWARE	2.4	2.9%
30	SOUTH DAKOTA	2.9	7.8%	30	SOUTH CAROLINA	10.8	2.4%
31	RHODE ISLAND	2.8	2.2%	31	RHODE ISLAND	2.8	2.2%
32	DELAWARE	2.4	2.9%	32	IDAHO	1.1	1.6%
33	NEW JERSEY	2.3	0.3%	33	KANSAS	1.8	0.8%
34	KANSAS	1.8	0.8%	34	ILLINOIS	6.2	0.5%
35	IDAHO	1.1	1.6%	35	NEW JERSEY	2.3	0.3%
36	ALASKA	-4.3	-13.8%	36	NEW YORK	-4.7	-0.3%
37	NEW YORK	-4.7	-0.3%	37	PENNSYLVANIA	-12.5	-1.0%
38	MONTANA	-5.2	-13.5%	38	CONNECTICUT	-6.8	-1.5%
39	NEW MEXICO	-6.1	-6.9%	39	MASSACHUSETTS	-12.6	-1.7%
40	CONNECTICUT	-6.8	-1.5%	40	UTAH	-8.2	-6.3%
41	NORTH DAKOTA	-6.9	-19.9%	41	NEW MEXICO	-6.1	-6.9%
42	UTAH	-8.2	-6.3%	42	WEST VIRGINIA	-17.2	-11.0%
43	PENNSYLVANIA	-12.5	-1.0%	43	COLORADO	-37.1	-12.3%
44	MASSACHUSETTS	-12.6	-1.7%	44	TEXAS	-218.6	-13.2%
45	WYOMING	-14.3	-30.4%	45	MONTANA	-5.2	-13.5%
46	WEST VIRGINIA	-17.2	-11.0%	46	ALASKA	-4.3	-13.8%
47	COLORADO	-37.1	-12.3%	47	LOUISIANA	-70.4	-19.1%
48	OKLAHOMA	-65.8	-22.4%	48	NORTH DAKOTA	-6.9	-19.9%
49	LOUISIANA	-70.4	-19.1%	49	OKLAHOMA	-65.8	-22.4%
50	TEXAS	-218.6	-13.2%	50	WYOMING	-14.3	-30.4%

NOTE: Production includes mining, construction and manufacturing employment.
Source: Dept. of Labor, Bureau of Labor Statistics, machine-readable files 1988

TABLE 14 Change in Trade Employment, January 1984 to January 1988: Ranked by Absolute and Percent Change (in thousands)

	Area	Employment Change Absolute	Percent		Area	Employment Change Absolute	Percent
1	CALIFORNIA	396.3	16.3%	1	NEW HAMPSHIRE	34.8	36.1%
2	FLORIDA	286.7	26.4%	2	MAINE	33.2	35.9%
3	NEW YORK	171.6	11.4%	3	VERMONT	13.2	29.3%
4	OHIO	155.4	16.5%	4	SOUTH CAROLINA	69.0	28.2%
5	MICHIGAN	143.5	20.0%	5	VIRGINIA	134.0	27.3%
6	VIRGINIA	134.0	27.3%	6	FLORIDA	286.7	26.4%
7	NORTH CAROLINA	124.6	23.7%	7	NEVADA	21.0	25.6%
8	PENNSYLVANIA	123.1	12.3%	8	ARIZONA	70.1	25.4%
9	GEORGIA	118.4	20.8%	9	NORTH CAROLINA	124.6	23.7%
10	ILLINOIS	110.5	9.9%	10	DELAWARE	13.6	23.5%
11	NEW JERSEY	107.2	14.2%	11	RHODE ISLAND	18.7	22.2%
12	MARYLAND	89.1	20.9%	12	MARYLAND	89.1	20.9%
13	MASSACHUSETTS	83.4	13.3%	13	TENNESSEE	81.9	20.8%
14	INDIANA	83.0	17.7%	14	GEORGIA	118.4	20.8%
15	TENNESSEE	81.9	20.8%	15	ALABAMA	56.1	20.2%
16	ARIZONA	70.1	25.4%	16	MICHIGAN	143.5	20.0%
17	SOUTH CAROLINA	69.0	28.2%	17	KENTUCKY	52.5	19.4%
18	MISSOURI	67.1	14.4%	18	INDIANA	83.0	17.7%
19	WISCONSIN	63.1	14.7%	19	CONNECTICUT	55.5	17.4%
20	WASHINGTON	57.8	14.7%	20	OHIO	155.4	16.5%
21	ALABAMA	56.1	20.2%	21	CALIFORNIA	396.3	16.3%
22	CONNECTICUT	55.5	17.4%	22	HAWAII	17.3	16.0%
23	KENTUCKY	52.5	19.4%	23	OREGON	37.9	15.7%
24	MINNESOTA	51.9	12.0%	24	ARKANSAS	24.8	15.1%
25	TEXAS	42.5	2.7%	25	WISCONSIN	63.1	14.7%
26	OREGON	37.9	15.7%	26	WASHINGTON	57.8	14.7%
27	NEW HAMPSHIRE	34.8	36.1%	27	MISSOURI	67.1	14.4%
28	MAINE	33.2	35.9%	28	NEW JERSEY	107.2	14.2%
29	KANSAS	25.1	11.0%	29	NEW MEXICO	15.1	13.5%
30	ARKANSAS	24.8	15.1%	30	MASSACHUSETTS	83.4	13.3%
31	COLORADO	22.0	6.6%	31	PENNSYLVANIA	123.1	12.3%
32	NEVADA	21.0	25.6%	32	MINNESOTA	51.9	12.0%
33	RHODE ISLAND	18.7	22.2%	33	NEW YORK	171.6	11.4%
34	MISSISSIPPI	18.3	10.9%	34	KANSAS	25.1	11.0%
35	HAWAII	17.3	16.0%	35	MISSISSIPPI	18.3	10.9%
36	IOWA	15.6	5.8%	36	UTAH	14.3	10.6%
37	NEW MEXICO	15.1	13.5%	37	WEST VIRGINIA	13.3	10.5%
38	UTAH	14.3	10.6%	38	ILLINOIS	110.5	9.9%
39	DELAWARE	13.6	23.5%	39	NEBRASKA	13.0	8.3%
40	WEST VIRGINIA	13.3	10.5%	40	COLORADO	22.0	6.6%
41	VERMONT	13.2	29.3%	41	SOUTH DAKOTA	3.8	6.1%
42	NEBRASKA	13.0	8.3%	42	IOWA	15.6	5.8%
43	IDAHO	4.4	5.5%	43	IDAHO	4.4	5.5%
44	SOUTH DAKOTA	3.8	6.1%	44	NORTH DAKOTA	1.8	2.8%
45	NORTH DAKOTA	1.8	2.8%	45	TEXAS	42.5	2.7%
46	MONTANA	-1.7	-2.3%	46	LOUISIANA	-7.7	-2.1%
47	ALASKA	-2.1	-5.1%	47	MONTANA	-1.7	-2.3%
48	WYOMING	-5.2	-11.8%	48	ALASKA	-2.1	-5.1%
49	LOUISIANA	-7.7	-2.1%	49	OKLAHOMA	-22.0	-7.8%
50	OKLAHOMA	-22.0	-7.8%	50	WYOMING	-5.2	-11.8%

NOTE: Trade includes wholesale and retail trade employment.
Source: Dept. of Labor, Bureau of Labor Statistics, machine-readable files 1988

TABLE 15 Change in Service Employment, January 1984 to January 1988: Ranked by Absolute and Percent Change (in thousands)

	Area	Employment Change Absolute	Percent		Area	Employment Change Absolute	Percent
1	CALIFORNIA	896.2	16.7%	1	DELAWARE	39.4	31.6%
2	FLORIDA	536.3	24.2%	2	ARIZONA	174.4	29.7%
3	NEW YORK	524.7	12.2%	3	NEW HAMPSHIRE	50.9	28.1%
4	TEXAS	386.9	12.7%	4	FLORIDA	536.3	24.2%
5	PENNSYLVANIA	285.1	12.8%	5	NEVADA	63.5	22.7%
6	OHIO	266.4	13.8%	6	VIRGINIA	259.2	21.6%
7	NEW JERSEY	264.5	16.3%	7	GEORGIA	227.9	20.2%
8	VIRGINIA	259.2	21.6%	8	TENNESSEE	155.3	19.6%
9	ILLINOIS	239.9	10.5%	9	MAINE	39.0	19.1%
10	MICHIGAN	233.3	15.2%	10	SOUTH CAROLINA	99.2	19.1%
11	GEORGIA	227.9	20.2%	11	NORTH CAROLINA	194.0	19.1%
12	MASSACHUSETTS	222.6	16.2%	12	VERMONT	20.0	18.9%
13	NORTH CAROLINA	194.0	19.1%	13	CONNECTICUT	126.8	18.5%
14	ARIZONA	174.4	29.7%	14	UTAH	53.3	17.1%
15	TENNESSEE	155.3	19.6%	15	CALIFORNIA	896.2	16.7%
16	MARYLAND	151.7	15.4%	16	NEW JERSEY	264.5	16.3%
17	WASHINGTON	138.0	16.2%	17	MASSACHUSETTS	222.6	16.2%
18	INDIANA	136.0	15.1%	18	WASHINGTON	138.0	16.2%
19	MINNESOTA	129.5	14.6%	19	MARYLAND	151.7	15.4%
20	MISSOURI	129.1	13.1%	20	MICHIGAN	233.3	15.2%
21	CONNECTICUT	126.8	18.5%	21	INDIANA	136.0	15.1%
22	WISCONSIN	100.7	11.4%	22	MINNESOTA	129.5	14.6%
23	SOUTH CAROLINA	99.2	19.1%	23	HAWAII	36.2	13.9%
24	KENTUCKY	75.7	13.4%	24	OREGON	70.5	13.9%
25	ALABAMA	73.6	11.4%	25	OHIO	266.4	13.8%
26	OREGON	70.5	13.9%	26	KENTUCKY	75.7	13.4%
27	NEVADA	63.5	22.7%	27	MISSOURI	129.1	13.1%
28	COLORADO	62.4	8.8%	28	RHODE ISLAND	24.3	13.0%
29	UTAH	53.3	17.1%	29	PENNSYLVANIA	285.1	12.8%
30	NEW HAMPSHIRE	50.9	28.1%	30	TEXAS	386.9	12.7%
31	ARKANSAS	42.3	12.2%	31	ARKANSAS	42.3	12.2%
32	IOWA	42.1	7.9%	32	NEW YORK	524.7	12.2%
33	KANSAS	41.5	8.7%	33	ALABAMA	73.6	11.4%
34	MISSISSIPPI	40.9	10.8%	34	WISCONSIN	100.7	11.4%
35	DELAWARE	39.4	31.6%	35	NEW MEXICO	32.3	11.4%
36	MAINE	39.0	19.1%	36	MISSISSIPPI	40.9	10.8%
37	HAWAII	36.2	13.9%	37	ILLINOIS	239.9	10.5%
38	NEBRASKA	33.3	9.7%	38	NEBRASKA	33.3	9.7%
39	NEW MEXICO	32.3	11.4%	39	COLORADO	62.4	8.8%
40	RHODE ISLAND	24.3	13.0%	40	KANSAS	41.5	8.7%
41	VERMONT	20.0	18.9%	41	IOWA	42.1	7.9%
42	WEST VIRGINIA	16.9	5.7%	42	IDAHO	11.2	6.7%
43	IDAHO	11.2	6.7%	43	SOUTH DAKOTA	8.7	6.4%
44	SOUTH DAKOTA	8.7	6.4%	44	WEST VIRGINIA	16.9	5.7%
45	NORTH DAKOTA	8.0	5.5%	45	NORTH DAKOTA	8.0	5.5%
46	MONTANA	6.5	4.1%	46	MONTANA	6.5	4.1%
47	LOUISIANA	2.6	0.3%	47	LOUISIANA	2.6	0.3%
48	WYOMING	-1.5	-1.5%	48	OKLAHOMA	-3.7	-0.6%
49	ALASKA	-1.9	-1.4%	49	ALASKA	-1.9	-1.4%
50	OKLAHOMA	-3.7	-0.6%	50	WYOMING	-1.5	-1.5%

NOTE: Service includes transportation, utilities, F.I.R.E., service and government.
Source: Dept. of Labor, Bureau of Labor Statistics, machine-readable files 1988

TABLE 16 Labor-Force Characteristics and Unemployment by Region, January 1976 to January 1988 (*21–23*)

REGION	YEAR	LABOR FORCE	EMPLOYED	UNEMPLOYED NUMBER	UNEMPLOYED RATE
Northeast	1976	21,449,901	19,191,144	2,258,757	10.5%
	1978	22,045,300	20,282,300	1,763,000	8.0%
	1980	23,102,063	21,361,011	1,741,052	7.5%
	1982	23,198,926	21,032,627	2,166,299	9.3%
	1984	23,442,310	21,546,385	1,895,925	8.1%
	1986	24,348,182	22,772,506	1,575,676	6.5%
	1988	25,054,200	23,826,200	1,228,000	4.9%
Midwest	1976	25,392,136	23,393,806	1,998,330	7.9%
	1978	26,776,800	25,027,600	1,749,200	6.5%
	1980	27,774,176	25,733,856	2,040,320	7.3%
	1982	27,966,608	24,900,981	3,065,627	11.0%
	1984	27,892,732	25,116,821	2,775,911	10.0%
	1986	28,743,917	26,331,334	2,412,583	8.4%
	1988	29,501,800	27,321,800	2,180,000	7.4%
South	1976	29,489,817	27,238,105	2,251,712	7.6%
	1978	30,702,600	28,680,600	2,022,000	6.6%
	1980	33,381,273	31,309,393	2,071,880	6.2%
	1982	35,340,380	32,292,079	3,048,301	8.6%
	1984	37,073,849	33,943,451	3,130,398	8.4%
	1986	38,761,016	35,868,712	2,892,304	7.5%
	1988	40,423,100	37,541,700	2,881,400	7.1%
West	1976	17,175,579	15,403,329	1,772,250	10.3%
	1978	18,174,900	16,779,500	1,395,400	7.7%
	1980	20,384,381	18,994,828	1,389,553	6.8%
	1982	21,417,792	19,389,920	2,027,872	9.5%
	1984	22,274,848	20,257,239	2,017,609	9.1%
	1986	23,345,457	21,623,735	1,721,722	7.4%
	1988	24,778,800	23,188,600	1,590,200	6.4%

FUTURE POPULATION AND EMPLOYMENT TRENDS

The regional, state, and metropolitan patterns of employment and population growth are well established, but will they continue into the 21st century? Extrapolating trends has put egg on the faces of many demographic and economic forecasters in years past. Even with the best current information available and sophisticated forecasting algorithms, unforeseen events have proved to invalidate even the most scientifically based projections.

With the above caveat in mind, recent forecasts of such agencies as the Bureau of the Census, the Bureau of Economic Analysis, and the National Planning Association are gathered here to provide professionally based prognoses of the size, composition, and distribution of population and employment now anticipated for the first part of the 21st century.

Population Forecasts

The Bureau of the Census will soon be releasing a report projecting state populations to the year 2010 (*24*). These projections are summarized for the census regions and divisions in Table 17 and for the states in Table 18. Census Bureau projections indicate that more than 95 percent of the nation's population growth through 2010 will occur in the South and the West. The Northeast is projected to grow by less than 5 percent, whereas the Midwest is actually projected to decline slightly in population during the coming two decades (see Table 17). Among the census divisions, the South Atlantic Division is expected to expand the most in absolute numbers, capturing more than one-third of all population growth, closely followed by the Pacific Division. The projected population loss in the Midwest is expected to result entirely from declines in the East North Central Division, which is composed of Illinois, Indiana, Michigan, Ohio, and Wisconsin.

Between 1987 and 2010, the Census Bureau projects that more than half (53 percent) of all the nation's population increase will be absorbed by three states: California, Florida, and Texas (see Table 18). Other states expected to add at least 1.5 million people by 2010 include Arizona, Georgia, North Carolina, and Virginia. Thirteen states projected to lose population between 1987 and 2010 are Illinois, Indiana, Iowa, Kentucky, Michigan, Montana, Nebraska, North Dakota, Ohio, Pennsylvania, West Virginia, Wisconsin, and Wyoming. The largest projected absolute population losses are for Pennsylvania (740,000). On a percent basis, the biggest loser is expected to be Iowa (444,000, or 15.7 percent).

The census projections for the divisions are based in good measure on state demographic trends during the first half of the 1980s when, as discussed

TABLE 17 Population Projections, 1987 to 2010 (in thousands) (*24*)

AREA	1987	2010	Change 1987-2010 Absolute	Percent
United States	243,308	282,055	38,747	15.9%
Regions				
Northeast	50,140	52,496	2,356	4.7%
Midwest	59,450	59,018	-432	-0.7%
South	84,060	104,919	20,859	24.8%
West	49,658	65,622	15,964	32.1%
Divisions				
New England	12,820	14,243	1,423	11.1%
Middle Atlantic	37,320	38,253	933	2.5%
East North Central	41,836	41,111	-725	-1.7%
West North Central	17,614	17,907	293	1.7%
South Atlantic	41,628	55,110	13,482	32.4%
East South Central	15,310	16,847	1,537	10.0%
West South Central	27,122	32,961	5,839	21.5%
Mountain	13,271	17,679	4,408	33.2%
Pacific	36,387	47,943	11,556	31.8%

earlier, many southern and western states dominated U.S. population gains. In the author's professional judgment, although the South and the West will continue to be the focus of at least 80 percent of the nation's population growth during the next three decades, projections suggesting that these regions will capture 95 percent of all U.S. growth are on the high side. Indeed, the Census Bureau is currently preparing a set of alternative projections that will have a number of northern states losing fewer people by 2010 than Table 18 suggests.

The National Planning Association in 1987 projected population growth through the year 2010 for the nation's 100 largest metropolitan areas. These projections, presented in Table 19, are listed in rank order of percent population increase projected for the 25-year period between 1985 and 2010 (*25*). All the top 30 metropolitan growth areas are projected to be in either the South or the West. Consistent with Bureau of the Census state population

TABLE 18 State Population Projections: 1987 to 2010 (in thousands) (*24*)

AREA	1987	2010	Change 1987-2010 Absolute	Percent
Alabama	4,086	4,609	523	12.8%
Alaska	544	765	221	40.6%
Arizona	3,432	5,319	1887	55.0%
Arkansas	2,386	2,624	238	10.0%
California	27,531	37,347	9816	35.7%
Colorado	3,308	4,098	790	23.9%
Connecticut	3,212	3,532	320	10.0%
Delaware	641	790	149	23.2%
Dist. of Columbia	621	672	51	8.2%
Florida	11,962	17,530	5568	46.5%
Georgia	6,244	9,045	2801	44.9%
Hawaii	1,081	1,559	478	44.2%
Idaho	1,006	1,079	73	7.3%
Illinois	11,569	11,495	-74	-0.6%
Indiana	5,518	5,409	-109	-2.0%
Iowa	2,826	2,382	-444	-15.7%
Kansas	2,469	2,564	95	3.8%
Kentucky	3,733	3,710	-23	-0.6%
Louisiana	4,504	4,545	41	0.9%
Maine	1,184	1,308	124	10.5%
Maryland	4,532	5,688	1156	25.5%
Massachusetts	5,838	6,255	417	7.1%
Michigan	9,191	9,097	-94	-1.0%
Minnesota	4,243	4,578	335	7.9%
Mississippi	2,643	3,028	385	14.6%
Missouri	5,100	5,521	421	8.3%
Montana	814	794	-20	-2.5%
Nebraska	1,595	1,529	-66	-4.1%
Nevada	993	1,484	491	49.4%
New Hampshire	1,058	1,455	397	37.5%
New Jersey	7,687	8,980	1293	16.8%
New Mexico	1,518	2,248	730	48.1%
New York	17,759	18,139	380	2.1%
North Carolina	6,422	8,154	1732	27.0%
North Dakota	674	611	-63	-9.3%
Ohio	10,767	10,397	-370	-3.4%
Oklahoma	3,295	3,511	216	6.6%

TABLE 18 ***continued***

AREA	1987	2010	Change 1987-2010 Absolute	Percent
Oregon	2,716	2,991	275	10.1%
Pennsylvania	11,874	11,134	-740	-6.2%
Rhode Island	982	1,085	103	10.5%
South Carolina	3,420	4,205	785	23.0%
South Dakota	707	722	15	2.1%
Tennessee	4,848	5,500	652	13.4%
Texas	16,937	22,281	5344	31.6%
Utah	1,694	2,171	477	28.2%
Vermont	547	608	61	11.2%
Virginia	5,883	7,410	1527	26.0%
Washington	4,514	5,282	768	17.0%
West Virginia	1,902	1,617	-285	-15.0%
Wisconsin	4,791	4,713	-78	-1.6%
Wyoming	506	487	-19	-3.8%

Source: U.S Bureau of the Census, Current Population Reports, series P-25, forthcoming report.

projections, the slowest-growing metropolitan areas are disproportionately concentrated in the upper Midwest. Viewed in absolute numbers, metropolitan areas projected to grow by more than 1 million residents by 2010 include Los Angeles (3.28 million), New York-Newark (1.91 million), San Francisco-Oakland (1.70 million), Houston (1.21 million), Dallas-Ft. Worth (1.16 million), Philadelphia (1.03 million), and Washington, D.C. (1.03 million).

Although separate projections are not available for the central cities and suburban rings of major metropolitan areas, all indications are that the suburban rings will continue to far outpace the central cities in employment growth. A significant future change will likely be a bottoming out of population losses for major cities in the Northeast and the Midwest, with some small growth recommencing. At the same time, growth of younger southern and midwestern cities should slow as they approach "build-out" capacity by the year 2000. Apropos the bottoming-out trend, Bureau of the Census mid-decade estimates for cities in the Northeast and the Midwest indicate that a number of major cities that had been rapidly declining for decades had begun to add population again (e.g., New York City, Boston, Chicago).

Tables 20–23 give the population growth trends for the 10 largest metropolitan areas in each census region between 1960 and 1986. One can see that the 1970s was a calamitous decade for the larger central cities in the Northeast; all 10 lost population, cumulatively nearly 1.5 million. By the

TABLE 19 Rankings of 100 Largest Metropolitan Areas in Terms of Projected Percent Change in Population, 1985 to 2010 (25)

Metropolitan Area	Total Population (1000s) 1985	2010	Population Change Absolute	Percent
1 West Palm Beach	722.0	1,156.7	434.7	60.2%
2 Las Vegas	555.8	857.3	301.5	54.2%
3 Orlando	865.0	1,320.5	455.5	52.7%
4 Phoenix	1,843.7	2,712.0	868.3	47.1%
5 Tucson	585.0	839.9	254.9	43.6%
6 Colorado Springs	365.3	515.8	150.5	41.2%
7 Austin	694.4	975.3	280.9	40.5%
8 Sacremento	1,256.2	1,730.2	474.0	37.7%
9 San Diego	2,129.4	2,926.8	797.4	37.4%
10 Denver	1,611.5	2,203.9	592.4	36.8%
11 Albuquerque	463.6	632.6	169.0	36.5%
12 Tampa	1,865.7	2,539.4	673.7	36.1%
13 Atlanta	2,467.7	3,351.1	883.4	35.8%
14 McAllen	351.7	477.3	125.6	35.7%
15 Miami-Ft Lauderdale	2,873.8	3,867.1	993.3	34.6%
16 Houston CMSA	3,617.6	4,831.3	1,213.7	33.5%
17 Dallas-Ft Worth	3,505.9	4,663.7	1,157.8	33.0%
18 Chattanooga	424.9	556.4	131.5	30.9%
19 Washington D.C.	3,483.9	4,516.8	1,032.9	29.6%
20 Raleigh-Durham	631.1	817.9	186.8	29.6%
21 Charleston	481.0	622.3	141.3	29.4%
22 San Francisco-Oakland CMSA	5,800.2	7,488.7	1,688.5	29.1%
23 Salt Lake City	1,023.1	1,310.8	287.7	28.1%
24 Baton Rouge	543.2	695.3	152.1	28.0%
25 Columbia SC	438.7	554.2	115.5	26.3%
26 Los Angeles-Anaheim CMSA	12,718.1	15,996.0	3,277.9	25.8%
27 San Antonio	1,233.7	1,531.1	297.4	24.1%
28 Portland OR. CMSA	1,351.8	1,669.3	317.5	23.5%
29 El Paso	544.1	670.5	126.4	23.2%
30 Honolulu	813.4	1,000.8	187.4	23.0%
31 Jacksonville	822.3	1,009.7	187.4	22.8%
32 Minneapolis-St. Paul	2,258.7	2,771.9	513.2	22.7%
33 Tulsa	732.0	896.4	164.4	22.5%
34 Columbus	1,285.7	1,574.4	288.7	22.5%
35 Norfolk	1,287.5	1,575.2	287.7	22.3%
36 Seattle-Tacoma	2,243.9	2,738.6	494.7	22.0%
37 Bakersfield	480.2	578.8	98.6	20.5%
38 Allentown	649.0	780.7	131.7	20.3%
39 Lakeland	464.6	556.6	92.0	19.8%
40 Baltimore	2,249.3	2,692.8	443.5	19.7%
41 Little Rock	497.7	591.6	93.9	18.9%
42 Fresno	579.0	684.3	105.3	18.2%
43 Stockton	417.6	492.7	75.1	18.0%
44 Philadelphia CMSA	5,767.3	6,797.9	1,030.6	17.9%
45 Charlotte	1,047.3	1,228.8	181.5	17.3%
46 Greenville	598.7	696.7	98.0	16.4%
47 Knoxville	591.7	688.4	96.7	16.3%
48 Richmond	799.3	928.1	128.8	16.1%
49 Indianapolis	1,201.2	1,393.3	192.1	16.0%
50 Worcester	654.5	758.5	104.0	15.9%
51 Oklahoma City	974.3	1,128.4	154.1	15.8%
52 Hartford CMSA	1,072.5	1,241.8	169.3	15.8%
53 Nashville	908.3	1,048.6	140.3	15.4%
54 Lancaster	386.0	445.5	59.5	15.4%
55 Augusta	379.8	437.9	58.1	15.3%
56 Albany	839.9	967.5	127.6	15.2%
57 Spokane	355.7	409.6	53.9	15.2%
58 Kansas City	1,491.4	1,714.8	223.4	15.0%
59 Boston CMSA	3,706.1	4,259.2	553.1	14.9%

TABLE 19 *continued*

Metropolitan Area	Total Population (1000s) 1985	2010	Population Change Absolute	Percent
60 York	393.1	451.3	58.2	14.8%
61 Omaha	610.6	700.3	89.7	14.7%
62 New Haven	774.3	886.6	112.3	14.5%
63 Corpus Christi	358.2	408.8	50.6	14.1%
64 Providence	882.3	1,002.0	119.7	13.6%
65 Jackson	384.2	436.0	51.8	13.5%
66 Springfield MA	584.3	662.5	78.2	13.4%
67 Mobile	468.4	527.6	59.2	12.6%
68 Des Moines	371.5	418.0	46.5	12.5%
69 Greensboro	891.1	1,001.9	110.8	12.4%
70 Grand Rapids	633.9	708.9	75.0	11.8%
71 Cincinnati CMSA	1,677.3	1,875.6	198.3	11.8%
72 New Orleans	1,322.3	1,473.8	151.5	11.5%
73 Memphis	943.2	1,050.5	107.3	11.4%
74 New York-Newark CMSA	17,771.6	19,681.6	1,910.0	10.7%
75 Harrisburg	572.0	633.3	61.3	10.7%
76 Milwaukee-Racine	1,547.8	1,712.0	164.2	10.6%
77 Lansing	417.9	462.0	44.1	10.6%
78 Scranton	722.3	796.9	74.6	10.3%
79 St. Louis	2,408.6	2,650.0	241.4	10.0%
80 Birmingham	902.4	990.6	88.2	9.8%
81 Chicago-Gary CMSA	8,072.3	8,833.8	761.5	9.4%
82 Syracuse	650.1	709.4	59.3	9.1%
83 Johnson City	441.9	482.1	40.2	9.1%
84 Louisville	962.8	1,049.0	86.2	9.0%
85 Rochester NY	980.7	1,059.9	79.2	8.1%
86 Canton	400.6	431.4	30.8	7.7%
87 Wichita	465.5	500.8	35.3	7.6%
88 Detroit-Ann Arbor	4,574.0	4,905.4	331.4	7.2%
89 Fort Wayne	350.4	375.6	25.2	7.2%
90 Dayton	929.6	995.2	65.6	7.1%
91 Pittsburg CMSA	2,333.7	2,496.3	162.6	7.0%
92 Shreveport	361.8	385.0	23.2	6.4%
93 Toledo	607.2	643.3	36.1	5.9%
94 Youngstown	512.0	540.1	28.1	5.5%
95 Flint	433.2	454.9	21.7	5.0%
96 Buffalo-Niagara CMSA	1,186.1	1,244.2	58.1	4.9%
97 Cleveland CMSA	2,772.0	2,890.6	118.6	4.3%
98 Beaumont	380.8	392.6	11.8	3.1%
99 Davenport	376.6	378.4	1.8	0.5%
100 Saginaw	406.8	408.1	1.3	0.3%

mid-1980s suburban growth in the Northeast had revived and even the central cities exhibited a small aggregate increase.

Midwestern cities, many still dominated by older, stagnating industrial bases, continued to decline in the aggregate, albeit not as rapidly as during the 1970s. Suburban population growth in the Midwest also slowed further in the 1980s in contrast to the suburban turnaround exhibited in the Northeast.

Strong population growth remained the characteristic feature of central cities and the suburban rings of the largest metropolitan areas of the South and the West. In fact, the central cities in both the South and the West exhibited greater absolute and percent increases during the first half of the 1980s and during their rapid expansion in the 1970–1980 decade. Like cities in the

TABLE 20 Metropolitan Area and Principal City Population Change, 1960 to 1986 Northeast Region: (in thousands) (*2, 7, 11, 26*)

METROPOLITAN AREA	1980-86		1970-80		1960-70	
New York-Newark CMSA	556	3.2%	-660	-3.7%	1,898	11.7%
New York City	191	2.7%	-824	-10.4%	114	1.5%
Suburban area	365	3.5%	164	1.6%	1784	21.3%
Philadephia CMSA	152	2.7%	-68	-1.2%	618	12.0%
Philadelphia	-45	-2.7%	-261	-13.4%	-54	-2.7%
Suburban area	197	4.9%	193	5.1%	672	21.5%
Boston CMSA	393	10.7%	-47	-1.3%	352	10.5%
Boston	11	2.0%	-78	-12.2%	-56	-8.0%
Suburban area	382	12.3%	31	1.0%	408	15.3%
Pittsburgh CMSA	-107	-4.4%	-133	-5.2%	-19	-0.7%
Pittsburgh	-37	-8.7%	-96	-18.5%	-84	-13.9%
Suburban area	-70	-3.5%	-37	-1.8%	65	3.3%
Buffalo-Niagara CMSA	-61	-4.9%	-106	-7.9%	42	3.2%
Buffalo	-33	-9.2%	-105	-22.7%	-70	-13.1%
Suburban area	-28	-3.2%	-1	-0.1%	112	14.5%
Providence-Pawtucket CMSA	242	27.9%	11	1.3%	77	9.9%
Providence	0	0.0%	-22	-12.3%	-28	-13.5%
Suburban area	242	34.1%	33	4.9%	105	18.4%
Hartford-New Britain CMSA	31	3.0%	17	1.6%	188	22.2%
Hartford	2	1.5%	-22	-13.9%	-4	-2.5%
Suburban area	236	33.3%	39	4.4%	192	28.0%
Rochester NY, MSA	9	0.9%	9	0.9%	161	20.1%
Rochester	-6	-2.5%	-53	-18.0%	-24	-7.5%
Suburban area	15	2.1%	62	9.3%	185	38.4%
Albany-Schenectady MSA	8	1.0%	25	3.1%	65	8.7%
Albany	-5	-4.9%	-14	-12.1%	-14	-10.8%
Suburban area	13	1.8%	39	5.6%	79	12.8%
Scranton-Wilkes-Barre MSA	-3	-0.4%	33	4.7%	5	0.7%
Scranton	-6	-6.8%	-16	-15.4%	-7	-6.3%
Suburban area	3	0.5%	49	8.3%	12	2.1%
Sum of metro areas	1181	3.4%	-919	-2.6%	3387	10.5%
Sum of principal cities	72	0.7%	-1491	-12.1%	-227	-1.8%
Sum of suburban areas	1109	4.6%	572	2.4%	3614	18.2%

Northeast and Midwest, racial and ethnic minorities in major southern and western cities grew in absolute and proportional terms during the 1980s (*27*). A significant difference, however, is that minorities are far more likely to settle in the suburban rings and nonmetropolitan areas of the South and the West than in the Northeast and the Midwest. In both the Northeast and the Midwest, non-Hispanic whites continue to constitute more than 90 percent of the suburban populations of these regions and more than 95 percent of the metropolitan populations. This represented little change since 1975. In the South and the West, minority resident percentages in the suburban rings were much higher in 1985, ranging from 18 to 25 percent (*27*).

TABLE 21 Metropolitan Area and Principal City Population Change, 1960 to 1986: Midwest Region (in thousands) (*2, 7, 11, 26*)

METROPOLITAN AREA PRINCIPAL CITY	1980-86		1970-80		1960-70	
Chicago CMSA	179	2.3%	158	2.0%	844	12.2%
Chicago	5	0.2%	-364	-10.8%	-181	-5.1%
Suburban area	174	3.5%	522	11.8%	1025	30.3%
Detroit-Ann Arbor CMSA	-152	-3.2%	-35	-0.7%	565	13.4%
Detroit	-117	-9.7%	-311	-20.5%	-156	-9.3%
Suburban area	-35	-1.0%	276	8.4%	721	28.2%
Cleveland CMSA	-68	-2.4%	-166	-5.5%	268	9.8%
Cleveland	-38	-6.6%	-177	-23.6%	-125	-14.3%
Suburban area	-30	-1.3%	11	0.5%	393	21.2%
St. Louis MSA	61	2.6%	-52	-2.1%	268	12.4%
St. Louis	-27	-6.0%	-169	-27.2%	-128	-17.1%
Suburban area	88	4.6%	117	6.5%	396	28.1%
Minneapolis-St. Paul	158	7.4%	155	7.8%	371	23.0%
Minneapolis	-14	-3.8%	-63	-14.5%	-49	-10.1%
Suburban area	172	9.7%	218	14.1%	420	37.2%
Cincinnati-Hamilton CMSA	30	1.8%	47	2.9%	145	9.9%
Cincinnati	-15	-3.9%	-69	-15.2%	-49	-9.7%
Suburban area	45	3.5%	116	10.0%	194	20.1%
Milwaukee-Racine CMSA	-18	-1.1%	-5	-0.3%	154	10.8%
Milwaukee	-31	-4.9%	-81	-11.3%	-24	-3.2%
Suburban area	13	1.4%	76	8.9%	178	26.2%
Kansas City MSA	85	5.9%	60	4.4%	171	14.2%
Kansas City	-6	-1.0%	-66	-9.8%	77	12.9%
Suburban area	91	11.0%	126	18.1%	94	15.6%
Columbus MSA	55	4.4%	95	8.3%	191	19.9%
Columbus	1	0.2%	25	4.6%	69	14.6%
Suburban area	54	8.0%	70	11.5%	122	25.1%
Indianapolis MSA	46	3.9%	56	5.0%	167	17.7%
Indianapolis	19	2.7%	-36	-4.9%	261	54.8%
Suburban area	27	5.8%	92	24.6%	-94	-20.1%
Sum of metro areas	376	1.4%	313	1.2%	3144	13.3%
Sum of principal cities	-223	-2.6%	-1311	-13.4%	-305	-3.0%
Sum of suburban areas	599	3.2%	1624	9.6%	3449	25.5%

The most recent minority immigrant locational trends have reinforced these relative differences in minority confinement. Between 1975 and 1985, most minority immigrants to the Northeast and Midwest settled in the central cities of metropolitan areas, whereas in the South and West, the majority have settled in the suburban rings and nonmetropolitan areas (*27*). As will be seen later, such settlement patterns will have important implications for future job opportunities for minorities as well as for transportation policy.

The demographic future of nonmetropolitan America remains clouded. During the late 1970s and early 1980s, much was made of the rural demographic renaissance when it was discovered that, for a relatively short

TABLE 22 Metropolitan Area and Principal City Population Change, 1960 to 1986: South Region (in thousands) (*2, 7, 11, 26*)

METROPOLITAN AREA PRINCIPAL CITY	1980-86		1970-80		1960-70	
Dallas-Ft. Worth CMSA	724	24.7%	579	24.6%	636	37.1%
Dallas & Ft. Worth	144	11.2%	53	4.3%	201	19.4%
Suburban area	580	35.3%	526	47.2%	435	64.0%
Houston-Galveston CMSA	533	17.2%	932	43.0%	598	38.1%
Houston	118	7.3%	377	30.6%	296	31.6%
Suburban area	415	27.9%	555	59.4%	302	47.7%
Washington DC, MSA	313	9.6%	210	6.9%	826	37.3%
Washington DC	-12	-1.9%	-119	-15.7%	-7	-0.9%
Suburban area	325	12.4%	329	14.4%	833	57.4%
Miami-Ft. Lauderdale CMSA	268	10.1%	756	40.0%	619	48.8%
Miami	27	7.8%	12	3.6%	43	14.7%
Suburban area	241	10.5%	744	47.9%	576	59.0%
Atlanta MSA	423	19.8%	454	27.0%	436	34.9%
Atlanta	-3	-0.7%	-70	-14.1%	8	1.6%
Suburban area	426	24.9%	524	44.1%	428	56.2%
Baltimore MSA	81	3.7%	110	5.3%	269	14.8%
Baltimore	-34	-4.3%	-118	-13.0%	-34	-3.6%
Suburban area	115	8.1%	228	19.3%	303	34.4%
Tampa-St. Petersburg	300	18.6%	508	45.9%	286	34.9%
Tampa	6	2.2%	-6	-2.2%	3	1.1%
Suburban area	294	21.9%	514	62.1%	283	51.9%
New Orleans MSA	77	6.1%	157	14.3%	153	16.2%
New Orleans	-4	-0.7%	-35	-5.9%	-35	-5.6%
Suburban area	81	11.6%	192	37.9%	188	58.9%
Norfolk-Virginia Beach	150	12.9%	101	9.5%	182	20.8%
Norfolk	8	3.0%	-41	-13.3%	3	1.0%
Suburban area	142	15.9%	142	18.9%	179	31.3%
San Antonio MSA	204	19.0%	184	20.7%	152	20.7%
San Antonio	104	12.8%	156	23.9%	66	11.2%
Suburban area	100	38.2%	28	12.0%	86	58.1%
Sum of metro areas	3073	14.4%	3991	23.0%	4157	31.4%
Sum of principal cities	354	5.1%	209	3.1%	544	8.7%
Sum of suburban areas	2719	18.9%	3782	35.8%	3613	51.9%

period, nonmetropolitan counties were growing faster than metropolitan counties. Data for the first half of the 1980s, however, documented that metropolitan areas had recaptured their demographic growth advantage—and markedly so. Thus, although transportation and communication advances will continue to make many people and jobs more footloose, metropolitan areas appear to have a strong hold on externalities that will permit them to capture the vast bulk of future population increase. Most of this future metropolitan population growth, in turn, will no doubt be in the suburban rings, both because of the economic advantages they hold for business and industry (*7, 28*) and because preference surveys consistently document that the suburbs

TABLE 23 Metropolitan Area and Principal City Population Change, 1960 to 1986: West Region (in thousands) (*2, 7, 11, 26*)

METROPOLITAN AREA PRINCIPAL CITY	1980-86		1970-80		1960-70	
Los Angeles CMSA	1577	13.7%	1517	15.2%	2,229	28.8%
Los Angeles	290	9.8%	157	5.6%	333	13.4%
Suburban area	1287	15.1%	1360	19.0%	1896	36.0%
San Francisco-Oakland CMSA	510	9.5%	614	12.9%	1,031	27.7%
San Francisco & Oakland	88	8.6%	-60	-5.6%	-30	-2.7%
Suburban area	422	9.7%	674	18.3%	1061	40.6%
Seattle-Tacoma CMSA	192	9.2%	256	13.9%	408	28.6%
Seattle	-8	-1.6%	-37	-7.0%	-26	-4.7%
Suburban area	200	12.5%	293	22.4%	434	49.8%
San Diego MSA	339	18.2%	504	37.1%	325	31.5%
San Diego	139	15.9%	179	25.7%	124	21.6%
Suburban area	200	20.3%	325	49.2%	201	43.7%
Phoenix MSA	391	25.9%	538	55.4%	307	46.2%
Phoenix	104	13.2%	206	35.3%	145	33.0%
Suburban area	287	39.9%	332	85.8%	162	72.0%
Denver-Boulder CMSA	229	14.2%	380	30.7%	304	32.5%
Denver	12	2.4%	-22	-4.3%	21	4.3%
Suburban area	217	19.3%	402	55.6%	283	64.3%
Portland-Vancouver CMSA	66	5.1%	251	24.0%	193	22.6%
Portland	-9	-2.3%	17	4.5%	7	1.9%
Suburban area	75	8.3%	234	35.1%	186	38.7%
Sacramento MSA	191	17.4%	252	29.7%	193	29.5%
Sacramento	48	17.4%	19	7.4%	65	33.9%
Suburban area	143	17.4%	233	39.4%	128	27.6%
Salt Lake City-Ogden MSA	131	14.4%	226	33.0%	125	22.4%
Salt Lake City	-5	-3.1%	-13	-7.4%	-13	-6.9%
Suburban area	136	18.2%	239	47.0%	138	37.3%
Honolulu MSA	54	7.1%	132	20.9%	131	26.2%
Honolulu	4	1.1%	43	13.2%	31	10.5%
Suburban area	50	12.7%	89	29.1%	100	48.5%
Sum of metro areas	3680	13.1%	4670	20.0%	5246	29.0%
Sum of principal cities	663	8.5%	489	6.6%	657	9.8%
Sum of suburban areas	3017	15.0%	4181	26.1%	4589	40.2%

are, by a wide margin, the modal residential choice of the American population.

Three related types of demographic dynamics shaping America's future warrant attention. The first is the nation's changing racial and ethnic mix, which is being fueled by the declining birth rate of non-Hispanic whites and the growth of Hispanics and Asians—America's new immigrant groups.

Between 1985 and 2020, the nation's population is projected to grow by 58 million (*29*). Of this increase, 70 percent (40.33 million) will result from the growth of Hispanic (those with Spanish origins), black, and Asian residents. Whereas the non-Hispanic white population is projected to grow by 9.5

percent between 1985 and 2010, the Hispanic population is projected to grow by 111 percent, the Asian population by 114 percent, and the black population by 52 percent (see Table 24). Because expectations are that the very low birth rate of non-Hispanic whites will not rise during the next two decades and that immigration from Europe will also remain low, the non-Hispanic white population is projected to decline in absolute numbers after 2020.

From a territorial distribution standpoint, non-Hispanic whites should show absolute declines in the Northeast and the Midwest between now and 2020, with the largest declines experienced in their major central cities. Blacks, Asians, and Hispanics will expand modestly in the Northeast and the Midwest (*30*). The South and the West will add substantial numbers of non-Hispanic whites along with the continuing growth of their black, Hispanic, and Asian populations. Hispanic population increases will be dramatic in the South and the West, and the majority of the national increase in the Asian population will occur in the West (especially in California).

The second striking compositional change over the next three decades will be a substantial aging of the U.S. population. This aging will characterize all major racial and ethnic groups (see Table 25). Although the median age of the total population will rise from 31.4 in 1985 to 39.3 in 2020, that of the non-Hispanic white population will rise from 32.9 to 42.3. Although between 1985 and 2010 the median age of the Hispanic population will increase from 25.0 to 31.2, that of blacks from 26.2 to 33.5, and that of Asians and others from 28.5 to 37.5, the median-age gap between non-Hispanic whites and minorities will widen.

Of the total national population increase of 58 million projected between 1985 and 2020, only 3.3 million will be added to the population of those under

TABLE 24 Total Population by Race and Spanish Origin: 1985 to 2020 (in millions)

Year	Total	Spanish origin	White non-Hispanic	Black	Other races
1985	238.6	17.3	186.8	29.1	6.4
1990	249.7	19.9	192.0	31.4	7.5
1995	259.6	22.6	196.2	33.7	8.5
2000	268.0	25.2	198.9	35.8	9.5
2010	283.2	30.8	202.6	40.0	11.7
2020	296.6	36.5	204.5	44.2	13.7

Source: U.S. Bureau of the Census, 1986.

TABLE 25 Median Age of U.S. Population by Race and Spanish Origin, 1985 to 2020

Year	Total	Spanish Origin	White non-Hispanic	Black	Other races
1985	31.4	25.0	32.9	26.2	28.5
1990	33.0	26.3	34.6	27.7	30.4
1995	34.7	27.2	36.5	29.2	32.1
2000	36.3	28.0	38.5	30.2	33.5
2010	38.5	29.3	41.4	31.4	35.6
2020	39.3	31.2	42.3	33.5	37.5

Source: U. S. Bureau of the Census, 1986.

45 (a 5.7 percent increase). On the other hand, those 45 to 64 are projected to increase by 31.8 million (a 71 percent increase), and those aged 65 and over are projected to increase by 22.8 million (an 80 percent increase). Even more striking will be the growth of the population over 85, which is projected to rise from 2.7 million in 1985 to 7.1 million in 2020.

The third major demographic change is declining household size concurrent with increases in the number of households. Average household size has steadily dropped from 3.14 in 1970 to 2.66 in 1987 (*31*). Falling fertility rates have been reinforced by an expansion in the number of elderly single-person households, single-parent households, postwar Baby Boom married couples without children or with one child, "empty nesters," and households composed of unrelated adults (*33*). Projections by the Bureau of the Census (*32*) indicate that average household size will continue to drop to less than 2.5 by the turn of this century. At the same time, the number of households is projected to increase from 88 million in 1986 to 106 million in 2000, with married-couple households accounting for only slightly more than 5 million of this projected increase (*32*).

Apropos transportation policy, growth in the number of households is at least as important as growth in population. Thus, areas of slow population increase may find their more rapid increases in households creating additional demands for both public and private transportation infrastructure. Moreover, because more than one of every five drivers in the year 2020 will likely be over 65, such questions as licensing standards will arise, as well as needs for larger directional signs, brighter street lighting and roadway signs, more legible automobile instrument panels, fully automated seat belts, and minimum speeds on freeways (*33*). Finally, because most of the older population in the year 2020 will reside in the suburbs and smaller towns, issues of future public transportation availability and accessibility must be addressed.

Concerning employment policy, the low non-Hispanic white birth rate, together with recent declines in the birth rates of minorities, implies that serious labor-force shortages will likely appear by the 1990s. Indeed, without a substantial increase in immigration, the number of 25- to 34-year-olds will decline by 15.4 percent between 1990 and 2000 and the number of 18- to 24-year-olds will decline by 3.5 percent (*24*). This is one major reason to expect immigration laws to be relaxed during the 1990s and resulting population increases to exceed slightly the midrange estimates of the Bureau of the Census shown in Table 24. Most of the accelerated population increase, of course, will be composed of Hispanics and Asians.

Employment Forecasts

Because most projections of population growth for metropolitan areas, states, census divisions, and regions are based, in part, on future anticipated economic development, it should not be surprising that employment growth projections are found to roughly correspond to population growth projections. Table 26 presents the Bureau of Economic Analysis (BEA) employment projections to the year 2015 aggregated by census regions and divisions. As with population, the South and the West are projected to dominate the nation's employment growth picture. During the coming three decades, these regions will capture two-thirds of the total employment increase, with the South adding the largest absolute number of jobs and the West growing the most on a percentage basis. The Northeast and the Midwest are projected to add approximately an equal number of jobs (6.6 million) by 2015. At the census-division level, the South Atlantic and Pacific divisions will add the most employment, and the Mountain Division will grow the fastest on a percentage basis (see Table 26).

The substantial discrepancy between the Bureau of the Census projections of net population decline for the Midwest (Table 17) and the BEA employment growth projections for that region illustrates the risks inherent with many projections. Because it is unlikely that increased labor-force participation rates in the Midwest can generate employees sufficient to fill the 6.7 million additional jobs projected by BEA for that region, either the Census Bureau's population projection for the Midwest is far too low or the BEA's employment projection too high, or both.

Table 27 provides employment projections for the census regions by major industry categories [agriculture; mining; construction; manufacturing; transportation, public utilities, and communication (TPUC); wholesale and retail (W/R) trade; finance, insurance, and real estate (F.I.R.E.); services; and government]. For all regions, service industries and F.I.R.E. are projected to

TABLE 26 Total Employment Projections by Region and Division, 1983 to 2015 (in thousands)

Area	1983	2015	Change 1983 to 2015 Absolute	Percent
U.S. TOTAL	106,891.0	146,743.9	39,852.9	37.3%
Regions				
Northeast	23,087.4	29,693.1	6,605.7	28.6%
Midwest	26,454.7	33,119.9	6,665.2	25.2%
South	35,991.1	50,532.2	14,541.1	40.4%
West	21,357.8	33,398.7	12,040.9	56.4%
Divisions				
New England	6,321.8	9,069.8	2,748.0	43.5%
Middle Atlantic	16,765.6	20,623.3	3,857.7	23.0%
East North Central	17,969.2	22,096.0	4,126.8	23.0%
West North Central	8,485.5	11,023.9	2,538.4	29.9%
South Atlantic	18,114.2	25,747.4	7,633.2	42.1%
East South Central	6,266.4	8,138.1	1,871.7	29.9%
West South Central	11,610.5	16,646.7	5,036.2	43.4%
Mountain	5,567.4	9,669.7	4,102.3	73.7%
Pacific	15,790.4	23,729.0	7,938.6	50.3%

Computed from BEA OBERS projections data reprinted by Hershey Consultants, King of Prussia PA., in the Strategem file, 1986.

TABLE 27 Employment Projections by Region and Industry, 1983 to 2015 (in thousands)

Area and Industry	1983	2015	Change 1983 to 2015 Absolute	Percent
NORTHEAST				
TOTAL	23,087.4	29,693.1	6,605.7	28.6%
Agric.	413.5	509.8	96.3	23.3%
Mining	55.9	67.0	11.1	19.9%
Const.	923.9	1,290.6	366.7	39.7%
Manuf.	4,642.4	5,239.4	597.0	12.9%
TPUC	1,156.7	1,544.6	387.9	33.5%
W/R Trade	4,906.1	6,513.0	1,606.9	32.8%
FIRE	1,589.6	2,265.4	675.8	42.5%
Services	5,875.9	8,768.6	2,892.7	49.2%
Gov't.	3,523.4	3,494.6	-28.8	-0.8%
MIDWEST				
TOTAL	26,454.7	33,119.9	6,665.2	25.2%
Agric.	1,581.0	1,497.4	-83.6	-5.3%
Mining	125.6	176.5	50.9	40.5%
Const.	1,059.1	1,487.4	428.3	40.4%
Manuf.	5,288.8	6,183.5	894.7	16.9%
TPUC	1,287.5	1,636.9	349.4	27.1%
W/R Trade	5,795.6	7,438.0	1,642.4	28.3%
FIRE	1,432.9	2,044.3	611.4	42.7%
Services	5,766.4	8,566.5	2,800.1	48.6%
Gov't.	4,117.8	4,089.2	-28.6	-0.7%
SOUTH				
TOTAL	35,991.1	50,532.2	14,541.1	40.4%
Agric.	1,842.9	1,929.0	86.1	4.7%
Mining	601.3	782.5	181.2	30.1%
Const.	2,092.9	2,914.7	821.8	39.3%
Manuf.	5,785.9	7,739.2	1,953.3	33.8%
TPUC	1,800.4	2,691.2	890.8	49.5%
W/R Trade	7,560.6	11,455.1	3,894.5	51.5%
FIRE	1,850.6	2,993.5	1,142.9	61.8%
Services	7,435.2	12,278.8	4,843.6	65.1%
Gov't.	7,021.2	7,748.0	726.8	10.4%
WEST				
TOTAL	21,357.8	33,398.7	12,040.9	56.4%
Agric.	933.8	1,206.8	273.0	29.2%
Mining	196.2	312.2	116.0	59.1%
Const.	1,022.1	1,788.7	766.6	75.0%
Manuf.	3,104.9	4,669.7	1,564.8	50.4%
TPUC	1,068.4	1,706.7	638.3	59.7%
W/R Trade	4,631.7	7,507.9	2,876.2	62.1%
FIRE	1,295.9	2,236.8	940.9	72.6%
Services	5,086.5	9,259.1	4,172.6	82.0%
Gov't.	4,055.6	4,711.2	655.6	16.2%

Compiled from BEA OBERS data reprinted by Hershey Consultants in the Strategem file, 1986.

grow the most on a percentage basis, with the largest proportional gains in these industries occurring in the South and the West. Considering absolute employment increases, W/R trade will follow services as each region's second most important growth industry. The South and the West should also experience major increases in manufacturing employment during the next three decades. Contrary to conventional wisdom, employment growth in manufacturing is actually projected to exceed employment growth in F.I.R.E. in all regions except the Northeast.

Table 28 shows employment growth projections to 2010 for the nation's 100 largest metropolitan areas ranked in terms of percent change. The projections were prepared by the National Planning Association (NPA) (25). Whereas the top five projected growth areas all fall in the South and the West (Nashville, Tucson, Austin, Phoenix, and Fresno), it may surprise some that the NPA projects that the next five will be the older Frostbelt metropolitan areas (New Haven, Indianapolis, Youngstown, Lansing, and Cincinnati).

In terms of projected absolute employment increases, the Los Angeles and New York City Consolidated Metropolitan Statistical Areas (CMSAs) will dominate, adding 2.9 million and 2.5 million jobs, respectively. Other major metropolitan areas projected to add more than 1 million jobs between 1985 and 2010 include San Francisco-Oakland (1.64 million), Boston (1.15 million), Houston (1.13 million), Philadelphia (1.04 million), Chicago (1.04 million), and Washington, D.C. (1.01 million). Along with Los Angeles and New York, these metropolitan areas will also dominate in total employment during the first part of the 21st century.

Within metropolitan areas, the suburban rings will continue to be the focus of the majority of employment growth. The successful economic transformation of a number of northern cities from goods production to service provision has reversed decades of employment decline, yet their modest growth during the 1980s was overwhelmed by employment growth in their suburban rings. These trends should continue.

The Bureau of Labor Statistics provides monthly data that enable the nature and scale of employment change between 1980 and 1988 to be highlighted in four major metropolitan cities—Philadelphia, Baltimore, Washington, D.C., and New York—and the suburban rings of three of these cities. Employment changes within these areas are shown in Table 29 for seven basic industry categories (construction, manufacturing, transportation and communication, wholesale and retail trade, F.I.R.E., service, and government). Industry employment is further aggregated into goods production (PROD.), consisting of construction and manufacturing; retail and wholesale trade (TRADE); and the remaining service-sector industries (SERV).

To assess the most recent employment trends, total and industry employment changes are further decomposed into those that occurred between 1980

TABLE 28 Relative Change in Total Employment for the 100 Largest Metropolitan Areas, 1985 and 2010 (in thousands) (25)

	Metropolitan Area	Total Employment 1985	Total Employment 2010	Employment Change Absolute	Employment Change Percent
1	Nashville	498.1	906.5	408.4	82.0%
2	Tucson	291.9	523.3	231.4	79.3%
3	Austin	378.5	673.1	294.6	77.8%
4	Phoenix	991.4	1,672.1	680.7	68.7%
5	Fresno	280.8	468.1	187.3	66.7%
6	New Haven	430.9	697.8	266.9	61.9%
7	Indianapolis	629.4	1,005.4	376.0	59.7%
8	Youngstown	260.9	415.7	154.8	59.3%
9	Lansing	202.1	321.8	119.7	59.2%
10	Cincinnati CMSA	892.5	1,414.5	522.0	58.5%
11	Seattle-Tacoma	1,130.1	1,780.4	650.3	57.5%
12	Miami-Ft Lauderdale	1,504.9	2,367.4	862.5	57.3%
13	Tampa	1,000.0	1,565.9	565.9	56.6%
14	Fort Wayne	111.6	174.5	62.9	56.4%
15	Cleveland CMSA	1,491.7	2,316.9	825.2	55.3%
16	Washington D.C.	1,900.2	2,912.5	1012.3	53.3%
17	Houston CMSA	2,140.1	3,273.7	1133.6	53.0%
18	Memphis	514.7	786.2	271.5	52.7%
19	Tulsa	420.8	638.5	217.7	51.7%
20	Boston CMSA	2,269.9	3,415.9	1146.0	50.5%
21	San Francisco-Oakland CMSA	3,429.5	5,073.8	1644.3	47.9%
22	Little Rock	257.8	381.2	123.4	47.9%
23	Bakersfield	239.4	352.1	112.7	47.1%
24	Charleston	252.6	370.7	118.1	46.8%
25	Hartford CMSA	613.6	898.0	284.4	46.3%
26	New Orleans	714.6	1,044.1	329.5	46.1%
27	Jacksonville	447.4	649.8	202.4	45.2%
28	Baltimore	1,238.7	1,777.1	538.4	43.5%
29	Los Angeles-Anaheim CMSA	6,752.6	9,651.3	2898.7	42.9%
30	Las Vegas	276.3	391.8	115.5	41.8%
31	Atlanta	1,393.7	1,969.4	575.7	41.3%
32	Portland OR. CMSA	722.9	1,013.7	290.8	40.2%
33	West Palm Beach	382.7	536.5	153.8	40.2%
34	Norfolk	711.7	997.7	286.0	40.2%
35	Dayton	498.4	697.7	199.3	40.0%
36	Wichita	227.8	318.3	90.5	39.7%
37	Orlando	463.6	646.6	183.0	39.5%
38	Buffalo-Niagara CMSA	616.6	856.6	240.0	38.9%
39	Rochester	527.3	730.7	203.4	38.6%
40	Baton Rouge	273.2	377.9	104.7	38.3%
41	Minneapolis-St. Paul	1,246.7	1,711.9	465.2	37.3%
42	Colorado Springs	169.1	231.2	62.1	36.7%
43	Worcester	352.7	478.2	125.5	35.6%
44	Chattanooga	204.0	276.5	72.5	35.5%
45	Mobile	234.2	317.3	83.1	35.5%
46	Columbus	674.5	913.5	239.0	35.4%
47	Philadelphia CMSA	2,977.4	4,020.9	1043.5	35.0%
48	Greensboro	483.7	653.1	169.4	35.0%
49	Detroit-Ann Arbor	2,357.2	3,171.2	814.0	34.5%
50	Harrisburg	279.4	375.7	96.3	34.5%
51	Des Moines	174.8	235.0	60.2	34.4%
52	Allentown	335.2	450.3	115.1	34.3%
53	Salt Lake City	537.7	722.3	184.6	34.3%
54	Spokane	165.9	222.4	56.5	34.1%
55	Sacremento	665.3	891.2	225.9	34.0%
56	Lakeland	221.0	295.8	74.8	33.8%
57	Honolulu	439.9	586.2	146.3	33.3%
58	Jackson	184.9	245.6	60.7	32.8%
59	Milwaukee-Racine	840.4	1,115.9	275.5	32.8%
60	Johnson City	214.0	284.0	70.0	32.7%

TABLE 28 ***continued***

	Metropolitan Area	Total Employment 1985	2010	Employment Change Absolute	Percent
61	Richmond	437.3	578.8	141.5	32.4%
62	Stockton	200.7	265.5	64.8	32.3%
63	Shreveport	168.9	223.3	54.4	32.2%
64	Omaha	325.2	429.0	103.8	31.9%
65	Syracuse	348.7	459.8	111.1	31.9%
66	Columbia SC	214.0	280.0	66.0	30.8%
67	Scranton	411.3	537.4	126.1	30.7%
68	Kansas City	829.1	1,081.1	252.0	30.4%
69	San Antonio	634.1	826.0	191.9	30.3%
70	Flint	208.6	271.6	63.0	30.2%
71	Oklahoma City	526.3	684.8	158.5	30.1%
72	Pittsburg CMSA	1,291.5	1,671.5	380.0	29.4%
73	Birmingham	494.6	636.4	141.8	28.7%
74	Denver	846.1	1,076.6	230.5	27.2%
75	Springfield MA	288.1	366.2	78.1	27.1%
76	Canton	195.3	247.8	52.5	26.9%
77	Albany	458.6	581.0	122.4	26.7%
78	Grand Rapids	334.0	422.5	88.5	26.5%
79	Greenville	312.4	395.0	82.6	26.4%
80	New York-Newark CMSA	9,402.1	11,875.4	2473.3	26.3%
81	Raleigh-Durham	326.9	411.8	84.9	26.0%
82	Knoxville	307.1	386.6	79.5	25.9%
83	Providence	477.4	597.2	119.8	25.1%
84	Saginaw	198.1	247.4	49.3	24.9%
85	Chicago-Gary CMSA	4,185.4	5,225.1	1039.7	24.8%
86	San Diego	1,050.4	1,301.7	251.3	23.9%
87	York	192.4	238.2	45.8	23.8%
88	Toledo	317.4	392.4	75.0	23.6%
89	El Paso	273.2	336.9	63.7	23.3%
90	Louisville	523.7	645.8	122.1	23.3%
91	Dallas-Ft Worth	2,130.5	2,627.1	496.6	23.3%
92	Davenport	177.8	217.7	39.9	22.4%
93	Charlotte	568.6	692.3	123.7	21.8%
94	Albuquerque	219.1	266.5	47.4	21.6%
95	Beaumont	182.0	220.4	38.4	21.1%
96	St. Louis	1,382.6	1,667.2	284.6	20.6%
97	McAllen	160.1	189.4	29.3	18.3%
98	Corpus Christi	167.5	197.6	30.1	18.0%
99	Augusta	179.6	210.5	30.9	17.2%
100	Lancaster	189.8	206.1	16.3	8.6%

and 1984 (1982–1984 for Baltimore) and those that occurred between 1984 and 1988. The results show that employment increased in all four major cities between 1984 and 1988, and in New York City between 1980 and 1984 as well.

In all cases for which comparable data are available, however, it can be seen that central-city job increases were greatly surpassed by employment growth in the suburban rings. The data also highlight the selectivity of employment change in major cities, with manufacturing continuing its precipitous decline and services the growth leader. In New York City, for instance, 329,100 jobs were added between January 1980 and January 1988 (a 10.1 percent overall employment increase), whereas 125,100 manufacturing jobs were lost (a greater than 25 percent decline in the past 8 years). As will be shown in the

TABLE 29 Change in Central City and Suburban Ring Employment: Selected Metropolitan Areas, January 1980 to January 1988 (in thousands) (*34*)

AREA	TOTAL	CONST	MANUF	TRANS	WHOL/RET	FIRE	SERVICE	GOVERN	PROD.	TRADE	SERV
Philadelphia											
Central city											
1980-1984	-59.8	-3.3	-34.3	-9.0	-9.4	-4.3	10.8	-10.3	-37.6	-9.4	-12.8
1984-1988	41.7	0.6	-12.7	-1.5	6.4	8.5	33.2	7.2	-12.2	6.4	47.5
1980-1988	-18.1	-2.7	-47.0	-10.5	-3.0	4.2	44.0	-3.1	-49.8	-3.0	34.7
% change	-2.3%	-14.6%	-33.0%	-19.2%	-2.0%	6.0%	20.8%	-2.1%	-31.0%	-2.0%	7.2%
Suburban ring											
1980-1984	70.0	-2.7	-26.7	3.6	32.6	9.6	56.6	-3.0	-29.4	32.6	66.8
1984-1988	189.5	23.9	-5.2	2.8	44.1	18.9	60.4	5.4	18.9	44.1	87.3
1980-1988	259.5	30.7	-29.9	8.6	86.1	32.4	129.5	2.1	0.0	86.1	173.4
% change	23.1%	55.7%	-9.6%	19.4%	32.1%	57.3%	55.7%	1.3%	0.0%	32.1%	35.5%
Baltimore											
Central city											
1982-1984	-4.5	0.2	-3.1	-5.5	-6.6	1.2	10.7	-1.4	-2.9	-6.6	5.0
1984-1988	23.0	3.7	-10.5	-5.3	7.3	4.1	20.8	2.9	-6.9	7.3	22.6
1982-1988	18.5	3.9	-13.6	-10.8	0.7	5.3	31.5	1.5	-9.8	0.7	27.6
% change	4.3%	27.7%	-23.2%	-27.8%	0.7%	13.8%	29.7%	1.8%	-13.4%	0.7%	10.4%
Suburban ring											
1982-1984	23.7	10.2	0.6	6.1	7.2	2.2	13.7	-16.3	10.8	7.2	5.7
1984-1988	101.2	19.5	-1.2	1.3	35.3	9.8	37.1	-0.7	18.3	35.3	47.6
1982-1988	124.9	29.7	-0.6	7.4	42.5	12.0	50.8	-17.0	29.1	42.5	53.3
% change	25.1%	137.5%	-0.7%	42.0%	33.8%	63.2%	54.9%	-12.7%	26.7%	33.8%	20.3%
District of Columbia											
Central city											
1980-1984	-6.9	-4.0	-1.3	-0.2	-2.5	-0.1	22.8	-21.6	-5.3	-2.5	0.9
1984-1988	55.7	5.6	2.4	-1.2	1.7	2.8	35.7	8.7	7.9	1.7	46.1
1980-1988	48.8	1.6	1.1	-1.4	-0.8	2.7	58.5	-12.9	2.6	-0.8	47.0
% change	8.1%	11.5%	7.2%	-5.4%	-1.3%	7.8%	33.5%	-4.7%	8.9%	-1.3%	9.2%
Suburban ring											
1980-1984	192.2	9.3	19.7	12.4	50.0	12.0	87.4	1.4	29.0	50.0	113.2
1984-1988	304.9	40.2	10.7	24.2	75.0	23.7	116.4	14.7	50.0	75.0	179.9
1980-1988	497.1	49.5	30.4	36.6	125.0	35.7	203.8	16.1	79.0	125.0	293.1
% change	53.0%	78.3%	75.4%	88.6%	53.7%	67.1%	87.3%	5.9%	75.7%	53.7%	48.8%
New York City											
Central city											
1980-1984	115.1	15.8	-72.0	-18.6	2.5	60.9	116.1	10.5	-55.9	2.5	168.6
1984-1988	214.0	30.9	-53.1	-23.2	18.1	54.3	128.6	58.5	-23.6	18.1	219.6
1980-1988	329.1	46.7	-125.1	-41.8	20.6	115.2	244.7	69.0	-79.5	20.6	388.2
% change	10.1%	65.4%	-25.4%	-16.3%	3.4%	26.4%	28.1%	13.5%	-14.1%	3.4%	18.7%

Note: Prod. includes mining, contruction and manufacturing employment. Trade includes wholesale and retail trade employment. Serv. includes employment in transportation, utilities, communication, finance, real estate, insurance, service and government.

next section, most of New York's service-sector job increases have been in information-processing industries requiring substantial formal education.

The emerging information-age economy is placing major cities and metropolitan areas in stronger positions to add future jobs. Although 20th-century advances in transportation and communication technologies typically have deconcentrating effects on population and jobs, the interaction of more recent technological advances and the globalization of the economy may well improve the attractiveness of the largest cities and metropolitan areas. For example, good domestic and international airline accessibility will be a pivotal factor influencing employment growth during the coming decades. Research by Irwin and Kasarda (*35*) shows that the growth of producer services in metropolitan areas (the fastest-growing employment sector) corresponds closely to the latter's position and centrality in the U.S. airline flow network. Massey (*36*) observes that air access is among the primary factors in business relocation or expansion and is responsible for substantial employment growth in many areas. Air freight is also taking on an increased role in the movement of goods.

There is little question that as global economic exchanges expand, those U.S. metropolitan areas with excellent international airline access will benefit disproportionately. Just a few decades ago, Atlanta was competing with Birmingham as the dominant metropolis of the South. With the expansion of Hartsfield International Airport, Atlanta has become "the economic engine of the South." Direct benefits of the airport alone were calculated to be worth $7 billion to Atlanta in 1987 (*36*). Indirect (multiplier) benefits are many times that figure. For example, 20 years ago there were few international banks located in Atlanta. Since Hartsfield substantially expanded its international access in the 1970s and 1980s, the number of international banks in Atlanta has increased to 32 (*37*). In short, the virtually certain increased importance of large airports to the future economy of the nation should provide a unique comparative advantage to major metropolitan areas in capturing employment growth in the years ahead.

Like advances in transportation technologies, modern advances in communications technologies have both centralizing and deconcentrating spatial effects. On one hand, they allow most of those who process information to be located virtually anywhere as long as they have electronic access. On the other hand, they have facilitated the concentration of many office functions in particular areas, especially the central business districts (CBD). Because information (as opposed to people and products) is highly space compact and can flow electronically in a vertical dimension as efficiently as in a horizontal one, the stacking of both information producers and consumers, layer upon layer, in highrise office structures is possible. Indeed, such stacking and resulting proximity may actually increase the productivity of those whose activities require a substantial amount of nonroutine, face-to-face interaction (*7, 28*). Electronic information flows also increase the capacity of CBD activity by reducing congestion and allowing the simultaneous control of multiple production, sales, service, or back-office sites.

Mitchell Moss argues that in the information age (*38*, p. 35)

> Telecommunications is creating a new urban hierarchy in which certain cities will function as international interaction capitals, with the most extensive electronic infrastructure and richest opportunities for human interaction. Other cities will serve as regional information hubs, linked to principal international capitals, but with a less extensive geographic reach.

He contends that telecommunications is not an antiurban force, but one that will reinforce and likely even strengthen the position of those cities that exploit the growing demand for information-based activities in a transforming global economy.

With information becoming the new currency for major cities, Moss sees modern telecommunications advances enhancing the future competitive position of these cities for employment growth. For example, fiber-optics systems are being built along the rights-of-way that were initially granted for railroads in the 19th century. Likewise, new microwave paging systems are being installed in the 30 largest metropolitan areas and teleports in only the very largest. Diffusion to smaller cities and peripheral areas could take decades.

Finally, Moss reminds us not to underestimate the growing importance of face-to-face contact in transmitting timely information in a reliable and confidential manner. As a current example, he points to the insider trading scandals in the securities industry, which were done face to face because outgoing calls are a matter of public record.

Although major metropolitan areas will receive a substantial employment boost from modern transportation and telecommunications technologies, the author believes that most employment growth will continue to occur in the suburban rings. Already the suburbs and exurbs are evolving their own relatively self-sufficient hierarchy of activity centers, ranging from higher-order regional commercial and employment centers to lower-order convenience goods and residential centers. The evolution of this multifunctional, nested hierarchy of activity centers is giving rise to a new polycentric form of spatial organization that has replaced the technologically antiquated structure of the monocentered industrial metropolis. The extent to which interdependence among peripheral sites is developing is revealed in 1982 data on commuters: 27 million workers traveled between suburbs in contrast to half that number who commuted from the suburban rings to the central cities (*39*).

At first glance, such a spatial pattern might be considered a return to scale, which theories of decentralization suggest is an alternative when systems become too large to be effectively integrated by existing technological and organizational arrangements. However, given the evidence of the interconnectedness of multiple urban nodes (*40*), it is more appropriate to conceive of the polycentric metropolitan field as a reasonably well-integrated territorial unit that owes its functional integrity to interlocking expressways and telecommunications—technological adaptations that couple spatial separation with functional accessibility (*41*). Within this new, more diffuse form of spatial organization, the traditional metropolitan CBD has become just one specialized node in a multinodal, multiconnective urban field of interdependent activity centers, extending outward as far as 100 mi from the metropolitan core. The fact that the cost-effectiveness and productivity of many modern economic activities are enhanced in outlying nodes has made them valuable job generators for the U.S. economy. Moreover, as outlying activity centers have grown, they have begun to develop their own nearby labor sheds, reducing employee commuting distances and thus daily travel expenses. Polycentric nodes also reduce problems of convergence, congestion, air pollution, and wear and tear on core infrastructure (i.e., streets, highways, and bridges) associated with extensive journey-to-work commutation and truck shipments into and out of the traditional monocentered metropolis (*42*).

In sum, spatial deconcentration of employment to the suburbs and exurbs should remain the predominant trend into the 21st century. Retail and consumer services will continue to follow their suburbanizing clientele. In some cases, peripheral employment growth nodes such as regional shopping malls and administrative office, research, and industrial parks will attract additional businesses in close proximity. Trucking firms and large automated warehouse facilities will continue to take up sites along peripheral beltways and freeways. In this increasingly automobile- and truck-dependent polyconcentric form, points of congestion will emerge that will begin to rival those of the CBDs of the largest central cities. Yet traditional public transportation will likely be eschewed by those working in the periphery because of its spatial and temporal inflexibility and the related characteristic that most suburbanites want to be unconstrained in their movements, even at additional cost.

Education, Jobs, and Emerging Urban Mismatches

A concept germane to much transportation policy research is that of "mismatch," which may be defined as a discordant distribution of labor qualifications vis-à-vis qualifications required for available jobs at a point in time. Mismatch has both nonspatial (nationwide) and spatial-specific (community) aspects. The nonspatial aspect results from transformations in the overall economy from industrial to postindustrial and corresponding shrinking demand for traditional blue-collar labor. A tacit assumption in much of the literature on postindustrial society is that, through the interplay of market forces, displaced labor will adapt to the transforming economy by shifting from one sector to another (e.g., from manufacturing to services). Appropriate skills will eventually be acquired or sufficient numbers of service-sector jobs (both low skill and high skill) will be created, absorbing the displaced and relieving the mismatch.

Spatial-specific mismatches emerge where transformations in local employment bases occur at a faster pace than their local labor can adapt to through longer-distance commuting, retraining, or relocation. These mismatches are most apparent in larger, older cities in the Northeast where declines in retail trade, wholesale trade, and traditional blue-collar industries and the concurrent growth of information-processing industries have been rapid and substantial. So different are the skills used and education required in these growing versus declining urban industrial sectors that skill adaptation by the displaced is exceedingly difficult. In the final section of this paper some of the author's recent research conducted on emerging mismatches between the education levels of residents of major U.S. cities and the education demands of new urban growth industries will be summarized. The following sections are based on a recently published discussion by Kasarda (27).

URBAN EMPLOYMENT IN TRANSITION

Table 30, derived from annual data available on a select set of cities in the Census Bureau's County Business Patterns, shows the nature and scope of industrial transformation in the oldest and largest U.S. cities. Between 1953 and 1985, New York City lost more than 600,000 manufacturing jobs. During this same period, white-collar service industries (defined as those service industries in which executives, managers, professionals, and clerical employees exceed more than 50 percent of the industry work force) grew by nearly 800,000. Corresponding to industrial redistributional trends discussed above, retail and wholesale employment in New York City has declined by 168,000 and blue-collar service employment by 58,000 since 1970.

Philadelphia, Baltimore, Boston, and St. Louis likewise experienced substantial employment declines in manufacturing, retail and wholesale trade, as well as blue-collar services. Between 1953 and 1985, Philadelphia lost over two-thirds of its manufacturing jobs (from 359,000 to 109,000), dropping employment in this industry from over 45 percent of the city total in 1953 to

TABLE 30 Central City Employment by Sector, 1953, 1970, and 1985 (in thousands)

NEW YORK CITY	1953		1970		1985	
	Number	%	Number	%	Number	%
Total Employment[a]	2,977	100.0%	3,350	100.0%	2,990	100.0%
Manufacturing	1,070	35.9%	864	25.8%	464	15.5%
Retail/Wholesale	805	27.1%	779	23.3%	611	20.4%
White Collar Services[b]	646	21.7%	1,172	35.0%	1,427	47.7%
Blue Collar Services[c]	344	11.6%	424	12.6%	366	12.2%
Other	111	3.7%	112	3.3%	122	4.1%

PHILADELPHIA	1953		1970		1985	
	Number	%	Number	%	Number	%
Total Employment[a]	788	100.0%	772	100.0%	604	100.0%
Manufacturing	359	45.5%	257	33.3%	109	18.0%
Retail/Wholesale	206	26.1%	180	23.3%	134	22.2%
White Collar Services[b]	98	12.5%	220	28.5%	277	45.9%
Blue Collar Services[c]	85	10.8%	81	10.5%	62	10.3%
Other	40	5.1%	35	4.5%	22	3.6%

BOSTON	1953		1970		1985	
	Number	%	Number	%	Number	%
Total Employment[a]	402	100.0%	465	100.0%	483	100.0%
Manufacturing	114	28.4%	84	18.1%	49	10.1%
Retail/Wholesale	132	32.8%	111	23.9%	84	17.4%
White Collar Services[b]	87	21.7%	194	41.6%	278	57.6%
Blue Collar Services[c]	51	12.6%	55	11.7%	59	12.2%
Other	18	4.4%	21	4.6%	13	2.7%

TABLE 30 ***continued***

BALTIMORE CITY	1953 Number	1953 %	1970 Number	1970 %	1985 Number	1985 %
Total Employment[a]	342	100.0%	367	100.0%	323	100.0%
Manufacturing	130	38.1%	105	28.6%	55	17.0%
Retail/Wholesale	89	26.1%	94	25.5%	71	22.0%
White Collar Services[b]	44	12.8%	108	29.5%	139	43.0%
Blue Collar Services[c]	51	14.9%	44	12.1%	40	12.4%
Other	28	8.1%	16	4.2%	18	5.6%

ST. LOUIS CITY	1953 Number	1953 %	1970 Number	1970 %	1985 Number	1985 %
Total Employment[a]	431	100.0%	376	100.0%	262	100.0%
Manufacturing	194	44.9%	133	35.3%	66	25.2%
Retail/Wholesale	103	23.9%	89	23.6%	54	20.6%
White Collar Services[b]	50	11.5%	96	25.5%	97	37.0%
Blue Collar Services[c]	46	10.6%	44	11.8%	34	13.0%
Other	39	9.1%	14	3.8%	11	4.2%

SOURCE: U.S. Bureau of the Census, *County Business Patterns*, 1953, 1970, 1985, and 1970 Occupation by Industry Statistics.

[a]Total Employment is Total classified employment.
[b]Service industries (excluding government, retail, and wholesale) in which more than one-half the employees hold executive, managerial, professional or clerical positions.
[c]Service industries (excluding government, retail, and wholesale) in which fewer than one-half the employees hold executive, managerial, professional or clerical positions.

under 20 percent in 1985. During the same period, manufacturing employment declined in Boston from 114,000 to 49,000; in Baltimore from 130,000 to 55,000; and in St. Louis from 194,000 to 66,000. Employment declines in retail and wholesale trade and in blue-collar services followed suit, though the absolute and proportional losses were not as steep as those for manufacturing employment.

As in New York City, white-collar service employment expanded substantially in the other four cities between 1953 and 1985. St. Louis is the only northern city where white-collar service employment did not exceed 40 percent of the city total in 1985. By the same token, 58 percent of all Boston's jobs were in predominantly white-collar service industries in 1985 compared with 22 percent in 1953. Such increases in white-collar service employment across these cities clearly manifests their emerging information-processing roles in the computer age.

To highlight the overriding significance of predominantly information-processing industries for contemporary urban employment growth, total employment change in each city between 1970 and 1985 was divided into that accounted for by (a) its service-sector industries in which more than 60 percent of the employees are classified in executive, managerial, professional, and clerical occupations and (b) all other industries combined. The results are striking. New York City added 350,000 jobs in its predominantly information-processing industries (a 41 percent increase) and lost over 700,000 jobs in all its other industries combined (a 30 percent decrease). Boston's information-processing industries expanded by 42 percent, and its other industries dropped by 21 percent. Boston, in fact, is the only major northern city that added more jobs between 1970 and 1985 to its predominantly information-processing industries than it lost in other industries. Conversely, employment gains in the information-processing industries of Philadelphia, Baltimore, and St. Louis were overwhelmed by job losses in their more traditional industrial sectors.

Rising Educational Requisites

Corresponding to the functional transformation of major northern cities from centers of goods processing to centers of information processing, there has been an important change in the education required for employment in these cities. To demonstrate this phenomenon, the 1982 Current Population Survey machine-readable files were used to compute the mean level of education completed by central-city resident job holders in detailed classified industries. The categories of industries selected were (a) those in which job-holder education levels in 1982 averaged less than 12 years (i.e., high school was not completed) and (b) those in which job holders averaged more than 13 years of schooling (i.e., employees, on average, acquired some higher education). Aggregate job changes for each educationally classified industry within each city were then traced between 1970 and 1984 from the County Business Patterns files.

Table 31 reveals that major northern cities had consistent job losses in industries having lower employee educational qualifications. Note that, by far,

TABLE 31 Central City Jobs in Industries by Mean Education of Employees, 1959, 1970, and 1985 (in thousands)

City and 1982 Educational Mean of Industry	Number of Jobs 1959	1970	1985	Change 1959-70	1970-85
NEW YORK					
Less than high school	1,561	1,552	1,048	-9	-504
Some higher education	682	1,002	1,270	320	268
PHILADELPHIA					
Less than high school	466	430	243	-36	-187
Some higher education	135	205	256	70	51
BOSTON					
Less than high school	190	189	137	-1	-52
Some higher education	117	185	261	68	76
BALTIMORE					
Less than high school	236	207	132	-29	-75
Some higher education	59	90	124	31	34
ST. LOUIS					
Less than high school	221	210	117	-11	-93
Some higher education	61	98	97	37	-1

Source: Bureau of the Census, County Business Patterns, 1959, 1970, 1985 and Current Population Survey March 1982 machine-readable file.

the heaviest job losses occurred in these industries after 1970. New York City, for instance, lost over half a million jobs between 1970 and 1985 in those industries where mean job-holder education levels in 1982 were less than completion of high school, whereas 268,000 jobs were added in those industries where mean employee education levels exceeded 13 years of schooling. Philadelphia, Baltimore, and St. Louis also lost substantial numbers of jobs in industries with low mean employee educations, and St. Louis also experienced a small loss in industries with high mean job-holder education levels.

Boston, on the other hand, added more jobs in its industries with high educational qualifications than it lost in its industries with low educational qualifications, contributing to overall city job growth since 1970. By 1985, Boston had nearly twice as many jobs in industries with high mean employee educations than in industries with low mean levels of employee education. This would indicate that Boston's economy had adapted especially well to the emerging postindustrial order, which should sustain that city's employment growth into the 1990s. New York City likewise has a relatively high percentage of its employment in knowledge-intensive service industries, implying that this city, too, should fare well in employment growth during the coming decade.

EDUCATION-LEVEL–JOB-OPPORTUNITY MISMATCHES

A rather clear picture emerges from the foregoing analysis. There have been sharp declines in employment in northern central-city industries that traditionally sustained large numbers of less-educated persons. The job losses have been replaced, at least in part, by growth in white-collar service industries with substantially higher educational requirements.

Growing numbers of minorities are at a structural disadvantage in cities losing blue-collar and other entry-level jobs because substantially larger proportions of these minorities lack the necessary schooling to participate in new urban growth industries. To illustrate this structural disadvantage, Table 32 presents data on years of schooling completed for white and black men residing in the central cities of the Northeast and the Midwest.

Bearing in mind the selective employment changes in these cities during the past 15 years, note that the modal category of education completed by white men is "Attended college one year or more." The smallest representative category for white men is "Did not complete high school." The education-completed distribution of white men residing in central cities in the Northeast and Midwest is therefore consistent with the distribution of job changes classified by education (see Table 31).

The opposite educational distributions hold for black men. Despite substantial gains in educational attainment during the past two decades, black men (over age 16) in northern cities are still most concentrated in the education-completed category in which employment opportunities declined the fastest since 1970 and are least represented in that category in which northern central-city employment has most expanded (Table 31). The consequence is a serious mismatch between the current education distribution of black residents in large northern cities and the changing educational requirements of their rapidly transforming industrial bases. This mismatch is a pivotal reason why both unemployment rates and labor-force dropout rates among central-city blacks are much higher than those of central-city white residents, and why black unemployment rates have not responded well to the recent economic recovery of many northern cities. Let us assess these concrete manifestations of mismatch.

The Current Population Survey, which is the basis of the nation's unemployment statistics, does not contain a sufficiently large sample to provide

TABLE 32 Central City Residents in Northeast and Midwest Aged 16–64 by Race and Years of School Completed, 1985

Race and Schooling	Region	
	Northeast	Midwest
White Males		
Did not complete high school	944,964	743,105
Completed high school only	1,096,986	1,136,702
Attended college one year or more	1,205,944	1,291,168
Black Males		
Did not complete high school	455,349	479,141
Completed high school only	366,932	404,121
Attended college one year or more	234,723	352,993

Source: U.S. Bureau of the Census, Current Population Survey, March 1985 machine-readable file.

reliable estimates of unemployment rates by both race and education level for individual cities. It is possible, however, to aggregate central-city samples by region and to calculate central-city unemployment rates by race and education completed within each region. These computations, which are shown in Table 33, document the increasingly important role that education has played in urban employment prospects. Consistent with the mismatch thesis, one finds a precipitous rise in unemployment rates between 1969 and 1982 for those who have not completed high school. Within central cities in the Northeast and the Midwest, unemployment rates of black men without a high school degree exceeded 30 percent in 1985. Indeed, for blacks in northeastern cities who lack a high school degree, the national economic recovery since 1982 has had no effect; unemployment rates for black men actually increased from 26.2 percent in 1982 to 30.4 percent in 1985.

Another statistic revealing the growing importance of education for urban employment prospects is the substantial increase in the absolute gap in unemployment rates between the poorly educated and the better-educated in 1969 versus 1985, regardless of race. For central-city white residents in all regions combined, the education-level gap in unemployment rates in 1969 was 2.7 (4.3 − 1.6). By 1985 it was 11.9 (15.5 − 3.6). For central-city blacks, the gap was 2.9 in 1969 (6.6 − 3.7) and 14.2 in 1985 (27.3 − 13.1). This widening gap over time in unemployment rates between less and more highly educated labor is slightly larger in cities in the Northeast and the Midwest.

TABLE 33 Unemployment Rates of Central City Men Aged 16–64 by Race, Region, and Years of School Completed, 1969, 1977, 1982, and 1985

Region and schooling	White				Black			
	1969	1977	1982	1985	1969	1977	1982	1985
All Regions								
Did not complete high school	4.3	12.2	17.7	15.5	6.6	19.8	29.7	27.3
Completed high school only	1.7	8.0	11.0	8.3	4.1	16.2	23.5	18.4
Exceed one year of higher education	1.6	4.7	4.4	3.6	3.7	10.7	16.1	13.1
Northeast								
Did not complete high school	3.7	13.9	17.2	16.0	7.6	20.9	26.2	30.4
Completed high school only	1.7	9.4	10.3	9.7	3.4	18.2	21.9	13.6
Exceed one year of higher education	1.4	6.0	4.8	3.9	7.1	13.9	18.6	11.7
Midwest								
Did not complete high school	4.9	12.8	24.3	23.2	8.3	26.2	34.8	32.8
Completed high school only	1.1	8.0	14.5	10.8	3.3	18.0	35.8	24.9
Exceed one year of higher education	1.3	3.5	3.8	3.7	1.4	12.3	22.2	18.4

Source: Computed from U.S. Bureau of the Census, Current Population Survey, Machine-Readable Files.

Examining central-city unemployment rate changes since 1982, it may be noted that although white male unemployment rate declines were generally consistent for all education categories, declines in black male unemployment were consistent only for those who had completed education beyond high school. The relatively large 1985 unemployment rates among better-educated black urban men (particularly in the Midwest) are troublesome and difficult to interpret. Quality of education may play a role here, as could racial ceilings in hiring practices of firms in major midwestern cities with large minority percentages such as Chicago, Cleveland, and Detroit.

Unemployment rates reveal only part of the picture of mismatch and the corresponding displacement of many minorities from the urban economic mainstream. These rates do not include persons who have given up looking for work because they believe no jobs are available (discouraged workers) and those who want work but cannot hold employment for a variety of physical or personal reasons. Such individuals are not considered to be in the labor force, and therefore they are not counted among the unemployed. Computing proportions of black men (aged 16 to 64) residing in northeastern and midwestern central cities who are neither in school nor in the labor force, one again finds a sharp rise in these proportions since 1969. By 1985, the component that is not in school or in the labor force among this demographic group had exceeded 20 percent in cities in the Northeast and Midwest. If one combines black unemployment rates (Table 33) with these labor-force nonparticipation rates, the dire straits of black men residing in central cities in the Northeast and Midwest are quickly apparent.

TRANSPORTATION PROBLEMS

An additional structural impediment faced by inner-city minorities is their increased distance from current sources of blue-collar and other entry-level jobs. As industries providing these jobs have dispersed to the suburbs, exurbs, and nonmetropolitan peripheries, racial discrimination and inadequate income have prevented inner-city minorities from moving with their traditional sources of employment. Moreover, the dispersed nature of job growth sites makes public transportation from inner-city neighborhoods impractical, requiring the vast majority of city residents who work in peripheral areas to commute by private vehicles (see Table 34).

The combined costs of maintaining, operating, and insuring an automobile in major cities are substantially higher than elsewhere. This is particularly the case in older, larger, densely settled cities. In fact, automobile ownership in the core areas of these cities is so expensive relative to the actual or potential

TABLE 34 Percent of Employed Full-Time Men in Chicago Who Commute to Work in Private Vehicle by Job Location, Education, and Race, 1980

	Non Hispanic White		Black	
Place of Work	Less than High School	High School Degree only	Less than High School	High School Degree only
CBD–same MSA	41.4	38.1	45.8	53.9
CC–same MSA	72.8	77.0	69.1	70.0
Suburbs same MSA	90.6	94.3	85.4	83.2

Source: U.S. Bureau of The Census, Public Use Micro-Sample File, 1980

incomes of their disadvantaged residents that most cannot afford this increasingly essential means of securing and maintaining blue-collar employment.

The severity of the problem of access to deconcentrating blue-collar job opportunities is documented in Tables 35 and 36. Table 35 presents the proportions of black and Hispanic households in New York City, Philadelphia, and Boston who do not have an automobile or truck available: more than one-half of the minority households in Philadelphia and Boston are without a means of personal transportation. New York City's proportions are even higher, with only 3 out of 10 black or Hispanic households having a vehicle available. More detailed breakdowns of data show that in New York City's core boroughs (Brooklyn, Bronx, and Manhattan), fewer than 3 out of 10 black or Hispanic households had an automobile or truck available.

It should be pointed out that the figures in Table 35 refer to all black and Hispanic households in each city or borough. It stands to reason that black and Hispanic households whose members have lower income and educational attainment have even less access to personal means of transportation.

In Chicago, for example, automobile availability was examined among out-of-school male blacks aged 16 to 64 who were either unemployed or not in the labor force. Of those without a high school degree and unemployed, only half resided in a household in which an automobile was available. Of those without a high school degree and out of the labor force, less than half were in households that had an automobile available (see Table 36). The corresponding percentages rose very little for the unemployed and out-of-the-labor-force black men with only a high school degree.

The difficulty of getting to suburban jobs by public transit is exemplified by travel time to work by Chicago's black central-city residents working in the suburbs. Among those without a high school degree who used public transit,

TABLE 35 Central-City Minority Households with No Automobile or Truck Available, 1980

Central City	Black Households (%)	Hispanic Households (%)
Philadelphia	50.9	50.8
Boston	51.3	54.9
New York	69.3	71.3
Bronx	71.1	72.9
Brooklyn	72.2	73.9
Manhattan	84.7	83.5
Queens	43.4	49.4
Staten Island	54.2	38.6

SOURCE: Bureau of the Census (*26*, Detailed Housing Characteristics).

TABLE 36 Percent of Out-of-School Central City Men Aged 16–64 in Chicago with Automobile Available in Household by Education, Race, and Employment Status, 1980

	Education Level			
	Less than High School		High School Degree Only	
	Non-hispanic White	Black	Non-hispanic White	Black
Employed Full-time	85.6	78.0	89.6	81.6
Employed Part-time	74.6	63.2	83.5	73.0
Unemployed	76.8	53.8	75.9	55.1
Not in Labor Force	64.8	43.8	68.2	49.6

Source: U. S. Bureau of the Census, Public Use Micro-Sample File, 1980.

mean travel time to work was 55 min in 1980. For those with a high school degree only who used public transit, mean travel time to work was 64 min, more than 20 minutes longer than the commuting time of the corresponding demographic group who commuted by private automobile. Thus, even where it is possible to obtain public transportation from city residence to suburban jobs, time costs are immense, further confining lesser-educated minorities to areas of blue-collar employment decline.

SUNBELT ANALOGIES

The data discussed speak only to education–job opportunity mismatches and corresponding transportation problems in major cities in the Northeast-

Midwest corridor. What about the Sunbelt cities? The situation in Atlanta is similar in that in the Northeast and Midwest in terms of structural change. Atlanta is losing manufacturing and other blue-collar jobs, but its white-collar job growth has more than compensated for the loss, accounting for net job increases. The automobile cities, such as Los Angeles and Phoenix, are not losing blue-collar jobs at the precipitous rate of those cities once based on heavy industry. Economic displacement does not exist there on the scale that it does in the Midwest. But the emerging problems are analogous. If the residents of the Sunbelt cities do not achieve the education levels for the knowledge-intensive employment that is sure to grow in all cities as the 21st century approaches or have access to expanding lower-skill jobs in the suburbs, they too will face structural unemployment as severe as that now faced by poorly educated residents in northeastern and midwestern cities.

The sobering dimensions of the future problem can already be seen in the analogous high school dropout rates between New York and Los Angeles. The fact that 4 out of 10 students are not completing high school is extremely worrisome, for it comes at a time when not only the high school degree is required, but education beyond high school is needed to prosper in the urban job market. The irony and the tragedy are that although there are growing surpluses of less-skilled labor in the cities, suburban businesses are facing severe shortages of such employees. For example, of black men aged 16 to 64 who are not in school, only 44.5 percent of those residing in central cities of the Midwest were employed in 1987. The corresponding figure (computed from the Current Population Survey March 1987 machine-readable file) for northeastern cities was 56 percent; for southern cities, 54.2 percent; and for western cities, just 39.2 percent.

Education–job opportunity problems will not be confined to metropolitan areas. Much of the rural population of the nation remains poorly educated. Even rural jobs that required little education in the past are likely to demand greater education in the future. This is clearly seen in the transformation of agriculture during the past 40 years. The small, labor-intensive farm has given way to technologically sophisticated, capital-intensive agrobusiness. Today the most financially successful farmers have developed skills in agronomy, animal husbandry, financial planning, and marketing.

With growing global competition in manufacturing from low-wage, labor-surplus nations, the rural and small-town communities can no longer compete on the basis of wages and limited unionization. Competitiveness for employment growth will increasingly depend on their providing a better-educated labor force capable of adapting to and utilizing advanced technologies.

What all this means is that a fundamental transformation is occurring in the skill needs of the nation, both urban and rural. With brainpower replacing horsepower as the essential driving force of our emerging postindustrial economy, education is rapidly becoming the keystone on which future improvements in productivity and competitiveness will depend. At the same time, a good education will likely become a sine qua non for individual opportunity and social mobility in the 21st century.

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APPENDIX: LOCAL AREA UNEMPLOYMENT STATISTICS FOR DIVISIONS

AREA	YEAR	LABOR FORCE	EMPLOYED	UNEMPLOYED NUMBER	UNEMPLOYED RATE
New England	1976	5,624,901	4,983,144	641,757	11.4%
	1978	5,806,800	5,392,300	414,500	7.1%
	1980	6,082,363	5,693,111	389,252	6.4%
	1981	6,143,598	5,728,512	415,086	6.8%
	1982	6,241,226	5,747,627	493,599	7.9%
	1983	6,265,148	5,709,126	556,022	8.9%
	1984	6,409,710	5,980,285	429,425	6.7%
	1985	6,516,037	6,176,330	339,707	5.2%
	1986	6,601,982	6,295,506	306,476	4.6%
	1987	6,663,564	6,380,656	282,908	4.2%
	1988	6,838,500	6,571,900	266,600	3.9%

AREA	YEAR	LABOR FORCE	EMPLOYED	UNEMPLOYED NUMBER	UNEMPLOYED RATE
Middle Atlantic	1976	15,825,000	14,208,000	1,617,000	10.2%
	1978	16,238,500	14,890,000	1,348,500	8.3%
	1980	17,019,700	15,667,900	1,351,800	7.9%
	1981	17,032,900	15,577,800	1,455,100	8.5%
	1982	16,957,700	15,285,000	1,672,700	9.9%
	1983	16,889,200	15,008,100	1,881,100	11.1%
	1984	17,032,600	15,566,100	1,466,500	8.6%
	1985	17,328,700	16,038,100	1,290,600	7.4%
	1986	17,746,200	16,477,000	1,269,200	7.2%
	1987	17,802,800	16,746,000	1,056,800	5.9%
	1988	18,215,700	17,254,300	961,400	5.3%

AREA	YEAR	LABOR FORCE	EMPLOYED	UNEMPLOYED NUMBER	UNEMPLOYED RATE
East North Central	1976	18,038,232	16,507,564	1,530,668	8.5%
	1978	18,889,500	17,560,200	1,329,300	7.0%
	1980	19,673,021	18,081,711	1,591,310	8.1%
	1981	19,612,802	17,472,395	2,140,407	10.9%
	1982	19,725,220	17,311,691	2,413,529	12.2%
	1983	19,738,993	16,813,254	2,925,739	14.8%
	1984	19,512,582	17,400,145	2,112,437	10.8%
	1985	19,929,035	17,946,421	1,982,614	9.9%
	1986	20,141,172	18,344,500	1,796,672	8.9%
	1987	20,330,523	18,666,686	1,663,837	8.2%
	1988	20,578,800	18,958,500	1,620,300	7.9%

AREA	YEAR	LABOR FORCE	EMPLOYED	UNEMPLOYED NUMBER	UNEMPLOYED RATE
West North Central	1976	7,353,904	6,886,242	467,662	6.4%
	1978	7,887,300	7,467,400	419,900	5.3%
	1980	8,101,155	7,652,145	449,010	5.5%
	1981	8,273,237	7,706,524	566,713	6.8%
	1982	8,241,388	7,589,290	652,098	7.9%
	1983	8,295,476	7,462,656	832,820	10.0%
	1984	8,380,150	7,716,676	663,474	7.9%
	1985	8,538,150	7,901,714	636,436	7.5%
	1986	8,602,745	7,986,834	615,911	7.2%
	1987	8,770,057	8,197,176	572,881	6.5%
	1988	8,923,000	8,363,300	559,700	6.3%

AREA	YEAR	LABOR FORCE	EMPLOYED	UNEMPLOYED NUMBER	UNEMPLOYED RATE
South Altantic	1976	14,854,773	13,602,987	1,251,786	8.4%
	1978	15,374,500	14,295,200	1,079,300	7.0%
	1980	16,616,999	15,585,701	1,031,298	6.2%
	1981	17,079,428	15,852,006	1,227,422	7.2%
	1982	17,471,651	15,948,064	1,523,587	8.7%
	1983	17,955,494	16,076,497	1,878,997	10.5%
	1984	18,387,767	16,991,539	1,396,228	7.6%
	1985	18,986,361	17,658,224	1,328,137	7.0%
	1986	19,432,538	18,227,444	1,205,094	6.2%
	1987	20,133,900	18,959,575	1,174,325	5.8%
	1988	20,620,000	19,474,300	1,145,700	5.6%

AREA	YEAR	LABOR FORCE	EMPLOYED	UNEMPLOYED NUMBER	UNEMPLOYED RATE
East South Central	1976	5,636,356	5,224,424	411,932	7.3%
	1978	5,791,300	5,397,800	393,500	6.8%
	1980	6,185,805	5,729,176	456,629	7.4%
	1981	6,384,650	5,768,359	616,291	9.7%
	1982	6,411,572	5,653,764	757,808	11.8%
	1983	6,587,423	5,617,133	970,290	14.7%
	1984	6,633,514	5,883,600	749,914	11.3%
	1985	6,756,789	6,038,759	718,030	10.6%
	1986	6,856,741	6,166,102	690,639	10.1%
	1987	6,970,912	6,272,313	698,599	10.0%
	1988	7,116,900	6,513,500	603,400	8.5%

AREA	YEAR	LABOR FORCE	EMPLOYED	UNEMPLOYED NUMBER	UNEMPLOYED RATE
West South Central	1976	8,998,688	8,410,694	587,994	6.5%
	1978	9,536,800	8,987,600	549,200	5.8%
	1980	10,578,469	9,994,516	583,953	5.5%
	1981	11,128,473	10,410,903	717,570	6.4%
	1982	11,457,157	10,690,251	766,906	6.7%
	1983	11,982,148	10,836,932	1,145,216	9.6%
	1984	12,052,568	11,068,312	984,256	8.2%
	1985	12,363,138	11,376,469	986,669	8.0%
	1986	12,471,737	11,475,166	996,571	8.0%
	1987	12,764,126	11,441,867	1,322,259	10.4%
	1988	12,686,200	11,553,900	1,132,300	8.9%

AREA	YEAR	LABOR FORCE	EMPLOYED	UNEMPLOYED NUMBER	UNEMPLOYED RATE
Mountain	1976	4,249,180	3,880,539	368,641	8.7%
	1978	4,488,000	4,194,500	293,500	6.5%
	1980	5,192,003	4,867,270	324,733	6.3%
	1981	5,378,687	5,003,268	375,419	7.0%
	1982	5,552,677	5,106,166	446,511	8.0%
	1983	5,754,578	5,150,309	604,269	10.5%
	1984	5,907,583	5,460,595	446,988	7.6%
	1985	6,062,865	5,622,438	440,427	7.3%
	1986	6,193,946	5,709,474	484,472	7.8%
	1987	6,373,001	5,818,428	554,573	8.7%
	1988	6,428,400	5,950,300	478,100	7.4%

APPENDIX *continued*

AREA	YEAR	LABOR FORCE	EMPLOYED	UNEMPLOYED NUMBER	UNEMPLOYED RATE
Pacific	1976	12,926,399	11,522,790	1,403,609	10.9%
	1978	13,686,900	12,585,000	1,101,900	8.1%
	1980	15,192,378	14,127,558	1,064,820	7.0%
	1981	15,587,439	14,295,058	1,292,381	8.3%
	1982	15,865,115	14,283,754	1,581,361	10.0%
	1983	16,193,306	14,246,621	1,946,685	12.0%
	1984	16,367,265	14,796,644	1,570,621	9.6%
	1985	16,971,379	15,536,502	1,434,877	8.5%
	1986	17,151,511	15,914,261	1,237,250	7.2%
	1987	17,637,136	16,355,631	1,281,505	7.3%
	1988	18,350,400	17,238,300	1,112,100	6.1%

Life-Style and Travel Demand

RYUICHI KITAMURA

TO DEAL WITH THE challenge to urban transportation, one must first recognize that congestion is not the problem but merely a symptom. The true problem is the life-style to which Americans aspire; the American dream is to live in a suburban single-family house on a half-acre lot with a three-car garage. If this is the root of the urban transportation problem, then obviously a fundamental solution to the issue of congestion cannot be reached without addressing the question of life-style. The concept of life-style is important to travel behavior because the automobile, the dominant mode of urban travel today, is basic to the American life-style. As Flink (*1*) notes, patterns of "courtship, residence, socialization of children, education, work habits, and use of leisure time were radically altered by the adoption of the automobile." The relation of the automobile to American culture has inspired many authors. For example, focusing on "the car's role in the larger dream/nightmare patterns dominating American life and thought," Dettelback (*2*) notes that "as the most favored—and problematic—offspring of that particularly American union of space, romance, and technology, the automobile occupies a central place in our fantasies as well as in our daily lives." If the American life-style is inspired by such fantasies, the automobile is an end in itself as well as a means.

Unfortunately there has been no commonly accepted definition of the term "life-style" in the field of travel behavior analysis and demand forecasting.

Ryuichi Kitamura is Associate Professor of Civil Engineering, University of California, Davis. Before his appointment at the University of California, he was a research assistant at the University of Michigan. His research areas include travel behavior, life-styles, and socioeconomic factors of urban travel choice.

Little empirical evidence exists on how an individual acquires a particular life-style, how it is correlated with measurable attributes of the individual and his household, and how it is related to travel behavior. Nevertheless, the life-style concept extends the scope of travel behavior analysis and may possibly lead to improved predictive performance of forecasting models. For example, a recent analysis of trip generation behavior using longitudinal observations finds that there is an unexplained individual-specific effect, or idiosyncrasy (*3*). This idiosyncrasy, which is not explainable by sociodemographic variables, can be viewed as arising from the life-style of the individual.

The term "life-style" as used in the literature has two meanings: (a) activity and time-use patterns and (b) values and behavioral orientation. These two are interrelated, but a critical difference exists: life-style as activity patterns may change as an individual adapts to a change in the environment, whereas life-style as orientation is one that the individual attempts to maintain by modifying behavioral patterns and adapting to the change. Change in life-style as orientation takes place in the long term through changes in values, attitudes, and preferences.

Life-style changes with socioeconomic, institutional, and technological changes. Increasing real income, decreasing working hours, and new consumer technology all contribute to the ever-evolving life-style of urban residents. The seemingly ever-expanding consumer demand leads to new products and services, industries and institutions, and urban forms. To gain an understanding of life-style and to develop the capability to predict its changes in the future, it is necessary to examine changes that took place in various elements of urban life and see how these changes are related to changes in life-style and travel behavior. This will constitute a basis for a more fundamental approach to long-range travel demand forecasting.

The objectives of this paper are (a) to offer a review of the monetary expenditure and travel characteristics of households across population subgroups defined in terms of variables believed to be correlated with life-style, (b) to determine the usefulness of this body of knowledge in long-term forecasting of travel demand, and (c) to identify factors that may influence life-style and travel behavior but that have not been incorporated into travel behavior analysis and demand forecasting.

The paper is organized as follows. The definitions of life-style found in the literature are reviewed in the next section and variables that have commonly been associated with life-style are identified. Then the life-styles of population segments are reviewed using consumer expenditure statistics. The findings in the literature on travel characteristics of these segments are summarized; trends in the variables associated with life-style are reviewed, and likely changes in travel behavior are noted using the travel characteristics identified earlier. The discussion is extended to include those contributing factors that are typically not considered in travel behavior analysis. The last section presents conclusions and recommendations.

What Is Life-Style?

Proposed definitions of life-style range from quantitative to conceptual. For example, Allaman et al. (*4*) adopt a highly operational definition: Life-style "can be defined as how individuals and households allocate time to alternative activities such as work, in-home time, and recreation." Life-style, then, is a typology of time-use behavior.

Reichman's definition is similar (*5*, pp. 143–152): "Households, or individuals, have established a certain life style, or activity pattern, from which travel requirements are being derived." Life-style is again related to the individual's activities. Reichman's definition, however, extends beyond this (*6*): "Life-styles are assumed to be shaped by recurrent behavioral responses to socioeconomic conditions, as well as to deeper personal or social attitudes, roles, or values." Life-style is thus seen to underlie travel behavior and is related to fundamental human values and needs. In particular, Reichman challenges the wisdom that travel demand is a derived demand (*5*): "Is transportation only a means to an end, or does it really fulfill some ends in itself?"

The definition by Reichman offers important implications. First, according to Reichman, life-style is not merely a typology of observed behavior but a latent factor that motivates behavior. Life-style thus defined is termed "life-style as behavioral orientation" as opposed to "life-style as a behavioral typology." Second, if an individual's travel behavior is driven by his life-style aspirations, adaptation behavior cannot be studied without knowledge of the values that the individual holds. Driving a car to work may not necessarily imply that driving has been chosen by an objective cost-benefit calculation of alternative modes; it may be an indication that the commuter assigns values to the act of driving itself.

Viewing life-style as a concept for broad characterization of households, Sharp (*7*) defines life-style in terms of "a household's size and age, the social roles contained within it, the resources available to it, and the density and variety of activities open to it." This leads to a quite practical definition of life-style using life-cycle stage, income, and residential location. Life-cycle stage is viewed as "an indicator of the social roles present in different households, as well as the size and age of the household"; income represents available resources; and residential location is related to the accessibility to opportunities (*7*). Sharp thus defines life-style without reference to observed behavior; the definition is a typology of households, but not necessarily of their behavioral patterns.

Havens (*8*, pp. 269–287) adopts the view that two societal factors, role and life-style, influence the demand for various types of activities and consequently influence travel behavior. A role is defined as "the set of behavior patterns and their associated societal norms that fulfills a function or set of functions," and life-style as (*8*) "an ordered set of roles; the specific series of activities that fulfills them; and an individual's psychological orientation (values, attitudes, satisfaction, and dissatisfaction) to the activities." Again, life-style is not merely a behavioral pattern but is tied to the individual's attitudes and values. As possible segmentation bases to obtain homogeneous life-style groups, Havens proposes social class, life-cycle stage, sex, minority status, and rural or urban residential location.

Salomon (*9*, pp. 290–310) and Salomon and Ben-Akiva (*10*) adopt a similar, but more specific, definition of life-style as "a pattern of behavior under constrained resources which conforms to the orientations an individual has toward three major 'life decisions' he or she must make: (a) formation of a household (of any type), (b) participation in the labor force, (c) orientation toward leisure." The choice of a life-style is viewed as a longer-term decision that conditions short-term decisions such as daily travel choices. Life-style is an observable behavioral pattern, but at the same time it is an orientation that underlies behavior.

Common in most of these definitions is the notion that life-style is associated with behavioral patterns. In addition, life-style offers a useful conceptual framework as it relates to the individual's values or orientation, which is especially the case in the analysis of adaptation behavior. Using life-style as a framework, however, poses an immediate problem, because values and orientation are not measured in typical transportation surveys. Consequently researchers have resorted to the use of population segments defined in terms of objective and frequently available person or household characteristics on the assumption that these segments offer internally homogeneous groups of behavioral units. Variables believed to causally influence behavior are chosen as segmentation bases, most frequently life-cycle stage, employment status (or income, or both), and sex. None of the studies reviewed in this section use perceptional or attitudinal data to define life-style segments.

Because of this difficulty in empirically investigating life-style as orientation, previous empirical analyses were concerned only with life-style as a typology of behavior. Although it is fully acknowledged that life-style as orientation offers a valuable conceptual framework, the usefulness of this notion in demand forecasting is limited if orientation needs to be inferred from revealed behavior. Furthermore, if the fundamental element that determines the individual's life-style orientation is the values that he or she holds, then an attempt to investigate the formation of life-style must address the question of how an individual forms his or her values, a task beyond the scope of typical transportation planning studies.

One obvious value of life-style as orientation is that it offers guidelines in defining the dimensions of analysis; life-style offers a theoretical medium that links revealed behavior and measurable characteristics of individuals. This undoubtedly is valuable in the construction of an analytical framework for travel behavior studies.

In the following two sections, life-style characteristics as revealed in consumer expenditures and travel patterns are discussed along the dimensions of life-cycle stage, age, employment, sex, income, car ownership, and license holding. Many of these parameters have been theorized to have a primary association with the individual's or household's life-style as causal factors that condition and constrain life-style (e.g., income), as factors that determine or reflect roles (sex, employment, and life-cycle stages), or as the outcome of conscious life-style choices (e.g., employment status, presence of children, car ownership, and license holding).

Life-Style Revealed by Consumer Expenditure Patterns

Published personal consumption expenditure statistics (*11–13*) make up the data base for this discussion. Historical trends in aggregate consumer expenditures are first examined with the intent of identifying long-term trends in life-style. Household expenditure patterns are then examined using income, life-cycle stage, and age as classifiers.

Because life-style as reflected in consumer expenditures is the subject of analysis, the following discussion does not immediately reveal the linkage between life-style and travel behavior. Nonetheless, monetary expenditures, similar to time use and trip generation, discussed in the next section, constitute one dimension along which urban life-styles may be characterized. The analysis in this section is motivated by the belief that an investigation of expenditure patterns of various population subgroups will aid in the determination of their life-style characteristics.

Historical Trends

Aggregate consumer expenditures on durable goods, nondurable goods, and services expressed as a percentage of total expenditure in 1982 dollars do not vary dramatically during the period 1953 through 1983 (Figure 1). However,

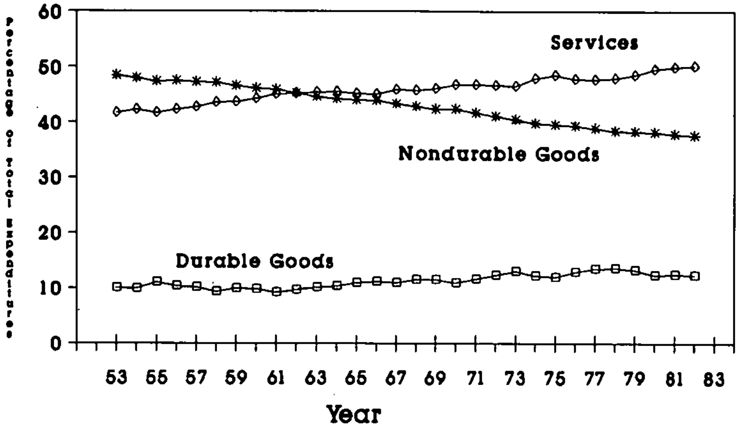

FIGURE 1 Consumer expenditure on durable and nondurable goods and services.

several moderate but steady long-term trends exist that may extend into the near future.

The relative expenditure on durable goods shows a slight increase from less than 10 percent of total consumption in the early 1950s to more than 13 percent in the late 1970s. The major changes in consumer expenditures are in the categories of nondurable goods and services; nondurable goods shows a decrease from around 48 to 38 percent during the 30-year period. This decline is attributable mainly to a substantial decline in food expenditures. Service expenditures, on the other hand, show a steady increase from 42 percent in the early 1950s to 50 percent in the 1980s.

The increase in service expenditures is due primarily to increasing medical care and housing expenditures (Figure 2). Interestingly, the increase in housing and medical care expenditures approximately equals the decline in food expenditures. As a result, the total expenditure for these three categories of subsistence items remained virtually unchanged over time (Figure 3), and so did the relative budget size for discretionary activities. This is shown by recreational expenditures, perhaps the most discretionary, which remained stable at around 2 percent of the total expenditure except for a slight increase from the beginning of the 1970s.

In addition, educational expenditures remained around the 2 percent range, with a slight decline since the 1970s. Expenditures in personal care declined, which may be a reflection of the prevalence of casual life-styles. The relative expenditure on clothing, which also declined gradually until 1970, started to increase afterward.

Motor vehicle consumption conforms to the stable pattern shown for expenditures on nondurable goods; it increases from less than 5 percent in the

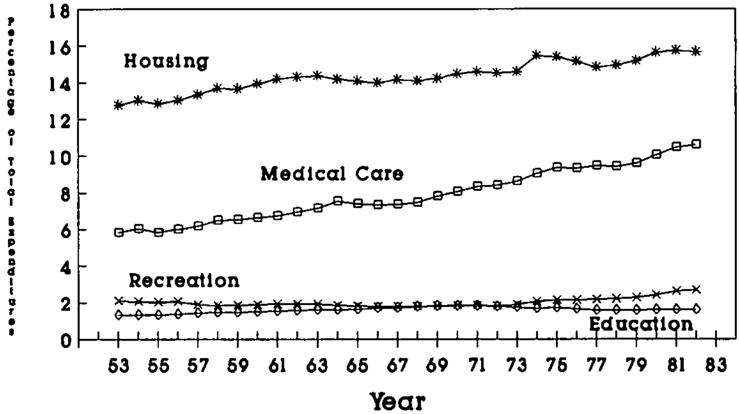

FIGURE 2 Relative expenditures on housing, medical care, recreation, and education.

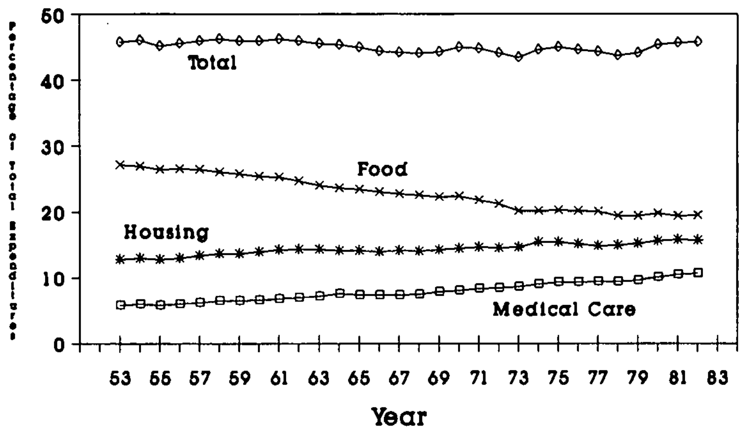

FIGURE 3 Stability in expenditures on housing, medical care, and food.

early 1950s to more than 6 percent in the late 1970s (Figure 4). The decline in the early 1980s is presumably a reflection of the economic depression during that period. Expenditures on transportation services (mainly public transit, including air) fluctuate, but do not exhibit any trend. Consumption of gasoline remained stable over the three decades despite the two oil embargoes, with a minimum of 4.35 percent observed in 1981 and 1982, and a maximum of 5.43 percent in 1971. Overall transportation expenditures remained stable except for the peaks around 1973 and 1977, which are primarily due to the increased expenditures on motor vehicles, as Figure 4 clearly shows.

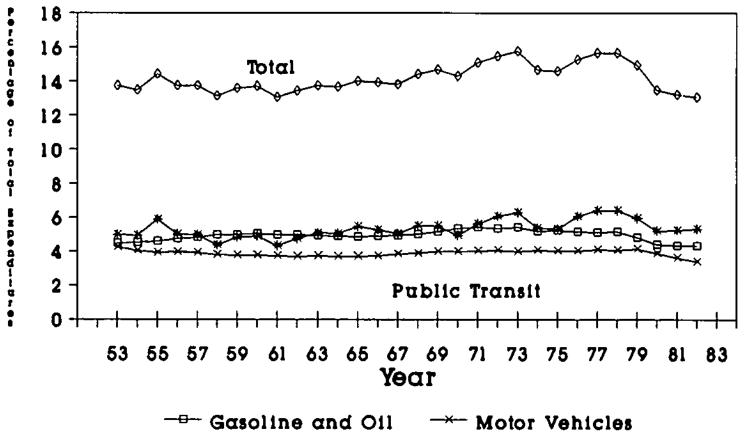

FIGURE 4 Transportation-related consumer expenditures.

In summary, the relative share of food in the total consumer expenditures has declined during the three decades starting in 1953, but this decline is offset by increases in housing and medical care. The share of transportation expenditures has been surprisingly stable despite the two energy crises in the 1970s. Expenditures on recreation also remained stable. Notable changes are all in expenditures at the subsistence level and little has changed in discretionary expenditures. The relative expenditure figures used in this analysis do not represent precisely what the consumer was able to purchase for the money. Nevertheless, if the relative expenditures are correlated with life-style, the trends just outlined suggest that consumer life-style has been very stable during the past three decades.

Income

Longitudinal stability in life-style does not necessarily imply cross-sectional uniformity. The remainder of this discussion is based on the published results of a 1982–1983 survey of consumer expenditures (*12, 13*). The effect of income on expenditures can be seen in Table 1, where relative expenditures as percentages of the total expenditure are presented by quintiles of household income before taxes. The average total expenditure varies across the five groups shown from $8,324 to $35,171 per household per year. If income can be viewed as "a surrogate for the propensity of the individual to spend time out of home" for activities (*14*), variations in expenditure patterns along the dimension of income should reveal the relationship between life-style orientation and income that is relevant for travel demand analysis.

TABLE 1 Annual Expenditures of Urban Households by Quintiles of Income Before Taxes, 1982–1983: Percentage of Total Expenditure (*13*, Table 1)

Household size	1.8	2.3	2.6	3.0	3.3
No. of workers	0.6	1.0	1.3	1.7	2.1
Age of reference person	49.9	48.7	43.8	42.3	44.3
No. of children under 18	0.4	0.6	0.8	0.9	0.9
No. of persons over 65	0.4	0.5	0.3	0.2	0.1
No. of cars available	0.8	1.3	1.8	2.3	2.8
Income before taxes ($)	4,097	10,611	18,129	28,231	52,267
Total expenditure ($)	8,324	12,155	16,733	22,425	35,171

	Income Quintile				
Expenditure Category	Lowest 20 Percent				Highest 20 Percent
Food	21.1	19.2	17.2	16.1	13.7
Food at home	15.9	14.7	12.4	11.3	8.8
Food away from home (FAFH)	5.1	4.5	4.8	4.8	4.9
Alcoholic beverages	1.6	1.6	1.6	1.6	1.3
Housing	35.8	32.9	30.1	28.8	29.0
Shelter	20.8	18.1	16.9	16.2	16.6
Own dwelling	7.0	6.9	7.9	9.9	12.7
Rented dwelling	12.3	10.3	7.9	5.0	1.8
Other lodging	1.4	1.0	1.1	1.3	2.1
Utilities, fuels, public services	10.8	10.1	8.3	7.4	6.0
Household operations	1.5	1.3	1.2	1.3	1.6
House furnishing and equipment	2.7	3.4	3.7	3.9	4.7
Apparel	5.2	5.0	5.2	5.2	5.8
Men and boys	1.1	1.1	1.2	1.3	1.6
Women and girls	2.1	2.0	2.0	2.0	2.4
Other	2.0	2.0	1.9	1.8	1.9
Transportation	14.8	18.6	20.6	20.5	19.8
Cars and trucks, new (net outlay)	1.0	2.6	3.4	4.2	5.4
Cars and trucks, used (net outlay)	3.2	3.2	3.8	3.2	2.7
Vehicle finance charges	0.4	0.6	1.0	1.0	1.0
Gasoline and motor oil	5.2	6.3	6.3	6.0	4.8
Maintenance, repairs, insurance	3.2	4.1	4.3	4.3	3.8
Public transit	1.3	1.2	1.1	1.0	1.3
Other	0.5	0.6	0.8	0.8	0.8
Health care	6.2	6.6	4.9	3.9	3.1
Entertainment	3.4	3.5	4.2	5.0	5.3
Fees and admissions	1.1	1.0	1.3	1.5	1.9
Television, radios, sound equipment	1.3	1.5	1.5	1.6	1.5
Other equipment and services	1.0	1.1	1.4	1.9	1.9
Personal care	1.0	1.0	0.9	0.9	0.9
Reading	0.7	0.7	0.7	0.7	0.6
Education	3.2	1.0	0.8	0.9	1.6
Tobacco and smoking supplies	1.5	1.5	1.3	1.2	0.7
Miscellaneous	1.6	1.3	1.4	1.5	1.5
Cash contributions	1.7	2.2	3.2	3.1	3.9
Personal insurance and pensions	2.3	4.7	7.8	10.5	12.9

An inspection of Table 1 immediately reveals several well-acknowledged relations. The relative expenditure on food decreases with increasing income. Housing expenditures show the same tendency, with expenditure on rented dwellings diminishing as income increases. The relative expenditure on health care also decreases with income, whereas that on clothing is stable.

Of particular interest in travel behavior analysis are expenditures on food away from home (FAFH), transportation, and entertainment. Regardless of the total income, the relative FAFH expenditures are stable at around 5 percent of the total. In terms of absolute values, however, the highest-income group spent four times as much on FAFH as did the lowest-income group, reflecting obvious differences in life-style across income groups and supporting the previous finding that higher-income groups make a larger number of eat-meal trips (*4*).

Higher-income households spend more on entertainment, in both absolute and relative terms. Although the historical trend does not indicate substantial longitudinal changes in expenditures in this category, the presence of cross-sectional variations is evident. The result suggests that the orientation toward leisure is strongly correlated with income.

Relative expenditures on transportation exhibit only weak correlations with income, except for the very low expenditure by the lowest-income group. In terms of the absolute amount of expenditure, the highest-income group spent three times as much on transportation as did the lowest-income group (Table 2). The average annual expenditure on automobiles ranges from $385 for the lowest-income group to $3,202 for the highest-income group. The average number of automobiles available varies from 0.8 to 2.8 across income groups, with the average expenditure per vehicle ranging from $480 to $1,150 a year.

The relative share of the expenditure on gasoline shows a weak association with income (Table 1). The absolute amount of expenditure, however, ranges from $429 to $1,692 a year across income groups. Gasoline expenditure per vehicle has a small range of $536 to $608 per vehicle per year, with the expenditure increasing with income. High-income households tend to own more automobiles and to use each of these automobiles slightly more extensively than do low-income households (this tendency may in fact be

TABLE 2 Annual Transportation Expenditures of Urban Households by Quintiles of Income Before Taxes, 1982-1983 (*13*, Table 1)

	Expenditure ($) by Income Quintile					
Expenditure Category	Lowest 20 Percent				Highest 20 Percent	Total
Cars and trucks, new (net outlay)	81	311	566	942	1,914	764
Cars and trucks, used (net outlay)	268	386	640	716	934	589
Vehicle finance charges	36	78	159	232	354	172
Gasoline and motor oil	429	763	1,062	1,351	1,692	1,060
Maintenance, repairs, insurance	269	502	722	958	1,320	755
Public transit	105	149	176	222	461	223
Other	43	70	126	183	275	140
Total	1,231	2,259	3,451	4,604	6,950	3,703

more pronounced if high-income households, which are capable of replacing their automobiles more frequently, tend to own newer, fuel-efficient automobiles). The result is consistent with the well-accepted finding that travel-time budgets and vehicle use increase with income (*14–17*).

Lower-income groups have higher shares of expenditure on nonprivate transportation, indicating their dependence on public transit. The absolute amount of expenditure, however, again increases with income. This may be due to long-distance commuting and intercity travel by air by the higher-income groups, although available data are not sufficient to determine the exact causes.

It is evident that income has a predominant impact on household expenditure; higher-income households spend substantially larger amounts on food away from home, entertainment, automobiles, and gasoline. Higher income seems to be accompanied by a distinct life-style. This result must be critically evaluated, however; many past analyses of trip generation indicated that income is not a primary determinant of trip generation (*4, 19*). The ineffectiveness of income is in part due to the fact that car ownership, which is strongly correlated with income, represents a household's long-term mobility choice and therefore better accounts for observed travel behavior than does income. Indeed, past results suggest that trip generation is conditionally independent of income, given car ownership. The foregoing analysis, on the other hand, has shown that income is strongly tied to expenditures on items that lead to trip making, for example, food away from home and entertainment. Further analysis is clearly needed on the linkage between life-style as reflected in consumer expenditure patterns and travel behavior, in particular trip generation.

Life-Cycle Stage

The use of the life-cycle concept in transportation planning studies dates back to the 1960s when a set of trip generation models was formulated using life-cycle stages in the Detroit Transportation and Land Use Study (TALUS) (*20*). A 1971 35-day travel diary survey in Uppsala, Sweden, used life-cycle stages as the basis for its stratified sampling (*16*). Recent examples include the ongoing Dutch National Mobility Panel survey, which also employs a stratified sampling scheme using life-cycle stages (*21*, pp. 81–95). Extensive efforts were made in the late 1970s to early 1980s to investigate the relationship between the life-cycle stage of a household and the travel behavior of its members (*4, 7, 16, 22–38*).

Behind this historical use of life-cycle variables is the fact that life-cycle stages provide "a convenient base for empirical analysis—a composite variable combining imperfectly, but adequately, many of the major sources of variation among households" (*32*). Typically defined in terms of the age and marital status of the adult members and the presence and age of the children of a household, life-cycle stages are viewed as indicators of the needs and constraints governing activity and trip making.

The role most clearly defined by life-cycle stage is that of child rearing. It is not difficult to imagine how this role may shape and constrain the activity and travel behavior of adult family members, especially mothers. In reference to the contributions made by activity-based approaches to travel behavior (*30, 32, 39, 40*), it is noted that (*41*, pp. 470–474) "the single most important 'discovery' of activity work to date has been the importance of children—not primarily because of their own trips . . . but because the very fact of children in a household imposes highly complex and binding constraints on the activities and travel patterns of all other members of the households."

Life-cycle stages define an axis for travel behavior analysis because of its association with various roles that a household and its members play. As discussed earlier, marriage (or cohabitation), another parameter that defines life-cycle stages, leads to the assignment of breadwinning and homemaking roles between men and women. Therefore, if life-style is interpreted as "an ordered set of roles" (*8*), a fundamental association must exist between life cycle and life-style.

Consumer expenditure patterns are presented by household structure in Table 3, where households are classified by the presence of children by age group and by the marital status of the adult members. This categorization in a published tabulation (*13*) does not precisely represent stages in the life-cycle, because the first category in Table 3, couples without children, includes both young couples before they have children and older couples who hold "empty nests." Similarly the last category, singles, includes both young individuals before marriage and those who do not marry. Nonetheless, the expenditure patterns shown in the table offer certain variations that are indicative of changes in life-style along life-cycle stages.

Households with Children Total transportation expenditures increase toward the last stage of child rearing in both absolute and relative terms. This is in agreement with findings obtained from analyses of travel patterns (*23, 28, 33, 42*). Mean car ownership, gasoline expenditure, and gasoline expenditure per person all show the same tendency and peak among the households with the oldest children (18 years or older). Furthermore, income and expenditures on food, apparel, personal care, reading, and education all follow the same pattern; a broad range of a household's mobility and activity levels reaches a peak as its oldest child becomes 18.

An interesting exception is housing expenditures, which are highest among households in the earliest stage of child rearing, when the oldest child is less than 6 years of age. This is presumably based on the group of young households that acquired a home recently after home ownership costs increased substantially (Figure 2). Another important exception is entertainment expenditures, which peak among households in which the oldest children are between 6 and 17. This presumably reflects the entertainment needs of school-age children.

Couples Without Children The expenditure pattern of the first category in Table 3, husband-wife couples with no children, differs in several important ways from the pattern shown by the second category, couples whose oldest child is less than 6. The expenditures on FAFH of the former group are much larger than those of the latter group in both absolute and relative terms; their average FAFH expenditure per person ($531 per year) is the highest among the groups, exceeding those of the four household groups with children ($213, $263, $364, and $182, respectively), the single person ($505), and single parents ($199). Dining out is part of the life-style associated with couples without children.

Couples without children on average spend larger proportions of their income on new automobiles, house furnishing, personal care, reading, and health care than do any other groups shown in Table 3. The first two items indicate that many couples in this group are starting new households, whereas the large share for health care suggests that the group contains older couples who have passed the child-rearing stage. Unfortunately, expenditure patterns of these two subgroups cannot be determined from the available tabulation.

Single Individuals The expenditure pattern of the last group in Table 3, single persons and other households without children, can be characterized by the large per-person expenditures on FAFH and alcoholic beverages, suggesting the outward orientation of their life-style. The share of expenditures on nonprivate transportation of this group (1.6 percent) is the largest of the seven groups. The group's average expenditure on own dwellings is the lowest and that on rented dwellings is the second highest. The group is mobile; its average per-person gasoline expenditure ($448) is among the highest, next only to that of couples without children ($554). The discussion here is again limited, because a distinction between young and old single-person households cannot be made from the available data.

Single Parents This group has the smallest income and smallest expenditures on FAFH, alcoholic beverages, new automobiles, health care, and reading. The fraction of renters is high, average per-person recreational

TABLE 3 Annual Expenditures of Urban Households by Household Structure, 1982-1983 (*13,* Table 5)

Household size	2.0	3.5	4.2	4.0	5.2	3.0	1.5
No. of workers	1.2	1.6	1.7	2.7	2.4	1.0	0.9
Age of reference person	54.4	29.9	38.3	52.3	47.7	35.4	47.4
No. of children under 18		1.5	2.2	0.6	1.6	1.8	0.1
No. of persons 65 and over	0.6			0.2	0.5		0.3
No. of cars available	2.0	2.0	2.5	3.2	2.6	1.0	1.1
Income before taxes ($)	26,010	27,356	31,153	37,037	30,561	12,939	14,684
Income after taxes ($)	22,938	24,440	27,864	32,967	26,934	12,111	12,991
	Expenditure ($) by Household Structure						
	Husband and Wife						
Expenditure Category	No Child	Child <6	Child 6-17	Child ≥18	Other Units	Single Parent	Single Person
Food	3,210	3,241	4,445	5,093	4,397	2,759	2,064
Food at home	2,148	2,492	3,340	3,638	3,449	2,161	1,305
Food away from home	1,062	748	1,105	1,455	948	598	758
Alcoholic beverages	302	264	277	328	288	145	292
Housing	6,294	7,863	7,756	7,208	6,805	4,748	4,131
Shelter	3,424	4,533	4,378	3,632	3,402	2,620	2,540
Own dwelling	2,237	3,046	3,341	2,686	2,282	1,053	925
Rented dwelling	772	1,264	688	399	692	1,446	1,427
Other lodging	415	222	349	546	429	121	188
Utilities, fuels, public services	1,605	1,554	1,933	2,252	2,091	1,392	1,021
Household operations	242	792	421	211	339	309	142
House furnishing and equipment	1,023	985	1,024	1,114	973	427	429

Apparel	1,042	1,107	1,478	1,639	1,364	907	687
Men and boys	252	262	413	465	349	183	157
Women and girls	441	343	600	684	520	415	272
Others	349	502	465	490	495	309	258
Transportation	4,154	4,085	5,046	6,319	5,007	2,130	2,404
Cars and trucks, new (net outlay)	1,063	743	1,202	1,135	993	187	451
Cars and trucks, used (net outlay)	548	845	850	1,110	579	471	384
Vehicle finance charges	155	217	267	318	278	105	97
Gasoline and motor oil	1,108	1,165	1,454	1,919	1,630	680	672
Maintenance, repairs, insurance	819	773	915	1,359	1,111	443	491
Public transit	299	182	194	269	277	177	203
Other	162	160	164	209	139	67	106
Health care	1,178	789	867	1,097	1,186	480	562
Entertainment	934	1,010	1,476	1,243	1,026	590	528
Fees and admissions	342	254	461	412	312	194	181
Television, radios, sound equipment	278	311	459	403	356	204	190
Other equipment and services	313	445	557	428	358	192	156
Personal care	220	150	216	288	237	136	115
Reading	160	126	154	173	131	75	94
Education	145	98	374	863	291	179	213
Tobacco and smoking supplies	209	194	250	315	355	166	152
Miscellaneous	278	240	296	361	384	223	234
Cash contributions	824	365	603	1,142	618	259	376
Personal insurance and pensions	1,975	2,023	2,367	2,814	2,175	798	879
Total	20,926	21,555	25,606	28,884	24,264	13,595	12,732

expenditure is low, and the relative share of food expenditures is the highest among the seven household groups. The expenditure pattern thus offers indications of the poor economic status of this group, as is often noted in the literature (*43–46*).

This group has the lowest level of car ownership, smallest average per-person expenditure on gasoline, and smallest expenditure on automobiles. Consumer expenditure patterns thus suggest that single-parent households are the least mobile among the groups studied here.

Age

Household income and expenditure peak when the representative household member is 45 to 54 years old (Table 4). Expenditures on food, transportation, and personal insurance and pensions have a similar peak, whereas housing and entertainment expenditures peak at 35 to 44 years. The youngest group (less than 25) and oldest group (65 and over) have similar total expenditure levels, but their budget allocations are different; the younger group spends more on FAFH, alcoholic beverages, transportation, and entertainment. Health-care expenditures increase substantially and expenditures on alcoholic beverages decrease with age. The share of apparel in the total expenditure also decreases with age.

The expenditure patterns shown in Table 4 are consistent with the common finding that the mobility of individuals peaks when they are in their 30s and 40s, and that the elderly are the least mobile (*47*). It appears that households go through a period of expansion in their expenditures and then a period of contraction. The life-style of a household, then, changes as it ages and progresses through the life-cycle stages. At the same time it is plausible that individuals in the same age group share certain life-style traits that are maintained over time despite their aging (cohort effect), thus leading to the emergence of new life-styles as these individuals enter later stages of the life-cycle (*48–50*).

Summary

Household expenditure patterns have been shown to vary by income, life-cycle stage, and age. These results are generally in agreement with common findings from travel behavior research. In addition, expenditure patterns for automobiles, gasoline, housing, entertainment, and food away from home, not generally available from transportation surveys, have been described. With these expenditure characteristics of population subgroups as background, the discussion now turns to travel characteristics of urban residents.

WHAT IS KNOWN ABOUT TRAVEL BEHAVIOR?

The discussion in this section is motivated by the question, What is known about the association between travel behavior and those parameters that are believed to be associated with life-style? A review is presented of findings available in the literature on travel characteristics of various population subgroups. The measures of behavior used in the discussion include trip rate, trip distance, travel-time budget (expenditure), mode use, and time use.

There exists a set of factors that are believed to constrain and direct an individual's activity choice and life-style. They consist of (*22*, pp. 13–26) "certain personal characteristics (e.g., sex, stage in the life cycle, and health status) and roles that society assigns to persons (e.g., the breadwinning role long assumed in Western countries by the male partner of the household and the homemaking role by the female partner)." This, combined with the emphasis of this study on anticipated demographic changes and likely shifts in life-style, has led to the use of life-cycle stage, sex, employment, age, income, and car ownership in the analysis of this section. These variables have quite often been used in sample segmentation with the intent of creating subgroups with internally homogeneous life-styles. Ethnicity and education are also used occasionally as segmentation bases. It has been claimed that (*24*) "significant behavioral variations, which may result from differences in tastes, motivations, and personalities, may be captured through population segmentation" using these variables.

Life-Cycle Subgroups

Empirical results from past analyses of urban household travel behavior exhibit strong commonality as to the association between life-cycle stages and travel patterns. This association is in general in good agreement with the monetary expenditure patterns discussed in the previous section. Although a controversy does exist about whether one can improve the model's predictive capability by using a life-cycle variable in trip generation analysis (*38, 51, 52*), it is evident that analyzing travel patterns along life-cycle stages offers a rich depiction of household behavior.

Important in this context is the rapidly changing household structure with the increase of nontraditional families (*43*): "Most conventional transportation planning methods do not reflect and respond to the growth and diversity of non-traditional families." The explanatory power offered by simple, conventional variables such as household size is seriously limited in light of the ongoing changes.

TABLE 4 Annual Expenditures of Urban Households by Age of Reference Person, 1982–1983 (*13*, Table 3)

	<25	25–34	35–44	45–54	55–64	≥65	Total
Household size	1.8	2.7	3.5	3.2	2.4	1.7	2.6
No. of workers	1.2	1.4	1.8	2.0	1.4	0.4	1.3
Age of reference person	21.7	29.7	39.0	49.6	59.4	73.4	46.2
No. of children under 18	0.3	1.0	1.5	0.7	0.2	0.1	0.7
No. of persons 65 and over				0.1	0.1	1.4	0.3
No. of cars available	1.1	1.8	2.2	2.5	2.0	1.1	1.8
Income before taxes ($)	11,537	23,835	29,718	31,198	24,450	13,583	22,702
Income after taxes ($)	10,282	20,992	26,455	27,068	21,865	12,739	20,182
	Expenditure ($) by Age of Reference Person						
	<25	25–34	35–44	45–54	55–64	≥65	Total
Food	1,835	2,949	4,046	4,166	3,328	2,288	3,137
Food at home	1,163	2,011	2,894	2,938	2,326	1,700	2,204
Food away from home	672	938	1,152	1,228	1,002	588	933
Alcoholic beverages	343	356	322	307	260	133	285
Housing	3,410	6,409	7,494	6,870	5,374	4,123	5,784
Shelter	2,151	3,915	4,411	3,658	2,697	2,073	3,262
Utilities, fuels, public services	668	1,305	1,789	1,969	1,701	1,342	1,489
Household operations	115	359	327	226	208	267	271
House furnishing and equipment	475	831	968	1,016	767	440	762
Apparel	782	1,071	1,428	1,366	993	515	1,030
Transportation	2,623	4,052	4,758	4,991	3,656	1,972	3,712
Cars and trucks (net outlay + finance charges)	1,184	1,913	2,174	2,048	1,297	641	1,572
Gasoline and motor oil	745	1,073	1,308	1,493	1,145	603	1,062
Maintenance, repairs, insurance	318	423	538	585	457	258	430
Public transit	126	229	253	267	281	189	228
Other	250	414	485	598	476	281	420

Health care	307	547	753	936	1,056	1,228	822
Entertainment	581	977	1,294	1,075	799	390	870
Fees and admissions	186	273	413	386	289	163	287
Television, radios, sound equipment	223	317	420	338	233	136	282
Other equipment and services	172	387	461	351	277	90	301
Personal care	92	148	203	223	213	166	176
Reading	74	121	154	153	140	106	127
Education	489	180	343	590	197	45	274
Tobacco and smoking supplies	139	196	249	290	244	116	205
Miscellaneous	119	244	347	356	329	198	270
Cash contributions	100	297	695	925	754	665	576
Personal insurance and pensions	722	1,724	2,209	2,469	2,155	401	1,625
Total	11,617	19,271	24,296	24,718	19,497	12,346	18,892

Presence of Children Empirical evidence is abundant that the presence and age of children in the household strongly influence its members' travel behavior. For example, Allaman et al. conclude that (*4*) "such life-cycle effects as having preschool children present, having the youngest child reach school age, and progressing to other points in the life cycle do indeed prompt changes in time allocation." Mobility indicators in general vary along a concave curve as the household progresses through life-cycle stages [exceptions are social-recreation trips (*28*) and the amount of time spent out of home and on travel by adult members of household, which decline as a household progresses through life-cycle stages (*53*)].

The presence of preschool children has a "strong inhibiting effect," constraining the adult members' travel behavior, whereas households with school-age children have the highest person-trip rates (*4*), partly because of the size of these households. Using a 1968 Washington, D.C., data set, McGinnis (*23*) examined the complex interaction among sex, employment, and presence of children. Households with children have higher total trip rates and non-work-trip rates. This is also the case for shopping trips and, of course, serve-passenger trips. McGinnis reports that families with children have slightly lower work-trip rates and, surprisingly, lower social-recreation-trip rates. In terms of household car trip generation, a study indicates that households with driving-age children generate most car trips (*42*).

Similar patterns can be observed at the individual level: those with preschool children show lower trip rates, and those from households in which the youngest child is school age (5 to 17 years old) are the most mobile (*28, 33*). Participation in out-of-home activities shows the same concave curve along life-cycle stages (*25*). Also commonly found is the tendency for individual mobility to decline in later stages of the life cycle (*28, 33, 54*).

These findings support the notion that a change in the role played by an individual has a systematic impact on his travel behavior. In addition, the systematic variations observed along life-cycle stages at the individual level indicate the important effect that the interaction among household members exerts on each individual member's travel behavior.

Although common findings have emerged, it is a complex and unobservable process that determines the need to travel, the assignment of tasks across household members, and joint engagement in activities. The presence of conflicting findings in the literature is not surprising. For example, McGinnis (*23*) notes that when the wife in a household is employed, the household's weekday discretionary activities decrease and certain activities are transferred from the wife to the husband, but that no significant change takes place in the total trips or total nonwork trips made by the husband and wife when children are present. McGinnis concludes (*23*):

In summary, the results indicate that the presence of children has little effect on the travel of the husband and wife in the household. The travel by the children, however, significantly increases total household travel.

Single-Person Households Young single individuals are in general more mobile than married individuals in the same age group (*25, 33*). In particular, single persons show greater participation rates in, and duration of, leisure activities (*55*), showing the outward orientation of their life-style. This tendency is more pronounced among single men than single women (*4*). However, a study shows that single men and women have similar person-trip rates (*24*).The mobility of individuals gradually declines as they move past the life-cycle stage in which they have school-age children; adults with older children generate fewer trips than those with school-age children, and older adults without children generate even fewer trips. A tabulation indicates that working single persons of at least 45 years old who have no children living with them have slightly lower trip rates than their married counterparts. Older single nonworking persons, on the other hand, have higher trip rates than married non-working individuals (*33*).

Single Parents An analysis based on census data indicates that of the 30 million families in the United States with children under 18, 19.5 percent are not headed by a married couple and that about 85 percent of these are headed by women (*44*). Of all children under 6, 20.5 percent lived with a single parent in 1982, which is up from 6.1 percent in 1960 (*56*). Although only minimal work has been done on the transportation problems of single parents (*44, 45*), recent studies nonetheless illustrate their travel characteristics.

Using Canadian large-scale data, Rutherford and Wekerle (*46*) report that single mothers tend to be in the labor force more than do married women with children, but that their incomes tend to be below average. Consequently the car ownership rate is low among single parents. For example (*44*), "of all female headed households with children under 18 in the City of Chicago, 65.1 percent do not own a vehicle." "Nationally, 43% of all single parents in Canada did not have access to a car in 1982, contrasted with only 11% of all two parent families with children under the age of 18" (*46*). Combined with the lower rate of license holding among women (*50, 57*), single parents' primary mode of travel tends to be public transit. For example, the bus is used more frequently in Chicago by single mothers for their work trips (*44*).

Because single parents often perform both breadwinning and homemaking roles, they tend to be subjected to tighter time constraints (*43, 46, 57, 58*). Presumably because of this, total trip rates of single-parent households are only marginally higher than those of nuclear families when their vehicle ownership patterns, age structure, and residence patterns are accounted for (*5*). Kostyniuk et al. (*59*) conclude that the apparent lack of mobility of single parents is due to limited transportation resources (the automobile and the driver's license) available to them and that, given the availability of these resources, single parents make slightly more trips than their married counterparts. It is also noted that the activity patterns of (*43*) "single working parents were not greatly different from comparable working women with spouses." There appears to be a consensus that, given the level of car ownership and license holding, single parents' travel patterns are not appreciably different from those of their married counterparts. Note, however, that this result may be due to conceivably lower survey response rates among single parents. In addition, it should be kept in mind that the analyses of observed travel behavior may not accurately reflect the travel needs of single parents.

Sex and Employment Status The issue of sex, role, and travel behavior has received extensive attention in the past decade. Empirical results have been accumulated to illuminate behavioral differences between men and women; studies have focused on changes over time in travel behavior with the intent of identifying the trend and determining whether the "gender gap" is narrowing.

There are several well-accepted sex differences in travel behavior. Women make trips less frequently than men even when employment status is accounted for (*28, 60–62*). As noted earlier, single men are more mobile than single women, principally because of a higher frequency of entertainment trips and return-home trips (*4*). It is also well established that women's trips tend to be shorter compared with men's (*24, 63*), their travel-time expenditures tend to be less (*17*), and they tend to be passengers rather than drivers, although this tendency varies with age (*24, 62*).

There also exists the commonly found tendency for women in two-worker households to use public transit, walk more, and use the automobile less than do men (*62, 63*). This tendency is not more pronounced among single parents (*45*), suggesting that the woman's transit dependency is in part attributable to the allocation of the family cars among family members. McGinnis (*23*) observes that "the allocation of the first car appears to be to the husband and the second car to the wife."

In short, women tend to be less mobile and more transit dependent. A question that arises is whether these tendencies are changing and sex differences are diminishing as more women gain employment and assume some of the household and societal roles that were once in the male domain. Before empirical results that offer clues to this question are reviewed, more characteristics of travel and time use patterns will be covered.

Previous studies have repeatedly pointed out that women have a higher shopping-trip rate. Women's trip rates for personal business and shopping are higher than those of men in the same life-cycle stages, especially among women from one-worker households (*62*). Examining the percentage of trips by purpose controlled by employment, sex, and life cycle, a study notes that (*23*) "the highest percentages of shopping trips are associated with suburban homemakers, next by the urban employed homemakers." Evidently "nonworking wives have a higher participation rate for household support activities than do working spouses of either sex" (*55*).

More generally, homemakers and individuals who are not employed engage in more nonwork travel (*64, 65*). Women from one-worker households pursue more social-recreation, personal business, and shopping trips than do men (*28*). Substantial sex differences also exist in time use in addition to the well-recognized difference in travel-time expenditure (*28, 61*). An analysis of multicountry time-use data (*66*) indicates that women spend more time than working men on household care (no data on nonworking men are shown). Married working women spend less time on household care than their nonworking counterpart, but they spend more time on this activity than do single working women. The time spent for household care increases with the number of children, so women with preschool children spend the least amount of time out of home and on travel (*28*). Finally, analyses of multiday travel behavior have offered consistent indications that women's travel patterns are more variable over time than those of men (*67, 68*). This tendency is interpreted as an indication of sex differences in activity engagement and constraints.

These observations support the notion that the apparent sex differences in travel and time-use patterns are due to sex-based role assignment, in which employment is a principal factor. The increasing labor force participation by women is evident from statistics. For example, the percentage of women in the civilian labor force increased from 42.6 percent in 1970 to 49.1 percent in 1978. The increase is particularly noticeable among women with children (*43*), which is reflected in the increased work-trip rate of women from households with preschool or school-age children (*28*). Although employed women tend to work fewer hours than do employed men (*66*), it is obvious that the assignment of breadwinning and homemaking roles is now less sex based. Is this change then reflected in the travel patterns of working men and women?

Many study results suggest that role assignment between men and women remains sex based even when both are employed. For example, an analysis of Australian data (*69*) indicates that employed men spend more hours on work-related activities and commuting than do employed women. The average time expenditures by employed women on housework, shopping, and child care are approximately 3 hr, 0.8 hr, and 0.5 hr per day, respectively. The corresponding time expenditures by men are less than 1 hr, 0.4 hr, and 0.3 hr, respectively.

This demand for housework and child care leads to less leisure time available to women. A study indicates that free time as a proportion of a 24-hr day varies from 17 percent for housewives to 14 percent for employed men to 10 percent for employed women (*66*). Wigan and Morris (*69*) also note that employed men tend to have more free time on weekdays. Time expenditure for (out-of-home) recreation was obtained from 35-day diaries to be 9.4 hr for women and 17.3 hr for men for the 35-day period (*62*). An analysis of Dutch, French, and U.S. data sets also shows that leisure activity and visits are less frequent among female workers of two-worker households (*45*).

Previous studies suggest that household responsibilities, which vary by the presence and age of children, do not have a strong impact on the activity patterns of men (*43*). This is exemplified by the finding that life cycle influences women's travel patterns much more significantly than it does men's (*28*), in particular, women's serve-passenger trips (*33*). The presence of children has no impact on men or on women who are not employed; "for employed women, however, the transition to having a young child prompts less time in pleasure travel and more time spent in shopping" (*4*). These findings all suggest that differences based on sex cannot be changed by the increasing labor-force participation of women.

Nevertheless, aspects of travel behavior and time use exist in which sex differences appear to be narrowing. For example, "for the household with only the male working, the wife provides the majority of the household support, whereas for the two-worker household, the husband does more of this activity" (*55*). Pas (*36*) acknowledges that "the daily travel-activity patterns of adult males and females are differentially affected by the presence or absence of young children in the household," but maintains that the effect on employment supersedes this.

Although noting that "intra-household division of labor for out-of-home maintenance activities continued to be gender-based," Kostyniuk and Kitamura (*28*) also observed that sex differences are very small among two-worker households with preschool children; in fact, men in these households shop and pick up children slightly more frequently than do women. Although it is true that pronounced differences exist between women and comparably situated men and that "family and household responsibilities [are] strong motivators of women's travel and employment behavior" (*43*), the increase in working women is necessarily changing role assignment within households and hence travel behavior of men and women.

The Elderly Individuals over the age of 65 are the fastest-growing group in the United States. It is projected that by the year 2000 they will make up 13 percent of the population, and by 2030 this will increase to 21 percent (*70*). As some of the studies using life-cycle stages have shown earlier, the elderly have lower trip rates, although this is in part due to the absence of work trips among retired individuals. A study reports that (*4*) "household members under 35 account for . . . about 2 more trips than those 65 and older."

Perhaps most important is capturing the changing behavioral patterns of the elderly. Wachs and his colleagues (*48, 49*) describe the stereotype of the elderly of today as living in higher-density areas, dependent on public transit, having a lower income, and being less mobile. The decline in mobility, however, may not be entirely attributable to the process of aging itself, but to the life-style that the cohort of the current elderly population long ago established. Wachs et al. anticipate that (*48*) "the elderly of the next 20 years will include many suburbanites, many drivers, and many who travel a great deal." Unfortunately, little empirical evidence exists to indicate the changing travel patterns of the elderly population.

Income, Car Ownership, and Other Factors Household income, an obvious determinant of consumer expenditure patterns and therefore a determinant of their life-style, has been one of the primal variables in travel demand analysis. Past studies have shown that higher income is associated with higher person-trip rates (*47*), more vehicular trips (*71*), more social trips (*60*), increased work-trip length (*72*), and more frequent multistop trip chains (*53*). Recent studies include an analysis of daily travel frequency and distance by mode that shows clearly that the percentage of driver trips and driver trip distance increase with income, whereas passenger trip frequency and distance and the percentage of public transit trips decrease with income. Public transit trip distance, however, is at a minimum in the middle-income range, beyond which it increases with income, suggesting long-distance commuting trips made by higher-income individuals (*18*).

Empirical results are also abundant in which income does not exhibit a logically consistent and statistically significant effect or is excluded from the model, presumably because of its insignificance. For example, Allaman et al. (*4*) maintain that "income is not a significant determinant of total trip-making behavior, although it has marginal positive impact in the work and entertainment purposes," and income is not significantly associated with time allocation by employed individuals, although certain associations are found for time allocation by not-employed individuals.

The apparent lack of significance of income is presumably due to the fact that car ownership, which is strongly correlated with income, is more directly associated with travel behavior than is income. Being the consequence of a long-term household mobility decision, household car ownership reflects "a certain type of life-style which one cannot measure with existing household interview data" (*4*). Accordingly, many aspects of travel behavior are conditionally independent of household income, given household car ownership.

Household car ownership is another primal variable in travel demand analysis (*73*). Indeed, practically all models of trip generation and mode choice incorporate a car ownership or car availability variable (*28*). In general, higher levels of car ownership imply higher trip rates, increased car use, increased trip lengths, and more trip chaining (*42, 64, 74*).

A question of critical importance in this context is whether car ownership is a variable that explains observed variation in travel behavior, or whether it is a dependent variable that merely reflects a household's propensity to travel. Car ownership may be viewed more appropriately as a surrogate for unmeasured propensity to travel, part of which is attributable to life-style. The existing modeling approach using car ownership as a primal explanatory variable is adequate if the association between car ownership and travel behavior does not change substantially. Recent studies, however, indicate that this association does change over time and that the explanatory power offered by household car ownership declines as motorization progresses (*19, 52*). Thus it is desired that the car ownership variable be replaced by another variable more intrinsically related to travel behavior.

Other factors that are less frequently used in travel behavior analysis but are nonetheless relevant here include education, ethnicity, and residence location. Education is used by Salomon as one of the dimensions along which the life-style orientation is defined (*9*). Past studies have found certain associations between education and travel behavior (*60*). Allaman et al. (*4*) found education to be associated with the time spent working, eating away from home, in entertainment, and in travel by employed individuals. Reviewing the literature on survey methods, Kitamura and Bovy (*75*) suggest that the apparent positive effect of education on trip rates is in part due to reporting errors. Ethnicity is used only occasionally in travel behavior analysis. For example, Nicolaidis et al. (*76*) used language (English versus French) as one of the segmentation bases applied to an Ottawa data set. Their "multidimensional demographics," based on language, age, home ownership, and sex, appear to capture the major dimensions of life-style. Available results suggest the presence of ethnic differences in trip rates and time use. Studies indicate that white individuals engage in social activities that require trips more frequently than do minority groups (22) and that differences based on ethnicity also exist in time use (*4*). These observations are consistent with the hypothesis that (*5*) "cultural traits may account for different weights given to basic human needs, in a way not very different from differential weights caused by shifts in life cycle, or in economic status." However, relatively little is known about the association between ethnicity and travel, possibly due to the multitude of ethnic and cultural backgrounds. In addition, the frequently observed correlation between ethnic background and socioeconomic status makes the isolation of an ethnic effect a difficult task.

Residential location is extremely relevant to the discussion if suburban life-style is the cause of urban congestion problems. Relatively little attention has been paid in travel demand analysis to the factors that influence choice of residential location. The key issue that needs to be addressed is how households trade off among commuting distance (and time), housing price, and various amenities that vary greatly by location. Among the preferred housing attributes are "better" neighborhood quality, better schools, a new house in a well-established neighborhood, a housing unit all on one floor, and a large lot (*77*). Obviously these preferences are correlated with the life cycle and life-style of the household. But what is the relation between housing preferences and household travel behavior? Unfortunately, little is known that might answer this question.

The existing results indicate that trip generation is negatively correlated with population density, suggesting geographical variations in life-style within a metropolitan area (*4, 78*). The significant effect of home ownership found in several studies (*51*) may again be viewed as an indication of the association between population density and travel behavior. An analysis of daily travel patterns concludes that (*36*) "those residing in low-density areas are significantly more likely to undertake a multistop daily pattern."

Although some insights are already available, more detailed and extensive examination is desirable on the subject of life-style and residential location.

Analyses in this subject area have not advanced, possibly because of the conviction that there exist spatially invariant trip generation rates and that trip generation models are geographically transferable. Attempts to determine the effects of accessibility on trip generation have shown only minor results (*79, 80*). Thus, the conventional planning models implicitly assume that households of given characteristics will exhibit the same travel patterns no matter where they are located.

Still another problem is that many attributes of a metropolitan area, including transportation service levels and characteristics of household members and their preferences, are spatially correlated. Because of this, cases of ecological fallacy are the likely consequences of a marginal analysis of travel characteristics in which a limited number of contributing factors is controlled for. Because of these limitations, it is not possible to determine whether a particular travel pattern exhibited by a household is due to the household's life-style aspiration or to residence location and car ownership.

A very fundamental question is whether travel behavior is conditionally independent of life-style orientation, given residence location, car ownership, and other measurable factors. An answer to this question will determine the importance of the life-style concept in travel demand forecasting and where in the forecasting process the concept can contribute most.

EXTRAPOLATION

How useful is this information on behavioral characteristics of population subgroups? Is adequate information available to determine likely future travel demand? If so, what does the available evidence indicate as future pictures of urban travel? In this section the discussion is concerned with the usefulness of existing empirical findings in long-range forecasting.

It is important to distinguish two types of changes that may take place in the future:

- Shift of behavioral units across life-style segments, and
- Shift in the behavioral pattern of each life-style segment.

Demographic trends offer strong indications that household size and structure, labor-force participation, car ownership, license holding, and age distribution will continue to change (*81*). If the magnitude of these changes can be determined and future life-style segment sizes can be estimated with reasonable accuracy, and if the behavior of each segment remains stable over time, then the available evidence as summarized in the previous section should offer useful long-range forecasts of travel demand. In this section, characteristics of future travel demand as inferred from observed travel patterns of population segments are briefly summarized.

Sociodemographic Changes

The salient trends in household size and structure have been summarized by Spielberg et al. (*81*) as a sharp decline in the average size of households (3.33 persons in 1960 to 2.78 in 1979) with increasing single-person households, an increase in the proportion of non-family households and single-parent households, a dramatic increase in the number of suburban households, and a slow increase in central city households of smaller sizes. The percentage of married couples with children is gradually declining, that of married couples without children remains stable, and the fraction of individuals living alone steadily increases in all age groups (*81*, *82*). The labor-force participation by women has been increasing, resulting in an increasing proportion of two-worker households with young children (*28*).

These trends are reflected in the changing distribution of life-cycle stages, with a much smaller proportion of households with children in recent years

(*27*). Resulting changes in travel demand that can be inferred using the travel characteristics of life-style segments (*28*) are increases in

- The number of work trips because of an increase in working women;
- The number of person trips because of an increase in young, single individuals;
- The number of social-recreation trips because of an increase in single individuals and young couples without children; and
- The number of person trips and total travel time expenditure by women because of an increase in the number of two-worker households.

Likewise, there will be decreases in

- The number of person trips and number of serve-passenger trips by married women in both one-worker and two-worker households because of a decreasing number of households with children,
- The number of shopping trips by women from one-worker households because of the decreasing number of one-worker households with children, and
- Mobility because of the increased number of households consisting of older individuals.

In addition, on the basis of the information available at this point, the increasing number of single-parent households will lead to a decline in mobility due primarily to the lower levels of car ownership and license holding by single mothers. The combined effects of these changes cannot be determined without performing a formal analysis that explicitly incorporates changes in segment sizes in the population.

In addition to an increase in the number of work trips, an increase in two-worker households will lead to changes in trip rates by purpose, linking of trips, trip timing, and destination locations. For example, it is typical for shopping and work to be combined in working women's trip chains (*83*). This may involve changes in the destination and timing of the shopping trip. A thorough assessment of the impact of the increased number of two-worker households requires a comprehensive investigation of daily travel behavior by one-worker and two-worker households, including geographical and temporal aspects.

Car Ownership and License Holding

Ownership and use of the automobile in the United States increased dramatically after World War II. The percentage of households that did not have access to cars decreased from 41 percent in 1950 to 13 percent in 1980. The percentage of households with two or more cars available increased from 7 percent to 52 percent during the same period (*28*).

Approximately 85 percent of the adult population is currently licensed to drive, and the proportion of license holders among those 25 to 35 has reached 96 percent. As the driving population expanded, its age and sex composition changed. In 1940 only 25 percent of all drivers in the United States were 40 or older and 1.7 percent were over 65. In 1983 about 45 percent of the drivers were over 40, about 24 percent were over 55, and 11 percent were over 65 (*50*). An estimate indicates that by 2000, 28 percent of all drivers will be over 55 and by 2050 this proportion will be 39 percent (*84*).

According to the Federal Highway Administration, an estimated 152 million individuals were licensed to drive in 1983. The number of male drivers increased by 2.9 million—from 76.6 million in 1979 to 79.5 million in 1983; during the same period the number of female drivers increased by 6.1 million—from 66.5 million to 72.6 million. The proportion of female drivers in the total driving population was 30 percent in 1960, which increased to 43 percent in 1970 (*85*) and 47.7 percent in 1983. The proportion of female drivers in 1983 varied slightly by age group. The youngest age group, less than 20 years old, made up 46.4 percent of the total driving population. The proportion increased with age, peaked with 48.5 percent observed for those 40 to 44, and then declined. Sex differences in license holding thus appear to be diminishing.

Statistics are abundant showing that household car ownership or car availability is positively correlated with trip generation (*28, 47, 54*), although the effect of car ownership may be exaggerated because trips by non-mechanized modes are not included in the analysis. Whether or not trip generation increases further if household car ownership continues to increase needs to be critically examined. As noted earlier, it can be argued (*52*) that car ownership does not serve as a strong indicator of a household's propensity to travel once motorization has reached a mature stage in which a household can easily adjust the number of automobiles because of decreasing real costs of car ownership and maintenance (*86*). Recent tabulations, in fact, indicate that car ownership variables are not necessarily significant in trip generation models (*75, 78*).

It is logical that if an overall increase in household car ownership is primarily due to an increase in the number of cars owned by multicar households, then its impact on trip generation may be limited. With the high level of car ownership in the United States, the acquisition of a new car may often imply that the number of cars exceeds the number of drivers in the household. In this context, it is important to note that highly mobile households tend to include teenage drivers in addition to adult drivers (*42*);

the number of drivers may be a better indicator of trip generation and car use by a household. In a recent simulation analysis using a dynamic model system of household car ownership, trip generation, and mode use, the number of drivers was shown to be the most crucial determinant of car and public transit use. Despite the overwhelming empirical evidence that car ownership is positively associated with trip generation and car utilization, the impact of increasing car ownership needs to be critically evaluated.

Changes in the Travel Environment

The basis of the discussion in the previous section is the assumption that the travel behavior of each segment will remain unchanged over time. Possible shifts in behavioral patterns within each life-style segment will be discussed to determine whether this assumption is plausible.

Changes anticipated are not limited to sociodemographic characteristics but will involve many elements of the travel environment: transportation supply characteristics, land use patterns, housing supply, retail distribution systems, service and entertainment industries, new consumer technology and products, telecommunications systems, and forms of employment and performing work. It is inevitable that these changes will influence and transform life-styles of urban residents.

Consumer Technologies and Products

Consumer technology has shown a drastic change in the past few decades. Such home appliances as washing machines, dryers, refrigerators, freezers, dishwashers, and, more recently, microwave ovens are now prevalent in American homes. A wide variety of prepared food is available, and food preparation can be speeded up by electric and electronic kitchen gadgetry. One would expect that the time spent in homemaking had substantially decreased because of these advances.

Contrary to this expectation, a study indicates that the domestic work-load for urban women has not decreased appreciably over time, despite these technological advances. Observing time-series data from three different sources, Wigan and Morris (*69*) conclude that "while modest time savings have been made in some types of domestic work, others (including shopping) seem to demand more time than before." Unfortunately, information is virtually absent to assess the impact of household appliances on urban travel, this aspect of urban living having been traditionally outside the scope of travel behavior analyses.

Home entertainment has also changed drastically; there is now a television set in virtually every home. More recently, videogames, videocassette recorders, big-screen television sets, cable television, and a variety of home computers have been introduced into American homes. Concurrent with this, video rental outlets are mushrooming in suburban shopping centers. It seems as if "home-based leisure" (*87*) is replacing traditional out-of-home social-recreation activities.

An analysis of the temporal stability in trip generation indicates a decrease in the number of social-recreation trips made during the evening (*27, 28*). This suggests that out-of-home social and recreational activities have been replaced by in-home activities using home entertainment devices. The impact of home entertainment devices on travel is again difficult to assess because of the lack of adequate data and also because these devices may induce new trips such as visits to a video rental store to pick up movie cassettes (*40*).

Telecommunications

Rapid advances are being made in telecommunications technology. New telecommunications capabilities now available offer the potential of replacing certain shopping and personal business trips. Through the use of home computers or television sets, consumers can shop electronically for an increasing variety of goods and services. Bank transactions can be made from home using the telephone. The potential travel impacts of the evolving telecommunications technology have been reviewed by Salomon (*88*).

These developments have made telecommuting a realistic alternative to commuting. Permitting workers to perform their tasks without leaving their homes, telecommuting will have an immediate and substantial impact on the travel behavior of workers and their family members. In addition, telecommuting will have a long-term effect on the spatial and organizational structures of many economic and social activities. New forms of employment are likely to emerge, allowing telecommuting workers to engage in part-time employment with multiple employers that may be scattered throughout the country; telecommuting lifts geographical constraints that have so long bound the location decision of both employers and workers, possibly leading to new urban forms.

The potential of telecommuting in relieving traffic congestion, reducing energy consumption, mitigating air pollution, and saving infrastructure construction and maintenance costs remains to be determined. Unfortunately, assessments of the impact of telecommunications technology on life-style, residential location, and travel demand tend to be educated guesses. One critical difficulty is the lack of data that can support the effort to determine whether in-home activities may substitute for out-of-home activities, whether out-of-home activities will be suppressed, or whether new out-of-home activities will be induced as a result of new telecommunications technology.

An excellent opportunity for this assessment is offered by an ongoing experiment by the state of California that began in January 1988. The pilot project involves approximately 200 volunteer state workers who will telecommute and about the same number of conventional commuters as a control group. Information on household travel behavior will be obtained through 3-day travel diary surveys to be conducted in January 1988 (before telecommuting begins), in January 1989, and in January 1990. These observations will provide an invaluable data base for analysis of the short-term impact of telecommuting on travel and life-style.

Urban System

As suburbanization continues without adequate levels of investment in infrastructure, suburban congestion has emerged as a new focus of the urban transportation planning effort. Retail activities appear to be congregating in increasingly larger suburban shopping malls and extremely labor-efficient discount outlets. The continuing growth of suburbs is shown in demographic statistics (*81*, *82*), in housing output (*11*), and by the suburban congestion problem itself. Return to the central city is a movement often noted (*89*), but its magnitude has never been comparable with that of the explosive move toward the suburbs. Will suburbanization continue indefinitely? Will urbanites continue to aspire to suburban life-styles? Will there be a turning point?

European countries are also experiencing the same trend of suburbanization. Their assessment is (*90*):

> The locations of both homes and employment will become much more dispersed and urban densities will continue to fall. The shift from heavy engineering (industry) towards high technology manufacturing and the service industries, and the development of information technology, will lend impetus to this process.

Therefore trips will be dispersed more uniformly, and the central cities will continue to decline (*90*). Serious concern is voiced that "transport and land-use policies seem capable of exerting only a relatively weak influence on the prevailing trends in urban structure and transport choice. . . . It seems likely that public transport use in most places will eventually reach a peak value and then experience decline" (*90*) as it did in many metropolitan areas in the United States.

If American households are eternally to aspire to a more spacious life-style, then the ongoing suburbanization process can be curbed only by an increase in the cost of pursuing this life-style. Although European researchers observe that (*90*) "the inner city generally contains some high-class residential areas, and social attitudes generally are more likely to result in the maintenance of the urban way of life," the advanced stage of suburbanization in the United States suggests that the attraction of the central city is generally lacking. If the trend of suburbanization were to stop, it would presumably be because of the cost of suburban lifestyles rather than the attraction of the inner city.

Two increasing cost elements are travel time and housing. It is not clear whether suburbanization increases or decreases commuting travel time; it is conceivable that commuting distance, and possibly commuting time, declines as suburbanization transforms the once-typical radial commuting pattern between suburb and central city to a more uniformly distributed spatial pattern. Suburban congestion may not act as a deterrent to suburbanization. Increasing housing prices, however, may motivate a larger fraction of households to seek housing alternatives in high-density areas. In particular, an increasing number of couples without children are turning to urban life-styles.

New Values and Life-Style

There are additional elements that may influence life-style and travel behavior of urban residents importantly in the future. Behind the abundance of consumer products, including the automobile, is the increasing level of real income. Increasing discretionary expenditures will generate demand for new types of goods and services, increased awareness of health and physical conditions, and demand for educational and cultural activities.

Life-style will continue to evolve with the aging of the cohorts of individuals who had acquired life-styles and travel habits in which the automobile played a central role. Social attitudes toward sex roles are changing. Waves of immigrants constantly bring in their own cultures and life-styles. New values continue to emerge and form new life-styles. Although the issues of changing sex roles and the new elderly have been well recognized, analytical efforts by transportation planners tend to be motivated by the desire to prove that travel behavior is stable and that travel demand models remain valid over time. This discussion of the many changes that are pertinent to travel behavior indicates that future effort must focus on understanding and predicting the direction and magnitude of behavioral changes.

Discussion

A solid body of empirical evidence exists on the travel characteristics of population segments defined in terms of life-cycle stage, sex, employment, income, age, car ownership, and license holding. Empirical results are in general consistent and portray differences in life-style across the segments.

If the life-style and travel behavior of each segment remain stable, the knowledge available now can readily be applied to forecast future travel demand once the future population size of the segment has been forecast. The results of an initial attempt to obtain qualitative trends were presented in the section on extrapolition.

Aspects of travel behavior that have been examined in the past tend to be limited, however. Although trip generation, trip length, travel mode, and time use have often been investigated to form an accumulation of comparable findings, only isolated analyses exist on other aspects, such as timing of trips, vehicle occupancy (which is correlated with joint activity participation by household members), trip destination, and linking of trips. Little is known about how these travel attributes change in response to changes in the travel environment.

Further effort is needed to investigate the characteristics of behavioral changes. Past efforts have tended to emphasize behavioral stability rather than behavioral change. Behavioral changes are not usually viewed as a process of adaptation, that is, the process in which an individual or a household makes conscious decisions and adjusts to a new set of conditions in the travel environment. The concept of life-style will be useful in the analysis of adaptation patterns.

More attention also needs to be devoted to change in life-style and resulting change in travel behavior. Numerous elements in the travel environment change continuously. New consumer products appearing constantly on the market greatly reduce the time spent in homemaking; home entertainment equipment is enriching in-home leisure activities; institutional and technological changes are transforming the way urban residents work; and social attitudes and values are evolving. How these changes transform life-style and affect travel demand is difficult to assess at this point. A research effort must be initiated for this assessment that will call for new conceptual frameworks, survey formats, and analytical structures.

Some of the tasks and issues involved in this future effort are as follows:

- In order to study adaptation behavior adequately, more detailed characterization of travel behavior is necessary. Furthermore, the characteristics of changes in travel behavior over time must be identified. Available origin-destination survey data should be used for extended assessment of behavioral characteristics and their changes over time.

- The adequacy of the standard approach in life-style analysis (i.e., identification of sample segments using available socioeconomic measurements) must be critically examined. The variation in life-style that can be accounted for by adopting such a segmentation scheme may be limited. Analytical methods need to be developed to account for individuality, or idiosyncrasy, in life-style.
- It is likely that the life-styles of population segments evolve over time. It is essential that dynamic viewpoints be adopted to capture such changes. The conventional method of inferring behavioral changes over time on the basis of cross-sectional variations may not offer useful insights and accurate forecasts (*91, 92*). More extensive use should be made of existing origin-destination survey results as repeated cross-sectional observations. This type of data set, already collected and readily available, will offer useful information on the changing sex roles and travel behavior of new elderly populations. In addition, it is desirable that an effort be initiated to establish a panel of households for longitudinal analysis of life-style and travel behavior to gain a better understanding of and predictive capability for future life-style and travel behavior.
- The emphasis on changes and adoption of dynamic viewpoints calls for alternative methods for demand forecasting as well as data collection. Promising is stochastic simulation of household behavior using dynamic models applied to sample panel households (which may be expanded with synthetically generated sample households). The feasibility and potential benefits of such new forecasting methods should be investigated. In addition, methods to forecast future demographic characteristics, especially such pertinent variables as life-cycle stage, need to be developed.

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Respondents' Comments

Alan E. Pisarski I would like to make a few points to supplement some of the things that we have just heard on two general areas. One is the transportation implications of the projections and observations that we have heard. The second is how these projections interact and how much faith might we put in them. So I will just pick out a couple of points that I think are pertinent to getting some sense of scale on where we are going in transportation in the 32-year span we are talking about.

First, household size, I think, is one factor that perhaps hasn't been emphasized enough. We are still looking at a long-term decline in household size. The census projections now take us to a household size of about 2.5 persons per household in the year 2000, from about 2.75 today. My own favorite personal projection is that in the year 2000, we in fact will have 2.5 persons per household and 2.5 vehicles per household. (If you look at those two long-term trends, it appears to me that they are going to converge somewhere around the year 2000.)

I think it is also worth making the point that we are not just talking about smaller households; we are talking about very different compositions to those households, and so one-person households in the future will be very different households than one-person households today.

We heard some projections about where we are going as a nation in terms of age and how we are all getting older. I know that is true of my own case and probably a lot of you, but I don't think that we ought to get too excited about that trend too soon. There's a tendency to say that in the year 2020 17 percent of the population will be over 65 years of age. But if you look at the

Alan E. Pisarksi is a transportation consultant living in Falls Church, Virginia. He is author of Commuting in America, National Transportation Trends and Choices, *and* Transport Tomorrow. *He is chairman of TRB's Committee on Transportation Data and Information Systems.*

projections, and I think the projections here are safe because all of the people who will be 65 in 2010 or 2020 are already here, the fact is that the change in population over 65 between now and about 2010 is really not very dramatic. The bubble begins in the year 2010 when the first of the baby boomers hit 65 and then we start to get a boom. So, those who are getting very nervous about the big markets that are going to occur in transportation for suburban elderly in 2020 shouldn't go out and buy their buses or prepare their other responses just yet, because we are going to have a relatively stable situation in the over-65 population until about 2010 or so.

In that vein, however, we need to talk briefly about driver's licenses. I think it is worth discussing because that's one of the sources of trip generation. I think it is fair to say that we are very close to something like saturation in driver's licenses in the general population. In fact, the only growth market for new driver's licenses, to the extent that one exists, exists in the over-65 population.

Now, we don't have to go and convince a lot of people over 65 to go get driver's licenses for that number to change. All we have to do is wait for the 55-year-olds to turn 65. If we look at the numbers, in 1983 about 62 percent of those over 65 had licenses, and that was rather strongly skewed at 82 percent male and 49 percent female. If you just take that forward 10 years to 1993, when the 65-year-olds will be those who back in 1983 were 55, we see that they, in fact, will have driver's license levels of 95 percent male and 78 percent female and the cohort right behind will be the same.

About 5 years from now, we are going to be looking at an over-65 population with dramatic increases in the number of driver's licenses they hold, and I think the shares of travel and the shares of activity that are going to be coming from that sector are going to be substantial.

We don't know an awful lot about the surrendering of driver's licenses as people get old, and I think that is going to be a very interesting phenomenon to observe. But, we are still on the leading edge of that. After all, the people who are 75 now are those who were born in 1910 or so, and they didn't spend a lot of time getting driver's licenses and going to driver's education classes in the twenties. I think that this phenomenon is one that we want to watch very closely in terms of what is going to be happening to the scale of travel activity.

The other area I want to discuss is commuters, and particularly how many of them are going to be out there. Depending upon the numbers that we have heard in this and the previous session, and whose projections you listen to, you get very different answers, and I think it is something that we want to consider very closely, because there is, in fact, some incoherence in the different numbers.

If you take the forecasts or the projections of total employment that we heard here this morning, we get numbers on the order of about 40 million new commuters—that is to say, 40 million new job holders—between now and 2020, which takes us from roughly 107 million in 1983 to a future number that was given as 147 million or so.

But if we look at some of the other forms of projection, we get very different numbers, and I think this is where we all have to be a little bit careful. If we look at the numbers that Kasarda presented on what's happening to the labor force, we find out that growth in the labor force is not going to be that big, which has been documented in other reports. The new young people entering the labor force are not going to be there, and, in fact, if you take the scale of the labor force out to about the same period of time, you find that if you really stretch it, you are going to be adding about 30 million workers or so. So there is a discontinuity. Where are the other workers going to come from?

There are a couple of answers. If I take the current level of employment and the current level of participation in the labor force, I get about 130 million commuters in the year 2015, just to stay comparable with what we have heard here.

An employment number on the scale that the Bureau of Labor Statistics is projecting would require a further dramatic increase in the participation rate in the economy, and we already have the highest in the world. So, we are talking about a discontinuity that at this moment doesn't make too much sense. Something is going to have to give, which may be immigration. The other choice, I guess, is that everybody is going to have to have two jobs.

The point I am trying to make in all of this, aside from the fact that it would be nice to pin down what kind of commuting growth we can expect, is that some of these projections are just that—they are taking current trends and projecting them, and they lead at least to some caution and some fear that they might just lead us astray.

If we look at some of the historic projections, we can see how quickly events have turned them around. If we look at shifts in population growth in eastern cities and how they went up and down, and back up again, rural population growth and how it bubbled over briefly in the last few years, projections can make you very nervous about their stability.

Regarding the long-term trends that we heard about, such as half of the population going to California, Texas, Florida, it's very hard to believe that that kind of trend is going to persist. Using those numbers, we get, for instance, that 18 percent of national population growth in the eighties went to the four Standard Metropolitan Statistical Areas (SMSAs) of California of over one million, and I certainly don't want to wish that on the people of California on a continuing basis.

For many of these trends—nine out of ten going to the South and West, three out of five going to the suburbs—I think, although Kasarda has done a great job in giving us some of the reasons for that, I tend to be very nervous about whether we can just automatically project them indefinitely.

I did want to spend a moment on a point that Kasarda made and that focuses on some of the positive attributes of the new suburban development patterns. He calls them "polycentric forms of spatial organization." I tend to call it "sprawl with lumps." But I think we both agree that it has some very interesting and productivity-oriented positive effects that we ought to be examining in the future as to their implications for a more productive society.

Sandra Rosenbloom I'd like to draw together some important themes in both papers. Both of these papers were incredibly complicated, detailed documents. I urge you to read them; the authors could only present a small amount of the richness of their material in their comments to you. I am responding as much to the written papers as to the presentations.

Kitamura alerted us to the fact that there are different measurable, potentially predictable, and possibly continuing activities and behavior patterns that are associated with different life cycles and different people in society. These patterns have implications for both transportation policymakers who want to provide services for these people and to transportation planners who run the models to try to predict what they do. It is important, of course, to consider, as Pisarski has mentioned, that you can't always assume that current trends will continue into the future. But it is also important, as Kitamura has suggested, that you figure out what those trends are now and why they have emerged. He mentions that when you look at what people are doing—when you look at their activities or their consumption patterns—you really don't know whether they are adapting to their environment or they are changing their environment to meet their needs.

So many things in people's environment can't be changed: their jobs, their homes—a lot of things are relatively inflexible. But one of the things that gives people a way to change their environment and meet their needs is the car. It is important to understand how important the car is to all of these different life cycles, how it allows people in very different circumstances to deal with the inflexibility of their life and the lack of choice and the constraints they face daily.

Sandra Rosenbloom is Professor of Community and Regional Planning at the University of Texas in Austin. She has been a member of the Technical Staff of the General Research Corporation and of the Political Science Department at California State University.

It is important to understand these constraints; Kitamura notes that one of the greatest discoveries of the travel behavior theorists lately is how big a constraint children are on the family. They require serve-passenger trips; they themselves make a lot of trips; they require parents, generally their mother—all empirical evidence shows that it is usually the mother—to chauffeur them around.

The constraints imposed by children are often a forgotten variable. Planners not only need to measure the impact of children's behavior on their parents' behavior in order to extrapolate transportation trends into the future, they must also look at the fact that children have transportation needs that might be met by other "modes" than their parents.

The major question Kitamura has raised is, Will these life-cycles always be associated with the same sets of attitudes, references, and behaviors in the future? We don't know. That's what Pisarski is warning us about. We can't know that a young couple with small children 20 years in the future will behave the same way even if all of the socioeconomic characteristics are the same.

One of the things I found missing in Kitamura's paper—simply because he didn't have time to get to it—is some understanding of how prevalent are what we often call nontraditional life cycles and life-styles.

Right now, one out of five households in America is headed by a woman alone and 17 percent of all family households are headed by a woman alone. Female-headed families are the fastest-growing households in the country: one out of five, or 20 percent—the figure was less than half of that 13 or 14 years ago. Whether that growth pattern will continue or not, we can't tell, but we can say is that single mothers constitute a very large travel market.

The number of two-worker families with small children is also very large. The family where the wife is not in the paid labor force is in the minority in America today. Over 60 percent of children under 3 years old have both parents in the work force if their parents are living together. Over 80 percent of children under 3 years who live with only one parent have mothers in the full-time work force.

So we are not talking about small splinter groups; we are talking about major numbers of society, large groups of nontraditional households whose travel patterns are different from the patterns that we have traditionally studied.

Another message of Kitamura's paper is how badly the kinds of variables that we have used to predict behavior have in fact predicted behavior. He didn't mention in his oral presentation that his own work has shown that when a society reaches a certain level of automobile maturity, car ownership no longer predicts travel behavior, and income ceases to be a very good predictor of travel behavior, either. But, income and car ownership are factors that run a lot of our models. Kitamura shows that we need to question the way we predict travel behavior, as well as the way in which we respond to it.

I think Kasarda's paper had a number of important contributions and I want to again link them with the contributions that Kitamura has made. Obviously Kasarda mentions a whole list of things about which we, as citizens, ought to be concerned—the loss of the industrial base in this country; the obvious and serious mismatch between the education of workers and the needs of employers; the low skill levels of employees, particularly minorities; the absence of a young labor force after the turn of the century; and so on. What does the graying of society really mean? What is the impact of communications technology?

Those are really important issues, but Kasarda also raised some other ones that resonate with the themes raised by Kitamura. One of them is the question of whether people are really moving to the West and to the South, whether they are moving in the numbers that have been seen previously, and whether they will continue to move as they have previously.

Whatever the actual numbers, it is obvious that in the future a large group of people are going to be living and working in low-density suburban environments and that they are going to be traveling often from one low-density suburban environment to another.

Kasarda notes that in 1982, 27 million workers commuted from one suburb to another suburb, whereas less than half that number went from suburb to central city to work. What always amazes me is why this is such a recent discovery: this growth in the suburban-suburban commute and the decreasing relative attractiveness of the central city have been with us for over 40 years. These numbers pose really serious questions about how people are going to be living in the suburbs and commuting to work.

Kasarda also discussed the high percentage of minorities that are going to live in the suburbs in the South and the West. We tend to have a vision of the suburbs as white yuppiedom. In fact, in many metropolitan areas for which Kasarda has data, as high as 35 and 40 percent of the inhabitants of the suburbs are minorities. This means that we are looking at totally different suburbs than those we have looked at before. The questions that Kitamura raises about life cycles become more important, particularly questions about whether there are ethnic and racial differences in travel that can't be explained by socioeconomic characteristics.

There will be an incredible growth into the next century of two groups of minorities, Asians and Hispanics. The figures that Kasarda quotes are stunning: from 1985 to 2010, a 114 percent increase in Asians and a 111 percent increase in Hispanics. Most of that growth is going to be in the West and the South.

We are talking about very different suburbs than ever before, about suburban areas with people with remarkably different life-styles. There is a growing body of literature that shows that ethnic groups have different travel behavior even when location and socioeconomic characteristics are controlled for. Ethnic life-style has been a forgotten thing; maybe it has been offensive to people to consider that there could be racial and ethnic differences in travel and activities that represent varying beliefs and preferences.

Wachs' landmark study of Los Angeles found significant differences between elderly blacks, elderly Chicanos, and elderly whites, even when he controlled for location and other socioeconomic variables. A major study done in Denver found travel differences between working-age Anglos and working-age Chicanos even when all of the common socioeconomic variables were controlled for. The Argonne Lab, in analyzing data from the Nationwide Personal Tranportation Study, found significant travel differences between compatible low-income whites, blacks, and Hispanics.

Exploring the life-style differences among "new" suburban residents is an interesting and a fruitful area. Kasarda's paper should alert us to the fact that we are facing a future of suburbs very different from those we have known historically.

Overall what we get from Kasarda's paper merged with Kitamura's is that we must focus on the suburbs and suburban life-style, choices, and patterns. Central cities have problems, but in the future a major focus will have to be on the suburbs. Moreover, the suburban travel problem is not simply congestion at large-scale employment concentrations. It is questions of where do the kids go, how do people go shopping, how do we serve needs that are going to exist in low-density suburban areas? Clearly most suburban trips are not well served by radial transit or radial highways. We have to be thinking about other ways to serve these kinds of needs.

Kasarda did an analysis of the large number of "stranded" inner-city residents in Philadelphia, Boston, and New York—workers who did not have cars. Given the suburbanization of jobs, the situation exemplifies the classic inner-city "reverse commute" problem, but in other metropolitan areas, I have found very different situations. I find a lot of poor people with cars. In fact, the NPTS data show that in 1983 almost two-thirds of all households in the United States with incomes under $10,000 had one or more cars; 20 percent had two or more cars. A lot of poor people in areas that are not historically transit dependent have made major sacrifices to own a car because you can't live and work in the cities that we have now—these low-density, decentralized cities—if you don't have a car.

My own research shows that more single parents with incomes under $10,000 in Houston and Dallas had cars than comparable married women in two-worker households. The need to balance employment and household responsibility in low-density areas puts enormous pressure on people, and so they are willing to make tremendous sacrifices to own and operate a car.

Those of us who are concerned with predicting the behavior of people living in the suburbs and those of us who are concerned about meeting their transportation needs have to understand that this is the wave of the future—we need to understand what is going on in the suburbs and to understand how and why people at different life stages and with different life-styles make the kinds of decisions that they do.

CAMPBELL GIBSON Reflecting my own background as a demographer, my comments will be focused primarily on the Kasarda paper. I think Kasarda's paper is really excellent. His purpose was to provide an overview of demographic and employment dynamics in the United States, past, present, and future, and I think he did a very good job of that, particularly in drawing together a wide range of data, not all of which are easily accessible, and presenting them in a very understandable manner. My comments on his paper will not be on the major thrust but more on what I might characterize as demographic caveats or perspectives that I would like to add to points that he made.

The order will reflect the order in which these points come up in the paper. The first issue is statistical rather than substantive. The tone of the paper indicates the tremendous importance of migration, particularly interregional migration, in population trends in this country since World War II and in what we see for the future. I would like to add a caveat and I may sound for a minute like a mathematical statistician at the Census Bureau.

The problem here is the net migrant, and as demographers know, analytically there is no such thing as a net migrant. A person can be a nonmigrant, a migrant, an in-migrant, or an out-migrant, but net migration is a statistical aggregate. This is important because data on net migration from surveys are subject to a tremendous amount of sampling variability because they reflect the sampling variability on both the ins and the outs. Frequently, when the net figure is quite low, it still has an amazingly high sampling variability, which may be higher than the estimate itself. I raise the point particularly in regard to

Campbell Gibson is currently demographer advisor at the Bureau of the Census. He has had numerous positions with the Bureau as a demographer in the Fertility Statistics Branch and the National Population Estimates and Projects Branch.

data from the Current Population Survey. It is not so much a problem with data from the decennial census for large geographic areas.

Migration trends from 1985 to 1987, which indicate a continuation in general of recent trends in internal migration, show a continued net in-migration into the South and the West and a continuing net out-migration from the Northeast. For the South, where the figures show over 300,000 net in-migration, a standard two-sigma confidence interval for that number would actually include a net out-migration from the South. This is because there is separate sampling variability on the in and out, and also because of combining annual data for 2 years.

I would encourage users of net migration data to bear with me in my plea to always include estimates of sampling variability with these figures because they are subject to such high sampling variability.

Moving on to more substantive points, I would like to make an observation with regard to domination of population growth by the South and West. It has been noted that this growth was over 90 percent during the 1970s and in the 1980–1986 period. Based on 1987 estimates, the figure since 1980 has now dropped to slightly below 90 percent, reflecting the fact that an increased proportion of the growth in the United States has occurred in the North, specifically the Northeast and the Midwest.

I would support Kasarda's view that in the future, this 90 percent figure will probably be high. I think it is unlikely that we will see the South and the West so totally dominant in population growth in the United States in the foreseeable future.

In discussions of population distribution and changes therein, the focus is almost entirely on the effects of migration. It certainly is the case that migration, both internal migration and immigration from abroad, have been the dominant factors in the changing distribution of the population in the United States.

But I think sometimes we overlook the role of natural increase; there is a tremendous difference in the rates of natural increase by region in the United States. To give one example, during the 1980–1987 period, over one-third of the differential in the growth rates between the Northeast and the West was due to different rates of natural increase. In the West there is a natural increase rate of over 1 percent a year, and in the Northeast it is less than 0.5 percent a year.

So natural increase, itself, would lead to some redistribution of population, albeit at a slower rate. I should stress that the two components, natural increase and net migration, are highly related. This is because many migrants are young adults, particularly immigrants from abroad. They produce a younger age structure, which, everything else being equal, leads to a higher rate of natural increase.

Kasarda also mentioned briefly some Census Bureau population projections for the states. We had a commitment to release these new projections before we were able to get out a published report, and the problem with this procedure is that we put the numbers out in the public domain without a description of the methodology and the assumptions. As those of you who have done projections know, the underlying assumptions are all-important.

We put out just one set of projections per state, and the rationale is that we will be coming up with another set of projections within a short period of time. It should be stressed that the fact that only one set of projections was released does not mean that it should be interpreted as a forecast.

The key underlying assumptions in these projections are a continuation of migration trends from the 1975–1986 period, so whatever happened in that period for any particular state is heavily reflected in the projections for 2000 and 2010. Iowa, as many of you probably know, has had a rough time in the last decade, with heavy net out-migration, and that is reflected in these projections. I personally think it unlikely that such extreme trends will continue unabated up to the year 2010. The very fact that something is historically extreme in itself suggests a possibility that something is going to change or that people will change something to change that condition.

As an example of how sensitive projections are to the base-period assumptions, one can compare for New York State the most recently released projections and the projections released in the early 1980s. There is a tremendous difference. In 1980, New York was going to lose nearly 3 million population in the following 20 years, and now we show New York with very little change. This reflects the fact that New York has experienced a major change in net migration during the 1980s compared with the same situation in the 1970s.

In general, I would add the caveat that projections are no better than the underlying assumptions. It is crucial for the user to be aware of what those assumptions are and what the limitations of those assumptions are.

I would also like to comment about the relative growth in population and households. Kasarda's paper noted the tremendous loss in population in central cities, particularly in the Northeast and the Midwest, during the 1970s. It is not as simple as that, particularly if one interprets population decline as a sign of decay. During the 1970s, the average population per household in the United States dropped 12 percent, from 3.11 down to 2.75, and a lot of the population declines that were stressed were about that order of magnitude—not in places like St. Louis, where they were much larger, but certainly in New York City, Boston, Philadelphia, and a number of other cities. These cities experienced population declines but had virtually no change in households, and in some cases they had increases in households.

In some of the Northeastern cities where there is not much land available, it is perfectly understandable that there would be a population decline when there is a decline in average population per household, and that in itself should not be taken as a sign of economic decay.

I will mention also with regard to the future that the average population per household has continued to decline quite rapidly, down to 2.66 in 1987, and our middle projection series shows it declining to 2.48 by the year 2000. What is important to note here is the decline in the rate of decline. The primary reason for this is historical trends in fertility.

The biggest decline in population per household was during the 1970s and reflected the aging of the Baby Boom and the subsequent so-called "birth dearth." We now have more people in the prime childbearing ages and as many people are being born each year as are entering the adult ages.

The average number of children per household dropped dramatically in the past two decades, and the drop in the average population under 18 per household accounts for about 80 percent of the overall decline. That will no longer be the case in the future. The average number of children per household will not decline as rapidly as it has in the past. There are all sorts of factors here, including the changing age of marriage, divorce patterns, and so on, but the fact of the matter is that those have little effect compared with the effect of the change in fertility.

I might mention also a flip side to this change in the average population per household with regard to regional distribution. The focus in this session is on the regional redistribution of the population, but for some purposes, one may want to look at trends in households, and it has not been the case that the South and the West have been so totally dominant in household growth.

I don't know the best way to explain this, but it is essentially the arithmetic that results from the declining population per household. During the 1970s and the early 1980s there were many states in the Midwest and Northeast with virtually no change in population, but because of the declining population per household, which is pretty uniform throughout the country, there usually were increases in households.

Thus, whereas the South and the West accounted for over 90 percent of population growth during the 1970s and almost that so far in the 1980s, they have accounted for only about two-thirds of household growth.

My other comments on Kasarda's paper are more minor. He mentions the possibility of a labor-force shortage in the future. I am not a labor-force economist, so I will simply raise an issue that perhaps can be discussed this evening. It is true that we have a decline in the number of young adults entering the working ages, but there are also some compensating changes. As the Baby Boom works its way through the young adult ages, the demand for housing may be less, and there may be less demand for labor in construction.

There is also the fact that the average age of retirement, if my recollection is correct, has actually stopped declining and maybe has increased slightly, reflecting possibly people's concern about the long-term viability of Social Security and their own retirement systems. So there may be some offsetting factors to look at in the future labor-force situation.

My final point on the Kasarda paper is really a question. He presented some population and employment projections from the National Planning Association for the largest metropolitan areas. What struck me was the tremendous differential in the rates of population and employment growth projected for those areas, and it is not clear to me what the explanation is.

To some extent the explanation can be differences or changes in age structure or changing labor-force participation rates. But some of the differences seem more extreme, and I would be interested in an explanation. In the case of the Nashville Metropolitan Area, it was projected to have a population increase of only about 15 percent but an employment increase of about 80 percent. The average differential in the projections is about 20 percentage points. It is important to indicate the explanation for this tremendous variation in the relationship.

I will close with a couple of comments on the Kitamura paper. Like the Kasarda paper, I found it very interesting and very good in that it gathered together a wide range of material from a lot of sources. As was mentioned in the presentation and also in the comments by Rosenbloom, one of the basic problems is distinguishing cause and effect in life-style—actual life-style activity or behavior versus life-style values—and it is not always easy to indicate what comes first or what influences what.

We have good analogy in demography in historical trends in the birth expectations of women and their ideal family size. We found in the 1960s that birth expectations began to drop quite rapidly, but people's ideas about ideal family size held up and then dropped afterwards, reflecting probably in part people's adjustment to a changing environment. It no longer appeared ideal to have four children, given some constraints of the Baby Boom, like a lot of people competing in the entry-level labor market. Things weren't as rosy for the early baby boomers as they were for the people who reared their children during the 1950s.

We have a parallel situation in the difficulty of separating cause and effect. My own view based on the material on consumer expenditure patterns and life-cycle stages is that there is little that one can use to make very accurate predictions of travel demand in the future.

Although there are changes in living patterns, the fact is that we all go through the life cycle: the vast majority of us go through a period of young, single adulthood after completing school, get married, and have children, and so on. At the aggregate level, most of these changes are offsetting.

In addition, people are amazingly adaptable. A primary example here is during the 1970s, when the home ownership rate in the United States stayed about the same despite the fact that the cost of housing increased tremendously relative to inflation. There are various studies showing that the average percentage of income that is devoted to housing has increased tremendously, from about 20 percent of income back in the 1940s when interest rates were low and housing was inexpensive to about 40 percent now for recent home buyers.

It is very significant that people are that adaptable; they make the sacrifices necessary to buy the home they want to live in. The same observation has been made concerning travel. People are willing to drive great distances, even at increased costs. Thus the general point is that people are very adaptable, and some external conditions that might be thought to change behavior dramatically don't always do so.

I think one factor that will be particularly important concerning travel is the aging of the population, and it is not just the increase in the population 65 and over. As was mentioned, that is not going to be such a tremendous factor until the leading edge of the Baby Boom reaches that age around 2010. Gerontologists and sociologists are focusing now not only on the elderly as a group, but on the subgroups: 65 to 74, 75 to 84, and particularly 85 and over. The population in the 85-and-over age group is still small, but it is growing at an extremely rapid rate. I think that this is important in looking at future travel demand.

Some of the effects of aging are not so easily dealt with. I mentioned that people can adapt to changes in the cost of housing and their travel environment, but some of the limitations of aging are physical ones to which people cannot always easily adapt. I think this is one of the firm factors that we can look at in terms of its effect on travel demand.

THOMAS MERRICK I am going to limit myself to three very brief points. My first point relates to the geographic dimension of the population projections and forecasts. We have had an excellent overview of regional trends and projections and discussion of differences between labor-force and population projections.

As I read the papers, particularly the Kasarda paper, and thought about putting this information to work in transportation planning and other applications of demographic information, it struck me that for most of you the real action is not at the regional level but at a minimum at the state level and is probably even more likely to be at the metropolitan area or county level.

Here projections become more problematic. Your interest is really in trends within trends, but I think it is important to emphasize that there are a lot of countertrends and hot and cold spots within some of these larger regional trends. Texas is a good example. I suspect that the Census Bureau's next round of population projections will have some fairly significant revisions for Texas, given the experience since 1985 when population growth has slowed down rather dramatically.

One of the problems that we face in working at lower levels of aggregation is that the areas that we are most interested in are also the areas that are subject to the greatest changes and that are most likely to turn up with deviations from the longer-term trends. So, while agreeing totally with the presentation of the regional trends, I would urge a great deal of caution in looking out even 5 years at these lower levels of aggregation.

A second point relates to aging and the points that Campbell Gibson just raised: that it is important to pay attention not only to the 65-and-over population as a whole but also to changing composition within older age groups, the 65-to-75, 75-and-85, and the so-called 85-and-older, "older old." Although the overall growth of the population 65 and older is going to be fairly stable until the leading edge of the Baby Boom hits in the next century, those older age groups are growing very rapidly. Many of the patterns of accommodation in terms of living arrangements, transportation, and health care and so on that are made will determine the degrees of freedom that society will have for responding when that Baby Boom wave hits in the second and third decades of the next century.

A final point I want to make is that in my reading of these papers, I came away once again convinced that demographics really do make a difference—

Thomas Merrick is Director of the Population Reference Bureau in Washington, D.C. His past positions include research associate for the Population Center at the University of Pennsylvania, economist with the Office of Program and Policy Coordination of the Agency for International Development, and population specialist for the Ford Foundation.

that it is important in the work that you do in the transportation field to pay attention to sociodemographic trends. But I am concerned that in the brief amount of time we have had for the presentation of this material—particularly if for some of you it is the first time you are hearing it—you may be a bit frustrated because our story is one that tends to be rich in information and rich in technical terminology. I sense that some of you may have the feeling of having just speed-read the statistical abstract, something akin to trying to get to a drink of water from a fire hose, as you have tried to absorb the vast amount of material that has been thrown at you in the last two hours. I would urge you to take some time to read these papers carefully. There is an immense amount of wealth about demographic trends.

SESSION 3

Energy and Environment

Transportation Energy to the Year 2020

David L. Greene, Daniel Sperling, and Barry McNutt

TRANSPORTATION USES MORE THAN one-fourth of all energy consumed in the United States, almost two-thirds of all oil, and more oil than all developing countries combined use for all purposes. Changes in U.S. transportation energy use can have major effects on world energy markets. However, in this paper the converse question is addressed: What effect will the changing energy markets of the future have on the U.S. transportation system through 2020?

The answer is "a great deal, and very little." A great deal in that there will be a tightening of the petroleum market during this period, with the attendant rise in market power of a few producers. The resulting higher prices and economic vulnerability will heighten the need for improved efficiency and begin to generate viable markets for alternative energy sources. A great deal in that much will have to be done to advance the technology of transportation energy use both for alternative energy sources and the efficiency of motor fuel use. Indeed, real activity in alternative energy sources is expected before 2020 in the form of significant regional or niche markets, which will be the precursors of the transition to a non-petroleum-based transportation system.

David L. Greene is leader of the Transportation Group and Senior Research Staff at Oak Ridge National Laboratory. He is the author of numerous articles on motor fuel and motor vehicle demand, energy conservation in transportation, and travel behavior. He is current chairman of TRB's Committee on Energy Conservation and Transportation Demand. Daniel Sperling is Associate Professor of Civil Engineering at the University of California, Davis. His areas of speciality include energy conservation and demand, alternative fuels, and transportation policy analysis. He currently chairs the TRB Subcommittee on Alternative Fuels. Barry McNutt is Engineer and Policy Analyst in the Office of Planning and Policy Analysis, U.S. Department of Energy. He has spent the last 10 years with DOE, specializing in policy analysis on such transportation issues as fuel efficiency and alternative fuels.

Concerns about environmental quality and national security are likely to be the driving forces that will begin the transition to alternative fuels.

But the energy problem alone will not force fundamental changes in the nature of the transportation system in the next three decades. This assertion is offered with two critical qualifications:

1. The oil market will continue to evolve, with no upheaval that permanently distorts the resource base (price shocks are expected), and
2. There will be no unforeseen breakthrough in energy-using or -storing technology (e.g., no breakthroughs in batteries or fuel cells).

Under these circumstances (and putting aside for the moment other important issues such as environment or congestion), a transportation system is predicted that can function in 2020 with much the same characteristics as it has today, namely,

- Automobile-dominated personal transportation,
- Truck-dominated freight transport, and
- Expanded use of air travel.

Transportation responded to the energy upheavals of the 1970s and 1980s almost entirely by improving vehicle efficiency. These improvements have proven to be robust, having been little affected by the sharp decline in oil prices in recent years. With effective energy policy and improved technology, tomorrow's vehicles will also be more efficient—perhaps able to get twice the fuel efficiency of today's 28-mile-per-gallon (mpg) automobiles. Moreover, although they may be powered by diesel and flexible-fuel engines, vehicles will be similar in interior size and performance to today's cars and trucks.

By 2020 a modest amount of alternative fuels will be used as the prices of petroleum products rise relative to alternatives and as further efficiency improvements become more expensive. However, these fuels will be dispensed through normal retail outlets and used in dual- or flexible-fuel and dedicated-fuel vehicles that differ only slightly from their conventional petroleum-fueled counterparts.

These changes will occur in an environment of modestly rising oil prices during the early 1990s followed by steeper increases in the late 1990s and into the 2000–2010 decade (Figure 1). Price shocks, such as those experienced during the decade of the 1970s, are likely along the way and may temporarily speed up or slow down the rate of change. U.S. energy policies on efficiency and alternative fuels during this period can serve to slow the rate of price increase and smooth its path by reducing the risk and size of market price disruptions.

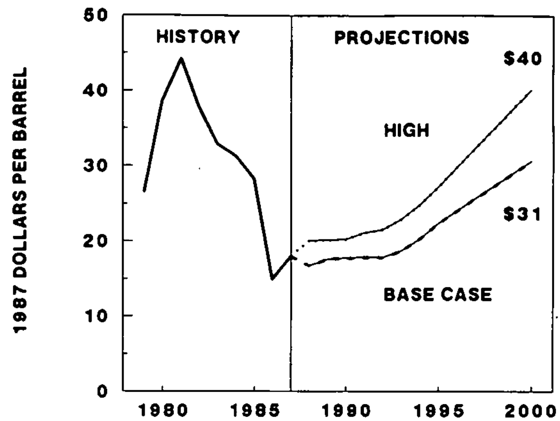

FIGURE 1 World oil price projections.

The key factors that form this prognosis are the following. Energy resources are available worldwide and will be extractable at reasonable prices well into the next century. Transportation's dependence on petroleum, however, is a problem because of the concentration of reserves in the few members of the Organization of Petroleum Exporting Countries (OPEC) and because of the environmental costs of continued air pollution and production of CO_2 by transportation vehicles. In fact, because of its size, continued growth, and near-total dependence on petroleum, the transportation sector has come to dominate the U.S. energy problem. In the past, efficiency improvement has been the sector's response to the energy problem. Further improvements are possible and desirable, but it is also likely that alternative fuels will play a significant role by 2020. Initially, movement to alternative energy sources will be motivated by environmental concerns. The economic viability of alternative fuels, however, will rest on the long-run increase in the price of petroleum as supplies are gradually drawn down.

Yet transportation faces its own set of special problems that will influence the choice of energy paths. In the coming decades, traffic congestion, safety, and air quality concerns will dominate the list of transportation issues. The marketplace will favor technological advances that make transport faster or cheaper while maintaining or increasing the very high level of personal mobility enjoyed today. The challenge for transportation is to make significant improvements to energy efficiency and to begin a transition to alternative, nonpetroleum energy sources in ways that contribute to a clean, safe environment and improve economic efficiency.

AVAILABILITY OF ENERGY

The U.S. energy problem is not one of running out of energy. It is principally a problem of reducing dependence on imported petroleum and managing in a timely fashion the transition to desirable alternative fuels. There is no prospect of running out of economically useful oil by 2020. Oil reserves in the market economies are estimated to be more than 600 billion barrels compared with projected worldwide annual consumption for the year 2000 of 18 billion barrels (*1*, pp. 15–16). Thus, even if no new reserves are added, there is more than a 30-year supply at year-2000 rates. However, experience from 1980 to 1986 showed additions to reserves of more than 26 billion to 27 billion barrels a year, 11 billion to 12 billion barrels a year in excess of consumption. Although such success in finding oil reserves is not likely to continue and there is great uncertainty in projecting both discoveries and consumption, it is clear that for the next 30 years there is no danger of a worldwide physical shortage of economically recoverable oil (Figure 2).

Nonetheless, petroleum is ultimately a depletable resource whose price is likely to rise substantially by 2020, reflecting increased costs of finding new oil, the reduced amount of reserves, and perhaps most important, the increasing concentration of those reserves in the hands of a few OPEC producers with very low production costs, minimal domestic demand, and thus tremendous export capacity. Members of OPEC account for 80 percent of total reserves and almost half of the estimated undiscovered reserves (Figure 3). As a result of this concentration of oil production and reserves, there are also likely to be periodic price shocks with which to contend. Current projections

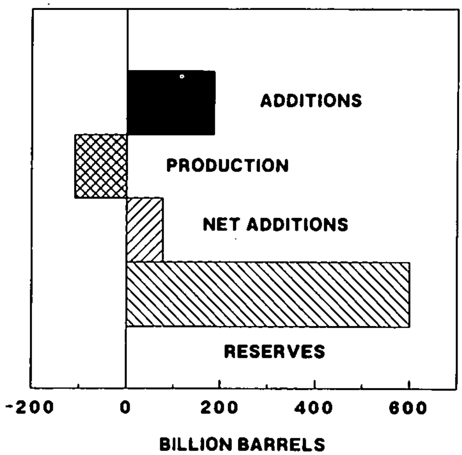

FIGURE 2 Total crude oil production and reserves, 1980–1986.

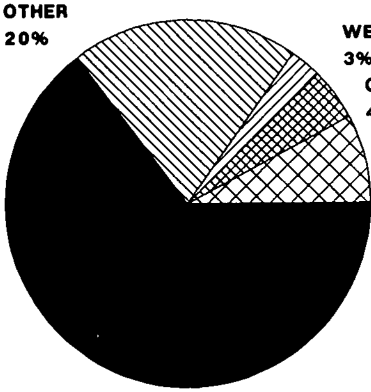

FIGURE 3 World crude oil reserves.

(2, p. 4, Tables A1, C1) are for oil prices to remain in the $20/barrel range through the early 1990s, followed by an increase to $30/barrel to $40/barrel by 2000 (in 1987 dollars). Although oil price predictions are notoriously inaccurate, it is this trend plus an expectation of periods of price shocks (rapid increases or decreases around the trend) on which the authors' view of the future is based.

Natural gas, coal, and oil shale are all available in larger quantities than petroleum, worldwide as well as in the United States. Proven world coal reserves are three times greater than proven petroleum reserves, and proven U.S. coal reserves are 30 times greater than proven oil reserves (Table 1). Natural gas is also abundant. In the United States, proven conventional reserves of natural gas are larger than proven oil reserves. Worldwide they are slightly smaller but increasing. In addition, there exist huge reserves of unconventional natural gas (now too expensive to develop) in coal seams, in tight sands, dissolved in subsurface water, and in deep geopressured gas formations. Thus, sufficient energy resources are available at or near 1980 costs for at least another century.

Thus, there will be energy, and indeed petroleum, for transportation through 2020, but it will become increasingly expensive and less dependable in supply. Given effective energy policy and advances in technology, efficiencies will rise as prices increase, and a potential for fuel substitution will be created, mitigating against higher prices and extending supplies. By 2020 a transition from petroleum to a more diverse energy base for transportation will have begun, the nature of which will depend primarily on what technological advances are made between now and then. If greater efficiency and significant but limited fuel-switching capability are achieved, these changes in the energy market will not constrain the way in which the transportation system operates.

TABLE 1 Estimated Proven World Energy Resources for Selected Countries with Large Nonpetroleum Reserves (3)

	Billions of Barrels of Oil Equivalent					
			Not Proven			
	Petroleum	Coal[a]	Oil Shale[b]	Oil Sands[b]	Natural Gas	Heavy Oil
United States	27	667	2,100	Small	34[c]	110
Canada	7	NA	Small	945	16	200
U.S.S.R.	63	1,000	Small	605	249	NA
China	19	370	Small	—	5	NA
Venezuela	26	—	—	693	9	700
Western Europe	24	147	Small	—	36	—
World total	698	2,560	3,150	2,270	585[c]	Uncertain

NOTE: NA = not available; dashes indicate amount not significant.

[a]Assumes 10,000 Btu/lb.

[b]Only a small percentage of these resources would be economically recoverable because of geological constraints and low concentration of some of the reserves.

[c]Conventional sources only. Unconventional sources (e.g., geopressured gas, gas from tight sand formations, and coal seams) would yield 902 billion barrels.

TRANSPORTATION FUEL PROBLEM: PETROLEUM

By far the largest and fastest-growing consumer of petroleum, the transportation sector has taken center stage in the nation's confrontation with the energy problem. The energy efficiency of transportation has improved tremendously since the petroleum crises of the 1970s yet, despite this, consumption of petroleum fuels in transportation continues to increase. In 1972, the year before the first Arab oil embargo, the transportation sector used 8.55 million barrels per day (mbpd) of petroleum fuels. In 1986 its consumption had risen to 10.18 mbpd. During that same period automobile fuel efficiency improved from 13.4 to 18.3 mpg for the vehicle population (*4*) and 26.9 mpg for new cars (*5*). Light trucks registered smaller but also impressive gains: from 1976 to 1986 fuel efficiency for new light trucks improved from 15.6 to 20.9 mpg. Automobiles and light trucks account for nearly two-thirds of the sector's energy use, essentially all of that being gasoline. Despite these impressive gains in energy efficiency, U.S. gasoline consumption grew 3 percent in 1986 and 2.1 percent in 1987 (*6*).

Heavy trucks and aircraft have also made important but smaller energy efficiency gains, yet their consumption too has shown an overall increase in recent years. Demand for transport services is outpacing the rate of energy efficiency improvement.

Efficiency improvements in the transportation sector have not been accompanied by increased use of or ability to use nonpetroleum energy sources. Nearly 15 years after the oil price shock of 1973–1974, the transportation sector remains 97.4 percent dependent on petroleum. The technical ability for petroleum fuel switching in existing equipment is essentially equivalent to the potential to substitute 10 percent ethanol in gasoline. For practical purposes this can be done for only 10 percent of the gasoline consumed, because of current limitations on supply (*6*). Although this is not a trivial amount of energy (759 million gal of gasohol was sold in 1986), it pales in comparison with the achievement of the other energy end users. Between 1973 and 1986 the combined petroleum consumption of the industrial, commercial, residential, and utility sectors decreased from 8.3 to 6.0 mbpd. The share of U.S. petroleum consumed by these sectors decreased from 48 to 24 percent (*7*).

The transportation sector is not only the largest consumer of petroleum products (63.2 percent of total U.S. petroleum consumption in 1987), it is the most dependent on petroleum according to a recent Department of Energy (DOE) study (*8*). DOE estimates the sector's ability to substitute for petroleum fuels at a mere 3 percent of total product use. By comparison, DOE estimated the short-term petroleum substitution potential of the residential, commercial, and industrial sectors at 35, 25, and 10 percent, respectively. The national petroleum problem is increasingly becoming a transportation fuel problem.

Increased transportation petroleum use and decreased domestic crude oil production now require the United States to import petroleum to supply the needs of the transportation sector alone. Since 1974, transportation oil consumption has exceeded domestic crude oil production from all sources. Although this figure is significant, it omits more than 2 quads per year of production of natural gas plant liquids (NGPL), a great deal of which is used for motor fuel. Adding NGPL to crude oil production, it can be seen that consumption of petroleum products in transportation exceeded domestic petroleum production for the first time in 1987 (Figure 4). Even at the height of petroleum importation between the two petroleum crises, there was a small cushion. In 1973 the United States produced 22.06 quads of petroleum and NGPL, and the transportation sector consumed 17.82 quads of refined products. In 1979 the United States produced 0.57 quad more than transportation used. In 1987 the transportation sector alone consumed three-fourths of a quad more petroleum than the United States produced (*9*), and the trends suggest that this gap will widen. It is of vital importance to national energy security that this problem be addressed.

The transportation sector's continued dependence on petroleum fuels is a problem for the following reasons:

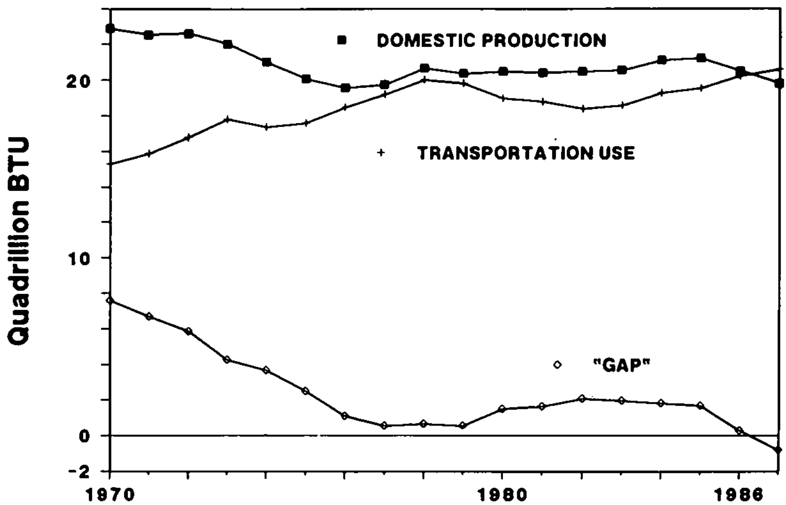

FIGURE 4 Transportation use of petroleum versus domestic production, 1987.

1. As supplies are depleted, petroleum fuels will become increasingly expensive;
2. Significant economic dislocations resulting from volatile oil prices are likely;
3. The geopolitical cost to the United States of dependence on imported oil is not reflected in its price; and
4. Significant environmental costs such as air pollution are not reflected in current oil prices.

Because the price of petroleum does not take into account these social costs and economic losses, efficiency improvements and fuel flexibility are undervalued. Thus, transportation continues to become increasingly dependent on petroleum and the economy becomes less able to respond to future oil price shocks (*10*).

The absence of a substantial alternative transportation fuel could cause substantial economic losses in the United States through higher fuel prices in the long run and price volatility in the short run. The availability of a readily substitutable nonpetroleum transportation fuel would dampen oil price volatility and restrain longer-run oil price increases. It is difficult to quantify the cost of not having a ready alternative, but a $1/barrel difference in the price of oil represents about $2 billion a year in higher oil import costs. Given the fuel substitution that has already occurred in other sectors of the economy, further reductions in petroleum consumption will likely be more difficult than in the 1970s and early 1980s, and a greater share would have to be borne by the transportation sector. Because introducing new fuels and improving fleet fuel economy takes about a decade, the response to price shocks is likely to be slow. As a result, higher prices may persist for a longer time.

The second aspect of the petroleum problem is dependence on oil imports. The cost of oil dependence is difficult to measure. It includes some part of the cost of military expenditures in the Middle East and other important supply regions, the cost of maintaining the Strategic Petroleum Reserve (now containing more than 500 million barrels), the risk of supply disruptions, and losses in national income from contraction of demand for U.S. goods and services. The sum of these costs has been estimated at $21 billion to $125 billion a year (*11*). The use of any alternative fuel would reduce oil imports, although some alternative fuels would also probably be imported. Fuels likely to be imported are those made with natural gas [compressed natural gas (CNG), liquefied natural gas (LNG), and methanol] because natural gas is available less expensively outside the United States.

A third important aspect of the petroleum problem is pollution. The use of petroleum for transportation results in large quantities of pollutant emissions from vehicles, refineries, and fuel stations. These external costs amount to $11 billion to $187 billion a year, the large range depending mostly on uncertainty about the number of deaths and illnesses due to pollution and the monetary value assigned to death (*11*).

The fourth element of the petroleum problem is the most uncertain, but also carries the greatest risk—global warming due to the collection in the atmosphere of carbon dioxide and other trace greenhouse gases (*12*). At this time there is no strong commitment to mitigate the greenhouse effect, either in the United States or elsewhere, in large part because of uncertainty over the severity, location, and timing of the impacts. The scientific community is now in agreement that the globe's temperature is increasing, but there remains uncertainty as to how fast this is happening and how climatic patterns will change (*13–16*). It is expected that the warming will be disproportionately near the poles, causing melting of ice masses and increases in ocean levels. Gradual but ultimately dramatic changes will occur in local and regional climates. Rainfall will increase in some areas and decrease in others, and atmospheric temperatures will change, increasing in most but not all locations. Unfortunately, these climatic changes cannot be predicted accurately with existing meteorological models. In any case, the potential for environmental and economic damage is enormous.

The principal sources of carbon dioxide and other greenhouse gas emissions are carbon-bearing fossil fuels: oil, coal, natural gas, and oil shale. Transportation accounts for about 25 percent of greenhouse gases emitted in the United States (*12*). As scientific evidence becomes more certain, the possibility exists that a strong commitment will be made to reduce the use of carbon fuels. The only strategy for reducing carbon dioxide emissions from transportation is to reduce consumption of fossil fuels, either through fuel efficiency or the use of nonfossil fuels, including biomass, or hydrogen or electricity made from nonfossil fuels.

IMPROVEMENT OF ENERGY EFFICIENCY

Energy efficiency improvements in transportation during the past 15 years, especially for light-duty highway vehicles, have been nothing short of phenomenal. Though little is made of it, automobile and light-truck efficiency improvements since 1973 constitute a major triumph of national energy policy. Credit belongs to the automotive industry for achieving these improvements primarily through better technology. Consumers had to give up very little in performance, carrying capacity, and other attributes to save tens of billions in fuel costs. The direct cost in higher vehicle prices is very difficult to estimate, but is probably on the order of $200 to $400 per automobile (*17*). Better technology made this possible without the high gasoline prices found in Europe or Asia. Still further fuel economy improvements are desirable and possible. Yet achieving another doubling of mpg without loss of mobility or utility will require technological advances in several areas.

In the decade following the first OPEC oil price increase of 1973–1974, the energy efficiency of automobiles in the United States increased from 14 to 26 mpg in 1983 and, it is estimated, will exceed 28 mpg for model year 1988 (*5*). (Efficiencies are based on the 0.55/0.45 weighted harmonic mean of city and highway cycle fuel economies as measured on the Federal Test Procedure.) New light-truck fuel efficiency also increased substantially, from 12 mpg in 1973 to 20 mpg in 1983 (Figure 5). The magnitude and rapidity of these efficiency improvements contrast with the significant but much smaller gains made by other developed countries (*18*). [Efficiency estimates from different countries in the Organization for Economic Cooperation and Development (OECD) are only roughly comparable. Only the general magnitude and trends are important here, however.] For example, new passenger-car fuel efficiency in West Germany increased from 22.8 mpg in 1973 to 28.3 mpg in 1982. Japanese automobiles showed a similar improvement, from 22.4 to 30.6 mpg, as did those in the United Kingdom: 21.4 to 29.0 mpg. By 1983 new passenger-car efficiency in the United States, which in 1973 stood at a relatively inefficient 14.2 mpg, had become 27 mpg, which was typical of the developed world (Table 2).

The U.S. achievement is remarkable for two reasons. First, the United States has had, and continues to enjoy, by far the lowest retail fuel prices

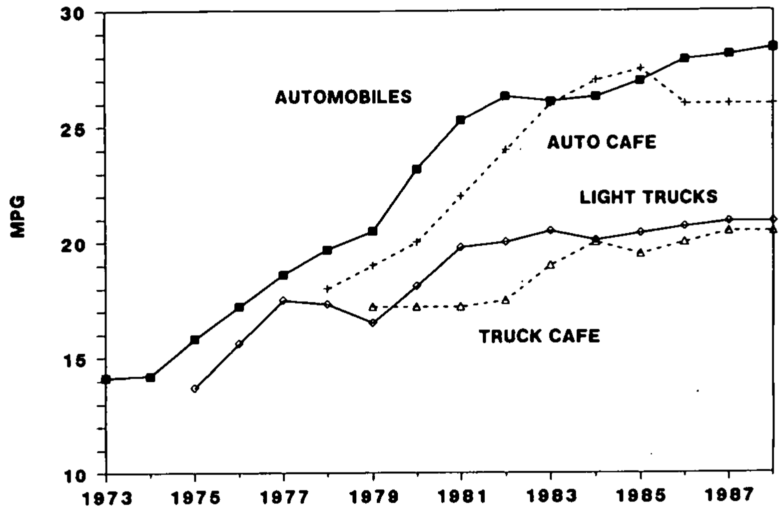

FIGURE 5 Automobile and light-truck efficiencies, 1973–1988 (estimated).

TABLE 2 New Passenger-Car Fuel Consumption in OECD Countries (*18*, Table 36)

	Fuel Efficiency Estimates (mpg)			
Country	1973	1978	1982	1983
Australia	22.8	19.9	24.0	25.0
Canada	—	20.5	27.7	28.0
West Germany	—	24.5	28.3	—
Ireland	—	28.3	—	—
Italy	28.0	28.3	—	—
Japan	22.4	26.7	30.6	—
Netherlands	—	25.6	27.7	—
New Zealand	—	—	—	28.7
Sweden	—	25.3	27.4	27.4
United Kingdom	21.4	25.8	29.0	—
United States	14.2	19.9	27.4	27.4

NOTE: Because test procedures vary by country, mpg estimates are not directly comparable. Dashes indicate data not available.

among the OECD countries (Table 3). Second, although U.S. cars are now lighter and have smaller engines, they are still significantly larger than those sold in Europe or Japan (Table 4). Lower fuel prices, heavier cars, bigger engines, yet similar fuel efficiencies—it sounds like a contradiction of basic economics. From 1970 to 1987, fuel price signals have been inconsistent, to say the least, yet fuel efficiency has increased nearly without interruption and consistently in conformity to the Corporate Average Fuel Economy (CAFE) standards so that although for the past several years U.S. fuel prices have been

TABLE 3 Gasoline Prices for Selected Countries (*7*)

	Retail Price of Regular Grade per Gallon (current $)	
Country	1978	1987
Australia	0.93	1.41
Brazil	1.55	2.94
Canada	0.67	1.30
West Germany	1.68	2.09
Italy	2.15	3.71
Japan	2.07	2.89
Netherlands	1.83	2.84
Sweden	1.47	2.39
Turkey	1.31	NA
United Kingdom	1.22	2.24
United States	0.63	0.82

TABLE 4 Comparison of New-Passenger Car Weight Distributions for Selected Countries, 1980 (*18*, Table 35)

	Percentage by Weight Class			
Country	0-800 kg	801-1000 kg	1001-1200 kg	>1200 kg
West Germany	20	40	20	20
Italy	43	43	10	4
Sweden	26[a]	—	26	48
United Kingdom	29	43	19	9
United States				
1980	3	25	10	62
1982	2	31	13	54

[a] Includes automobiles weighing up to 1000 kg.

barely half those of Europe and Japan, new U.S. cars are about equally as efficient.

By using improved technology, manufacturers were able to offer a mix of cars that met the CAFE standards and gave up little in size or performance. Although U.S. fuel economy improved 75 percent from 1978 to 1986, average vehicle size, weight, and power changed only slightly. Average size, measured by interior capacity, did not change at all; weight decreased 25 percent from 4,058 to 3,059 lb; and power (measured by horsepower-to-weight ratio or time to accelerate to 60 mph) actually improved: from 0.0366 hp/lb to 0.0388 hp/lb, or 14.2 sec down to 13.1 sec (*19*). Much has been said in the popular media about sacrificing size and performance for fuel economy, but analyses have shown that interior size and performance have not been lost, only weight and length (*20*, *21*).

The near doubling of automotive fuel economy since 1974 has been achieved without substantial loss in consumer satisfaction because the technology of automotive fuel economy has improved significantly. Electronic engine controls, widespread use of front-wheel drive, fuel injection, lock-up-torque conversion on automatic transmissions, friction reduction, improved aerodynamic designs, and other technologies, in addition to reduced weight and engine size, make up an array of engineering and design changes that have produced vastly more fuel efficient vehicles. A way to measure the technical improvement in fuel efficiency is to describe mathematically the trade-offs among fuel efficiency, weight, performance, and cost. This has been done using the concept of the "technology frontier," which describes the best production technology at a given point in time (*22*). The concept can be understood two-dimensionally from a plot of 1978 and 1985 model-year cars in weight-efficiency space (Figure 6). Note that the 1985 cars have generally shifted to the left, indicating generally lower fuel consumption rates at the same weight. Taking weight, performance, size, and price into account, it can be shown that a 21-mpg 1978 automobile produced with 1985 technology would achieve 24 mpg. Conversely, a 29-mpg 1985 automobile would achieve only 24 mpg if produced with 1978 technology (*22*). This and other studies suggest that about half of the fuel economy gain from 1978 to 1985 is attributable to reductions in engine size and weight, and half is attributable to better technology (*23*, *19*). Continued efficiency improvements through the use of better technology are still important for dealing with the transportation

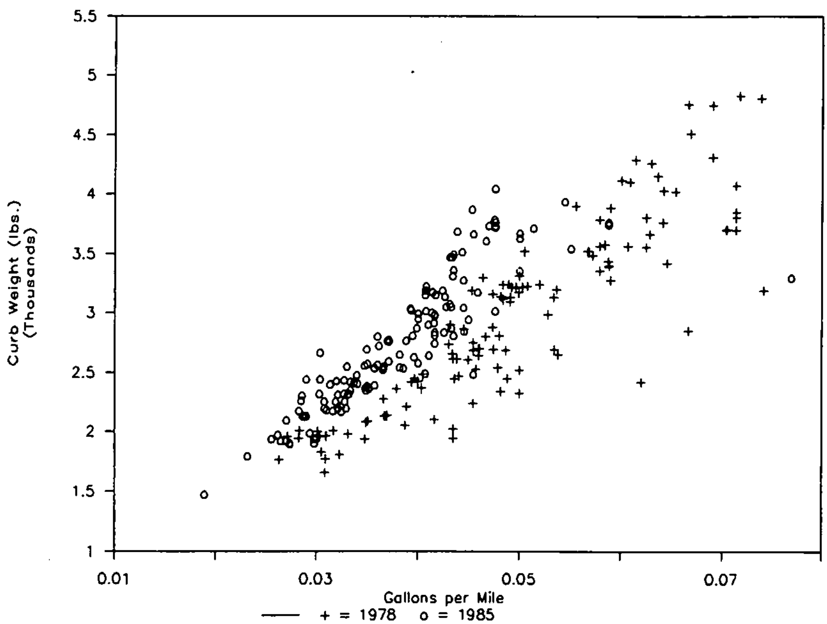

FIGURE 6 Automobile weight versus efficiency, 1978 and 1985.

energy problem during the next 30 years. To double fuel economy again, however, is likely to take more time and require significant technological advances.

The value of these fuel economy savings has been substantial. It is estimated that if automobile and light-truck fuel economy had not improved over 1975 levels, consumers would be purchasing 35 billion gal more gasoline than they do today. Evaluating past annual savings at the price of gasoline for the respective year and inflating to 1987 dollars and present value by using a 5 percent real discount rate puts the present value of these savings at $260 billion by the end of 1987 (Figure 7). Even if one does not inflate savings to present value but simply adds up the 1987 dollar value, the total is more than $200 billion.

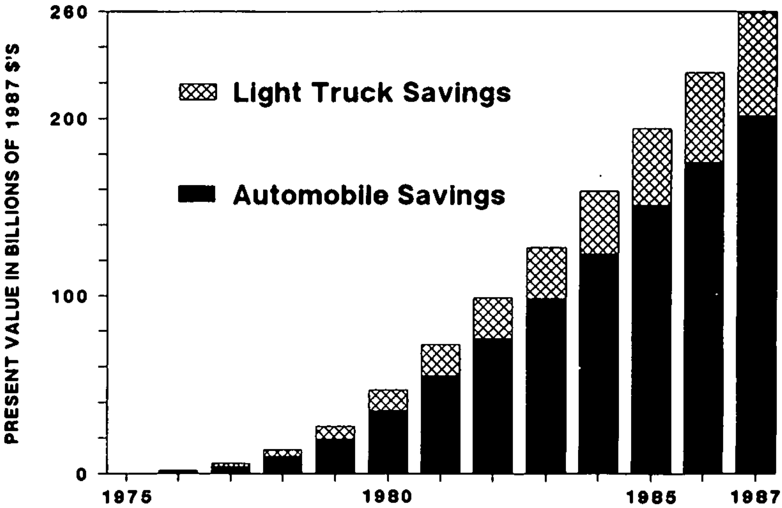

FIGURE 7 Cumulative savings, automobile and light-truck mpg improvements, 1975–1987.

The cost of these fuel economy improvements has been much lower. In 1977 the U.S. Department of Transportation (*24*) estimated the costs of a 20- to 27-mpg improvement at $195 (about $340 in 1987 dollars). A 1984 retrospective estimate (personal communication, K. G. Duleep, Energy and Environmental Analysis, Inc., Arlington, Va.) put the per-car cost at $200 to $400 (the midpoint would be about $330 in 1987 dollars). Using a figure of $333 per car and assuming 10 million cars a year for 12 years, this amounts to a total cost of $40 billion (1987 dollars uninflated to present value). In 1980 General Motors estimated the investment cost of fuel efficiency improvements to be $1 billion per 0.5 mpg. For a 12-mpg improvement this would be $32 million (in 1987 dollars) for GM (*25*). Multiplying by 2.5 (GM's 40 percent market share) would bring this to about $80 billion overall. Even this relatively high estimate is less than half of the $260 billion value of fuel savings to date. Unfortunately, past success in efficiency improvements does not necessarily imply that fuel economy can cost-effectively be doubled again.

According to analyses by DOE, domestic manufacturers already have the technology to improve the average fuel efficiency of new cars to 35 to 40 mpg by 1995 with technology that would be cost-effective at gasoline prices of $1.50/gal to $2.00/gal (in current dollars) (*26*). These projections assume only very minor changes in vehicle size-class market shares and are consistent with previous analyses (*27–29*). They assume only proven technologies, for example, increased use of four-speed automatic overdrive transmissions, multipoint fuel injection, four-valve-per-cylinder engines, further friction reduction, aerodynamic improvements, tires with lower rolling resistance, improved lubricants, turbocharging, and diesel engines. Because the DOE study was completed in late 1985, many of these technologies have already made their appearance in the new-car market. Light-truck fuel economy is projected to improve to about 25 mpg, even with fuel prices below $1.50/gal. Similar technologies (fuel injection, engine friction reduction, weight reduction, drag reduction, overdrive transmissions, and diesel engines) are sufficient to achieve this 25 percent fuel economy improvement.

To go beyond the readily achievable 25 to 40 percent improvements to the typical car and light truck of 1988 will require some advances in technology. Superefficient designs have been proposed that use continuously variable transmissions to enable an engine to operate at peak power output at any road speed as well as to reduce peak power requirements somewhat (*30*). By adding a flywheel to eliminate idling to an insulated, turbocharged, direct-injection diesel engine plus an extremely low aerodynamic drag coefficient of 0.3, superior tire rolling resistance of 0.0085, and a few other features such as reduced weight, one can design a hypothetical four-passenger car able to achieve 80 to 120 mpg.

Substantial improvements in heavy-truck energy efficiency are also possible, given advances in adiabatic or near-adiabatic engine technology. Kamo (*31*) estimates that by 2010, an adiabatic minimum-friction engine could reduce brake-specific fuel consumption by over one-third as compared with efficient diesel engines available today. Adding aerodynamic and rolling-resistance improvements to reduce horsepower requirements could result in heavy-truck efficiencies in the vicinity of 10 mpg (versus about 4.5 for the average heavy truck now in use and 6 to 7 mpg for new heavy trucks). Even without an adiabatic diesel but with near-term technologies such as electronic controls, reduced friction engine, turbocompounding, aerodynamics, new-generation tires, and reduced tare weight, it has been estimated that heavy-truck efficiencies near 9 mpg could be achieved by 2000 (*32*).

Whether such superefficient internal combustion-powered vehicles will come into being by 2020 will depend not only on the price of fuel but on the progress of technology and on U.S. energy policy. At efficiencies better than 30 mpg (7.5 L/100 km), the total per-mile cost of driving an automobile is insensitive to fuel economy because savings in fuel costs are approximately offset by increased vehicle costs over a wide range of efficiencies [Figure 8 (*30*)]. Given the likely uncertainty that will surround petroleum prices in the future, it is not at all guaranteed that the car market will respond to higher fuel prices by optimizing efficiency. With such small differences in total cost, consumer evaluation of the performance, convenience, reliability, and safety of superefficient vehicles may well dominate the choice. If these vehicles are perceived to be less desirable, alternatively fueled vehicles may supersede those with internal combustion engines in certain applications. These choices will depend primarily on the progress of technology in internal combustion engines, alternative fuels, and electric propulsion systems.

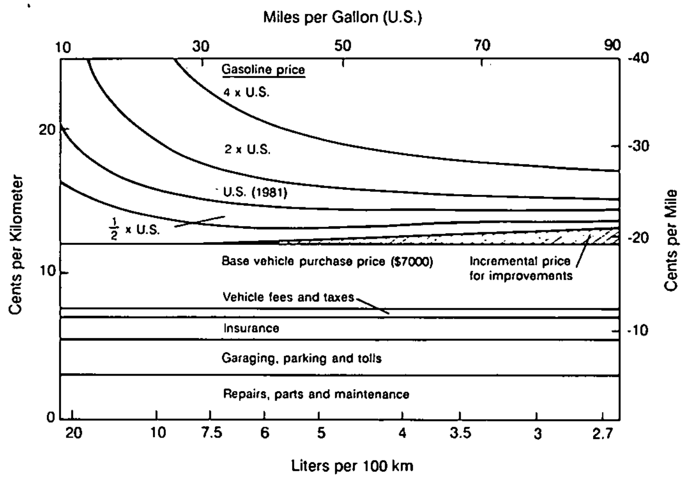

FIGURE 8 Cost of driving (1981 U.S. cents). [Reprinted with permission from *Energy* (*30*), © 1987, Pergamon Journals, Ltd.]

ALTERNATIVE ENERGY SOURCES FOR TRANSPORTATION

Alternative fuels for transportation can be derived from both fossil and nonfossil resources. There are many technically feasible and nearly economical candidates. In 1988 dollars, oil prices in 1981 were $43/barrel. At prices above $20/barrel but less than $43/barrel, LNG and gas converted into methanol are cost competitive. At or just above $43/barrel, biomass can be converted into ethanol or methanol; coal into methanol, substitute natural gas, or possibly petroleumlike liquids; and oil shale into gasoline and diesel fuel (*3*). With further research and development, these coal, oil shale, and biomass fuels could be produced at even lower costs, perhaps at less than $35/oil-equivalent barrel (*33–35*). Other possible alternatives include plant oils, fuel cells, electrified roadways (*36*), and hydrogen. All of these alternatives are likely to be implemented somewhere in the world; indeed, some have already gained widespread use. [A summary of worldwide alternative fuel use and testing can be found in Appendix D of a recent DOE report (*37*).] In the United States about 850 million gal a year of ethanol, produced mostly from corn, is used in a 10/90 blend with gasoline. Ethanol made from sugar cane is used as a neat fuel in over 90 percent of all Brazilian automobiles sold since 1983 (*38*). Compressed natural gas is burned in over 300,000 vehicles in Italy, 130,000 in New Zealand (representing over 10 percent of all automobiles in the country), and 15,000 in Canada. Synthetic gasoline made from natural gas now accounts for over 35 percent of all gasoline used in New Zealand. Propane is used in over 10 percent of all cars in the Netherlands and 500,000 U.S. vehicles. Petroleumlike liquids account for over 70,000 barrels of fuel in South Africa. Some alternatives are economically superior to gasoline and diesel fuel; others are being pursued for different reasons.

Alternative fuels that are economically competitive or nearly so do not immediately appear in the marketplace for several good reasons. Because of the different chemical and physical properties of alternative fuels, they generally require different distribution and storage systems. The modification of existing infrastructure or construction of new facilities for nationwide distribution represents a substantial capital investment. Even for methanol, which is in many ways very similar to gasoline, the costs of required modifications to existing distribution infrastructure would be substantial—about $6 billion for a 5.6-mbpd methanol market in 2000 (*39*). This would be enough to displace about 2.8 mbpd of gasoline, more than one-fourth of U.S. consumption.

Consumers are understandably reluctant to purchase vehicles for which an established fuel delivery system does not yet exist. Based on an analysis of the diesel car market, one study concluded that about 10 percent of all fuel stations (about 10,000 nationally) would have to offer a new fuel before any significant number of people would purchase a vehicle operating on that fuel (*40*). Experience with diesel cars has also shown that buyers are quite sensitive to the relative costs of alternative fuels. The increase in diesel costs relative to those of gasoline has been shown to be a major factor in the decline of the diesel car market in the 1980s (*41*, *42*). Thus, given the inherent uncertainty about petroleum prices, vehicle manufacturers will also be understandably reluctant to commit to significant production of vehicles using alternative fuels that do not have a clear, significant, and lasting cost advantage.

Currently methanol gets the most attention among alternatives to gasoline because there exists proven flexible-fuel technology for operating a vehicle on any mixture of gasoline and methanol (*43–45*). This technology, made possible by advances in sensors and computer chips, offers a solution to the old alternative-fuel dilemma: how to get alternatively fueled vehicles into a market where there is no fuel and how to get alternative fuels into a market where there are no vehicles to use them. Because of the significance of this technological achievement, methanol has taken center stage as the alternative fuel for highway transport (*45*).

The potential role for methanol in the next few decades, however, is limited. Methanol is produced most cheaply from surplus natural gas, in particular gas located in fields that do not have markets accessible by pipeline. When this remote gas is associated with petroleum production, it is flared (burned as waste) or reinjected into the ground. If the total worldwide supply of surplus natural gas (flare plus reinjection) were converted to methanol, it could be delivered to the United States for approximately 55 cents/gal, equivalent on an energy basis to about $1.10/gal of gasoline (*46*). At this price, about 60 billion gal of methanol could be delivered to the world market, about 30 percent of U.S. gasoline consumption on an energy-equivalent basis (Figure 9). Additional methanol could be obtained from coal at still higher (and less certain) cost.

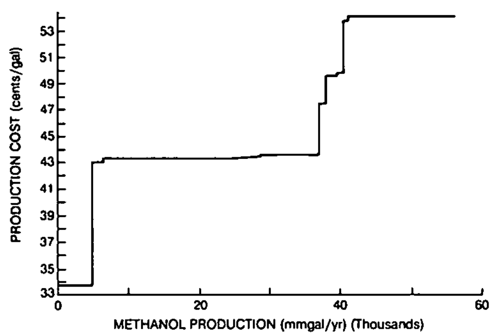

FIGURE 9 Long-run methanol costs of production.

Once supplies of flared and reinjected gas have been fully utilized, methanol would have to compete for methane with other gas consumers, almost surely driving up the price of natural gas and thus of methanol. During the past few years methanol prices have been as erratic as oil prices. Recently the world methanol market has been glutted by an estimated 2.2 billion gal per year of excess capacity (*47*). As a result, prices fell as low as 35 cents/gal delivered to the United States. The volatility of petroleum and methanol prices, combined with the ability of Persian Gulf producers to lower or raise world petroleum prices, creates substantial risk for potential producers, distributors, and retailers of methanol, as well as for methanol vehicle manufacturers. If governments determine to foster a transition to methanol as a matter of policy, then taxes, subsidies, or other means of ensuring a price advantage for the alternative will almost certainly be required.

Other near-term nonpetroleum fuel options are CNG and electricity. Like methanol, CNG can be made from natural gas or, at greater cost, from coal or biomass. Although CNG is less expensive than methanol and gasoline (on an energy-content basis), it requires more expensive on-board storage and refueling facilities. Because of CNG's lower energy density, vehicles must be refueled more often. Electric vehicles suffer the same driving-range disadvantage as CNG vehicles. Recharging of electric vehicles requires hours rather than minutes. A comparison of the characteristics of the foregoing fuel alternatives, plus ethanol, is presented in Table 5.

The costs of most alternative fuels cannot be specified precisely, either because the future price of the feedstock is uncertain or because the production process is still not commercially proven. Nevertheless, cost is the single most important evaluation criterion. Natural gas fuels are competitive with petroleum when crude oil prices are about \$15/barrel to \$30/barrel, methanol from natural gas at \$25/barrel to \$35/barrel, and coal-based and biomass-based methanol and corn-based ethanol at about \$40/barrel to \$150/barrel. With further advances, these costs could possibly be reduced to less than \$35/oil-equivalent barrel. The cost of petroleumlike liquids from coal and oil shale is more difficult to predict because the processes are still in an early stage of development. A second-generation plant would probably produce fuels at \$50 to \$70/oil-equivalent barrel, but with continuing improvements the cost could be less than \$35. Hydrogen would be the most expensive (*48*); electric vehicle costs are competitive at current oil prices of \$20/barrel, but their performance and driving range are highly inferior compared with all vehicles operating on liquid and gaseous fuels.

New fuels are likely to be introduced in the next few decades only if they receive some form of government support. Significant government action is likely to come about only if there is a consensus that action must be taken to protect the public interest. The problems likely to elicit such intervention are the greenhouse effect, dependence on foreign oil supplies, economic benefits of lower energy prices, and urban air pollution.

The different alternative fuels will vary greatly in their contribution to the greenhouse effect (*12*). The worst offenders are coal-based fuels. If coal were to replace petroleum as the transportation energy feedstock (for instance, to

TABLE 5 Characteristics of Alternative Fuels and Vehicles Compared with Gasoline and Gasoline-Powered Vehicles

	Ethanol	Methanol[a]	CNG[a]	Electricity
Near-term technology	Proven	Proven	Proven; satisfactory for some uses	Close to commercial
Unit price[b] $	1.25–1.45	0.35–0.45[c]	3.62–7.46/1,000 scf[d]	0.015–0.133/kWh
Dollars/million Btu[e]	14.9–17.2	5.5–7.0	2.1–8.3	1.7–37.9
Fuel volume	1.5 times that of gasoline	2 times that of gasoline	5 times that of gasoline	2–3 times that of gasoline[f]
Energy content				
Versus 18,500 Btu/lb for gasoline	11,500	8,600	21,300	N.A.
Versus 125,000 Btu/gal for gasoline	75,700	56,600	22,800	N.A.
Refueling procedure	Same as for gasoline	Same as for gasoline	Somewhat lengthier than for gasoline	Recharging takes hours
Fuel storage tank cost ($)	Nominal	Nominal	850–1,000	Depends on battery type
Current status of technology	In production in Brazil	Preproduction	Commercial	Used in niche markets
Performance characteristics	Small power gain	8% power gain	10% power loss	Trade-off for range
Exhaust emissions (HC, CO, NOx) and HC reactivity	Same as or better than gasoline; lower NOx and HC reactivity	Same as or better than gasoline; lower NOx and HC reactivity; potentially lower CO	NOx same as gasoline or higher; slight benefit or equal for nonmethane HC, lower CO	No mobile source emissions, emissions at power plants

[a]Assumes dual-fuel or flexible-fuel vehicles. Single-fuel vehicles designed and optimized for CNG and methanol would have significantly improved performance and emissions.

[b]Unit price for gasoline: $0.53–$0.78/gal.

[c]Methanol spot market prices vary; the estimate here is based on the estimated long-run cost of production.

[d]Scf = standard cubic feet.

[e]Gasoline: $4.2–$6.2/million Btu.

[f]Volume of typical battery pack for a lower range (approximately 100 mi) electric vehicle.

SOURCE: Adapted from DOE Report DOE/PE-0080 (*37*), Tables 2 and A-1.

manufacture methanol or petroleumlike liquids), greenhouse gas emissions would increase about 60 percent. If natural gas were the exclusive feedstock for transportation energy, whether as CNG or to make methanol, greenhouse emissions would decrease slightly (0 to 15 percent). If biomass were used to make any fuel or if "clean" energy were used to make electricity or to electrolyze water to make hydrogen, almost a 100 percent reduction in these emissions would occur. If the greenhouse effect is as severe as some scientists claim, the government should favor the "clean" fuels—hydrogen and electricity—and their introduction should be greatly accelerated.

Reduction of urban air pollution is likely to be the first and strongest motive to introduce new fuels. The prominent role of air pollution is due to highly precise and publicly popular rules for achieving healthy air. At the end of 1987, 68 metropolitan areas were exceeding ambient air quality standards for ozone and 59 were exceeding carbon monoxide standards. A total of 107 areas, including the 24 largest metropolitan regions, containing 135 million people, were violating one or both standards.

Carbon monoxide would be greatly reduced by the use of natural gas, hydrogen, and electricity and would be modestly reduced by methanol and ethanol, used either straight or in some cases blended with gasoline. The use of alcohol-gasoline (and other oxygenate) blends, as currently required in Denver, tends to increase ozone, however. Ozone would be greatly reduced by the use of hydrogen or electricity when they are made from clean resources and modestly reduced by natural gas and pure alcohol fuels. All petroleumlike fuels would have CO and ozone emissions similar to those of gasoline and diesel fuels.

One other prominent air quality role for alternative fuels is in urban transit buses. Recently promulgated Environmental Protection Agency emission standards require substantially reduced emissions from diesel engines in transit buses by 1991 and in diesel trucks by 1994. There are essentially two options available to engine manufacturers: expensive particulate traps or redesign of engines to operate on methanol or CNG. At this time, the methanol-CNG option seems cost-competitive in many situations (*49*, *50*). Because methanol and CNG dramatically lower smoke and particulate emissions, even more than trap-equipped engines do, it is likely that these fuels will be particularly popular for urban transit buses operating on city streets.

In the next 15 years or so, alternative fuels are expected to be used in transit buses (total market is 30,000 barrels/day) and centrally fueled truck fleets. Larger amounts of methanol and CNG may be used in certain regional markets with severe CO and ozone problems, including Denver and New York, but especially California. Severe ozone problems in Los Angeles, Sacramento, and other metropolitan areas in California; the strong commitment to environmental quality in that state; and the existence of powerful air quality regulators statewide and in Los Angeles suggest that methanol and to a lesser extent CNG and electric vehicles are likely to gain some share of the California market in the near future. The penetration level by 2005 is likely to be somewhere between 0.5 and 5 percent of the California highway fuel market; elsewhere it would be lower.

Because of the cost and risk of establishing a network of retail outlets providing alternative fuels, virtually all methanol and CNG use will be in multifuel vehicles that also run on gasoline. To ensure that these vehicles operate on nonpetroleum fuel it will be necessary to keep the price of the alternative fuel at or below the price of gasoline or constrain fuel use by fiat. Devising and implementing such regulations will be a key element of alternative-fuel policy.

By 2020 a full-scale transition to alternative fuels will likely be in progress. Methanol and natural gas will be the primary alternatives, but electric vehicles will be common and initial investments in oil shale will likely be proceeding. In southern California, where ozone standards will still be violated, it is possible that virtually all new vehicles will be designed to operate on methanol, CNG, or electricity, accounting for sales of almost 2 million vehicles a year. Unlike in the past, a multiplicity of transportation fuels will probably coexist, sometimes several in the same local market. The less efficient multifuel vehicles will have been superseded by low-polluting, efficient, single-fuel vehicles optimized to either methanol or CNG (or LNG).

If global warming continues as expected, there will also be strong pressure to switch to biomass and nonfossil fuels (including methanol made from wood), hydrogen from water with clean energy, and electrified roadways.

CONCLUSIONS

Energy does not have to be a significant constraint on highway transportation in the coming decades. Energy for transportation will be available, although petroleum will become increasingly more expensive and less reliable in supply. As prices rise, energy efficiency must improve and fuel substitution capability must be created. Whereas in the past energy efficiency improvements and energy price deregulation proved to be adequate as energy policy, future energy policy must also address the transition to alternative fuels.

If the transition is successful, neither the necessary efficiency improvements nor the transition to alternative energy sources will cause major changes in the way the transportation system operates. By 2020 a transition from petroleum to a more diverse energy base for transportation will have begun. Which energy sources will dominate will depend a great deal on the success of technology for fuel production and storage but also on the contribution of new energy systems to solving the problems of air quality, congestion, safety, and national security.

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Environmental Considerations in a 2020 Transportation Plan: Constraints or Opportunities?

John H. Suhrbier and Elizabeth A. Deakin

TRANSPORTATION PROFESSIONALS SOMETIMES VIEW environmental protection and enhancement as inconsistent with mobility and economic development objectives. Consider the four questions this paper is supposed to examine:

- What demand constraints are likely to emerge from the environmental side?
- What are the long-term environmental constraints to roadway expansion?
- How will air quality regulations affect transportation in the future?
- How serious a problem are the constraints in shaping the ability to supply transportation as well as meet the potential aggregate demand?

Each of these questions conveys the impression that environmental considerations may seriously block transportation progress.

John H. Suhrbier is Principal, Cambridge Systematics, Inc. He is currently working with UMTA as a part of their Suburban Mobility Initiative, Massachusetts Bay Transportation Authority on issues of handicapped accessibility, and the Department of Energy on the transportation aspects of acid rain. Elizabeth A. Deakin is Assistant Professor of City and Regional Planning and member of the research staff at the Institute of Transportation Studies, University of California, Berkeley. She has a law degree from Boston College Law School and has worked for Cambridge Systematics.

The authors contend that the treatment of environmental concerns as constraints, restrictions, and problems is itself a problem, and one that will have to be overcome if any 2020 transportation program is to succeed. They believe that a much more positive view of environmental protection is in order, that sustained economic growth and prosperity are not possible without simultaneously achieving environmental quality. In this view, the natural, built, social, and economic environments must be protected and enhanced by transportation projects, so that those projects are cost-effective in the long run as well as in the short term and do the best possible job of delivering the mobility, economic development, and quality-of-life benefits the American public demands and deserves. Thus, rather than treating environmental considerations as barriers to be overcome, restrictions on transportation professionals' ability to do their jobs, or simply one more set of externally imposed procedural requirements to be satisfied, it is argued that it is time to treat environmental protection and enhancement as major objectives and expected outcomes of transportation planning and project development.

Adequate consideration of the environment must be built into the process through which transportation decisions are reached—from systems planning through final design, construction, and operation. What alternatives are evaluated at each stage? What information is considered at important decision milestones? Who is given the opportunity to participate in those decisions and help shape the program or project? All of these matters affect results and hence are determinants of environmental quality.

Accordingly, in examining the environmental issues and their implications for a 2020 transportation program, it will be necessary to consider the ways in which transportation planning and decision making will be carried out and the circumstances in which transportation providers will be operating. In this paper, the broad view will be presented first, followed by a few topics of special concern.

Transportation Planning: A Changing Context

The nature of the planning and decision-making context over the next three decades will be discussed in this section, beginning with some predictions about how it will change.

Range of Alternatives

To meet the travel needs of the future, a much broader range of alternatives will be considered than is usually the case today. Alternatives will be fashioned to respond to the particular problems and opportunities of the implementation context; there will be less reliance on standardized, uniform approaches.

Some areas will construct new limited-access highway facilities on new rights-of-way, and others will develop or extend rail transit systems. But in many other areas, particularly those that are newly developing, construction is likely to focus on facilities of a very different scale—arterial streets, sidewalks, parking, transit connections, internal circulation systems. Older areas, urban and rural, will emphasize the upgrading of existing highway facilities, adding lanes and grade separations and control ling access and parking. Traffic operations improvements will be widely utilized. An increasing number of areas will make conscious decisions to supply less highway capacity than would be necessary to provide free traffic flow for an unconstrained level of demand; traffic mitigation and transportation demand management will be pursued instead. Transit, as shown by UMTA's Suburban Mobility Initiative, also will emphasize a broader range of nontraditional options, particularly in rapidly growing suburban service markets (*1*). Telecommunications and electronic data-interchange substitutes for transport will receive attention. High-technology highways, vehicles, and communications systems will be given serious consideration in later years.

As the range of alternatives being considered becomes more diverse, the range of environmental issues that must be assessed will also become broader and more complex. Environmental analyses will have to respond to this increased diversity by becoming more sophisticated. Simplistic "trends-extended" analyses will face diminished credibility. Concepts of uncertainty may also be more widely understood, and contingency planning may find greater acceptance.

Funding Constraints

Constraints on public funding for transport construction, operation, and maintenance are likely to continue, and creative financing will become more common. Developer dedications and exactions, developer and employer provision of transport services, benefit assessment districts, and road and parking pricing will all be utilized, along with more conventional sources of funding such as fuel taxes, sales taxes, and bonds.

The use of a variety of financing mechanisms will add to the complexity of planning and programming. Increasing numbers of projects will have their own unique financing packages, possibly involving several levels of government and private-sector beneficiaries. Skills in negotiation, economic analysis, law, and finance that are not now common in transportation agencies may well become critical.

Community Involvement

Meaningful community involvement in the development and selection of transportation projects will continue to be critical and may well grow in importance as the range of alternatives considered and the range of financing mechanisms utilized expand. The full range of interests, including local governments, regional agencies, private-sector organizations, and citizen and environmental groups, will need to be involved in the decisions, because programs and projects will have to attract substantial community support if they are to proceed. At the same time, those participating in project finance will want a strong say in planning, design, and scheduling. Private-sector desires for confidentiality may confront public expectations for disclosure. As the range of actors involved in transportation decisions increases, and as roles and responsibilities change, new and more sophisticated public involvement mechanisms may be needed, as well as thoughtful new policy on public agency procedures for this changed situation.

Assessment of Transportation Proposals

Transportation proposals will continue to be assessed in conjunction with desires to maintain and enhance social, economic, and ecological conditions. The authors see no evidence that the public is willing to downplay environmental concerns, even though desires for congestion relief and better mobility and access are strong. Rather, transportation providers will be expected to pursue better transportation and better environmental quality. Furthermore, environmental legislation seems likely to be strengthened, and litigation to ensure that environmental issues are given substantive consideration shows no sign of waning.

Especially at the system and programmatic levels, transportation cost-effectiveness will increasingly be judged from broad social, economic, and environmental perspectives rather than solely on the basis of mobility needs. At the project level, designs that create or enhance context-specific environmental qualities will be stressed.

Emphasis on environment-enhancing designs and impact mitigation will likely require additional environmental design capabilities within transportation organizations. Once again, standardized, uniform approaches will be of diminishing utility, and opportunities for creative responses will increase.

Combination of Transportation, Land Development, and Economic Development

A stronger government role in land use planning and control will be accepted, and programs combining transportation, land development, and economic development will increasingly be pursued, opening up new opportunities for transportation to enhance the social, economic, and natural environments.

Particularly in rural areas, there will be renewed interest in the use of transportation investments to attract and diversify employment opportunities or to support farming and resource extraction enterprises. The lessons of previous economic development efforts suggest that careful assessments will be needed. In urban and suburban areas, the focus will be on coordinating land development and transportation, with traffic reduction and timely provisions of infrastructure and services being emphasized. Here, experimentation, monitoring, and assessment of potential will be in order.

Necessary Action

Overall, it seems likely that the transportation planning and project development processes of the future will need to be more broadly scoped and flexible than ever, and that responsiveness to environmental problems and opportunities will be one test of excellence. From this perspective, then, a review of the current situation suggests several areas in which action may be needed.

Broader Scope To date, much of the discussion of future transportation policy has focused on the development of a national post-Interstate program for major highways. However, if in the future a much more diverse set of transportation alternatives will be considered, policy discussions should be scoped more broadly. The roles of arterials, collectors, transit, and transportation system management (TSM), along with their environmental implications, will have to be addressed. Time-series analyses of traffic volume data in Boston, for example, show that a major growth in traffic is occurring on secondary roadways because these facilities are increasingly absorbing the overflow from freeways and primary roads that have reached their practical capacity. This is resulting in a worsening of local traffic congestion and also causing localized air pollution problems.

Private- Versus Public-Sector Roles As private-sector funding for transportation projects becomes more common, clarification of the roles of other community groups in project deliberations may be necessary. Already there are troubling reports of negotiated decisions from which groups not contributing to the funding have been excluded, as well as an increase in the use of public relations programs to "sell" projects. Both situations raise serious questions about the role and responsibilities of public agencies.

Review of Environmental Provisions Existing environmental provisions affecting transportation, including environmental impact statements (EISs), Section 4(f) reviews, certification acceptance, and elements of the 3-C/MPO urban transportation planning process, resulted in large part from the controversies surrounding various Interstate highway projects in the 1960s. Today, however, both the projects being considered and the environmental issues have changed. As a result, current environmental regulations and practices may not be adequately serving anyone's needs. It will be important to review these provisions as part of the deliberations over future transport policy, and to take steps to ensure that they respond to the kinds of transportation projects that are desired and likely over the next 30 years.

Long-Range Environmental Impacts Long-range and even medium-range system planning largely disappeared with the winding down of the Interstate program and the financial troubles of the 1970s and 1980s. This has undermined the consideration of social, economic, and environmental impacts from a system perspective; areawide, cumulative, and long-term environmental impacts—positive as well as negative—are often missed or ignored in today's project-by-project decision making. Recent capital planning efforts at the system level have not filled the gap from an environmental analysis perspective. In devising a 2020 transportation pro gram, there will be opportunity to once again take a longer-range, more comprehensive look at environmental effects; this opportunity should be taken.

Air Quality State and urban area air quality plans are perhaps the most visible efforts to improve environmental quality through transportation actions. Unfortunately, the plans are hardly success stories. Their development continues to proceed largely independently of transportation decision making, and their implementation has been spotty. The regulatory orientation of federal and state air quality agencies and the decentralized, shared-power institutional arrangements for transportation decision making have proven to be incompatible, and rather than working together to meet the provisions of the Clean Air Act, transportation and air quality agencies are often at odds.

This has resulted in a situation where isolated examples of progress are usually more than offset by the implementation of other, inconsistent projects. Meanwhile, data are accumulating on the severity of the effects of transportation emissions. Finding practical, responsible ways to turn this situation around will be a challenge for the next decades.

Relationships Among Transportation, Land Use, and Economic Development Transportation agencies increasingly are attempting to justify the implementation of high-cost projects on the basis of their anticipated economic development benefits. Frequently, though, short-term benefits are grossly inflated, transfers are counted as benefits, costs (opportunity and otherwise) are disregarded, and other necessary conditions for achieving economic development are ignored. At the same time, the understanding of longer-range interrelationships among transportation, land use, and economic development remains weak. Past investments in major new transportation systems appear to have contributed to the physical and economic restructuring of urban areas, but these effects are still not completely understood. Some were not fully anticipated, whereas others, such as suburban development around Interstate ramps, were foreseen but not adequately planned for. In developing a 2020 transportation program, it will be critical to be realistic in the assessment of potential shifts in land use and economic development potential, to address cross-subsidies and transfers explicitly, and to make efforts to anticipate program consequences.

Environmental Topics

As this discussion suggests, a thorough examination of environmental factors and their implications for a 2020 transportation program would take far more time and space than is available here. Therefore, three topics will be discussed in some detail:

- The EIS process,
- Transportation and air quality considerations, and
- Treatment of relationships among transportation, land use, and economic development.

These are by no means the only environmental topics that will have to be dealt with in future transportation planning. For example, wetlands protection, hazardous materials, historical preservation, and noise also represent important and difficult environmental considerations that must be addressed with increased sensitivity in the future. The authors believe, however, that the foregoing three issues are timely and indicative of the kinds of issues that will have to be confronted if any future transportation program is to be a success.

Environmental Impact Statement Process

EISs are required by the National Environmental Policy Act (NEPA) for every major federal action significantly affecting the quality of the natural or human environment. Although NEPA applies only to projects in which the federal government is involved, many states have their own environmental quality laws that call for similar impact reporting on state and local projects. Some of these state laws are even more broadly scoped and detailed than NEPA, for example, California's Environmental Quality Act, which applies not only to state and local government actions but also to those private projects that require contracts, loans, grants, leases, permits, or licenses from a public agency. In addition, there are numerous other federal and state legislative provisions which require special consideration of particular aspects of the environment, ranging from parklands preservation [Section 4(f) of the Department of Transportation Act] to the Clean Air and Water Acts and historic preservation requirements.

With a few exceptions, this body of environmental law and regulation neither mandates nor prevents specific outcomes. Rather, the laws establish policy favoring respect for and enhancement of the environment, and prescribe planning and analyses intended to ensure that environmental quality is care fully weighed in program and project decisions. EISs and related documents are intended both to document the findings of those planning and analysis efforts, and to serve as the basis for responsible, fully informed decision making.

How well have these intentions been met? For transportation programs and projects, the evidence is mixed. Most areas can document success stories in which environmental studies have provided important information that has helped shape better projects or unintended harm has been avoided. In many other cases, however, EISs have come to be regarded as tedious paperwork exercises, consuming valuable resources and adding to the amount of time required to deliver projects without producing anything of substantive value. (Hereafter, the term "environmental impact statement" will be used to mean any such document prepared under federal, state, or local law, and not just NEPA documents.) Indeed, transportation staff, community and environmental groups, and elected officials too often agree that transportation EISs are reactive, fragmented, partial, unrealistic, and perfunctory.

The reasons for these harsh criticisms deserve attention, for they suggest what is wrong with the current environmental assessment process as well as what might be done to improve it.

First, many environmental documents are reactive. They are done late in the development of a program or project, in many cases not commencing until a preferred alternative has already been decided upon. Other alternatives may not have been considered, or may have been given only limited attention. In some instances so many resources have been committed to the development of the preferred alternative that it is hard, financially, politically, and emotionally, to give serious thought to major revisions or new options, even when environmental studies reveal serious problems or previously overlooked opportunities. Thus the environmental assessment merely reacts to the proposal at hand; significant changes in direction are seen as too costly, and even mitigation measures are constrained.

Second, environmental impact assessments tend to be fragmented. For transportation, this problem stems in large part from the current emphasis on individual projects rather than systems or programs and has been exacerbated by funding shortages that increasingly necessitate the splitting up of projects into small, fundable pieces—successive widenings of a few miles of a highway at a time, for example. The focus on "pieces" of projects makes it difficult to assess the overall effects of a series of improvements, and limits the consideration of significantly different approaches. For example, improvements along a parallel arterial might deliver equivalent benefits to a series of freeway ramp improvements at less cost. But when the ramp improvements proceed one at a time over a period of years, the arterial improvement option may not be apparent.

When environmental assessments are reactive and fragmented, they also tend to be partial. Cumulative impacts, positive and negative, are hard to discern or are so contingent on uncertain future projects that they are dismissed as mere speculation. Areawide effects similarly receive little attention, because the effects of small projects taken individually do not show up well from an areawide perspective. Concern about the cost of the assessment relative to the size of the project further limits the investigation of alternatives and impacts.

A lack of realism in the impact assessments also may result. Low-cost but simplistic analysis methods are often used, focusing only on short-term, obvious impacts and ignoring longer-term, secondary effects. Analysis is often based on whatever data are available. Alternatives may be "straw men" thrown together to meet the letter of the law only. Mitigation opportunities, limited by cost considerations and short-term focus, may be overlooked altogether or, especially when the project is controversial, may be presented in glowing terms unsupported by previous experience or analysis of the case at hand. Issues of incidence—who will benefit from the project, and who might lose—are dismissed or downplayed.

Finally, environmental assessment often is seen as perfunctory. Increasingly, assessment documents are stored on the computers of the lead agencies or their consultants, with a quick editing and a few pages of additional text resulting in a completed draft. Pages and pages may be devoted to ritualistic discussions of impacts that are not at issue for the project at hand; little more effort may be devoted to the major concerns raised by the project. Fat documents are produced, but they have little relevance to the decisions about the project—decisions that may already have been made, in fact. Indeed, it is becoming common for EISs to be produced years after the basic project development was completed—another trend that in part reflects the problems many transportation agencies face in project finance and delivery. The resulting document may satisfy a narrow interpretation of one particular section of NEPA or related state law, but more fundamental policy intentions are not well served.

This sorry state of affairs is sketched out in exaggerated terms. Yet the exaggeration is only a matter of degree. Too often, the current reality is that the EIS is a costly, time-consuming but ineffectual document destined to collect dust rather than to influence program and project development.

In some cases, the effects are even more negative. For many projects, review of environmental documents is the first significant opportunity for community groups to comment on the proposed action. Confronted with a document that seems to them to be incomplete or even misleading, and met with resistance to proposals that would require substantial amounts of additional study, these groups are increasingly fighting back. For some environmental documents, the comments on the drafts are lengthier than the documents themselves. Additional analyses may be necessitated; supplementary EISs and revisions are more and more frequent. In California—perhaps an extreme case, but perhaps a harbinger of things to come elsewhere in the country—it is becoming commonplace for several competing analyses to be carried out. In addition to the "official" analyses by the sponsoring agency, for example, separate analyses of the special concerns of affected local governments, community groups, and development interests are being produced. The official document is viewed as an advocacy piece; consequently, the other groups commission their own studies to defend their interests. Out of this process some compromises may be produced, but usually at significant monetary and time costs. These costs, in turn, eat up funds that might be more productively used to address both transportation needs and environmental concerns.

Lawsuits are another negative byproduct of the current EIS process. Transportation agency staff report that they feel under siege whenever an EIS for a controversial project is undergoing review; project opponents comb the document for any error or omission, however minor or irrelevant to the issues they are concerned about, that could be used to stop or delay the project. To "protect" the transportation agency, legal advice commonly is to carry out worst-case analyses, in order to block possible claims of failure to disclose. As a result, the analyses may describe situations that have only a remote chance of actually occurring, and may emphasize negative effects while ignoring beneficial ones. Community groups also find the litigiousness of the EIS process problematic. They say that in many cases, concerns about lawsuits lead to an early hardening of sponsoring agencies' positions, out of fear that admitting to the possible need for further study would be turned against them.

What might be done to improve this situation? First, it must be noted that many of the problems cited stem from broader concerns about transportation planning and project development, and not simply from environmental assessment practices. Consideration of alternatives is limited at least as much, if not more, by the current structure of federal and state aid to transportation, with its numerous categorical programs and restrictions on the transferral of funds from one type of project to another. A broad view of cumulative and areawide impacts is limited not only by transportation agency resistance but, fundamentally, by the need to proceed with projects in small, affordable segments. The conflicts with local officials, community groups, and environmentalists that are increasing reflect the failure of the institutional structure to afford early, meaningful opportunities to participate in program and project development; they are not simply a product of environmental assessment procedures but are in a very basic sense a product of more general project development practices. In this context, failures of the environmental assessment process reflect larger failures of the transportation planning process.

Addressing these failures accordingly will require a broadly scoped view of the problem and a willingness to consider fundamental changes in direction. Rather than adding environmental assessment at the end of transportation project development, it will be necessary to incorporate environmental concerns into the missions of transportation agencies, so that they are an integral part of both program and project development. Better focused attention to environmental concerns and objectives will necessitate greater flexibility in the use of funds, so that a full range of alternatives can be realistically considered in both system and project planning. Staff capabilities to develop projects that reflect the particulars of a local situation will be needed; the uniform standards that have been the mark of many transportation plans and projects of the past may well need to be replaced with specialized, responsive designs. Finally, procedures that allow affected interests to actively participate in project development—to propose alternatives, suggest impacts that need to be considered, and otherwise have a say in the outcome of the studies–will be critical to the success of a revised transportation planning effort.

A number of specific reforms to streamline the EIS process, make it more useful, and clarify responsibilities may also be needed, such as the following:

• Greater use could be made of EIS scoping in order to deal with truly significant impacts in detail and sharply reduce discussion of minor or uncontroversial impacts. Screening procedures, carried out with public review, would provide the basis for selecting the impacts to be analyzed in detail.

• Program-, systems-, and corridor-level EISs would allow review of the broad implications of a long-term plan or set of related projects and facilitate an assessment of cumulative and areawide impacts. Such EISs, although proving difficult to do really well and not eliminating the need for project EISs, do permit more focused EISs to be used at the project level (because impacts sufficiently dealt with in the "master" document do not need to be discussed again). Changes in program-, system-, or corridor-level plans would require an update to the project-level EIS, but this need not be a major undertaking unless the change in the program or plan is itself major. An important advantage of such broader, if more general, EISs is that they can help in the identification of overall benefits, rather than just negative impacts.

• A review of "acceptable professional practice" in EIS preparation may be appropriate at this time. Analysis methods for impact prediction need further development, and what constitutes a reasonable approach needs more attention. Requirements for timely production of environmental documents and for major updates if project delays cast doubt on an earlier study's continued validity also may need review and clarification. Procedures for handling minor updates and revisions perhaps could be streamlined.

Changes such as these could reduce some of the "game" aspects of the current EIS process and help redirect EISs toward their original policy intention. Such reforms, however, are unlikely to address the root problems unless also accompanied by fundamental changes in attitude and approach. The closing of the Interstate era of highway construction offers important opportunities to make such fundamental changes. But this will require a broad look at transportation problems and opportunities—the role of future transportation in enhancing the quality of life is at stake.

Air Quality Transportation Control Measures

The institutional relationship between transportation and air quality over the last 20 years is perhaps best summarized as contentious, or "a perverse and wearisome tendency to quarrels and disputes." Is this situation unavoidable? What are the prospects for improving this relationship over the next 20 years?

Highway engineers too often view air quality considerations as an unnecessary and unwarranted intrusion. Technical analyses may be conducted, but serious policy issues are unlikely to be addressed. The benefits produced by transportation control measures are judged to be small and simply not worth the high social, political, and economic costs.

The Clean Air Act, on the other hand, mandates a comprehensive program of initiatives covering stationary source controls, mobile source controls (alternative fuels and engine controls), and transportation control measures. In many urban areas, the reductions achievable by stationary source controls are being exhausted and the benefits associated with current vehicle emission standards are nearing their peak. Evaluations throughout the country of transportation control measures (TCMs) identified by EPA have shown that their implementation reduces emissions and that the associated benefits almost always exceed program costs:

- Voluntary no-drive days
- Trip-reduction ordinances
- Employer-based transportation management
- Improved public transit
- Parking management programs
- Park-and-ride lots and fringe parking
- Work schedule changes
- Road pricing (tolls)
- Traffic flow improvements
- Rideshare incentives

The effect on actual air quality levels will be a function of the particular nature of the air quality problem being experienced, weather and topographic conditions, and travel patterns. Whether such measures are called TCMs or, as is perhaps more common, TSM or transportation demand management (TDM), the pressure for their greater use seems inevitable. Local, state, and federal officials will continue to look to trans portation to take a meaningful role in achieving cleaner air throughout the country.

The authors conclude that the pressure to incorporate TCMs in various air quality management plans is likely to increase rather than decrease in the future. This is based on a review of the data on emissions sources and their health impacts, the growing recognition of transportation's role in acid rain, and the tenor of legislative discussions at federal and state levels. In the paragraphs that follow, these matters are discussed briefly. It is unlikely, though, that TCMs by themselves will suffice to produce clean air; longer-run attention will probably have to be given once again to vehicle technology.

Health-Based Ambient Air Quality Standards

Over the 10-year period 1977–1986, EPA reports improvements in each of the six air pollutants for which health-based ambient air quality standards exist: lead, sulfur dioxide, ozone, carbon monoxide, nitrogen dioxide, and particulates (2). However, ozone and carbon monoxide continue to present serious problems. EPA estimates that 100 million Americans live in urban areas that still violate Clean Air Act standards for these two pollutants. In fact, the number of metropolitan areas exceeding the allowable 1-hr ozone level of 0.12 part per million increased from 62 to 68 during 1987. For many U.S. urban areas, ozone levels were higher during the summer of 1988 than they had been at any time since 1983. As indicated in Figure 1, this trend is likely to worsen for ozone during the 1990s. For carbon monoxide, a similar reversal is projected to occur starting about the year 2000 (Figure 2). The critical assumption in both figures is that vehicle emission controls remain at current levels. These standards will have become fully effective, but the aggregate effects of increased vehicles and increased total vehicle miles of travel will more than offset the reduction in emissions per vehicle mile traveled.

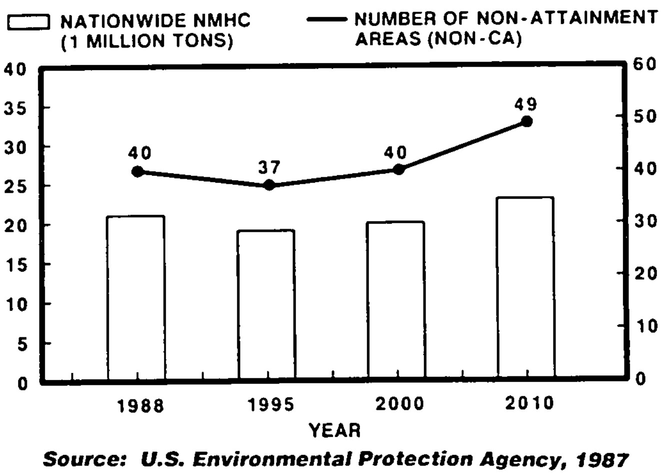
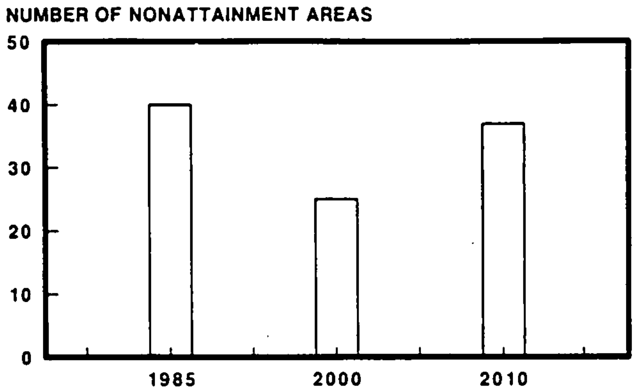


FIGURE 1 Hydrocarbon emissions and ozone nonattainment areas.

Pressure to retain TCMs as an element in the nation's clean air strategy also will result from the increased public concern over other air quality issues. For example, the National Oceanic and Atmospheric Administration reported early in 1988 that the earth's protective ozone stratosphere layer around the North Pole may be suffering the same type of man-made chemical attack as is



***Note:* 20 Degrees F, 10 MPH Avg. Speed**
***Source:* U.S. Environmental Protection Agency, 1987**

FIGURE 2 Carbon monoxide trends.

occurring in Antarctica. This summer's heat wave and drought brought almost daily reporting of the so-called greenhouse effect resulting from overall global warming, the role of fossil fuels, and the potentially long-term adverse impacts associated with this temperature increase.

Transportation and Acid Rain

Acid rain is commonly thought of as primarily an industrial problem, associated in particular with coal-fired power plants. Transportation sources, however, play an important contributing role. Transportation emissions important to acid rain include hydrocarbons, nitrogen oxides, and sulfur dioxide. The relationship to acid rain is that the presence of ozone and other oxidants in the air contributes to converting the precursor sulfur dioxide and nitrogen oxide emissions to sulfuric and nitric acids. The congressionally established National Acid Precipitation Assessment Program (NAPAP) estimates for 1980 indicate that of the total estimated U.S. NO_x emissions of 20.7 million metric tons, highway vehicles contributed 7.2 million metric tons, or 34.8 percent; nonhighway transportation sources produced 2.0 million metric tons, or 9.6 percent (*3*). Transportation is by far the largest single source of volatile organic compound (VOC) emissions, producing 8.2 million metric tons, or 38 percent, of the estimated 1980 U.S. man-made total of 21.4 million metric tons. (The next largest contributor, industrial processes other than surface coating, produced 3.9 million metric tons of VOC emissions in 1980.) Proposed acid rain legislation is beginning to recognize the contribution of transportation sources. In a bill jointly developed by officials of New York and Ohio, reductions would be required from mobile sources of pollution as well as from electric utilities.

Legislative Discussions

Acid rain legislation is just one element, however, of the larger discussion of federal air quality policy that will be taking place over the coming months and years. The Clean Air Act amendments of 1977 established a date of December 31, 1987, for attainment of the ambient air quality standards. Provisions of the act were extended, as an interim action, until August 31, 1988, when Congress was unable to agree on a comprehensive extension. It is beyond the scope of this paper to summarize provisions of each of the several legislative proposals that have been made and that are now under consideration. It is sufficient to report that both Senate and House bills, as well as proposed EPA policy, continue to assign an important role to transportation control measures (*2*). The Senate bill does not prescribe specific TCMs but defines eight categories of TCMs as reasonably available and requires "consideration" of these types of transportation actions. In particular, transportation measures would be used to offset the emissions associated with growth in vehicle miles of travel. Legislation under consideration in the House also would encourage the use of TCMs, with one proposal authorizing the EPA Administrator to impose a fee on gasoline and diesel fuel of up to 5 cents per gallon in severe nonattainment areas in order to cover up to 50 percent of the cost of TCM implementation.

A comprehensive post-1987 ozone and carbon monoxide policy has been proposed by EPA for areas not attaining national ambient air quality standards (*4*). Designated nonattainment areas would be required to submit a revised state implementation plan (SIP) demonstrating a minimum average annual emissions reduction of 3 percent starting in 1988 from a baseline emissions inventory and accounting for any emissions increases projected to occur because of growth. The proposed policy states (*4*):

> The EPA believes that many metropolitan areas will, of necessity, evaluate and select for the control strategy, transportation measures capable of offsetting the effects of such growth in the future to the extent necessary to provide for attainment and maintenance, and to meet the required rate of progress.

Appendix C of the EPA policy defines 10 categories of TCMs, which were listed earlier, that have proven, in EPA's judgment, to be effective in achieving emissions reductions and demonstrating expeditious attainment of air quality standards. In addition, EPA Administrator Lee Thomas announced in May

1988 that the agency is considering the extension of air quality controls to nonpolluted suburban areas if such areas are known to contribute to carbon monoxide or ozone violations in downwind urban areas.

The proposed post-1987 EPA policy would also reinforce the Section 176(c) conformity provisions of the Clean Air Act amendments of 1977. This provision requires

> federally approved or financially assisted actions (projects, plans, approvals, assistance, etc.) to conform to the SIP's for the areas in which those actions will take place. Metropolitan Planning Organizations (MPO's) are prohibited from approving any project, program, or plan that does not conform to the SIP for that area.

Achieving this level of conformity would require a much higher level of cooperation between transportation and air quality decision makers than typically has occurred in the past. Actions by the U.S. Department of Transportation (DOT) were temporarily exempted from the conformity requirement because of an inability to resolve the long-running disagreement between FHWA and EPA on how conformity should be defined. Mutually satisfactory resolution of this disagreement is important in the long run, because it is unlikely that the actions of one particular federal agency will be exempt from this important requirement on a permanent basis.

Any discussion of the relationship between transportation and air quality would be incomplete without at least some mention of sanctions and court cases. The November 1987 proposed EPA policy would continue the penalties of construction bans and highway sanctions for designated nonattainment areas having inadequate SIPs. Sanction provisions in both the Senate and House versions of proposed Clean Air Act amendments are stronger than the corresponding provisions in the 1977 amendments. Criteria for application are broadened, and sanctions could be applied statewide.

There also is evidence that lawsuits based on the Clean Air Act may play a more important role in the future than they have in the past for those urban areas that have been slow in implementing reasonable measures toward attaining the national ambient air quality standards. For example, the Arizona Center for Law in the Public Interest, acting on behalf of six plaintiffs, has filed a lawsuit against the EPA, DOT, the Arizona Department of Health Services, the Governor and state of Arizona, the cities of Phoenix and Tucson, and Pima County, charging noncompliance with various provisions of the Clean Air Act. Similar lawsuits may be filed in California, New York, and Illinois, where environmental groups have concluded that transportation agencies are failing to comply with provisions of the Clean Air Act. Litigation is seen as a mechanism for obtaining action, in particular the implementation of TCMs of the sort identified earlier.

In assessing what needs to be done in the future, it is interesting to go back and examine a 1975 Massachusetts Institute of Technology assessment of the transportation control planning process (5). Of the 10 major problems identified, significant progress has been made on all but one. The single deficiency is the failure of relevant air quality and transportation institutions to adapt to each other, "resulting in inefficient use of resources and lost opportunities." After a period of meaningful progress during the 1970s, there has been a deterioration during the 1980s in both the willingness and the ability of transportation and air quality agencies to work cooperatively. As a result, there is an increased willingness on the part of air quality agencies to step in as the lead agency for important transportation initiatives, as shown by the Voluntary No Drive Day Better Air Campaign of the Colorado Department of Health and the Regulation XV trip-reduction ordinance of the South Coast Air Quality Management District (Los Angeles). There is also a hardening of a construction-versus-regulation attitude—a relationship that was unsuccessful in the early 1970s and is unlikely to be any more successful in 2020. What is needed is a softening of positions on both sides, a mutual recognition of the significant progress that has been made in the last 20 years, and a joint resolution to work together in understanding and addressing the mobility and environmental problems that result from the significant restructuring of population and employment patterns that is now occurring.

Relationships Among Transportation, Land Use, and Economic Development

Land use and economic development changes are potentially important environmental impacts of transportation investments. The effects of past transportation investments are often apparent in today's development patterns; the compact arrangements and high densities of older central business districts in many cases reflect the organizing effect of rail transit stations, just as many of the emerging suburban "downtowns" reflect the access advantage provided by location at the intersection of major highways.

Too often, however, examples such as these become evidence that transportation investments will induce land development and economic growth and strongly influence its nature. The reality is that these relationships are considerably more complex. They are functions of several interacting social, economic, and geographic factors, none of which is perfectly understood. The lack of clarity of the relationships is perhaps best illustrated by the also-frequent claim that transportation projects will have no significant growth-inducing effects. Depending on the political expediency of the moment, potential land use and economic development impacts resulting from an investment in transportation infrastructure may be either seriously understated or grossly exaggerated.

Meanwhile, local governments are working with both community residents and private business on smaller-scale undertakings, attempting to coordinate land development and transportation. Efforts are being made to manage the transportation impacts of new development through detailed and extensive site planning, requirements for developer-provided transportation facilities and services, and demand management. At least on a localized level, these efforts may substantially alter the nature of the transportation facilities and services being provided, as well as their impacts.

Over the next 30 years, transportation, land use, and economic development relationships seem likely to receive more attention on both the local and state scales than they have in the recent past. The directions taken have considerable potential for significant social, economic, and environmental impact, and thus should be assessed carefully in a 2020 program. The reaction to growth, and the consequent increase in traffic volumes and decrease in perceived environmental quality, is too often a call for a policy of no-growth. Such absolute restrictions, however, have proven to have their own set of problems. The result is a search for a balanced growth management process, a search that can be greatly facilitated by a 2020 transportation program appropriately sensitive to local and regional land use concerns.

Local Land Use Management

Local government action in controlling the use of land traditionally has been an anathema in most areas of the United States. Yet an increasing number of local governments are now turning to their land regulation and development approval powers to control transportation finance and traffic impacts. A variety of approaches are being used, suggesting a new willingness to regulate development in order to preserve or obtain desired community benefits.

Whether these approaches will make a significant difference over the long run remains to be seen. The potential seems to be there for opening up new opportunities and new ways of managing transportation's impacts. They help to formalize private-sector participation, maintain equity by treating all participants alike, and respect both public- and private-sector needs. The various approaches are not without pitfalls, however. Further discussion and monitoring are in order.

Site Design Criteria Site design criteria are increasingly being employed in both downtowns and suburban settings to facilitate the use of commuting alternatives and reduce the need for automobile trips. Coupled with detailed subdivision and zoning provisions governing the mix and density of uses and their placement on parcels, these criteria aim to ensure convenience for nondrivers or those who do not wish to drive. Such elements as building clustering, preferential parking, and sheltered loading zones for rideshare and transit vehicles, and on-site services and amenities such as restaurants, bank outlets, child care, and exercise facilities may be included.

Site design criteria for the Parkway Center development in Dallas are typical (*6*). Mixed-use development is being actively encouraged so that there is "a true synergistic or interacting mix of commercial, residential and institutional uses rather than the 'multi-use' approach of various different land-uses occurring in the same general area but not physically integrated." A system of parkways and linear parks will serve as the core of an open-space plan linking the built areas. Detailed criteria on building placement, parking design, and site circulation have been established. The overall goal of these actions is to encourage a development pattern that can be served by transit as well as by automobiles. The project sponsors believe that this will also help develop a positive image for the Parkway Center area and increase its locational and economic competitiveness.

Developer Provision of Infrastructure Requirements for developer provision of transportation infrastructure are increasingly being integrated into local-government development approval processes. Among the devices being used to accomplish this are subdivision and zoning requirements for on-site, developer-provided streets and arterials, traffic signals, bike paths, and sidewalks; exactions and impact fees for off-site transportation improvements, including road widenings, intersection channelization, signal installation, and signal system retiming; and adequate public facilities ordinances that tie the approval and timing of development to the availability of acceptable public infrastructure and services through out the affected area.

These mostly supply-oriented strategies are largely intended to place the cost of transportation improvements more directly on the private sector. Because of their financial benefits, these strategies have come to be widely used, particularly in areas experiencing rapid growth. In increasing the costs of development, however, these mechanisms have the potential to change land values, development costs, and the prices of housing and commercial space. In some areas there is concern that they are in fact pricing out low- and moderate-income families and support-office functions. Indeed, only relatively affluent communities have found it politically feasible to pursue these strategies aggressively; less favored communities often fear that they will drive away needed development.

Trip Reduction Trip reduction is a demand-oriented approach to traffic management that is being increasingly utilized to manage the transportation impacts associated with commercial (primarily office) activities. Under a trip-reduction program, developers or employers within a designated geographic area are expected to reduce (or at least to attempt to reduce) vehicle travel. The geographic area of concern may be a particular parcel or site, a town or city, or an entire urban area.

Ordinances requiring trip reduction now exist in California, Washington, Virginia, New Jersey, New York, and Florida, and are under consideration in many other areas of the country. Actually, an ordinance is but one form that a trip reduction effort may take. Voluntary programs—agreements that are individually negotiated with key employers, requirements incorporated into environmental or "adequate facility" regulations, and requirements imposed only if special treatment such as rezoning for higher density is sought—are also common. Further, the programs may apply either to new developments only or to existing ones as well, may be triggered by different levels of employment or building size, and may incorporate a fee structure as well as trip-reduction actions. Frequently a private-public transportation management partnership organization (TMO or TMA) is established to help manage the particular mix of transportation strategies being employed.

Regulation XV, adopted in December 1987 by the South Coast Air Quality Management District (Los Angeles), typifies the kinds of trip-reduction efforts that are being sought (*7*). Under this regulation, all employers having 100 or more persons at any work site will be required to implement trip-reduction programs designed to achieve specified peak-period (6:00 a.m. to 10:00 a.m.) target levels of average vehicle ridership (AVR). These target AVR levels vary by location, being highest in the central city and lowest in suburban locations. Measures taken by an employer may include preferential treatment for high-occupancy vehicles, public transportation incentives, alternative work schedules, and use of telecommunications. Annual monitoring and plan updating will be required, together with a provision for the imposition of penalties.

State Economic Development

In developing a 2020 transportation program, it also is necessary to understand the potential macroeconomic development impacts of proposed projects and programs.

At the state and regional levels, there is strong interest in using transportation investments to promote economic development objectives, and major new initiatives are being undertaken in states as diverse as Massachusetts, California, Wisconsin, Texas, New Jersey, and Florida. The extent to which the projects implemented under those initiatives will produce results will undoubtedly depend on the specifics of each case. Local communities and businesses often place a great deal of importance on the role of highway improvements as an economic development catalyst. However, a state must also consider the opportunity costs of such investments, and must examine the trade-offs between maximizing total statewide benefits and benefits to a specific corridor or substate area.

It is no easy matter to properly assess the economic development impacts of large-scale transportation investments such as highways. Rigorous economic analysis is required to address and clarify such issues as the following:

- What is the real long-term economic development potential in the corridor with and without the proposed highway improvements?
- What subareas will receive the most benefit from highway investments and what communities may be negatively affected because of shifts in economic activity or access restrictions to a major regional facility?
- How much of the economic benefit in the corridor is a net gain for the state as a whole, and how much of the benefit represents a shift from elsewhere in the state?
- How much of the economic benefit accrues directly to users of the facility and how much is due to growth in economic activity?
- What existing businesses might be lost or decline if major access improvements are not made?
- What new business might be attracted because of major highway improvements?

Various methods ranging from input-output analysis to survey research have been used to assess these issues, and research on the issues continues. In practice, though, poorly defined economic evaluation approaches are easy to find. They include

- Facility studies that claim all economic activity occurring in the vicinity of the facility as a benefit,
- Urban rail studies that have used the cost of clearly infeasible alternatives (from both engineering and economic perspectives) as demonstration of the merits of a "lower-cost" approach,
- Infrastructure needs studies that assume away the problem by simply applying standards without any attempt to measure the benefits of those standards,
- A variety of approaches that do not distinguish between new and shifted economic benefits or simply double count benefits in particular categories (e.g., increased sales, lower business costs, increased incomes), and

- Studies that do not consider "sunk costs" as just that, that is, costs no longer relevant in evaluating the benefits of further expenditures.

The list could go on, but the point is simple; a careful economic analysis is needed to provide the information required by decision makers and to establish credibility for the recommended actions.

Findings from research illustrate the complexity of the matter. Two primary types of literature address the relationship between highways and economic development—that on transportation economics and that on regional planning and business location. In both types of studies, there has been difficulty in identifying the specific contributions that transportation improvements actually make to regional economic growth. This has particularly been a problem for before-and-after studies, in which it is difficult to distinguish the role of exogenous factors. The few economic evaluations that have attempted to be rigorous—for example, by using cross-sectional as well as time-series data—have found modest direct effects, in part due to narrowly defined impact measures. In addition, the scale of the project undoubtedly affects the level of economic impact. Localized improvements are likely to merely shift economic advantage within the region; only very large-scale projects offering a substantial improvement in overall transportation conditions offer much potential for net regional growth.

Overall, most investigators have concluded that transportation access is only one of several factors affecting potential regional development. Case studies in the literature, and the authors' experience, provide numerous illustrations of these points. For example, the recent completion of an Interstate highway through a depressed area of Massachusetts has directly contributed to substantial new high-technology industrial development in that area. However, the availability of a well-trained and sizable labor force, proximity to a major metropolitan area, aggressive marketing, and available building space all contributed to the successful development of the area. As a counterexample, a community in New York State built an industrial park adjacent to a highway interchange, anticipating that the highway location would be sufficient to attract new businesses. However, the park has been unable to fill their facilities. An unfocused marketing strategy and an unskilled labor force appear to have kept the region unattractive to businesses despite the highway access.

Surveys of businesses rating the importance of various factors in their location decisions are another source of evidence, although there is skepticism about the results because of a tendency for businesses to emphasize the factors discussed in negotiations with public agencies (taxes, regulation, public investment). In general, transportation ranks in the top 10 items in these surveys but rarely is a decisive or overriding factor. Interesting insights may also be gleaned from a recently published survey (*8*). Over 500 development officials were asked to identify the reasons why firms that had considered locating in their service areas ultimately decided to locate elsewhere. Characteristics of competing sites mentioned most frequently were availability of buildings (59 percent), incentives offered (30 percent), and better market access (17 percent). Superior highway access at the competition's site was a major contributing factor in 15 percent of the cases, ahead of access to suppliers (14 percent), lower labor costs (11 percent), and better air service (7 percent). It is noteworthy that respondents in smaller population centers were more likely than those in metropolitan or urban areas to name access to an Interstate highway as a major advantage of their competitor's.

The lesson is that the economic development potential of transportation investments cannot be assessed by an analysis that considers only the degree of transportation improvement. It is also necessary to assess whether other critical conditions are present, so that the business attraction potential created by the proposed highway improvements can be utilized effectively. This requires an evaluation of the region's assets and liabilities with regard to labor force characteristics, industrial mix, regional "image," and existing economic development assistance available to businesses. In many cases, in order to take advantage of the economic development opportunities created by the highway improvements, funds must first be spent to improve supporting economic development programs. This would effectively increase the total costs associated with the highway improvements necessary in order to realize the full potential economic benefits.

It also is critical to understand that transportation improvements can have a negative impact on individual businesses and communities. Local markets can become more accessible to penetration by competing outside firms. The upgrading of a road might bypass some town centers and eliminate some at-grade intersections, significantly reducing revenues to existing small businesses. Entire communities located near a limited-access highway but some distance from a new interchange might not gain any economic benefit (travel-related or other) from the highway improvement. In fact, they might find themselves at a competitive disadvantage because they have lost business formerly generated by through traffic. Economic growth may simply be shifted to communities directly served by the facility. These factors also need to be considered by decision makers.

Figure 3 shows the approach being used to estimate potential year 2020 economic development impacts of upgrading a 250-mi east-west transportation corridor in north central Wisconsin that connects Green Bay to the Minneapolis-St. Paul, Minnesota, area (*9*). The approach consists of three key elements:

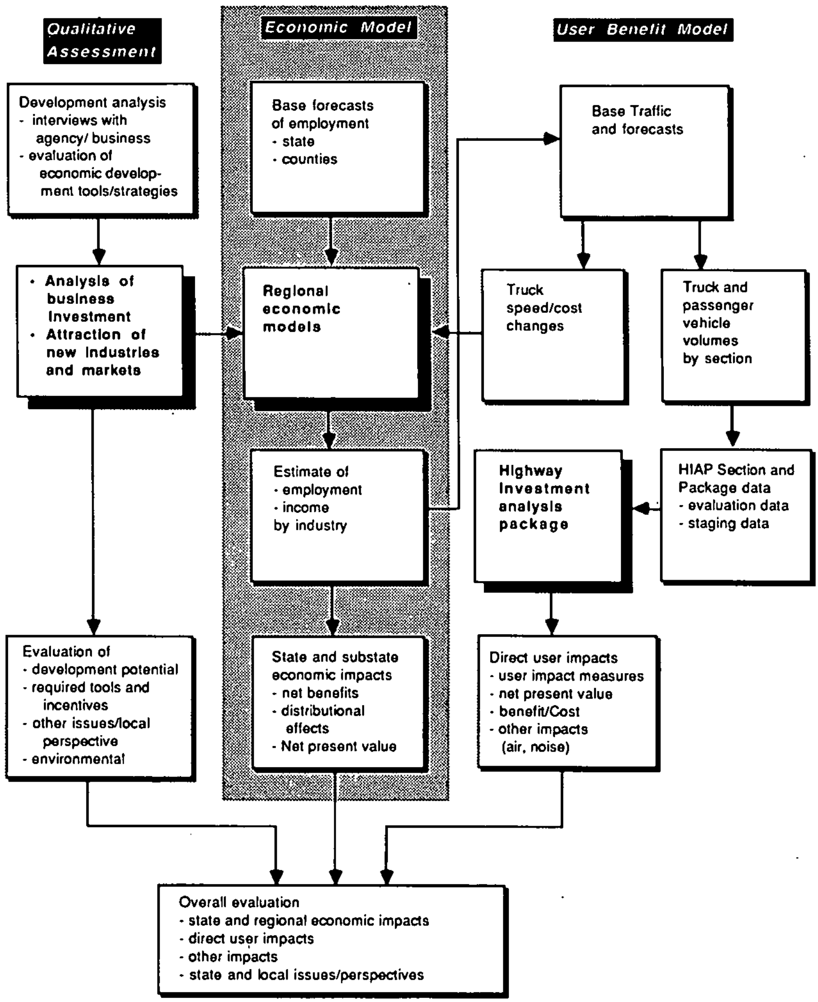


FIGURE 3 Wisconsin Highway 29/45 Corridor Study—overview of economic analysis methodology.

• Analysis of business attraction and new markets and other qualitative issues through an evaluation of the existing industrial-business mix, analysis of development strategies and incentives, and interviews and surveys conducted at the state and regional levels;

• Economic growth benefits estimated at the state, regional, and subregional levels using a statewide economic input-output forecasting and simulation model; and

- Direct user benefits analysis based on traffic forecasts.

The combined results of this analysis provide the basis for a comprehensive evaluation of the potential economic benefits of major transportation improvements in the corridor.

Although the focus of this particular effort is on a quantitative economic impact analysis, the study process has also had a major public involvement program to provide opportunity for public input to the technical tasks and discussion of the results. It is recognized that a positive net economic benefit from improvements in the highway corridor alone may not justify commitment of the resources required; the potential benefits from other projects or programs must also be weighed in a final decision along with impacts that do not lend themselves to formal economic analysis. Similarly, a negative net economic impact does not necessarily mean that an investment in corridor-wide improvements is not justified. However, in that case, the existence of other positive impacts, including equity or distributional objectives, would be required.

The Wisconsin work reveals the complexity of carrying out a sound regional economic analysis of a transportation investment. Overall, it is critical to distinguish economic shifts—from one business to another or from one community to another—from real economic growth. Many of transportation's impacts on economic development are of the first type. Yet it should also be noted that large-scale improvements can have a reorganizing impact, allowing new ways of doing business and even new businesses to emerge. These larger, longer-term effects are only partially understood and need further research.

Conclusions

Environmental considerations are often viewed as constraints on the planning and delivery of transportation projects. The authors conclude, however, that sustained economic growth and prosperity are not possible without environmental quality. Thus a change in approach is called for: rather than treating environmental considerations as limitations on what transportation can do, environmental enhancements should become a central objective of transportation planning and project development and a common sense element of good planning and engineering practice.

Current practices serve neither the environment nor transportation well. EISs are often too perfunctory, too reactive, and too late in the project development process to offer substantive guidance to decision makers. Regulatory reforms could help focus the statements on the serious issues at hand, encourage meaningful program-level environmental analyses, speed up the overall process, provide better information, and allow for more meaningful and constructive community involvement. But more fundamental issues need to be addressed as well. The inadequacies of the existing EIS process in large part reflect broader limitations imposed by the current structure of transportation planning and finance.

Transportation continues to be an important source of air pollution, and although legislative requirements currently are unsettled, it is highly probable that requirements for transportation air quality planning and action will continue. Many of the measures that are needed for cleaner air also serve other important objectives, such as congestion relief, and their overall cost-effectiveness is positive. Nevertheless, relations between transportation and air quality agencies are marked by contentiousness. Both sides need to move toward a recognition of shared interests, and a willingness to work together to provide both mobility and environmental quality.

Transportation, land use, and economic development interrelationships are receiving renewed attention. Local governments are increasingly active in requiring developer-provided transportation facilities and services, in managing land use with an eye to transportation impacts, and in mandating traffic mitigation activities. The long-term effects of these initiatives on transportation finance, land development patterns and practices, and environmental quality appear promising, but still must be proven. At the same time, an increasing number of transportation projects are being justified on the basis of their economic development potential. Too often, these benefits are exaggerated and the hard work needed to realize real economic gains is downplayed. Here, too, more responsible planning and analysis are needed.

Restructuring transportation planning and project development so that the effort responds effectively to social, economic, and environmental objectives rather than being constrained by them will necessitate a rethinking of the way transportation agencies do business. Yet that rethinking must happen anyway. To respond to changing urban, suburban, and intercity mobility needs and a new mix of nationally and locally important priorities, transportation efforts during the next 30 years will involve an increasingly diverse range of project types, a broad range of participants, and an increasing scope of impact considerations. The 2020 program must strive to provide the framework for responding to these changes in a positive manner.

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Respondents' Comments

SARAH LA BELLE These two papers laid out most of the important technical information that we need to consider on these issues. I see the areas of energy and environment as intertwined, because most of transportation's environmental impacts arise directly from energy consumption. I would like to propose four major issues for transportation over the next 30 years that arise from these two areas.

The first is urban air pollution, focusing mainly on carbon monoxide and ozone precursors. I think what we have heard is that transportation cannot hide anymore. The legislators and bureaucrats are going to turn to transportation emissions in total, not just the rate per automobile, since point sources in total have done, not maybe all they can do, but close to all they can do in terms of eliminating air pollutant emissions. That is a change from the last 30 years, most distinctly because the focus of transportation has been on cleaner engines, looking at the per-unit activity, and we have seen that this focus is not going to be enough in the future.

There are hardware solutions, some of which are still ahead. Diesels are going to get a lot of attention in the next 5 to 10 years in terms of technology. EPA is requiring much cleaner diesel engines. We don't have them yet. There has been much argument in the last year as to whether we will have them. But if we are technology optimists today, then of course we will have them in about 5 years.

There are still some improvements to be made in gasoline. In terms of future technology, networks and signalization are also ways to use technology to improve urban air pollution.

There are also demand solutions with regard to urban air pollution. They are very controversial. They have been used with some success in a few cities, but

Sarah La Belle is Superintendent for Marketing and Research with the Chicago Transit Authority. Before assuming this position, she was an environmental systems engineer in the Center for Transportation Research at Argonne National Laboratory.

in general they have been widely ignored. I would propose that if a significant share of the travel growth that we have been seeing and that has been documented here is in discretionary travel, which is the name for trips except the journey to work, that is soft demand, and there is a lot of room for management there. I would also think that there is a lot of room for responses to future price shocks because we are at least as soft in that sense as we were in the 1970s.

The second major issue is global pollutants—acid rain and carbon dioxide, and the greenhouse effect belong in that area. It is hard to see for sure if that is going to hit us in 30 years, but we had better be ready for it. There is a developing consensus among scientists and environmentalists that this is a real problem and that we know what the causes of the problem are.

If that is true, transportation burning fossil fuels exclusively is one big piece of the problem. Reading what I read and hearing the talks today, I don't see that with the current system happily chugging along on petroleum, we would be able to do anything about the greenhouse effect. It would require a complete switch in fuel to something that doesn't use carbon, which narrows things down considerably to hydrogen or electricity produced from photovoltaic sources or other noncarbon fuels. That is not a minor issue; those are big changes. You might say that technological miracles would be required to make such a switch possible. Travel reductions probably have nothing to do with addressing this issue, because the problem is just the presence of carbon itself, and travel reductions just can't get the level of carbon to an acceptable level because the only acceptable level is none.

The third issue has to do with the cost of transportation. I propose that right now we aren't charging users the full cost of transportation, and taxing fuel is one of the simplest ways to do that. I see that to meet the requirements for environmental quality and energy security, we have to have some financial resources. Pricing can help in that, and it may also manage travel demand somewhat if we don't assume that prices will be forever low.

It was noted by Greene et al. that the last increase we had in fuel taxes at the federal level was extremely painful and makes politicians afraid to try again. States, however, are having to wade into that area regardless, because they are running out of funds. So we may find out in the next few years whether it is indeed impossible.

I bring up at this point the conflict alluded to by Greene et al. between the total optimism on the adequacy of the fuel supply to 2020 versus the uncertainties, the price shock, the likelihood that supply might disappear at any time because of political actions of the supplier nations, who are different from the consumer nations. I believe that it makes a big difference which of those viewpoints we take. If we are in a situation of readily available fuel, so that we can just keep on going the way we have been going, then I think the proper focus for the next 30 years is building highways and rail lines as fast as we can in the suburbs to supply the capacity that is needed in those areas—that would be our sole goal within other constraints.

However, if we really think that there are going to be price checks, I don't think that they are that easily adjusted to and I think we would have to take some aggressive action to ensure the availability of those technologies that are supposed to be waiting in the wings to make us able to respond, or perhaps even make sure that they are out there ahead of the problem. Maybe it is the economist versus the engineer. Knowing the solution is nowhere near implementing the solution.

The last issue that I see is the lack of regional leadership. By regions I don't mean what we talked about this morning, the four parts of the country; I mean states and metropolitan planning organizations.

Many cities, that is, central cities and suburban cities, believe that there is nothing to be done at their level to address energy or environmental issues affected by transportation. They see their major focus as supplying capacity, building parking spaces. You could call that just short-run responses to developer and commercial and retail pressures.

I think they can do something and they are a part of this issue most essentially. Suhrbier and Deakin talked about this lack of coordination among levels of government mainly by focusing on the environmental impact statement (EIS) process, but addressing the air quality issues requires working together to manage transportation supply and perhaps demand. These are big policy decisions for big geographical areas, which require cooperation within the public sector. To get private-sector cooperation, the public sector will have to have more of a unified consistent set of policies across multiple levels of government.

Energy issues face the same problem; the energy is always consumed at the local level, and energy affects local governments quite differently than at the national level. The issues are more like safe distribution of the fuel system.

The methanol issue was discussed quite well. Whether use of methanol would be allowed is a very local issue. Experiments in methanol fuel in the city of Chicago, for example, are expected to be very difficult to undertake because of the extremely tight rules regarding fuel storage; the fire department is the maintainer of those rules and they are a very powerful group.

Thus, in summary, it is very difficult for local governments to embrace the regional perspective that is needed to make these solutions. They need to think about long-term consequences. It is important to have appropriate national policy thrusts to help local governments through problems that they have to solve. After hearing how in Phoenix, Arizona, they are boldly going ahead with experiments to sell methanol fuel and do everything they can to meet the clean air standards that their city now fails to meet, Chicago is also failing to meet those same clean air standards. The Planning Commission, often a source of controls, is considering changing downtown parking rules tied to zoning, as are many other cities at this time. They are right in the middle of this process and I had the opportunity to listen to some of their debates.

They heard very thoroughly and completely what the air pollution issues are and how Chicago is one of the areas that are in big trouble. Yet they are still talking about parking policies in the central business district and the balance between transit and automobiles in that area, because that is critically affected by the number of parking spaces. Although they are willing to go so far as to say that they want to have standards that maintain the current transit split and they are extremely happy that transit buses will be required to clean up their emissions over the next decade, they are unwilling to see that there is anything they can do that will affect air pollution. All that they can do is to continue to specify the right number of parking spaces for economic development, the major goal. The degree of contrast is enormous.

CHARLES A. LAVE I am not an expert on EIS reports, and I have never been a city planner, but, even so, it strikes me that there are some insights into these problems that are possible if we will take the perspective of "public choice," one of the subfields of economics.

The discipline of public choice addresses one simple question: Why does Congress pass bad laws? For example, why does it appropriate funds for tobacco price supports, water projects in the Arizona desert, or a heavy rail transit system in Los Angeles, my hometown?

The economists' answer to this question is pretty simple: look at it from the point of view of individual rationality. The gains from these projects may be small but those gains are highly concentrated, whereas the costs of the projects, though large, are quite diffuse. Hence dairyman Jones, faced with the gain of a $20,000 milk subsidy, can rationally spend a lot of his time and resources backing that law, whereas taxpayer Smith, faced with a tax increase of 10 cents to pay for the milk subsidy, doesn't find it worthwhile to spend his time and energy opposing the law.

Jones and Smith are simply behaving in an individually rational way. Now, let's try that same perspective on the EIS/legal suit/planning mess. It embodies the same kind of problem: a transportation improvement project that provides

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Charles A. Lave is Professor of Economics at the University of California, Irvine, and past chairman of the Economics Department. He has served as a research analyst with Charles River Associates, and as a consultant for Oak Ridge National Laboratories.

diffuse benefits for an entire region can be shot down or delayed interminably by the small group of people who will be harmed by the project if they utilize the variety of lawsuits and legal actions that are possible to them.

In a way, it is a story of minority rights run amok, an "Alice in Wonderland" legal system: no one can be harmed but nothing can get done. Many of the problems discussed by Deakin and Suhrbier seem inherent in the very process by which we have enfranchised minority interest groups, and I see no solution.

Greene et al. take on a problem that is solvable. Given the problem of a long-term shortage of transportation fuels, what might we do about it? How can we deal with it? Other authors might have suggested promotion of public transit as a solution to the energy problem, but Greene et al. are smarter than that. They know that you can't easily get people out of their automobiles. Instead, they suggest that one of the things we might do is to increase automobile efficiency. Within their behavioral perspective and mine, that is an entirely sensible solution because what we are doing is presenting consumers with a product (the energy-efficient car) that does the job we want done without asking the consumer to make any of those difficult changes that we know they are so reluctant to make.

Greene et al. also suggest that we should be promoting alternative fuels as possible replacements for the fuels we now have. And again, within the behavioral perspective that they have brought to this problem, they are looking at alternative fuels that don't require much change from consumers. Instead of promoting electric cars, which would require substantial behavioral changes, they are promoting methanol, a fuel that consumers can, essentially, treat the same as gasoline, so it's much more likely to be adopted.

Their paper does raise one paradox, at least it seems to me as an economist that it is a paradox. They point out that miles per gallon for the new car fleet is the same in the United States as it is in Europe. That is to say, Americans and Europeans buy cars with similar fuel efficiency but, and here is the paradox, European fuel prices are two to three times as high as American fuel prices. Thus, gasoline prices don't seem to be influencing consumer choice in the car-purchase decision. That is to say, price does not matter. Well, as a card-carrying economist, these are fighting words.

Let me try an alternative explanation, distorting some of their data, I must admit. They list prices of gasoline over time. If we look at the price changes from 1978 to roughly 1984 or 1985, in Europe versus the United States, we can see that European fuel prices have been essentially constant over that time. Some of the European countries have been completely constant; some had very slight rises. Meanwhile, U.S. fuel prices have doubled over the same period.

Thus my explanation of the paradox: Suppose that new cars are durable goods, and when you go to buy a new car, you are concerned about what that car is going to do for you over its entire lifetime. Knowing that you are going to have that car for a long time, you choose a car on the basis of your expectations about fuel prices over the entire time that you will own the car, not on the basis of today's fuel prices. Given the very different experience of American and European consumers—big price increase here versus stability there—it then seems to be entirely reasonable to expect that U.S. consumers will be anticipating future fuel price increases and hence choose more efficient vehicles today than you would otherwise get if you just looked only at current prices.

The overall conclusions of Greene et al. seem quite correct to me. What they are basically saying is that travel in 2020 is going to look like travel in 1988. They say automobiles are going to continue to dominate personal travel, that trucks are going to continue to dominate freight, that air travel is going to continue to expand. They say that we are going to be in the midst of some kind of gradual transition to alternative fuels, probably methanol. I agree with all of that.

I want to close in a kind of uncharacteristically cheerful manner for me. I am going to point out some good news about our environmental problems. I have just returned from London, a city with great theaters, operas, orchestras, and museums. But in this intensely civilized place, if you walk along the streets, you will be assaulted by automobile pollution and noise. The reason for this awful stink and roar is that England is still running on 1960s automobile technology. That's the baseline we started from in the United States, before all those government regulations set out to improve our environment. We have forgotten how bad things were, and have become spoiled by the clean exhausts and low noise of 1980s U.S. automobile technology.

In fact, a visit to any European city will give you some perspective on how much we have accomplished. We have, come a long, long way toward civilizing the automobile. And, at a conference like this, which naturally tends to focus on problems, we would do well to remember that we have some real achievements as well.

Paul Biggers I am limiting my comments to the paper by Suhrbier and Deakin, primarily because it addresses subjects with which I am most familiar.

Paul Biggers is Chief of Environment with the Illinois Department of Transportation. He is a career employee; in 25 years he has held many positions within the department.

The first thing that caught my attention is the statement that environmental enhancements should be a central objective of transportation planning and project development. The transportation industry is not yet prepared for such aproposal, in effect, using transportation funds for environmental enhancement. With funding for transportation severely limited, my engineer colleagues would say, "Let the environmentalists use their own money." Perhaps more important, I wonder how many transportation departments throughout the United States have environmental enhancement stated as part of their mission.

Environmental considerations in transportation have come a long way from the days when we began developing the Interstate system—when we drew a line on a map and let the interchanges fall where they may. Those days are over, in large part because of the environmental controls that have come along, one of which is public involvement. Public involvement is the heart of the environmental impact statement process. It is how we get at the planning issues that are otherwise very difficult to capture.

In Illinois great strides have been made in environmental considerations. However, one thing that we have been unable to do effectively is to develop an environmental impact statement process at the program level. A major reason for that is our programmers have been unable to develop a lasting statewide transportation plan.

If you have been involved in transportation planning, you are aware that funding doesn't come in a steady stream. It comes in spurts. And the people who appropriate those funds work in a political arena. So those who develop the plans and those who provide the funds do not necessarily have the same agenda. There are complex external forces that act on the environmental impact statement process.

I agree with the authors' conclusions that more detailed analyses are necessary, because impacts are often more complex than they seem. Everyone knows the hot environmental issues of the day—disposing of waste, for example. There are many environmental issues—hazardous and solid wastes are not new problems, but they are somewhat new to the transportation industry. There are other, older issues that just won't go away, for instance air quality and noise. The projections you have heard in other papers today tell us that our suburbs are where the major population growth will occur, and the more people in the suburbs, the more complex the air pollution and noise.

Suhrbier and Deakin recognize the root of many of the problems. To quote, "The inadequacies of the existing EIS process in large part reflect broader limitations imposed by the current structure of transportation planning and finance." These limitations have a direct effect on the environmental impact statement process.

Today, the EIS process doesn't work well at the program level. We have tried it with some moderate success, but it is very difficult when you are guessing at what your annual and multiple-year programs will actually be. Suhrbier and Deakin say, "Restructuring transportation planning and project development so that the effort responds effectively to socio-economic and environmental objectives rather than be constrained by them will necessitate a rethinking of the way transportation agencies do business." I think they are correct, but the statement has broad implications.

If, in the future, we are charged with incorporating environmental objectives into transportation planning, we will need to revise our institutions—and I am including my own department. We are not structured in a way to deal effectively with such an approach. Because planning needs to be done at the local level, incorporating such objectives into a state transportation agency's operation won't be easy.

Transportation agencies are not the only institutions subject to needed change. Our political institutions will need to rethink the process of financial arrangements. Are transportation agencies, indeed, going to fund environmental enhancement? Will motor fuel taxes be the source of such funds? And other institutions? Are consultants who design our mass transit systems and contractors who build our highways going to have the needed skills and equipment? I think the bottom line is that our institutions, including the transportation industry in general, will need to adapt to environmental challenges. I am not sure how these adaptations can be realized. The authors have done an excellent job showing us where the problems lie and what the future needs will be.

THEODORE J. HACKWORTH The general conclusion I reached from the paper by Greene et al. is that we can and will find an accommodating way to ameliorate future energy problems through greater vehicle efficiencies and/or alternative combustive fuels. Therefore, any investment we make in transportation systems can be utilized without any significant dislocation because of future energy problems. Further, energy is not a deterrent to transportation infrastructure investment. Specifically, with respect to the imperatives for vehicle efficiencies and alternative fuels, we do need to consider the threat of economic dislocations, pollution, energy, security, and global warming.

Theordore J. Hackworth is a member of the City Council of the City of Denver. He is a member and past chairman of the Denver Regional Council of Governments. He is also a member of the National Association of Regional Councils and is its incoming president.

I concur with these imperatives. I am concerned, however by the two positions taken in this paper, first, that there is plenty of fuel and the market will control the price, then second, that fuel costs will be too high, even though there is plenty of it.

As a decision maker, I guess what I need to do is to monitor the situation and do nothing if the market controls fuel prices, and if the market fails to control fuel prices, then I need to provide an incentive to accelerate greater vehicle efficiency and alternative fuel use. That sounds easy, doesn't it? That solves the problem; I am not a bad decision maker. But many of you know that if I wait and then try to put money into encouraging the incentives, it will be too late. If I spend the money ahead of time, when we have a serious financial shortfall, I will be criticized for spending money I don't have. As a locally elected official, I hope that any future energy policies are anchored on a sound consensus, not crisis predictions of the outlook for petroleum on non-petroleum-based energy use and its implications.

I agree with the general conclusions by Suhrbier and Deakin that sustained economic growth and the transportation facilities to accommodate it need to be accomplished with adherence to environmental quality and environmental-quality goals. I agree that the emphasis must be on long-range system planning and how that planning can be accomplished while embracing the regional environmental goals, especially in the area of air quality. And I agree that we must pay more attention to making transportation investment decisions based on costs and benefits, the emphasis on benefits being to enhance and retain the community economic vitality.

I do disagree with some of the statements in this paper, for instance, that candidates will face no-growth mandates. Colorado just went through 12 years of that "do not build transportation facilities so that we will have no growth." Well, let me tell you that Colorado knows that that doesn't work, and even our former Governor admits that that is a bad policy.

I disagree with the position on more complex environmental decisions in the future. But I agree that the EIS process has not been successful in protecting the environment and it is seen negatively by policy makers and the public in general. For this reason, I believe that we will see a more streamlined, meaningful process, as the paper finally suggests. Also, missing from their list of reasons why you make transportation investments in the area of economic development is a very important item to local government officials—local tax generation. I do not know of any major city that doesn't have a money problem. Therefore, it is an important element of the decision-making process.

I also have a problem with the statement about the lack of public involvement, because as a local government official, I believe that I represent the public, and I object strongly to suggestions that I do not represent them when I speak at any kind of hearing.

I disagree with the implications that we must treat environmental objectives as absolutes, and I think we need to look at our environmental regulations and carefully evaluate them.

David Burwell In terms of my areas of agreement with these two papers, I agree that air quality and concerns about acid rain and atmospheric warming will probably be the major environmental constraints on the development of transportation systems in the year 2020. I agree that energy availability will not be a major constraint on transportation use in 2020. And, I agree strongly that many environmental regulatory strategies, particularly those attached to the project development stage, are too late and don't work very well. These include the EIS process, transportation air quality planning, land use planning, and the 3C planning process. For a long time, the environmental community wanted input. Now we realize that we have input, but these processes don't give us much output.

I agree that the economic benefits of transportation improvements are significantly overstated. Meanwhile we are ignoring real transportation problems we need to solve. I think that transportation dollars should be concentrated on solving those problems rather than trying to promote economic boosterism or jobs programs.

In terms of additions or corrections to these papers, I would have liked to have more information on past trends in emissions and why our projections have turned out to be off center. Second, I am skeptical about the statement that sanctions are going to be used more and more. I think that sanctions, while important, have tremendous political problems. It is very difficult to impose sanctions when the costs are specific and the benefits are generalized.

On land use controls, Suhrbier and Deakin suggest that land use controls will play a greater role. I would add a caveat to that. Land use considerations will continue, but land use controls are extremely difficult, particularly in this judicial environment. Property rights advocates, supported by recent Supreme Court cases, say that if you zone and you later are found to have exceeded your authority to zone, you then have to pay damages to the people whose property has not been developed in the interim, requiring compensation for temporary taking of property. I think land use planning, therefore, must be implemented through investment decisions—decisions not to provide

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David Burwell is president of Rails-to-Trails Conservancy, a nonprofit organization in Washington, D.C., that counts 3,000 members in its ranks. He is a member of the TRB Committee on Environmental Issues in Transportation Law.

transportation or sewer improvements and other types of infrastructure improvements as a way of trying to control land use. If this strategy is adopted by local communities, it will have a very significant effect on transportation investment.

Finally, there are other environmental externalities that are not addressed in either of these papers. Ideas such as historic preservation and conservation of community integrity are developing a fast-growing constituency, and there is going to be greater and greater emphasis on preservation of the built as well as the natural environment. Also, all transportation-versus-environment issues do not relate to highways and motor vehicles. My particular organization is concerned about the dismantling of the built rail system in this country. Almost 300,000 mi of rail corridor were constructed in this country; about 140,000 mi remain. These corridors have habitat and historical value. They may very well be needed in the future, if not for rail, for fiber-optics corridors, oil and gas pipelines, and other utilities. We should not be destroying this huge existing transportation system.

There are other significant environmental problems that have not been addressed by either paper, such as leaking underground storage tanks from gas stations. How should we deal with these externalities, air quality and otherwise? Where will the environmental community focus its efforts?

First of all, these problems can't be ignored. A recent federal highway administrator, when faced with community demands to look at these problems, said, "We are civil engineers; we are not social engineers." I think this remark misses the point. The transportation system in this country is already a huge social experiment. The American culture itself is often described with some pride as based on the highway and the love of freedom and mobility. The transportation system we have constructed has tremendous social consequences, and we have to address these consequences, both positive and negative.

There are three primary ways to do it: through regulation, through infrastructure investments, and through taxes. As far as the environmental community is concerned, regulation through the EIS process will be less of a tool to decision making.

The idea of program environmental statements I think is a good one but the question is how to do it. Our concern with program environmental statements is that they tend to be done the same way Congress does budgeting. That is, you adopt the "rosy scenario" and plan everything accordingly, and by the time it comes to look at the consequences you are already in the soup.

I think conformity between air quality planning and transportation planning is still going to be a fight, and land use controls are going to be difficult. Therefore, the environmental community in terms of regulation will focus on strengthening the fuel economy standards and is probably going to propose that passenger and light-truck standards go up to at least 45 mpg and 35 mpg by the year 2000. As pointed out by Greene et al., the benefits of such improvements vastly outweigh the costs in terms of fuel saved and have other ancillary benefits.

In terms of infrastructure, again, let's take care of what we have before we reach for more. Here is an area in which the environmental community and the professional transportation community can develop a strong alliance. To take care of what we've got requires increasing the total transportation spending pie. We have deferred expenses for reconstruction, efficiency improvements, and maintenance and we need to increase them.

I think the attitude in the environmental community 10 to 15 years ago was that the only way to solve our environmental problems was to bust the Highway Trust Fund and stop transportation investment altogether. I think that is not the attitude now. We need to have funds better directed toward maintenance and efficiency improvements, retrofitting some bad projects, and taking better care of the existing system.

In terms of taxes, the proposal floating now in the environmental community is to increase the federal gas tax 10 cents per year until it reaches 50 cents in the mid 1990s. The average price per gallon in the United States was about 90 cents/gal in 1987. In Italy it is \$3.71. In Denmark it is \$3.58, and about 70 percent of that price is tax. In the United States only about 30 percent of the cost of a gallon of gasoline is tax. As pointed out by Greene et al., when the cost of a gallon of gas reaches \$1.50 to \$2.00, fuel efficiency improvements to 35 or 40 mpg become cost efficient as well. Oil prices will probably remain stable for the next several years before they start rising, so now is a good time to impose such a tax.

In conclusion, the environmental and energy externalities of transportation are now widely accepted, as is the importance of addressing these externalities. They will increase in importance as the burning of our fossil fuels and the greenhouse effect become more significant problems. I think that there now is great room for alliances between the environmental community and the professional transportation community to increase total transportation spending, if we can agree on the priorities. The single most significant thing we can do now is to raise the gas tax to 50 cents/gal. Finally, we probably won't do any of this until the events overtake us. I am reminded by the comment made in the middle of the 1979 oil crisis by Senator Dale Bumpers, when environmentalists rebuked him for voting for the Synthetic Fuel Corporation and the Energy Mobilization Board—two proposals that were anathema to the environmental community. We said, "Why did you do this when you are such a good conservationist?" He replied, "Well, my constituents demanded that I do something, even if it was wrong." I think we have to avoid the situation where we have to do something, even if it's wrong.

SESSION 4

Patterns of Future Development

Planning for Urban Sprawl

IRA S. LOWRY

IN 1983 THE UNITED STATES spent about $463 billion for the local movement of goods and people, including the annualized capital cost of roadways and vehicles, current expenses for maintenance and operations, and the expense of administering and policing the system.[1] With such a large sum at stake, even a small improvement in the efficiency of the local transportation system could save substantial amounts of public and private money.

However, "efficiency" does not imply rearranging people's lives to minimize transport costs. Rather it implies a search for a suitable balance between transport costs (including the value of travelers' time) and the costs of compatibly configured land uses. Where people live in relation to their jobs, schools, churches, suppliers of domestic goods and services, places of entertainment, and the homes of friends and how they move among these sites determine the fabric and quality of their daily lives.

As the population grows, as personal wealth increases, as structural and transport technology advances, and as relative resource costs shift, each generation rearranges both land use and travel patterns in a ceaseless search for better lives. Sometimes these rearrangements yield the hoped-for results, but often the actions of individuals each pursuing his own interests lead to unintended outcomes for all. The role of public planning is to anticipate such failures of decentralized decision making and ameliorate them.

This essay reviews recent trends in the pattern of human settlement in the United States as those trends bear on national policies concerning local transportation technology, system design, and infrastructure investment. It offers explicit projections of future settlement patterns by region for urban and

Ira S. Lowry is currently a housing and development consultant in Pacific Palisades, California, heading his own firm. He served as Senior Economist at the Rand Corporation from 1968 to 1987. He has written extensively on urban housing and development issues as well as on transportation.

rural environs, and discursive but less explicit forecasts of the dispersion of residences and work places within urbanized areas and of the general configuration of these areas. These projections and forecasts lead to estimates of local travel modes and volumes in the year 2020.

It is all too easy for both authors and audience to interpret projections and forecasts as "facts" when they are only plausible suppositions. Yet they are valuable insofar as they free the imagination from the assumption that the future will necessarily resemble the recent past. Although the future is unknown, one can usually accommodate the several most plausible trends. From the perspective of transportation planning, the following conclusions from this scenario are the most important for policy makers to keep in mind:

- The United States is emerging from a period of rapid population growth and entering a period of much slower growth. In addition, the population is aging, and the elderly make fewer and shorter local trips than do younger adults. These demographic trends imply less pressure for expanding local transportation facilities than at any time since the 1950s.
- During the next several decades, the populations of the South and West are likely to grow considerably more than the populations of the North Central or northeastern regions of the nation. Although the latter regions may have more problems with decaying transport infrastructure, those problems are unlikely to be greatly exacerbated by growing traffic volumes. The South and West, however, will continue to need expanded capacity for local travel, implying substantial infrastructure investment.
- Within urbanized areas, both residences and work places are dispersing from the classical concentric configuration to a sprawling low-density arrangement that contains a number of local work-place clusters but even more unclustered employment. Home-to-work travel no longer has much radial orientation; work trips are both short and diffuse as to origin and destination. Nearly all work trips are now, and will continue to be, in private vehicles.
- Work trips, which have been the main focus of urban transportation planning, now account for less than a fourth of all local trips and less than a third of local travel mileage. Other local travel—personal or family errands, trips to school or recreation facilities, visiting friends—also depends heavily on private vehicles because in a low-density residential environment, distances are too great for pedestrians and volumes are too low to support public transit (except school buses). The era of the family car has passed; most households now have as many automobiles as licensed drivers.
- The most pressing tasks for local transportation planning over the next 30 years will be to expand capacity and improve traffic management on suburban streets and arterials, especially in the rapidly growing urbanized areas of the

South and West. Yet, however much capacity is expanded, congestion will not be far behind; it is the equilibrating factor that limits travel demand.

URBANIZATION OF AMERICA

The United States is one of a handful of nations that have become highly urbanized without becoming crowded.[2] In 1980, 61 percent of the U.S. population lived in census-designated "urbanized areas" that altogether occupied less than 1.5 percent of the national domain; another 12 percent lived in smaller urban places. Of the nation's 3,137 counties, only 680 were inhabited at densities of 100 persons/mi^2 or greater. There is abundant room for urban growth in this country.

The pattern of urbanization in this country reflects both the settlement of the vast national domain from the initial colonization of the Eastern Seaboard and the shift from an agricultural to an industrial economy. As settlement moved westward across the continent, new towns were seeded along the rivers and railroads; at the intersections of important travel routes; at places where coal, iron, other minerals, and forest products could be mined or harvested for manufacturing; and at locations convenient for transshipping the produce of local agricultural hinterlands.

Many of these towns faded, but others flourished because of their strategic location or fortunate economic specialization. The successful towns were fed by a steady stream of migrants from abroad and from their own rural hinterlands, which in general produced more people by natural increase than could be readily employed in agriculture. Urbanization as a process first becomes conspicuous in the 1840s, when the nation's population grew by 36 percent and the percentage living in urban places grew from 10.8 to 15.3 percent. However, in 1850 there were only 10 cities with more than 50,000 inhabitants and only one (New York) with more than 250,000 (2, Tables 5 and 13).

By 1900, the nation contained 78 cities with more than 50,000 inhabitants, including three with more than 1.0 million, and 40 percent of the nation's population was classified as urban. By 1950, 223 cities had more than 50,000 inhabitants and 5 had more than 1.0 million. Urban residents then accounted for 64 percent of the national total. Finally, in 1980, the decennial census enumerated 463 cities with more than 50,000 inhabitants, 173 with more than 100,000 inhabitants, 22 with more than 500,000, and 6 with more than 1.0 million. Urban residents then accounted for 74 percent of the national total.

As noted, there is plenty of room in the national domain for more cities or for larger cities, but there is considerable evidence that the transformation from a rural to an urban society is virtually complete. For the past century, growth in the population of U.S. cities has stemmed mostly from two sources:

migration from farm to city and immigration from abroad. The mechanization of agriculture has displaced so much of the farm population that there is no longer a substantial flow of farm-to-city migrants.[3] Immigration from abroad still significantly contributes to urban growth, but its impact is focused on a few cities and is small relative to the total urban population.[4] Although the urban population will continue to grow in absolute numbers, its share of the national total seems unlikely to exceed 80 percent for the foreseeable future.

Regional Patterns of Urbanization

Recent trends in the urban and rural populations of the nine census divisions are summarized in Table 1; the constituent states of each division are mapped in Figure 1. Considering first the entries in Table 1 for 1980, note that the urban share of total population varies between divisions from about 56 to 87 percent. The least-urbanized section is the East South Central Division (Kentucky, Tennessee, Mississippi, and Alabama), although rural population densities are higher here than in the vast deserts and ranges of the Mountain Division. The most highly urbanized section of the country is not the Eastern Seaboard, but the Pacific Division (California, Oregon, Washington, Alaska, and Hawaii). Among individual states, the two most urbanized are otherwise very different: California (91 percent urban) and New Jersey (89 percent urban). The least urbanized states are Vermont (33 percent urban) and West Virginia (36 percent urban).

Table 1 also shows rates of growth since 1950 for the urban and rural populations of each census division. Those rates reflect an abrupt shift during the 1970s in the locus of growth from metropolitan counties to nonmetropolitan counties and, as shown in Table 1, from urban to rural places. During the 1950s, the nation's urban population grew 29 percent, whereas its rural population declined slightly. Urban growth subsequently slowed to 20 percent during the 1960s and 12 percent during the 1970s. However, after decades of decline, the rural population suddenly began growing during the 1970s. For the nation as a whole, the urban, rural, and total population all grew at about the same rate during the 1970s.

The unexpected resurgence of nonmetropolitan and rural populations sent demographers scurrying for explanations. Retirement-related migration, the development of mineral resources in the Mountain Division states, extreme suburbanization of residences among people functionally linked to metropolitan employment centers, and recession-related unemployment in cities were all suggested as explanatory factors (*4–6*). The broadest study of the phenomenon concluded that the mobility conferred by widespread automobile ownership and the ease of long-distance telecommunication had eroded the

TABLE 1 Urban and Rural Population by Census Division: United States, 1950–1980 (2, Table 13)

Census Division and Year	Thousands of Inhabitants			Percent Change from Preceding Census			Percent of Total Population	
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
New England:								
1950	7,102	2,213	9,315	---	---	---	76.2	23.8
1960	8,032	2,478	10,510	13.1	12.0	12.8	76.4	23.6
1970	9,075	2,767	11,842	13.0	11.7	12.7	76.6	23.4
1980	9,269	3,079	12,348	2.1	11.3	4.3	75.1	24.9
Middle Atlantic:								
1950	24,272	5,892	30,164	---	---	---	80.5	19.5
1960	27,808	6,360	34,168	14.6	7.9	13.3	81.4	18.6
1970	30,437	6,762	37,199	9.5	6.3	8.9	81.8	18.2
1980	29,636	7,150	36,786	-2.6	5.7	-1.1	80.6	19.4
East North Central:								
1950	21,186	9,214	30,400	---	---	---	69.7	30.3
1960	26,435	9,790	36,225	24.8	6.3	19.2	73.0	27.0
1970	30,127	10,126	40,253	14.0	3.4	11.1	74.8	25.2
1980	30,534	11,148	41,682	1.4	10.1	3.6	73.3	26.7
West North Central:								
1950	7,305	6,756	14,061	---	---	---	52.0	48.0
1960	9,046	6,348	15,394	23.8	-6.0	9.5	58.8	41.2
1970	10,393	5,926	16,319	14.9	-6.6	6.0	63.7	36.3
1980	10,986	6,198	17,184	5:7	4.6	5.3	63.9	36.1
South Atlantic:								
1950	10,391	10,791	21,182	---	---	---	49.1	50.9
1960	14,852	11,120	25,972	42.9	3.0	22.6	57.2	42.8
1970	19,650	11,021	30,671	32.3	-0.9	18.1	64.1	35.9
1980	24,813	12,146	36,959	26.3	10.2	20.5	67.1	32.9
East South Central:								
1950	4,485	6,992	11,477	---	---	---	39.1	60.9
1960	5,831	6,220	12,051	30.0	-11.0	5.0	48.4	51.6
1970	7,007	5,797	12,804	20.2	-6.8	6.2	54.7	45.3
1980	8,166	6,500	14,666	16.5	12.1	14.5	55.7	44.3

TABLE 1 *continued*

Census Division and Year	Thousands of Inhabitants Urban	Rural	Total	Percent Change from Preceding Census Urban	Rural	Total	Percent of Total Population Urban	Rural
West South Central:								
1950	8,080	6,458	14,538	---	---	---	55.6	44.4
1960	11,478	5,473	16,951	42.1	-15.3	16.6	67.7	32.3
1970	14,045	5,275	19,320	22.4	-3.6	14.0	72.7	27.3
1980	17,435	6,312	23,747	24.1	19.7	22.9	73.4	26.6
Mountain:								
1950	2,786	2,289	5,075	---	---	---	54.9	45.1
1960	4,601	2,254	6,855	65.1	-1.5	35.1	67.1	32.9
1970	6,055	2,227	8,282	31.6	-1.2	20.8	73.1	26.9
1980	8,685	2,687	11,372	43.4	20.7	37.3	76.4	23.6
Pacific:								
1950	11,241	3,874	15,115	---	---	---	74.4	25.6
1960	17,186	4,012	21,198	52.9	3.6	40.2	81.1	18.9
1970	22,858	3,665	26,523	33.0	-8.6	25.1	86.2	13.8
1980	27,526	4,273	31,799	20.4	16.6	19.9	86.6	13.4
United States Total								
1950	96,847	54,479	151,326	---	---	---	64.0	36.0
1960	125,269	54,054	179,323	29.3	-0.8	18.5	69.9	30.1
1970	149,647	53,565	203,212	19.5	-0.9	13.3	73.6	26.4
1980	167,051	59,495	226,546	11.6	11.1	11.5	73.7	26.3

NOTE: Entries for all years are based on the 1980 definition of "urban." The previous definition, used through 1950, yielded an urban population that was about 93 percent of the new definition's urban population. The urban population includes all those who live in Census-designated urbanized areas, plus others who live in smaller urban places.

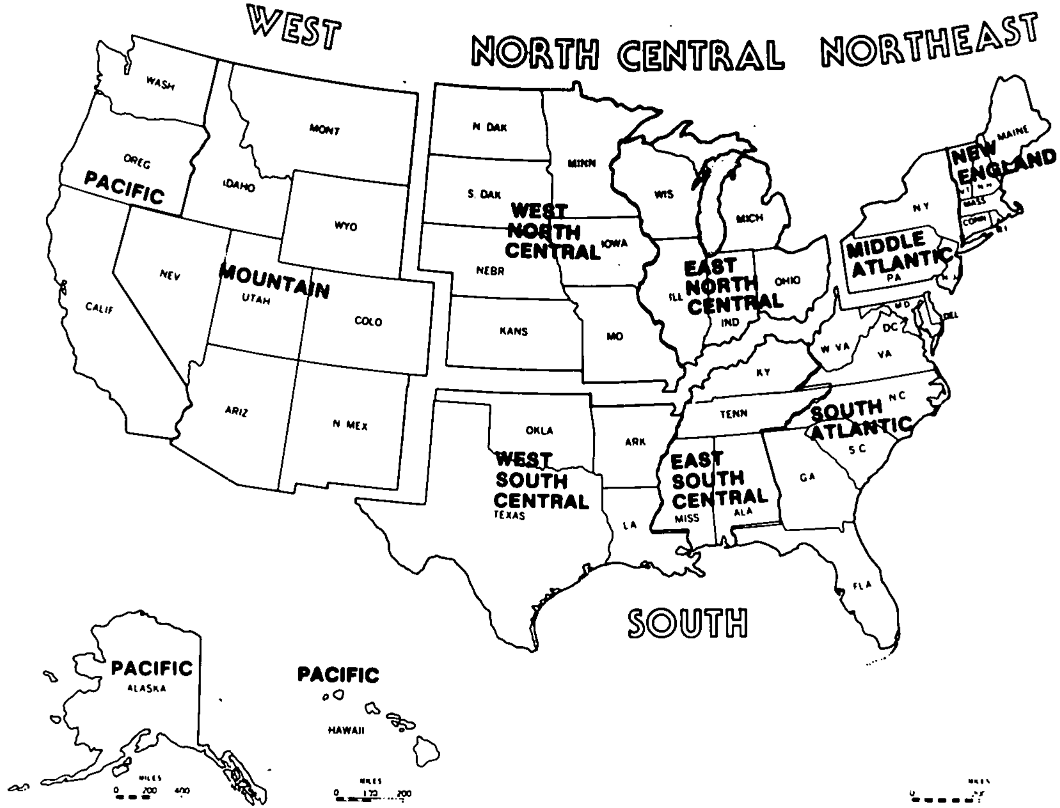

FIGURE 1 Regions and census divisions of the United States.

historic advantages of large urban centers for many kinds of economic enterprise, allowing deconcentration to intrinsically pleasanter environs (*7–9*).

However, since 1980, population estimates for metropolitan areas indicate that the deconcentration of the 1970s was an episode, not a trend. Whereas the metropolitan population grew at about the same rate from 1980 to 1984 as it did during the 1970s, the growth rate for nonmetropolitan population dropped sharply (*10*). Central cities are growing more (or losing less) than they did in the 1970s, but suburban growth has slowed (*11*). Intercensal estimates of urban and rural population growth are not available, but a recent study using indirect methods suggests that rural dispersion continues in nonmetropolitan counties (*12*).

Regional Prospects for Population Growth

Inspecting the intercensal growth rates in Table 1 is enough to discourage confident assertions about future settlement patterns even for areas as large as census divisions. Although demographers can reliably "age" an existing national population and can considerably narrow the range of possibilities for its aggregate growth, subnational forecasts are less tractable. Within the nation, people are free to move about, and do so. Although aggregate rates of geographic mobility are fairly stable over time, place-to-place flows of migrants are quite volatile and quite important in their local effects on population size.

Despite the hazards of subnational population forecasting, both public and private enterprises seem to have a compelling need to behave as though they knew what the future would bring. The Bureau of the Census accommodates such interests by periodically preparing internally consistent national and subnational population "projections" that are contingent on stated assumptions about fertility, mortality, immigration from abroad, and internal migration. Their current projection for individual states ages the 1986 population of each state, applies the state's recent fertility and mortality rates to the emerging age structure, and postulates continuance of the recent pattern of international and interstate migration.[5]

Table 2 summarizes the Census Bureau's projection for individual states by census division, a level of aggregation at which patterns emerge.[6] The national totals (bottom of table) show that the Bureau expects population growth to slow considerably during the next two decades. That expectation reflects the assumption that age-specific fertility rates will remain at or below their current levels[7] and the certain knowledge that the number of females in peak child-bearing years will decline as the large birth cohorts from the Baby Boom era (1950–1965) pass into middle age.

TABLE 2 Population Projections for Census Divisions, 1980–2010 (*2*, Table 13; *13*)

Census Division	Number of Inhabitants 1980	1990	2000	2010	Percent Change during Decade 1980-90	1990-00	2000-10
New England	12,348	13,077	13,776	14,243	5.9	5.3	3.4
Middle Atlantic	36,786	37,499	38,035	38,253	1.9	1.4	0.6
East North Central	41,682	42,054	41,745	41,111	0.9	-0.7	-1.5
West North Central	17,184	17,722	17,850	17,907	3.1	0.7	0.3
South Atlantic	36,959	43,742	50,002	55,111	18.4	14.3	10.2
East South Central	14,666	15,597	16,286	16,847	6.3	4.4	3.4
West South Central	23,747	27,937	30,632	32,961	17.6	9.6	7.6
Mountain	11,372	13,994	16,023	17,680	23.1	14.5	10.3
Pacific	31,799	38,257	43,400	47,944	20.3	13.4	10.5
U.S. Total	226,546	249,879	267,749	282,057	10.3	7.2	5.3

Within this general regime of slower growth, the Bureau projects a major shift in the population balance from the Northeast–North Central regions to the South and West. In 1980 about 48 percent of the nation's people lived in the first four census divisions listed in Table 2, about 33 percent lived in the three southern divisions, and about 19 percent lived the Mountain and Pacific divisions. By 2010 the distribution is expected to be approximately 40, 37, and 23 percent for the same regions.

The Bureau projects an increase of only 3 million in the total population of the Northeast–North Central regions from 1980 to 2010. During that time the South's population is expected to grow by 30 million and the West's is expected to grow by 23 million. If those projections are anywhere near the mark, it follows that the existing public infrastructure, including public roads and traffic management devices, will be generally adequate to serve the inhabitants of the Northeast–North Central regions through 2010, but will fall far short of foreseeable needs in the South and West.

There are local exceptions to the Northeast–North Central low-growth scenario: the populations of New Hampshire, Vermont, and Rhode Island are all expected to grow substantially between 1980 and 2010 (see Table 3). These are small states, however, collectively containing about 2 percent of the total population of the region.

The South's projected overall growth rate of 40 percent for the period 1980–2010 masks considerable local diversity. All of the South Atlantic states (excluding the tiny, fully developed District of Columbia) and Texas are expected to grow rapidly. Slow growth is the rule for the remaining South Central states, especially Kentucky, whose population is expected to peak about 1990 and to decline slightly thereafter.

Territorially, the Western Region consists mostly of arid plains, eroded badlands, and stony mountains (in Alaska, vast expanses of snow, permafrost, and mosquitoes)—not congenial habitats for humans. However, nestled among the barrens are pockets of well-watered, mild-weathered, agriculturally productive, amenable places to live. In 1980 California contained 55 percent of the region's 43 million inhabitants, mostly snuggled against the state's long coastline.

The Census Bureau projects rapid growth for California and the other four states bordering the Pacific—a 51 percent increase in population between 1980 and 2010. For the five southwestern states, the sagebrush empire, even faster growth is in prospect—a 67 percent increase in population between 1980 and 2010. Only the three northern states of the Mountain Division (Montana, Idaho, and Wyoming) are left out of the western growth scenario; the Bureau projects less than 6 percent increase in their combined populations.

TABLE 3 Population Projections for States, 1980-2010 (*2*, Table 13; *13*)

State	Number of Inhabitants				Percent Change during Decade		
	1980	1990	2000	2010	1980-90	1990-00	2000-10
Alabama	3,894	4,181	4,410	4,609	7.4	5.5	4.5
Alaska	402	567	687	765	41.1	21.2	11.4
Arizona	2,718	3,752	4,618	5,319	38.0	23.1	15.2
Arkansas	2,286	2,427	2,529	2,624	6.1	4.2	3.8
California	23,668	29,126	33,500	37,347	23.1	15.0	11.5
Colorado	2,890	3,434	3,813	4,098	18.8	11.0	7.5
Connecticut	3,108	3,279	3,445	3,532	5.5	5.1	2.5
Delaware	594	666	734	790	12.1	10.2	7.6
Dist. of Columbia	638	614	634	672	-3.8	3.3	6.0
Florida	9,746	12,818	15,415	17,530	31.5	20.3	13.7
Georgia	5,463	6,663	7,957	9,045	22.0	19.4	13.7
Hawaii	965	1,141	1,345	1,559	18.3	17.9	15.9
Idaho	944	1,017	1,047	1,079	7.7	2.9	3.1
Illinois	11,427	11,612	11,580	11,495	1.6	-0.3	-0.7
Indiana	5,490	5,550	5,502	5,409	1.1	-0.9	-1.7
Iowa	2,914	2,758	2,549	2,382	-5.3	-7.6	-6.6
Kansas	2,364	2,492	2,529	2,564	5.4	1.5	1.4
Kentucky	3,661	3,745	3,733	3,710	2.3	-0.3	-0.6
Louisiana	4,206	4,513	4,516	4,545	7.3	0.1	0.6
Maine	1,125	1,212	1,271	1,308	7.8	4.9	2.9
Maryland	4,217	4,729	5,274	5,688	12.1	11.5	7.8
Massachusetts	5,737	5,880	6,087	6,255	2.5	3.5	2.8
Michigan	9,262	9,293	9,250	9,097	0.3	-0.5	-1.7
Minnesota	4,076	4,324	4,490	4,578	6.1	3.8	2.0
Mississipi	2,521	2,699	2,877	3,028	7.1	6.6	5.2
Missouri	4,917	5,192	5,383	5,521	5.6	3.7	2.6
Montana	787	805	794	794	2.3	-1.4	0.0

TABLE 3 *continued*

State	Number of Inhabitants 1980	1990	2000	2010	Percent Change during Decade 1980-90	1990-00	2000-10
Nebraska	1,570	1,588	1,556	1,529	1.2	-2.0	-1.7
Nevada	800	1,076	1,303	1,484	34.4	21.1	13.9
New Hampshire	921	1,142	1,333	1,455	24.0	16.7	9.2
New Jersey	7,365	7,899	8,546	8,980	7.3	8.2	5.1
New Mexico	1,303	1,632	1,968	2,248	25.3	20.6	14.2
New York	17,558	17,773	17,986	18,139	1.2	1.2	0.9
North Carolina	5,882	6,690	7,483	8,154	13.7	11.9	9.0
North Dakota	653	660	629	611	1.1	-4.7	-2.9
Ohio	10,798	10,791	10,629	10,397	-0.1	-1.5	-2.2
Oklahoma	3,025	3,285	3,376	3,511	8.6	2.8	4.0
Oregon	2,633	2,766	2,877	2,991	5.0	4.0	4.0
Pennsylvania	11,864	11,827	11,503	11,134	-0.3	-2.7	-3.2
Rhode Island	947	1,002	1,049	1,085	5.8	4.7	3.4
South Carolina	3,122	3,549	3,906	4,205	13.7	10.1	7.7
South Dakota	691	708	714	722	2.5	0.8	1.1
Tennessee	4,591	4,972	5,266	5,500	8.3	5.9	4.4
Texas	14,229	17,712	20,211	22,281	24.5	14.1	10.2
Utah	1,461	1,776	1,991	2,171	21.6	12.1	9.0
Vermont	511	562	591	608	9.9	5.2	2.9
Virginia	5,347	6,157	6,877	7,410	15.2	11.7	7.8
Washington	4,132	4,657	4,991	5,282	12.7	7.2	5.8
West Virginia	1,950	1,856	1,722	1,617	-4.8	-7.2	-6.1
Wisconsin	4,706	4,808	4,784	4,713	2.2	-0.5	-1.5
Wyoming	470	502	489	487	6.9	-2.6	-0.4
U.S. total	226,546	249,879	267,749	282,057	10.3	7.2	5.3

Future Urbanization By Region

Because the transportation infrastructure needed for urban settlement is so different from that needed in rural areas, it is worthwhile to anticipate the settlement pattern of future state and regional populations. When a state's population increases, the increment rarely is distributed evenly over the entire state. Instead, population growth tends to occur in local clumps, which eventually reach the density conventionally called "urban." Once established, these urban clumps attract population from their rural hinterlands, so that total population growth and specifically urban growth both set the stage for more urbanization.

These tendencies are not immutable; any state with a large territorial domain could absorb a great deal of population growth at rural densities, with the arithmetical consequence of diminished urbanization. During the 1930s, some highly urbanized states became less urbanized because a substantial number of city dwellers moved back to the farms on which they were raised.

State population data for the period covered by Table 1 (1950–1980) were used to estimate the statistical relationships between current urbanization (i.e., percentage of total population living in urban places), urbanization 10 years previously, and the rate of population growth during the intervening decade. The fitted model, despite its simplicity, responds with surprising subtlety to new data provided by the state population projections discussed earlier. The model was used to estimate the level of urbanization for individual states in 1990, 2000, and 2010;[8] these estimates are summarized by census division in Table 4.

From this exercise the author concludes that urbanization of the U.S. population will tail off at less than 80 percent for the foreseeable future. Regional variation will persist, but will attenuate over time. The explicit estimates for 2010 indicate that in only 13 states will the population then be less than two-thirds urban. In only three states (California, Arizona, and Nevada) and the District of Columbia will the population be more than 90 percent urban. That leaves 34 states in the narrow range between 67 and 90 percent urban.

For transportation planning, a related point of considerable importance is that, especially in the highly urbanized states, most of the state's territory will be rural. For example, the Census Bureau estimates that Nevada's population will grow from 800,493 inhabitants in 1980 to 1,484,000 in 2010, an increase of 85 per cent. In 1980, 85 percent of this population was classified as urban, and 74 percent lived in the state's two urbanized areas, Las Vegas and Reno. These two areas contain 257 mi^2, or 0.2 percent of the state's total land area. Over 99 percent of the land area of Nevada was outside these urbanized areas, occupied at an average density of 1.86 persons/mi^2. Although the rural

TABLE 4 **Projected Urban and Rural Population by Census Division: United States, 1980–2010 (*2*, Table 13; *13*)**

Census Division and Year	Thousands of Inhabitants: Urban	Rural	Total	Percent Change from Preceding Census: Urban	Rural	Total	Percent of Total Population: Urban	Rural
New England:								
1980	9,269	3,079	12,348	---	---	---	75.1	24.9
1990	9,936	3,141	13,077	7.2	2.0	5.9	76.0	24.0
2000	10,608	3,168	13,776	6.8	0.9	5.3	77.0	23.0
2010	11,083	3,160	14,243	4.5	-0.3	3.4	77.8	22.2
Middle Atlantic:								
1980	29,636	7,150	36,786	---	---	---	80.6	19.4
1990	30,391	7,108	37,499	2.5	-0.6	1.9	81.0	19.0
2000	31,001	7,034	38,035	2.0	-1.0	1.4	81.5	18.5
2010	31,282	6,971	38,253	0.9	-0.9	0.6	81.8	18.2
East North Central:								
1980	30,534	11,148	41,682	---	---	---	73.3	26.7
1990	31,250	10,804	42,054	2.3	-3.1	0.9	74.3	25.7
2000	31,342	10,403	41,745	0.3	-3.7	-0.7	75.1	24.9
2010	31,117	9,994	41,111	-0.7	-3.9	-1.5	75.7	24.3
West North Central:								
1980	10,986	6,198	17,184	---	---	---	63.9	36.1
1990	11,769	5,953	17,722	7.1	-4.0	3.1	66.4	33.6
2000	12,203	5,647	17,850	3.7	-5.1	0.7	68.4	31.6
2010	12,537	5,370	17,907	2.7	-4.9	0.3	70.0	30.0
South Atlantic:								
1980	24,813	12,146	36,959	---	---	---	67.1	32.9
1990	31,273	12,469	43,742	26.0	2.7	18.4	71.5	28.5
2000	37,316	12,686	50,002	19.3	1.7	14.3	74.6	25.4
2010	42,320	12,791	55,111	13.4	0.8	10.2	76.8	23.2
East South Central:								
1980	8,166	6,500	14,666	---	---	---	55.7	44.3
1990	9,255	6,342	15,597	13.3	-2.4	6.3	59.3	40.7
2000	10,157	6,129	16,286	9.7	-3.4	4.4	62.4	37.6
2010	10,941	5,906	16,847	7.7	-3.6	3.4	64.9	35.1

TABLE 4 *continued*

Census Division and Year	----Thousands of Inhabitants-----			-----Percent Change from Preceding Census-----			Percent of Total ----Population---	
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
West South Central:								
1980	17,435	6,312	23,747	---	---	---	73.4	26.6
1990	21,440	6,497	27,937	23.0	2.9	17.6	76.7	23.3
2000	24,100	6,532	30,632	12.4	0.5	9.6	78.7	21.3
2010	26,379	6,582	32,961	9.5	0.8	7.6	80.0	20.0
Mountain:								
1980	8,685	2,687	11,372	---	---	---	76.4	23.6
1990	11,221	2,773	13,994	29.2	3.2	23.1	80.2	19.8
2000	13,206	2,817	16,023	17.7	1.6	14.5	82.4	17.6
2010	14,803	2,877	17,680	12.1	2.1	10.3	83.7	16.3
Pacific:								
1980	27,526	4,273	31,799	---	---	---	86.6	13.4
1990	33,844	4,413	38,257	23.0	3.3	20.3	88.5	11.5
2000	38,765	4,635	43,400	14.5	5.0	13.4	89.3	10.7
2010	43,007	4,937	47,944	10.9	6.5	10.5	89.7	10.3
United States Total								
1980	167,051	59,495	226,546	---	---	---	73.7	26.3
1990	190,379	59,500	249,879	14.0	0.0	10.3	76.2	23.8
2000	208,698	59,051	267,749	9.6	-0.8	7.2	77.9	22.1
2010	223,469	58,588	282,057	7.1	-0.8	5.3	79.2	20.8

The author allocated projected population totals for each state by urban and rural residence; see text for details.

NOTE: Entries for all years are based on the 1980 definition of "urban." The previous definition, used through 1950, yielded an urban population that was about 93 percent of the new definition's urban population. The urban population includes all those who live in Census-designated urbanized areas, plus 10 to 15 percent who live in smaller urban places.

densities of Nevada can be expected to be slightly higher in 2010, nearly all the population growth will occur within the current boundaries of Las Vegas and Reno.

SHAPE OF URBANIZED AREAS

Much of academic thinking about urban places is guided by a generalized concentric geometry: a central business district (CBD) is surrounded by an inner-city ring, both of which are part of a political jurisdiction, the central city. The central city is surrounded in turn by a suburban ring, whose outer edge is the urban fringe. This concentric complex is set in an amorphous rural area, the residual category of American economic and cultural geography.

Of course everyone knows that urbanized areas are seldom really concentric in their spatial geometry; the shapes observed on a map or from an airplane clearly reflect the singularities of local topography and surveyors' inexplicable preference for rectangles. Still, if a number of real urbanized areas were superimposed at the point of their highest daytime population density, most people would expect the palimpsest to reveal a clearly concentric pattern of land uses and population densities.

Although that expectation might have been well founded 30 or 40 years ago, it has been undermined by the postwar development of urbanized areas in the United States. Today, a palimpsest of urbanized areas superimposed at their respective points of highest daytime population density would more likely average out to an undifferentiated mixture of land uses and a broad plateau of population density. Each urbanized area does indeed have a "central place"—its historic CBD. Today, however, other central places scattered over the urban landscape challenge the primacy of the historic CBD, which no longer necessarily has the tallest office building or the biggest department store; those artifacts may instead be in an office park or shopping mall elsewhere in the city or in its suburbs. High-rise residential buildings are now found nearly as often in the urban fringe as in the central city (*14, 15*).

Urban Deconcentration

National statistics on urban form are handicapped by their dependence on civil divisions as territorial units for the aggregation of data on population, employment, and land area. These civil divisions—counties, cities, towns, and townships—vary greatly in size, are generally too large to reveal the details of urban form, and have boundaries that rarely reflect functional discontinuities in the urban landscape.[9]

Nonetheless, something can be gleaned from an examination of recent data for urbanized areas in the United States. The gross density of residential settlement or, equivalently, the nighttime population of central cities and urbanized fringes is readily calculable from published census data for 1960 through 1980. Density trends reveal something about the way in which urban settlement patterns are changing.

Table 5 shows the population density of all urbanized areas as measured in three successive decennial censuses. At each census the number of urbanized areas increased; the big jump between 1970 and 1980 reflects a change in the rules for defining urbanized areas rather than a sudden spurt in urbanization. In 1970 each urbanized area had to contain at least one incorporated place with 50,000 or more inhabitants; in 1980 an urbanized area had to include at

TABLE 5 Population Density of Urbanized Areas: United States, 1960–1980 (2, 16)

Year	Number of Areas (a)	Persons per Square Mile: Urbanized Area	Central City	Urban Fringe
		Unweighted Mean		
1960	211	3,290	5,100	1,959
1970	246	2,783	4,209	1,871
1980	365	2,177	3,337	1,565
		Area-Weighted Mean		
1960	211	3,837	5,502	2,648
1970	246	3,376	4,454	2,657
1980	365	2,676	3,557	2,177
		Population-Weighted Mean		
1960	211	4,537	9,926	2,992
1970	246	3,999	8,743	3,019
1980	365	3,219	6,848	2,565

NOTE: Area and population weights pertain to the indicated portion of each urbanized area. In other words, central cities are weighted differently than fringe areas. See text for interpretation of alternative weights.

Entries in this table for central city and urban fringe densities have not been adjusted for annexation by central cities of fringe area and population, but have been adjusted for reclassification of certain incorporated places as central or noncentral cities. Rural parts of "extended cities" are excluded from the urbanized area for 1970 and 1980, but not for 1960.

(a) Some urbanized areas consist solely of a central city. The number of areas with urban fringes was 204 in 1960, 241 in 1970, and 361 in 1980. A few urbanized areas that were separately listed in the 1960 or 1970 census were combined in 1980; for comparability, these have been restrospectively combined for 1960 and 1970. Two urbanized areas listed separately in 1980 were combined in earlier censuses, so were combined here for 1980. Because of these combinations, our counts of urbanized areas do not exactly match those in the source publications.

least one incorporated place, but the minimum of 50,000 inhabitants could live in several incorporated places or in adjacent, densely settled but unincorporated territory. In short, the Bureau moved most of the way to a functional, as opposed to a juridical, standard for urbanization.

Table 5 shows that the population densities of urbanized areas and their component parts dropped sharply between 1960 and 1980. If all urbanized areas in each decennial tabulation are weighted equally, the mean density drops by one-third, from 3,290 persons/mi^2 in 1960 to 2,176 persons/mi^2 in 1980. If the urbanized areas of each census are weighted by either their land areas or their populations, the decrease in density is nearly as large—about 30 percent.[10]

Because the natural course of urban growth is fringe development, one might suspect that this overall decrease in urban density merely reflects growth in the territorial extent of urbanized areas, diluting the densely settled core with a sparsely settled urban fringe. However, the density of central cities has dropped even more than fringe density. The author used the unweighted means in the first panel of Table 5 to calculate average central-city density, which dropped 34 percent, whereas fringe density declined only 20 percent.

The observed decrease in average density for central cities of urbanized areas could be a statistical artifact. At each decennial census, newly qualified urbanized areas are included in the average, and these by definition are relatively small places; very likely their central cities (especially those added in 1980) are less densely settled than those of older, larger urbanized areas. Moreover, existing central cities often annex adjoining territory and its population; such annexations are likely to decrease average density for the juridical central city without altering the physical pattern of settlement.

Table 6 addresses this issue by dividing 1980's roster of urbanized areas into vintages and showing the density trend for each vintage.[11] The vintage classification sacrifices rigor to convenience. Rather than trying to determine when each of the 211 urbanized areas that existed in 1960 would have qualified under 1960 rules, 1960 population was used as a proxy for age of urbanized area, creating five vintages as follows:

Vintage	*Year First Qualified*	*1960 Qualified*
1	1960 or earlier	1,000,000 or more
2	1960 or earlier	500,000–999,999
3	1960 or earlier	250,000–499,999
4	1960 or earlier	100,000–249,999
5	1960 or earlier	50,000–99,999
6	1970	50,000 or more
7	1980	50,000 or more

TABLE 6 Unweighted Population Density of Urbanized Areas by Vintage: United States, 1960–1980 (2, 16)

Vintage of Urban Area	Number of Areas	Persons per Square Mile 1960	1970	1980
		Urbanized Area		
1	17	4,596	4,180	3,386
2	20	3,701	3,193	2,758
3	31	3,212	2,796	2,400
4	82	3,114	2,664	2,211
5	61	3,067	2,462	2,103
6	35	---	2,695	2,373
7	119	---	---	1,086
		Central City		
1	17	11,426	10,731	9,063
2	20	5,503	4,870	4,177
3	31	5,429	4,487	4,145
4	82	4,504	3,750	3,272
5	61	3,839	3,267	2,866
6	35	---	3,132	2,756
7	119	---	---	2,627
		Urban Fringe (a)		
1	17	2,888	2,981	2,535
2	20	2,522	2,746	2,257
3	31	2,141	2,084	1,873
4	80	1,855	1,834	1,543
5	57	1,516	1,359	1,353
6	32	---	1,618	1,543
7	114	---	---	1,312

NOTE: See text for explanation of vintage classifications. In principle the classification indicates when a place became an urbanized area. The series runs from oldest = 1 to newest = 7.

Entries in this table for central city and urbanized fringe densities have not been adjusted for annexation by central cities of fringe area and population, but have been adjusted for reclassification of certain incorporated places as central or noncentral cities. Rural parts of "extended cities" are excluded from the urbanized area for 1970 and 1980, but not for 1960.

(a) Excludes urban fringes containing 1.0 square miles or less, because density estimates are unreliable for very small areas. The number of areas included varies slightly from year to year; the counts shown are for 1980.

Vintages 6 and 7 consist, respectively, of urbanized areas newly defined for the 1970 and 1980 censuses; most were small when they were added to the list, but 6 of the 35 added in 1970 and 14 of the 119 added in 1980 had populations in excess of 100,000.

Table 6 shows clearly that newer (smaller) urbanized areas are settled at lower densities than older (larger) urbanized areas, both in their central cities and in their urbanized fringes. Even if the new urbanized areas that are added during the coming decades are as dense as those added between 1970 and

1980, the national average of urban density should decline further as the new low-density urbanized areas "dilute" the older, larger places.

Examining the histories of individual vintages in Table 6, it can be seen that the average density for the whole urbanized area declines for each vintage, 1960–1970 and again 1970–1980. This reveals that as urbanized areas age—and, usually, grow in total population—they become less densely settled. One might expect that such an outcome would reflect mostly the addition of low-density fringe settlement to the census-defined urbanized area, but the table shows that central-city densities for each vintage have in fact decreased by more than fringe densities.

The diminution of central densities has been achieved in part by annexing sparsely settled territory to the central city. However, it is also clear that, controlling for annexation, many older central cities actually lost population between 1960 and 1970 or between 1970 and 1980, or during both periods.[12]

In short, urban densities are declining both because newly urbanized areas are forming at lower density and because older urbanized areas are dispersing their residential populations from their central parts to the urban fringe. That dispersion of population within the urbanized area sometimes raises fringe density—note, for example, the increase of fringe density, 1960–1970, for the two oldest vintages (last panel of Table 6).

During the life of an urban settlement, it is quite common for those who live in central cities to be displaced by redevelopment of residential land for commercial, industrial, or public uses, including freeway construction. Declining residential density in a central city might therefore reflect preemption of space for more intensive urban activities. Although a full test of this hypothesis is beyond the author's resources, the available evidence is against it.

Statistics on land area, population, and employment for the 25 largest urbanized areas (those with populations of 1 million or more) in 1970 and 1980 are given in Table 7. In this sample, the land area of central cities grew 11 percent during the decade as the cities annexed adjoining territory. By developing peripheral land at urban densities, the urban fringe both replaced the territory lost by annexation and added a third to its land area. (Note that the fringe expansion of an urbanized area results from land use changes, not legal annexation.)

The second panel of Table 7 shows a 7 percent decrease in the aggregate population of the central cities of these 25 urbanized areas, and the third panel shows an offsetting 9 percent increase in the number of central-city workers. However, in absolute numbers, the central cities lost 2.3 million residents and gained fewer than 1.4 million workers. (Annexation adjustment would increase the residential loss and reduce the employment gain.) The residential density of the central city decreased 16 percent and the employment density stayed approximately constant.

TABLE 7 Population and Employment Densities of Central Cities and Urban Fringes: 25 Largest Urbanized Areas, 1970 and 1980 (*2, 16, 18*)

Place of Residence or Employment	1970	1980	Percentage Change, 1970-80
		Number of Square Miles	
Central city	3,917	4,358	11.3
Urban fringe	12,720	16,937	33.2
Urbanized Area	16,637	21,298	28.0
		Thousands of Residents	
Central city	32,177	29,893	-7.1
Urban fringe	39,329	45,674	16.1
Urbanized Area	71,506	75,566	5.7
		Thousands of Workers (a)	
Central city	14,693	16,080	9.4
Urban fringe	12,888	17,728	37.6
Urbanized Area	27,581	33,808	22.6
		Residents per Square Mile (b)	
Central city	8,215	6,859	-16.5
Urban fringe	3,092	2,697	-12.8
Urbanized Area	4,298	3,548	-17.4
		Workers per Square Mile (b)	
Central city	3,751	3,690	-1.6
Urban fringe	1,013	1,047	3.3
Urbanized Area	1,658	1,587	-4.2

NOTE: The 25 urbanized areas included in this table are those whose residential populations were 1.0 million or more in both 1970 and 1980.

(a) Between 1970 and 1980, the Bureau of the Census reduced the number of places listed as "central cities" in four large urbanized areas (New York, Chicago, Los Angeles, and San Francisco). Because the tabulations prepared by the Joint Center do not take this reclassification into account, the 1970-80 increase in the number of workers is understated for central cities and overstated for urban fringes.

(b) Area-weighted density, used for this comparison because the employment data are not available for individual urbanized areas.

In contrast, the urban fringe gained enormously, both in residents (6.3 million) and in workers (4.8 million). However, as in the central city, residential density fell substantially and employment density stayed about the same. Both residential and employment densities are considerably lower in the urban fringe than in the central city.

Case of Los Angeles

The Los Angeles–Long Beach urbanized area is a good example of the dispersed pattern of urban development that has occurred since World War II. Sprawling over 1,827 mi^2 in 1980, the urbanized area contained nearly 9.5 million people. The largest single jurisdiction was the City of Los Angeles, containing nearly 3.0 million people living at an average density of 6,380 persons/mi^2, or just under 10 persons/acre. The area also contained 8 cities with over 100,000 inhabitants and 105 smaller incorporated places; about 868,000 people lived in unincorporated areas settled at urban densities.

Peter Gordon and his associates at the University of Southern California have explored the population and employment topography of the greater Los Angeles area[13] in some detail, using both census tracts and traffic analysis zones as units of areal aggregation. From 1980 work-place data gathered by the Bureau of the Census, they identified 17 "major activity centers" within the Los Angeles Urbanized Area, each containing at least 300 acres and 5,000 jobs (see Figure 2 and Table 8). The largest, the historic CBD of Los Angeles and its industrial environs, contained the work places of 373,283 persons in an area of 6,737 acres; the smallest, part of the outlying City of Ontario, had just under 5,000 workers on 305 acres. Of the 17 centers, only two—the Los Angeles Core and the Westwood–Beverly Hills–Century City complex—contained the work places of more than 50,000 persons; the median cluster size was about 20,000.

The remarkable finding is that these 17 clusters contained only 800,000 jobs, less than a fifth of the total work places located in the urbanized area. The largest single cluster, the Los Angeles Core, contained less than 10 percent of the urbanized area's work places. About 80 percent of the area's work places are so dispersed that they cannot be grouped into recognizable clusters.

In a related study (*19*), the analysts concluded that the employment-density surface of the five-county area containing Los Angeles could best be described topographically as though its major focus was in the vicinity of Los Angeles International Airport (see Figure 2), with a shallow density gradient extending 35 mi inland. Six local foci were identified, each with much higher peak density than the airport focus but with a steep density gradient extending

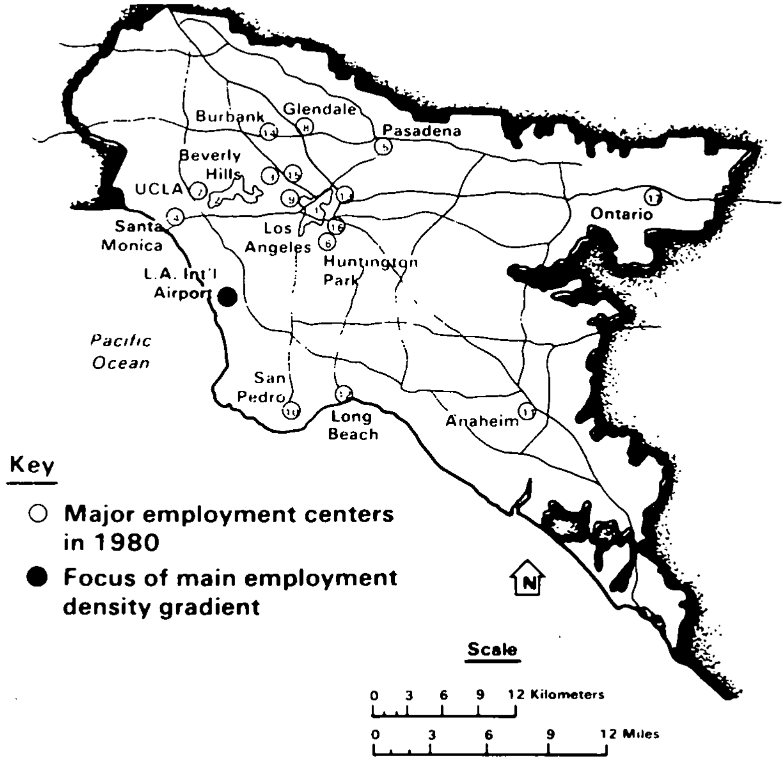

FIGURE 2 Major employment centers in the Los Angeles Urbanized Area, 1980. (Source: Peter Gordon.)

15 mi or less from the center. The airport focus, with its wide semicircular apron, accounted for 77 percent of the total number of jobs in the five counties, yet its peak density is so low that it does not even appear among the 17 places identified in Figure 2.

If employment is dispersed, residential population is even more so. The Southern California Association of Governments estimates that only 5.1 percent of the population of the Los Angeles Urbanized Area in 1984 lived in analysis zones with residential densities of 30 or more persons/acre; 82 percent lived in zones with fewer than 20 persons/acre, which is about the gross density of single-family houses on 50- by 150-ft lots.

Los Angeles is not offered as the "typical" urbanized area; few are as large or as diffusely settled.[14] But it is a major urbanized area in its own right, and also a bellwether for future urban growth. As noted in the preceding section, that growth is expected to occur almost entirely in the southern and western parts of the United States, where Los Angeles-style urbanization is the rule rather than the exception.

TABLE 8 Major Employment Centers in the Los Angeles Urbanized Area, 1980

Employment Center	Number of Jobs (a)	Number of Acres	----Employment Density---- Jobs per Acre	Jobs per Square Mile
1. Los Angeles Core	373,283	6,737	55.4	35,461
2. Westwood-Beverly Hills-Century City	89,447	2,956	30.3	19,366
3. Hollywood	44,802	1,902	23.6	15,075
4. Santa Monica	37,255	1,672	22.3	14,260
5. Pasadena	35,911	1,419	25.3	16,197
6. Huntington Park	30,429	556	54.7	35,026
7. University of California	30,029	607	49.5	31,662
8. Glendale	25,649	1,006	25.5	16,317
9. Mid-Wilshire	20,772	964	21.5	13,791
10. San Pedro	20,413	1,043	19.6	12,526
11. Anaheim	18,055	946	19.1	12,215
12. Long Beach	17,326	731	23.7	15,169
13. USC Medical Center-LAC General Hospital	16,316	437	37.3	23,895
14. Burbank	12,703	707	18.0	11,499
15. East Hollywood	12,383	418	29.6	18,960
16. East Los Angeles	10,471	593	17.7	11,301
17. Ontario	4,974	305	16.3	10,437
Total, all centers	800,218	22,999	34.8	22,268

SOURCE: Unpublished tabulation prepared by Peter Gordon and associates from journey-to-work records of the 1980 Census of Population.

NOTE: Worktrip destinations were coded to 1,147 traffic analysis zones in a 5-county area; within the Los Angeles Urbanized Area, 57 zones with the highest trip-generation volumes were clustered to form the 17 centers listed in the table. (Two additional centers were located in the San Bernardino-Riverside Urbanized Area.) Zonal areas were measured from boundary coordinates.

(a) Worktrip destinations.

Planning for Urban Sprawl

Among planners, urban sprawl has a bad name: it looks jumbled, untidy, and inefficient. Because daily destinations are not within walking distance and mass transportation fails in low-density environments, urban sprawl promotes dependence on private automobiles for local travel to work places, shops, doctors' offices, and schools. These innumerable private automobiles fill the air with hydrocarbon fumes, congest arterial streets and freeways, and require storage space at both the origin and destination of each trip. Surely there is a better way to live!

Planners had better get used to Sprawl City, precisely because the American people invariably choose it as the better way to live. Whatever the case with water and sewer service, fire and police protection, Sprawl City is not necessarily less efficient than Compact City with respect to local travel. The critical factor in local travel is the collocation of daily destinations: home, work place, school, grocery, fast-food outlet, movie theater, bank. The evidence from daily travel surveys is that as residences, work places, and retail establishments have dispersed, they have mutually located in ways that reduce travel rather than increase it. On the other hand, as local travel becomes easier, people do more of it, so that congestion is a perpetual problem, however efficient the spatial organization and the transportation system (*20*).

Journey to Work

One of the durable icons of American culture is the image of the white-collar commuter on his daily trip from a suburban single-family house to a downtown office building. In the 1920s, he traveled with effortless dignity by train or trolley; in the 1950s, the trolleys were gone, the trains were in shambles, and the commuter was riding an overcrowded, dirty, noisy bus; in the 1960s, he switched to a comfortable private automobile cruising effortlessly down a freeway. But by the 1980s, the freeways had become linear parking lots where harried commuters with loosened neckties sat and fumed while the minutes ticked away.

Today, more people than ever go to work in America—both more in absolute numbers and as a proportion of the population. In 1950, about 60 million men and women went off to work each day; in 1985, 109 million persons were employed. The proportion of all adults (16 years or older) with jobs has edged up gradually from 56.6 to 60.5 percent as more women have entered the labor force but men have dropped out earlier.

However, few of these workers fit the commuter stereotype, leaving their suburban homes for the downtown office job. Table 9 shows for all residents

TABLE 9 Place of Work by Place of Residence for Residents of Urbanized Areas: United States, 1970 and 1980 (*18*, Tables C-70, C-80)

Place of Residence	Central Business District	Other Part of Central City	Urban Fringe	All Workplaces
	Thousands of Employed Residents by Place of Work			
1970				
Central city	2,886	16,740	4,820	24,446
Urban fringe	1,206	6,037	14,149	21,392
Total, urbanized area	4,092	22,777	18,969	45,838
1980				
Central city	3,416	19,535	5,284	28,235
Urban fringe	2,048	9,394	21,913	33,355
Total, urbanized area	5,464	28,929	27,197	61,590
	Percent of All Employees by Places of Residence and Work			
1970				
Central city	6.3	36.5	10.5	53.3
Urban fringe	2.6	13.2	30.9	46.7
Total, urbanized area	8.9	49.7	41.4	100.0
1980				
Central city	5.5	31.7	8.6	45.8
Urban fringe	3.3	15.3	35.6	54.2
Total, urbanized area	8.9	47.0	44.2	100.0
	Percent of All Employees by Place of Work			
1970				
Central city	11.8	68.5	19.7	100.0
Urban fringe	5.6	28.2	66.1	100.0
Total, urbanized area	8.9	49.7	41.4	100.0
1980				
Central city	12.1	69.2	18.7	100.0
Urban fringe	6.1	28.2	65.7	100.0
Total, urbanized area	8.9	47.0	44.2	100.0

NOTE: Distributions include workers whose places of residence and work were not reported: 3,344,000 in 1970 and 5,622,000 in 1980. These were allocated to place of residence and workplace by mode of transportation in the pattern of those whose places of residence and work and modes of transportation were all reported.

of urbanized areas in 1970 and 1980 that only about 9 percent worked in a CBD; among those who lived in the fringes (rather than in the central city) of urbanized areas, about 3 percent worked in a CBD. Both in 1970 and 1980, two-thirds of those who lived in the urban fringes also worked there. In 1980 about 37 percent of all workers both lived and worked in the central city of their urbanized area and about 36 percent both lived and worked in the urban fringe. Only 27 percent commuted between the central city and the fringe.

The commuting pattern just described applies to large urbanized areas as well as to small ones, except that commuting across central-city boundaries diminishes with population size. A similar tabulation of 1980 data for the 25 largest urbanized areas shows that 72 percent of those who lived in the urban fringe also worked there, only 24 percent of all workers commuted across a central-city boundary, and only 8.5 percent entered the CBD.[15]

Given that most people live and work in the same part of an urbanized area, it should not be surprising that their work trips are short. Table 10 shows how work-trip length and duration varied in 1983 with type of area. Nationally, the mean length of a work trip was just under 10 mi and its duration was about 20 min. The longest trips, whether measured in miles or time, were for two extremes of the urbanization spectrum: villages or rural residences in places with fewer than 5,000 inhabitants and urbanized areas with more than 1.25 million inhabitants. Between these extremes, size of urbanized area does not seem to have had much effect on work-trip length.[16]

TABLE 10 Work-Trip Length and Duration by Area of Residence: United States, 1983 (*21*, Vol. 2, Tables E-117, E-118)

Area of Residence and Population Size	Thousands of Workers	Mean Worktrip Length (miles)	Mean Worktrip Duration (min.)
Not an urbanized area:			
Under 5,000	28,293	13.1	21.8
5,000 or more	9,340	6.9	13.7
Urbanized area:			
50,000 - 199,999	10,184	6.7	15.2
200,000 - 749,999	14,140	8.2	17.7
750,000 - 1,249,999	7,409	7.7	17.3
1,250,000 or more:			
With rail system	19,329	10.3	26.3
Without rail system	16,091	10.7	22.1
Area type unspecified	1,534	9.7	17.8
Total, all areas	106,325	9.9	20.4

NOTE: These entries are based on responses to questions about "usual" worktrips; evidence from daily travel diaries in the same survey suggests that actual trips are about 15 percent shorter in length (and probably also in duration) than "usual" trips.

Table 11 shows that work-trip lengths changed very little between 1969 and 1983, but a more important message from this table is that more than half of all work trips are less than 6 mi long. That is a remarkable statistic for a society in which more than 65 percent of all households that contain any employed persons contain two or more, complicating the choice of residential location by linking it to two work places instead of one. The heroic long-distance commuter, beloved of newspaper editors, turns out to be a rare bird: less than 4 percent of all work trips are longer than 30 mi—and that includes rural residents commuting on sparsely traveled roads to their jobs in small towns.

Mass transit is intrinsically a device for moving large numbers of people from a single origin to a single destination, and its efficiency increases in proportion to the distance between the origin and the destination. In contemporary urbanized areas, homes and work places are rarely clustered tightly

TABLE 11 Distribution of Work Trips by Trip Length: United States, 1969, 1977, and 1983 (*21*, Vol. 1, Table 7-13)

Trip Length (miles)	Percentage of all Worktrips 1969	1977	1983
Under 6	52.2	53.2	54.1
6 - 10	20.4	20.4	20.3
11 - 15	11.1	11.1	10.7
16 - 20	6.8	6.1	6.1
21 - 30	5.8	5.4	5.2
31 and over	3.7	3.8	3.6
Total	100.0	100.0	100.0
Mean length (miles)	9.7	9.3	9.9

NOTE: These entries are based on responses to questions about "usual" worktrips; evidence from daily travel diaries in the 1983 survey suggests that actual trips are about 15 percent shorter in length than "usual" trips.

enough to support the heavy capital cost of rail transit or even the heavy operating cost of closely spaced bus schedules. Even for the journey to work—the type of local travel that is most regular in volume, timing, and direction—the automobile has become and will remain the mode of choice.

Anyone who doubts this conclusion is invited to consult Table 12. In 1980, 84 percent of all work trips in urbanized areas were made by private conveyance—automobile, truck, van, motorcycle, or bicycle. Fewer than 10 percent were made by any form of public transportation. The only substantial users of public transportation were those who worked in the CBD of their urbanized area—about 9 percent of all urban workers. Even those who both lived and worked in central cities (but worked outside the CBD) were much more likely to travel by private conveyance (76 percent) than by public transportation (13 percent).

Local Travel in Perspective

The journey to work no doubt remains the most important regular trip made by household members, but it is by no means the only trip. Americans go home to wash and change clothes before going somewhere else. And when they go out again—to a friend's house, a fast-food outlet, a movie, or a shopping mall—they go by car.

Table 13 reports that in 1983 those over 5 years of age took nearly 224 billion local trips, an average of 974 trips per person, or 2.7 trips per

TABLE 12 Work-Trip Transportation Mode by Place of Residence and Place of Work: All Workers Living in Urbanized Areas, 1980 (*18*, Table C-80)

Place of Residence and Place of Work	Percent of All Workers by Mode of Transportation								
	-Private Auto	Vehicle- Other(a)	Bus or Trolley	Subway, El Rail	Surface Rail	Taxi	Walked Only	Worked at Home	Total
Live in Central City:									
Work in CBD	53.9	5.7	20.5	11.7	1.0	0.6	6.2	0.2	100.0
Work in CC, not CBD	65.9	10.5	8.2	4.5	0.2	0.3	8.3	1.9	100.0
Work in Urban Fringe	79.4	13.2	4.8	0.5	0.2	0.1	1.8	0.0	100.0
Live in Urban Fringe									
Work in CBD	61.8	5.6	18.3	4.1	9.9	0.1	0.3	0.0	100.0
Work in CC, not CBD	79.1	12.5	3.8	1.0	2.1	0.1	1.2	0.0	100.0
Work in Urban Fringe	78.3	12.0	1.8	0.1	0.1	0.1	5.5	2.1	100.0
Total workers	72.7	11.1	6.0	2.5	0.9	0.2	5.3	1.4	100.0

NOTE: Workers whose places of residence and work were not reported were classified by transportation mode; and within each mode, were distributed in proportion to those whose places of residence and work were reported.

(a) Truck, van, motorcycle, or bicycle.

TABLE 13 Number and Length of Person Trips by Trip Purpose: United States, 1983 (*21*, Vol. 2, Tables E-84, E-85)

Trip Purpose	--Person-Trips during 1983-- Millions of Trips	Millions of Miles	Average Trip Length (miles)	--Person-Trips during 1983-- Percent of All Trips	Percent of All Miles
Earning a living:					
Home to or from work	45,830	391,624	8.5	20.5	21.9
Other work-related	5,283	115,605	21.9	2.4	6.5
Subtotal	51,113	507,229	9.9	22.8	28.3
Family or personal errands:					
Shopping	40,659	219,187	5.4	18.2	12.2
Medical or dental	2,781	25,785	9.3	1.2	1.4
Other errands	36,161	256,978	7.1	16.2	14.4
Subtotal	79,601	501,950	6.3	35.6	28.0
Attending school, church, or civic affairs	26,488	129,953	4.9	11.8	7.3
Social or recreational:					
Visiting friends	24,746	283,568	11.5	11.1	15.8
Pleasure driving	1,192	24,204	20.3	0.5	1.4
Other recreation	35,461	302,209	8.5	15.8	16.9
Subtotal	61,399	609,981	9.9	27.4	34.1
Other purposes	5,184	41,402	8.0	2.3	2.3
All purposes	223,785	1,790,515	8.0	100.0	100.0

NOTE: Entries include all trips by persons 5 years of age or older. The estimated total of 223,785 million person-trips during 1983 is based on interviews with a national sample of 6,438 households concerning their activities on the day preceding the interview. The data shown here exclude 630 million long-distance trips that were part of vacation travel.

day.[17] Less than 23 percent of the trips and only 28 percent of the miles traveled were work related. Family or personal errands accounted for more trips and the same amount of travel mileage as did work-related trips; social and recreational travel also exceeded work-related travel, both in number of trips and mileage.

In this tabulation of actual trips, trips to and from work averaged 8.5 mi, somewhat less than the same respondents' account of their "usual" trips to work (see Tables 10 and 11).[18] Family and personal errands were shorter, but social and recreational trips were as long as trips to work. The important point, however, is that the average trip length for every category of trip is too far for most people to enjoy walking it. At the same time, the nonwork trips tend to be irregularly scheduled and variable as to destination, so public conveyances are not very helpful as a means of getting there.

Table 14 shows that the private automobile has become the mode of choice for nonwork trips as well as for work trips. In every category of nonwork trip except attending school, over four-fifths of all person-trips were made by private vehicle, and most of the remaining fifth were made on foot. Public conveyances were rarely used for nonwork trips.

The data in Table 14 reflect an unnoticed revolution in the transport arrangements of American households. In the 1950s, a major topic of discussion at mealtimes in most households was: Who gets the family car today (or tonight)? The husband, going off to work? The wife, with errands in town? Junior, who has a heavy date? In the 1980s, the issue hardly arises: nearly every family member over 16 has a personal automobile.

According to the 1983 Nationwide Personal Transportation Study (NPTS), 84 percent of all persons over 16 years of age then had driver's licenses, and the number of home-based motor vehicles almost equaled the number of licensed drivers. The NPTS time series of licensing and household vehicular ownership was used together with national projections of population by age[19] to estimate vehicular ownership and local travel mileage over the next 30 years, with the results shown in Table 15.

As indicated earlier (see Table 2), the Census Bureau's demographers expect the U.S. population to grow more slowly in the future than it has in the past. The narrow age bracket of 16–19 years will fluctuate in size, but for the next 30 years will be smaller than it was in 1980. The age bracket that has the highest proportion of active drivers (20 to 64 years) will grow moderately until 2010 and then level off. Only the number of elderly will increase rapidly over the next 30 years, from about 32 million in 1990 to 51 million in 2020.

Although the number of licensed drivers and vehicles has increased rapidly over the past 30 years, that trend is not expected to continue. The author estimates that the number of licensed drivers will level off soon after 2020, when about 84 percent of all adults will hold licenses. (By that year, those

TABLE 14 Distribution of Person Trips by Mode of Transportation and Trip Purpose: United States, 1983 (*21*, Vol. 1, Tables 6-3, 6-24)

Trip Purpose	Distribution by Mode of Transportation: Private Vehicle: Driver	Private Vehicle: Passenger	Public Conveyance	On Foot or Bicycle	Total
Earning a living:					
Home to or from work	75.2	12.2	4.7	7.9	100.0
Other work-related	68.1	16.1	4.2	11.6	100.0
Subtotal	74.5	12.6	4.6	8.3	100.0
Family or personal errands:					
Shopping	56.1	32.1	0.9	10.9	100.0
Medical or dental	46.5	44.1	4.5	4.9	100.0
Other errands	59.8	27.4	1.2	11.6	100.0
Subtotal	57.5	30.4	1.1	11.0	100.0
Attending school, church, or civic affairs	23.4	32.5	26.0	18.1	100.0
Social or recreational:					
Visiting friends	45.1	37.1	1.8	16.0	100.0
Pleasure driving	34.5	62.0	---	3.5	100.0
Other recreation	37.1	43.0	2.0	17.9	100.0
Subtotal	40.1	41.1	1.9	16.9	100.0
Other purposes	25.8	57.9	1.2	15.1	100.0
All purposes	51.8	30.2	5.1	12.9	100.0

NOTE: Entries include all trips by persons 5 years of age or older. The estimated total of 224,385,000 person- trips during 1983 is based on interviews with a national sample of 6,438 households concerning their activities on the day preceding the interview. The data shown here exclude long-distance trips that were part of vacation travel.

TABLE 15 Projections of Local Travel by Private Vehicle: United States, 1980–2020

Year	Millions of Persons: All Ages	Under 16 Yrs	16-19 Years	20-64 Years	65+ Years	Licensed Drivers	Vehicles per Driver	Millions of Vehicles	Annual Miles per Driver	Billions of Vehicle Miles
1980	227	55	17	129	26	141	0.96	135	10,191	1,434
1990	250	58	14	146	32	162	0.98	159	10,318	1,676
2000	268	60	15	158	35	176	1.00	176	10,300	1,814
2010	283	57	15	171	39	191	1.00	191	10,115	1,933
2020	297	59	14	172	51	199	1.00	199	9,906	1,975
						Percentage Change				
1980-90	10.2	4.5	-19.9	13.9	24.1	15.4	2.1	17.8	1.2	16.9
1990-00	7.3	3.3	9.9	8.0	10.2	8.4	2.0	10.6	-0.2	8.2
2000-10	5.7	-4.2	2.1	8.4	12.2	8.5	0.0	8.5	-1.8	6.6
2010-20	4.7	2.8	-6.8	0.3	31.2	4.3	0.0	4.3	-2.1	2.1

NOTE: Entries in this table pertaining to numbers of licensed drivers, vehicles, and vehicle-miles were derived by applying age-sex- specific rates of licensing and travel mileage (based on the 1969, 1977, and 1983 Nationwide Personal Transportation Studies) to national projections of the population by age and sex. The author is responsible for projecting licensing rates, vehicles per licensed driver, and annual miles per driver to 1990 and beyond. Estimates of annual miles per driver are based on direct estimates by survey respondents; extrapolation from individual trip reports yields substantially smaller annual totals.

SOURCE: Estimates by the author; *Personal Travel in the U.S.* (*21*, Vol. 1, p. 4-2, Table 4-1, Table E-10); 1980 Census, Series PC80-1-B1 (*23*, Table 43); Current Population Reports 952 (*24*).

over 65 will make up 22 percent of the adult population, and many of the elderly have will given up their licenses.)

These projections assume that by the year 2000 there will be a private vehicle for every licensed driver, so that vehicle and driver mileage will grow at about the same rate. Because the population is aging and the elderly make fewer and shorter trips even when they keep their automobiles, mileage per driver and per vehicle should drop slightly. The total number of miles traveled in private vehicles will increase much less rapidly in the future than it has in the recent past, and will level off just after the year 2020.

The good news, then, is that the demographic and life-style pressure for capacity expansion is decreasing nationally. Although some rapidly growing communities will need to expand their transportation systems to match suburban growth, most urban areas of the nation will have a breathing spell—time to plan and build sensible systems for local traffic management.

The bad news, to most of those who worry about urban problems, is that the plans must deal with the reality of nearly universal ownership of personal—not family—automobiles and a dispersed pattern of travel. One judges that more is to be gained from synchronizing traffic lights on suburban arterials than from building fixed-rail mass transit systems for commuters to the CBD.

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NOTES

1. The estimate of $463 billion is crudely derived from data published in *Statistical Abstract of the United States* (*1*, Tables 1004 and 1014). It includes only highway transport using passenger automobiles, buses, and freight trucks, and distinguishes local from long-distance trips.
2. Some of the others are Argentina (83 percent urban), Australia (86 percent urban), and Canada (76 percent urban). Most highly urbanized nations (such as the Netherlands, the United Kingdom, and Japan) are territorially small and densely settled throughout [*Statistical Abstract of the United States* (*1*, Table 1439)].
3. The farm population (people living on farms, a subset of those living in rural areas) increased throughout the nineteenth century, stabilizing at about 30 million persons in from 1900 to 1940. That stability was achieved by outmigration at the rate of about 600,000 persons annually. The annual outflow increased to nearly 1.2

million annually from 1941 through 1960, and the farm population dwindled from 30.5 million in 1940 to 15.6 million in 1960. As the pool of potential migrants diminished, so did the flow; by 1985 only 5.4 million persons lived on farms and the outflow was about 200,000 persons annually (*3*, Table K1-16; *1*, Table 1093).

4. Immigration from abroad peaked in the decade 1900–1910, when it averaged 880,000 persons annually, or 1.0 percent of the nation's population at the time. Although most immigrants first settled in seaboard cities, they later diffused to inland cities and some became farmers. The flow of immigrants virtually ceased in the 1930s because of restrictive legislation, which was liberalized after World War II. The statistics are poor, particularly with respect to de facto as contrasted with legal immigration, but the Bureau of the Census estimates that net civilian immigration, legal and illegal, peaked in 1980 at about 845,000 persons and has since declined to about 600,000 annually. These figures nearly match the annual flows at the turn of the century, but the receiving population is now much larger; the current annual inflow amounts to only 0.2 percent of the resident population (*1*, Tables 6 and 7).
5. At present, the projection exists only in the form of an advance release of the basic numbers; the methodological summary given in the text is based on a conversation with Signe Wetrogen, Population Projections Branch. The full report will be published as Current Population Report 1017, Series P-25 (*13*).
6. Detail for individual states is reported in Table 3; see Figure 1 for the states that compose each census division.
7. Since about 1974, the total fertility rate for U.S. females has been below the replacement level and remarkably stable over time. The total fertility rate is the number of live births per female that would result if current age-specific birth rates were applied longitudinally.
8. The estimating equation, fitted by Ordinary Least Squares regression on 153 observations (50 states and the District of Columbia for three decades) is as follows:

$$\hat{Y} = 0.8879X_1 + 0.1039X_2 + 9.1666$$

where

Y = current percent urban,
X_1 = percent urban 10 years previously, and
X_2 = percent population change during the preceding decade.

Because of the serial correlation between current and previous percent urban, the equation has a very high R^2 (0.945) and a very low root mean square error (0.0359). When the model is respecified to remove the serial correlation, the value of R^2 drops to 0.300, but its properties as an estimator are otherwise unchanged. Be it noted that this model does not purport to reveal anything profound about the process or consequences of urbanization; it is just a systematic way to make reasonable estimates from the available population projections. It was found to be quite sensitive to differences in the rate of population growth or decline and to different levels of prior urbanization.

9. The national source for such data is, of course, the decennial census. Although census returns are keyed to very small areas—census blocks, enumeration districts, and census tracts—the Census Bureau has not measured the land area of

these units, so small-area population or employment densities cannot be computed. Practically speaking, the best that can be done with 1980 census data alone is to contrast central cities with the remainder of their urbanized areas; or to contrast the central county of a Standard Metropolitan Statistical Area (SMSA) with the remaining counties (in New England, towns) composing the SMSA. However, at least one private firm, Geographic Data Technology, Inc., has converted the Bureau's geocoded street address file to digitized boundary descriptions and calculated areas for all of the census territorial units. So far, this resource does not seem to have been exploited for research into urban form.

10. Density measurements are intrinsically averages over space (*17*). When such averages for individual places are to be summarized, they can be weighted in any of several ways, depending on the analyst's interest. When one is exploring trends for urbanized areas, it seems most appropriate to weight all such areas equally. However, if the typical population density of urban space is being estimated, area weighting is appropriate; and if the typical density at which urban dwellers live is being estimated, population weighting is appropriate. As can be seen in Table 5, the choice of weights makes a substantial difference in the national average density for urbanized areas or their component parts. However, all three weighting systems convey the same message about density trends.
11. If the data could be recompiled to control for central city annexations of area and population, one source of ambiguity could be removed. As part of the 1970 Census of Population, the populations of areas annexed after 1960 were separately recorded, so they can be removed from 1970 central-city populations. A similar operation was contemplated for the 1980 Census of Population, but was dropped because of inadequate funding. It may be that for constant areas, the time trend by vintage is not as neat as that shown in Table 6.
12. Controlling for annexation between 1960 and 1970, 135 of 211 central cities lost population. Even including annexed populations, 94 central cities lost population between 1960 and 1970, 118 lost population between 1970 and 1980, and 77 lost population in both decades.
13. Gordon's analysis embraces a five-county area that includes the San Bernardino–Riverside Urbanized Area and the Oxnard–Ventura–Thousand Oaks Urbanized Area. He identifies two employment centers in San Bernardino and Riverside that are not included in this discussion of the Los Angeles Urbanized Area. The specific data discussed in this paragraph and the next are from unpublished tabulations that Gordon kindly allowed the author to use.
14. According to the 1980 Census of Population (*2*), the overall population density of the Los Angeles Urbanized Area is second only to that of the New York–Northeastern New Jersey Urbanized Area. However, the average density for the City of Los Angeles is 6,380 persons/mi^2, as compared with 23,416 for New York City, 13,180 for Chicago, 12,413 for Philadelphia, 8,848 for Detroit, 14,760 for San Francisco, 10,132 for Washington, D.C., and 11,979 for Boston.
15. The data are published in the source cited for Table 9 (*18*, Tables M-70 and M-80). Users of data from this source should know that the 25 largest urbanized areas contained 9 central cities in 1970 that were reclassified in 1980 as urban fringe. Those 9 cities contained 1,125,131 inhabitants, or 3.5 percent of the aggregate central-city population. To make the 1970 data comparable with the 1980 data, it is advisable to delete 3.5 percent of the employed residents from the 1970 central-city categories and add them to the urban fringe.
16. On the other hand, the same survey showed that work-trip length did vary systematically with size of SMSA, increasing from 7.1 mi for workers living in

SMSAs of fewer than 250,000 inhabitants to 11.2 mi for those living in SMSAs of more than 3.0 million inhabitants. It is puzzling that the relationship between work-trip length and size of area was more regular for SMSAs than for urbanized areas; one would expect the opposite. Pisarski (22) provides more detail about commuting flows within SMSAs.

17. A trip was defined as one-way travel from one address to another. Segments of a single excursion were counted as separate trips if the destinations were at least 5 min apart and were visited for different purposes. Thus, traveling from home to a shopping mall, visiting several of the mall's retail stores, and then returning home would count as two trips. Stopping at a drugstore on the way to choir practice and then returning home would count as three trips, provided that the drugstore was at least 5 min away from the church. The data presented in the table exclude non-local travel reported in the daily trip diary.
18. The authors of *Personal Travel in the United States* were puzzled by this result, finding (*21*, pp. 3-2 to 3-3) "no ready explanation . . . for the 1.4 mile difference between the usual and actual home-to-work trip lengths in 1983." However, they do not appear to have considered the definition of an actual trip given in the preceding footnote. The survey question about "usual trip to work" asks, "What is the one-way distance from [respondent's] home to [his] present place of work?" Because people often do other errands on their way to or from work, the "actual" work-trip segment need not begin or end at home. It would therefore be expected that "actual worktrips" would be shorter than "usual worktrips."
19. The national population projections used in the estimates shown in Table 15 were taken from a series prepared by the Bureau of the Census in 1984. The Bureau has completed a new series, to be published in the summer of 1988; the new series is reflected in the regional estimates given in Tables 2 and 4 and the state estimates given in Table 3. However, at the time of this writing, the age-sex detail of the new series was not available to the author. Comparing the projected totals, the differences between the old and new series were judged trivial in relation to their use for predicting local travel.

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Respondents' Comments

Ronald F. Kirby I greatly appreciate the opportunity to comment on the paper by Lowry. "Lowry" is a household word among those of us who have grown up in the transportation planning business over the last 20 years. He was really the father of land use and transportation modeling, and a lot of his early work is the basis for the transportation planning process that we conduct routinely now in our metropolitan planning organizations (MPOs).

In an aggregate sense, Lowry makes a strong case for the kinds of trends that we see in our metropolitan areas at the moment, and for things that we project over the next 20 years, namely, increasing ownership and use of private automobiles and dispersed travel patterns. There is nothing inconsistent in those aggregate statements with what we are doing in individual areas.

One of Lowry's statements that I really liked was that the role of public planning is to anticipate failures of decentralized decision making and ameliorate them. As a director of transportation planning, I think that that is definitely the case and we need to keep that in mind. Also, now that we are facing the results of two decades of what most of us would agree is rather inadequate linking of land development and transportation policies, the results of which are the object of much citizen dissatisfaction, this may be a good time for those of us who believe in planning to reassert the validity of Lowry's statement and to stress the importance of good public planning for the next 20 to 30 years, perhaps better planning than has been done in the recent past.

I do want to raise some questions, however, about some of the specific assertions in his paper, which I found to be somewhat at odds with what we are seeing and thinking about in the Washington metropolitan area. The first statement that struck me as surprising was that the North Central and northeastern regions aren't expected to grow very much. Lowry quotes a growth of

Ronald F. Kirby is Director of Transportation Planning for the Metropolitan Washington Council of Governments. Before joining the Council of Governments, he was Director of Transportation Research at the Urban Institute. He is currently chairman of TRB's Group 1 Council—Transportation Systems Planning and Administration.

only 3 million population from 1980 to 2010 in those areas, and the conclusion from that is that these areas are unlikely to have transportation problems exacerbated by growing traffic volumes and that they can concentrate on repairing their existing infrastructure.

Until I looked closely at the map, I thought that Washington, D.C., might very well be a part of the North Central and northeastern regions and I was about to take vigorous issue with that statement. However, I find that we just sneaked into the top of the South on that map; we are in the 30 million growth range. That weakens my case a little bit, because I was going to report that we are projecting a population growth in the D.C. region alone of 1.1 million. That doesn't leave much for anybody else, if the total is 3 million. I still feel that this point is somewhat questionable, and I would be interested in seeing the population projections from the MPOs and other groups for metropolitan areas in the North Central and northeastern regions, for cities like New York, Philadelphia, and Boston. I would be surprised if they were not substantially in excess of 3 million.

In conversations with my colleagues in those areas, I think it would be hard to convince them that they are not going to have their problems exacerbated by growing suburban traffic volumes. They are very busily trying to grapple with the same suburban growth issues that we are in the South.

Even if their total growth isn't going to be very great, I am sure that this dispersion phenomenon is going to create these same kinds of infrastructure problems. There were some interesting articles in the *New York Times* last year about the problems of expanding suburban roads outside of the New York Metropolitan Area and about the Metropolitan Transit Authority's proposal to close one of the main rail lines in the central area. This is the dispersion effect—the patronage is declining in some areas and growing in others.

The second assertion that puzzled me was that work trips will be short and in private vehicles. Short compared with what? Lowry's data show that trip lengths have changed very little from 1969 to 1983. They are around about 10 mi. Is that short? I don't know. Our experience in D.C. and our projections are consistent with Lowry's data in that the average work trip length has not changed much over those years and we are not expecting it to change very much over the next 20 years. With the growth in suburban employment centers, we are finding that residential growth is moving farther out and keeping that trip length around the same.

Suburban travel growth also raises some questions in that we do have continued growth in our area along the radial corridors. I would like to give our employment forecasts in different parts of the D.C. metropolitan area for the next 20 years to show you how sometimes the percentages can be a little misleading.

We are projecting a growth of 1.2 million jobs in this region from 1985 through 2010. The District of Columbia accounts for 200,000 of those jobs, and that is a 30 percent growth. Similarly, the outer suburbs in aggregate—Loudoun, Prince William, Charles, and Frederick counties account for 200,000 of those jobs, a 140 percent increase, which is much more attention-grabbing in percentage terms but in absolute terms about the same as D.C.

If you combine D.C., Arlington, and Alexandria, the inner jurisdictions, we have 400,000 jobs there, about one-third of the total for the region, 45 percent against the base. The inner suburbs—Prince Georges, Fairfax, and Montgomery counties—are the big ones in total, 600,000 jobs and 66 percent growth.

So, we have growth all over. In percentage terms it is greater as you move out, and that is where the infrastructure pressures are. However, growth is not declining in the central business district, so we are still going to need our subway system.

A point about private vehicles: in the table showing distribution of trips by mode, carpools and vanpools are not shown separately; I assume those would be considered private vehicles. In our region, the distribution of work trips is 18 percent transit, 25 percent carpool and vanpool, and 57 percent private automobile. We take great pride in the 25 percent carpool and vanpool. I suppose you might call those private vehicles, but that's not a troubling thing from our point of view because they do use the road system quite efficiently and we are working very hard with high-occupancy-vehicle (HOV) lanes and other incentives to promote ridesharing.

Work trips are a small portion, less than 25 percent of all trips. Nevertheless, the focus of transportation planning will still be to a large degree on the peak period, the commuter period, because that is where capacity is strained. It is also true that capacity is strained by weekend shopping and recreational travel at the moment, and in this respect, exclusive focus on work travel would not be appropriate.

Lowry's recommendation that our main task as transportation planners is to expand suburban streets and arterials is fine, but we do need to consider HOV facilities of various kinds. We are looking carefully at such facilities in this region, although they are controversial, both with the public and with the professionals, and there is also a lot of interest in future transit possibilities. There is a major study in Maryland on light rail, another HOV system.

I was interested in the basis for the subregional forecasts. Lowry points out the hazards of these forecasts—they are based on assumptions about fertility and mortality—and postulates a continuance of recent patterns of international and interstate migration. Thirty years is a long time and these patterns could shift because of economic and other factors.

Lowry's statement that Los Angeles is a bellwether for the future as far as urban growth is concerned raised eyebrows, because we don't look to L.A. as a model for future growth. However, many of the aspects of that growth are certainly occurring in our area. We are hoping to do a little more with HOV modes perhaps than L.A. has done, and we are also hoping to get more subregional centers and less sprawl.

There were not many policy implications in the paper; that was not its purpose. But I have to comment on Lowry's suggestion that, after all of the discussion, it is more important for us to concentrate on synchronizing traffic lights than on building fixed-rail mass transit to the CBD. That is at odds with what we are doing in D.C. We are building a rail system, and we do not have synchronized traffic lights in the suburbs. I don't think we are going to give up on Metrorail. Most of it is there, and it has plenty of riders and there are more coming. The problem is really to get them to the system by providing parking lots and access. We are projecting strong employment growth in the central area and strong growth in radial travel.

Finally, I would like to comment on causality issues—What is driving all of these projections? I think some planning can be effective. Furthermore, some of the forces that in the past were driving these projections don't necessarily have to continue in exactly the same form.

The Interstate highway program had a great deal to do with the extent of the dispersion that we have seen. That program is winding down. Something will take its place but whatever takes its place may not be quite the same. It might have very different implications.

Also, our transit program, I think, will be changed somewhat. It was designed as a kind of counterweight to the Interstate highway program. As the highway program changes, perhaps the transit program will change as well. I am struck by the thought that if we were standing here in 1950 taking those census projections without knowledge of the Interstate highway program coming along and projecting to 1980 without thinking about its influence, we probably wouldn't be too accurate in our forecast.

The other important factor that has had a tremendous impact on policies is the independent local government structure and the independent tax base structure of local governments. The suburban employment explosion that we have seen has been very much fueled by independent local governments scrambling to get a tax base to support the residential development. If we had a kind of a regional tax base where everybody shared in those tax revenues no matter where the development went, I think you might see less enthusiasm and more zoning control in the suburban areas.

Perhaps if we can get a greater understanding of these forces, we will get greater cooperation between local governments. I think that is coming simply out of necessity because of a sense of despair about the way things have turned out and the problems we have. Perhaps with that and some thinking about a new federal highway and transit program, these trends can at least be shaped and channeled to provide more efficient and attractive communities for those who will be around in 2020 looking back on our work.

RICHARD FORSTALL Northern metropolitan growth in the next three decades may, indeed, be modest, but still decentralization will result in substantial growth in some northern suburban areas. (This is a point that Kirby made a minute ago.) Also, a substantial share of home-to-work travel still has a radial orientation, because absolute central-area employment continues to rise.

I would modify Lowry's statement that the immigrants of earlier decades often became farmers. The great majority of immigrants between 1840 and 1940 came from rural areas in the Old World, but nearly all of them settled in urban communities in America. The main exceptions were German settlers in the Midwest and Texas in the mid-1800s and Scandinavian settlers in the upper Midwest after 1880. The very large groups of immigrants from Ireland, Italy, and Poland nearly all settled in cities, even though nearly all came from peasant backgrounds.

As the domestic sources of farm-to-city migrants have been drained in the United States, new sources of rural migrants have begun to be tapped outside the United States, shifting from Europe to Puerto Rico, Mexico, and Central America. I believe that most of these immigrants still come from rural backgrounds. Exceptions include a proportion of the post-1961 Cubans and perhaps a good share of the current wave of East Asians.

The trend noted for 1984 of some revival in central-city population growth since 1980 has continued to 1986, though at a reduced rate. Suburban growth has picked up since 1984 but is still considerably lower than in the 1970s. Nonmetropolitan growth has slackened considerably in the middle 1980s. Metropolitan growth continues rather steady at a rate of about 1 percent a year, as in the 1970s.

Relative to the state projections, I should note that there are a few typographical errors in the census division and state projected populations in Lowry's paper. Those interested in the exact numbers should obtain Press Release CB88-48, issued April 1, 1988, from the Census Bureau's Public Information Office or one of its regional offices. Also besides the Washington, D.C., area, West Virginia, in the South Atlantic Division, is not expected to

Richard Forstall is Chief of the Demographics and Statistics Branch, Population Division, Bureau of the Census. He has worked at Rand McNally as resident geographer and also as research geographer at the University of California, Berkeley.

grow rapidly between now and 2020 either. The discussion of density patterns within urbanized areas would benefit, as Lowry notes, from availability of national data on density for small areas like census tracts. Although the Census Bureau has not measured census tract areas in the past, it does expect to provide them as part of the 1990 census. In fact, the bureau is developing a digitized cartographic system known as TIGER that in principle will produce area data, and hence density data, for individual city and rural blocks as well as for all the higher levels of the census geographic hierarchy.

Lowry's excellent discussion of urbanized areas (UA's) and their density over time can be expanded using the delimitations of the UA's for 1920 through 1960 done by Pickard in 1968 for the Urban Land Institute. In addition to covering 1920, 1930, and 1940, Pickard also reviewed and modified the census UA definitions for 1950 and 1960 to increase consistency in the application of criteria, for example, by excluding sparse portions of some central cities from their UA, an approach the bureau itself adopted in 1970 and 1980.

Pickard also defined UA's for every area of at least 50,000; thus his lists of UA's are considerably longer than the bureau's for 1950 and 1960. Use of Pickard's 1920 to 1960 series with the bureau's data for 1970 and 1980 provides a relatively consistent coverage of the population clusters that had as many as 50,000 population in seven consecutive censuses. The main remaining gap is 1970, for which the bureau did not define all areas of as many as 50,000, although it did add 27 UA's in 1974 after broadening the rules for UA qualification.

Pickard's data show a mean density for 1920 of 6,156 persons per square mile in the 131 UA's of at least 50,000 at that time. By 1940 there were 190 UA's with a mean density of 5,562, about 10 percent lower than in 1920. There was a slight additional fall in density in the 1940s but the main drop clearly began in the 1950s when the mean density dropped at least 20 percent. Further drops of at least 15 percent each occurred in the 1960s and the 1970s, and in 1980, the mean density of the 366 census UA's was 2,676 people per square mile, or less than half the level of 1940. These results supplement and confirm Lowry's conclusions.

Lowry suggests that controlling central city data for annexations would clarify some key trends. There are several ways in which the population effect of annexations can be recorded. I won't attempt to go into detail here, but for those who are interested in this rather arcane topic, I would refer them to a long series of articles on annexations that have appeared in the *Municipal Year Book*, published by the International City Management Association. These include quite a lot of data for the 1970s and since 1980 on the population involved in large city annexations.

In evaluating population decline in developed urban areas, I think more stress should be placed on the significance of the nationally observed fall in average household size. As Gibson noted yesterday, some so-called declining cities have as many households today as 20 or 30 years ago, but the average household is much smaller now than then. Before assuming that population decline indicates some sort of decay in large cities, we might keep in mind that Manhattan peaked in population in 1905, with 2.4 million, nearly a million more than it has today, and with conditions of overcrowding that beggar the imagination.

The interesting discussion of Los Angeles and its 17 major activity centers raises several points. Much publicity has been given recently to the emergence of so-called new cities in the suburban rings of large metropolitan areas. The *Washington Post* has just completed a two-part series along these lines. It puzzles me that this development of an increasing range of jobs in the suburbs causes such amazement to many. Nationally, suburbs have been growing faster than central cities since World War I. The remarkable thing is that it took so long for them to acquire some of the characteristics long monopolized by downtowns.

We should be careful of invoking the stereotype that suburbs used to consist mostly of commuters to downtown. Aside from a handful of small elite bedrooms, I doubt that this was ever really the case. I know that the railroad commuter suburb where I grew up some decades back had plenty of residents who were employed locally or nearby in service jobs—rather than downtown, 18 mi away.

Los Angeles has often been suggested as a prototype of the multicentered metropolis. In fact, most of the 17 activity centers identified are not particularly new. Some, like San Pedro and Pasadena, antedate the emergence of metropolitan Los Angeles itself. The importance of the downtown area remains much greater than any of its outlying rivals. Table 9 in Lowry's paper shows that the Los Angeles core has as many jobs as the next 10 employment centers combined. It also has the highest job density on the list—this in a metropolis long regarded as very weak centered. It would be interesting to know more about the mix of jobs in the different activity centers and about what kinds of jobs are typically located outside any of the 17 centers.

Also striking to me is that at least 8 of the 17 centers are at least partly within the city of Los Angeles. In other words, they are not technically suburban at all. For those who deal with separate data for city and suburb, Los Angeles is an exercise in serious frustration because the so-called central city has wildly eccentric boundaries. For example, people living in Pacific Palisades and working in Santa Monica generally commute from a lower to a higher density, but officially they are commuting from the central city to a suburb. On the southeast edge of the downtown area, the corporate limits of Los Angeles remain where the Mexican pueblo placed them almost 150 years ago, just this side of an extensive industrial area that it has been agreed will not be annexed to the city. Some of this industrial area is probably included in the Los Angeles core area in Table 9, which thus embraces the central city's downtown and a section of what legally are suburbs.

In the opposite direction from downtown, the wide spaces of the San Fernando Valley probably come closer to typifying suburbia for many people than almost any other area in the country, yet this has been part of the city of Los Angeles for over 60 years.

In short, it is very difficult to reach any meaningful conclusions about core city and suburb characteristics from data for Los Angeles city and the balance of its UA or metropolitan statistical area. Admittedly, it is an extreme case, but a very large one.

There are other instances. Staten Island is part of New York City but Union City, New Jersey, much older and much more densely developed, is "suburban." Many Boston outliers, such as Chelsea, Somerville, Malden, and Arlington, would be within the central-city limits of any self-respecting Texas city.

Atlanta, for local reasons not known to me, has done virtually no annexing since 1952. So its central-city statistics look like a northeastern city's, with a heavy population loss in the last decade. Dallas, on the other hand, has generous boundaries and continues to grow in population within its corporate limits. In most other respects, these cities are quite comparable. But data for their central cities and suburbs do not match up at all. Does the contrast between the two cities indicate any actual functional difference, or does it exist only in the special context of municipal administration and finance?

Our understanding of metropolitan dynamics would be much advanced if we had some standard way of defining core city or inner city in terms of units like census tracts, independent of corporate boundaries. Such a definition would permit objective comparisons between cores and suburbs of different areas and different regions that are almost impossible using city political boundaries.

One other respect in which Los Angeles differs from most other major metropolitan areas is its relative lack of a far-flung low-density metropolitan fringe. The group of coastal lowlands near the city has been nearly filled up by urban development. The mountains nearby are almost empty and likely to remain so. The only major developable area within reach lies in the desert to the north. Thus, although Los Angeles lacks the very high population densities found in many older areas farther east and in San Francisco, by some measures it is one of the nation's denser urban areas because it has few areas occupied at densities in the range of 500 to 2,500 persons per square mile.
Finally, I have some comments on the pattern of commuting. Granted that the relative significance of the downtown area as a commuting destination has diminished in the post-war period, I think it is much too early to speak in

terms of largely unclustered employment and of an end to much radial orientation of commuting.

Table 9 shows that only 8.9 percent of workers worked in the CBD both in 1970 and 1980, but this represented an increase of more than 1 million in CBD jobs during that decade. (To be sure, some of this growth may be due to underreporting of the CBD as a work place in the 1970 census.)

The great expansion in suburban employment in the past two decades should not conceal the fact that total central-city jobs also have risen during that period. A review of commuting data for 1960, 1970, and 1980 for the main central cities of the 35 largest metropolitan areas shows that in the 1960s, 19 of the cities had population gains and 23 had job gains, but in the 1970s when only 11 of the cities gained in population, 27 had increases in jobs.

This sharp differential between population change and job change results from two phenomena. First, the labor force grew much faster than the total population in the 1970s because of the fall in the number of persons less than 18 years old and because of the increase in the share of women with jobs. Second, the falling population in these central cities resulting from decentralization was not followed to the same extent by decentralization of jobs. The net result of falling population and increasing jobs is, of course, major increases in commuting to many of these central cities, including those with falling populations. Only four of the 35 cities had declines in in-commuters in either the 1960s or the 1970s.

For the large cities in the North, total jobs fell slightly from 12.6 million in 1960 to 11.7 million in 1980, but total in-commuting increased from 3.4 million to 4.6 million. For example, Pittsburgh's population fell from 604,000 in 1960 to 424,000 in 1980, but in-commuting to the city rose during that period from 105,000 to 200,000. Growth of jobs and in-commuters was naturally greater in the southern and western cities.

If corresponding data were available for downtown areas as opposed to entire central cities, the growth in jobs and in-commuters would almost certainly be higher, because available evidence suggests that job losses in older cities have mostly involved industrial areas, not the downtown core.

In conclusion, I think we should anticipate continued moderate increases in downtown employment and in-commuting in most larger cities. In fact, I believe that this is quite consistent with the active downtown construction that all of us must be aware of if we visit almost any metropolitan area of more than 1 million. At least in the larger cities, public transit, it seems to me, will continue to play a major role in maintaining the typical high job density of downtown areas.

Frank Spielberg If this conference were being held in 1958, we would not be discussing what the future urban form would be but rather what it should be. There is a complete lack of any talk of "should" in this session, which is probably the most significant change that we have seen in the last 30 years.

I really can't disagree with any of Lowry's conclusions. The private vehicle will remain preeminent; the growth in metropolitan areas, especially those in the South and West, will present the greatest problems; and the challenge of today and the future is to expand capacity and improve traffic management. The national data that he has marshaled so effectively support these findings.

But this is a large and diverse nation, and it is always risky to engage in national generalization. It has been pointed out that Boston in the Northeast is growing rapidly, and Houston, the prototypical city of the South and the West, is experiencing slower growth.

So, although there are commonalities in setting national policy, we also need to recognize that there are a great many diverse differences among the urban areas. Further, although there is comfort in identifying the trends and examining their implications, it is really perhaps more interesting and certainly more fun to look at what is going on at the margin and see what little things are developing that could lead to real change in urban form if they were to evolve into mainstream behavior.

Along these lines of thought, first, what are some of the differences among urban areas? The smaller urban areas, which I will arbitrarily say are under 300,000, clearly have a better opportunity to deal with growth as it is occurring. The actual volume, if not the percentage, of growth is slower, and with adequate planning and funding they can get the facilities into place.

A strange observation about the large areas is that the transportation problems that are most talked about, and therefore presumably are the most severe, are those that are at the edges of the area rather than at the center. In Washington, D.C., conditions within the Beltway, partially due to Metro, are generally much better inside than they are at the Beltway and beyond. In our planning we have not really recognized or found the right balance between the capacity necessary for through travel and the capacity necessary to serve development. A large proportion of space in most suburban areas is devoted to roadways, but most of these are for land access rather than through travel.

It is often said that the military is well prepared to fight the last war. In the same way, zoning codes are very well adapted to solving the problems of the last cycle of development. We will, in time, work out the ways of defining the

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Frank Spielberg is currently president of SG Associates, a transportation consulting firm in Annandale, Virginia. He is the principal author of Profile of the 1980's, *prepared for the U.S. Department of Transportation.*

true needs of through traffic and seeing that they are provided at a scale that matches the development.

Lowry points out that travel times for work trips are relatively short, under 30 min. This is quite true on average and it is counter to what most of the public believes. We found the mean work trip length under 30 min in Montgomery County and had trouble convincing the client that we were right.

However, until work-place dispersion catches up, the more remote residential areas do produce longer trips. In this area, Loudoun and Prince William counties have about a 40-min work trip. In Stafford County, which is halfway to Richmond, it is about 45 min. The outer limits of the metropolitan area development are not set by the mean; they are set by the extreme trip lengths, the 1 hr 15 min to 1 hr 30 min trip. As jobs continue to migrate out, people who are keeping to their 45-min mean trip time just can leapfrog further out into the developing areas.

A couple of things may change development patterns and transportation needs. First, shortages—oil was talked about yesterday. Some time in the next 30 years, there probably will be some disruption; clearly there will be increases in real price. We might also see shortages in water supply, particularly in the South and Southwest, which could affect the growth projections for those areas. Ozone depletion is affecting the way we use chlorofluorocarbons, mainly freon, which supplies the coolant used in automobiles and home air conditioning. If we take freon out of production, we will have to bring in some other chemical that will probably not be as good and will probably be more expensive. That, again, could affect the South and West and also our overall suburban patterns.

Second, there is a trend to larger scale in developments, probably because of the way the capital markets have been changing. Not so long ago, a typical suburban development included, say, 200 to 400 homes on 50 to 100 acres. The capital markets now provide greater resources and we are seeing developments of 400 to 600 acres or even larger, and they include not only residential but also commercial and retail areas. I expect that we will be seeing larger developments in the future. When you have development of this size, much of the traffic that is generated remains internal to the development, and because large developers tend to hire reasonably competent traffic engineers, we can expect that the roadway facilities provided within these large developments will be adequate to handle the traffic and that we will have some reduction in the demands on the existing road systems.

Third, there are some trends to very different styles of residential developments. Some of the architects and planners that are being hired are experimenting with patterns that are not just replications of the postwar subdivisions, but rather draw on the image of small-town America and the era of the streetcar suburbs. Notable in this work is the team of Andreas Duany and

Elizabeth Plater-Zyberk. This firm proposes such radical ideas as houses that come close to the front lot line, grid street patterns, alleys behind homes that are used to reach garages, and walkways that rather than being hidden from view are actually along the public streets.

While the overall site densities average out to only four to five dwelling units per acre, basically to satisfy the financiers, the townhouse areas and the centers of their development will be as dense as 22 units per acre, with single-family housing at about seven to eight per acre and some of the apartment areas at up to 40. So far, the work has been well developed, well accepted. They are being hired, getting good writeups, and developers are finding financiers.

That such developments are desired, perhaps, can be shown by the land prices in some of the older suburbs that have been absorbed into urban areas, such as Leesburg, Virginia; the Main Line in Philadelphia; and Shaker Heights around Cleveland. There is a market, and if this trend continues, buyers may actually have a choice of the urban form in which they buy a new home. In these new old-style developments, transit service can actually be provided in efficient ways. There could be, if this style catches on, a trend to higher densities in suburban areas.

Fourth, suburban activity centers. Duany was quoted as saying, "The key to reforming America is to get hold of the codes." I alluded earlier to the effects of zoning. In a recent series on suburban centers, an article proclaimed that the Galleria in Houston was the most successful in creating a desirable environment. The writer went on to explain that this environment resulted from the proximity of uses. The entire site was built on. There was no expanse of parking to divide the buildings. People were able to walk from one activity to another inside, and the reason that this happened is that the land was so expensive that structured parking was the only solution.

The writer failed to note that in most places such dense development could not have been possible under any existing zoning code. The key factor in the success of this environment was the lack of zoning. So it is possible that the cost of land will ultimately lead to a relaxation of the codes that prohibit dense development, the kind that is really necessary to make walking and transit service both attractive modes for many people.

A similar pattern may also apply in residential uses. The density of the housing portion of suburban townhouse developments, when you get right down to just where the houses are, approaches that of cities such as Philadelphia. The site density is low only because of zoning and the space required to park the two or more cars required for each of the households.

In time, will the cost of land make surface parking in residential sites as uneconomic as it is becoming in suburban commercial areas? Will we get truly dense development in the suburbs?

Related to this is the affordability issue, which was discussed in Session 2 yesterday morning. The proportion of family income claimed by housing is increasing. In part, families have been able to keep pace by adding an extra wage earner. This is seen in the rapid increase in the female labor-force participation rates. But the participation rate for women is rapidly approaching that of men, and by 2020 we will surely have reached parity.

At that point, there will be no further supply of adults in the household to throw into the work force. Families will be forced to trade off the consumption elements of their life-style against the housing costs. My guess is that they will choose to keep consumption and look for more house and less land in an attempt to reduce the cost. This also will create further pressures for densification and relaxation of some of the zoning codes.

My point in all of this is that although the current forces and trends seem to suggest the continuation of those in the present, there are some very interesting things happening in small ways in a few places that could lead to significant change. We would be wise to keep an eye on these.

SESSION 5

Commercial Freight Transportation

The Outlook for Commercial Freight

PAUL O. ROBERTS AND GARY R. FAUTH

THE YEAR 2020 IS only 32 years away. To appreciate the difficulty of anticipating what freight transportation will be like in 2020, consider the forecasts that were put together by the experts 32 years ago, in the mid-1950s. How many experts then fully anticipated what effects diesel and jet engines, the computer, the Interstate highway system, containerization, and deregulation would have on today's dominant freight modes—railroads and motor carriers?

An essential step that must be taken to look ahead is to consider today's environment and how it developed. Whatever difficulties are associated with looking into the future, they will be all the more severe if the current situation is not accurately understood. Moreover, the powerful forces that have shaped and changed the current transport system are still at work and will remain at work into the future. The first section of this paper highlights the key recent trends and summarizes the resultant position of railroads and motor carriers in today's freight markets. In the second section, an assessment is made of where railroads and motor carriers might be in the future. It assumes that the seeds of the technologies and strategies that will be familiar in the year 2020 have already sprouted and are growing quietly.

Paul O. Roberts is President of Paul O. Roberts Associates. His prior experience includes Professor of Transportation at Massachusetts Institute of Technology and consultant-of-counsel with Booz, Allen and Hamilton, Inc. Gary Fauth is with Charles River Associates. Before that he was General Manager of Dun and Bradstreet Technical Economic Services. He has taught at Harvard University, and was on the staff of Union Pacific, the Interstate Commerce Commission, and the U.S. Department of Transportation.

RAILROADS AND MOTOR CARRIERS TODAY

Freight Market Trends

The rail and trucking industries have changed dramatically over the last 32 years, and especially in the last 7 years with the deregulated environment. This change is particularly noteworthy because overall freight markets have not been expanding rapidly. Since 1980, U.S. intercity ton-miles have grown slowly—more slowly than the gross national product (GNP) (Figure 1). Freight movements were dramatically affected by the 1981–1983 recession and by the drop-off in exports. The increase in the value of the dollar caused a second recession among key transportation-using industries, including export grain and fertilizer producers and export coal users. The net result is only about a 2 percent per year increase in growth in ton-miles since 1979.

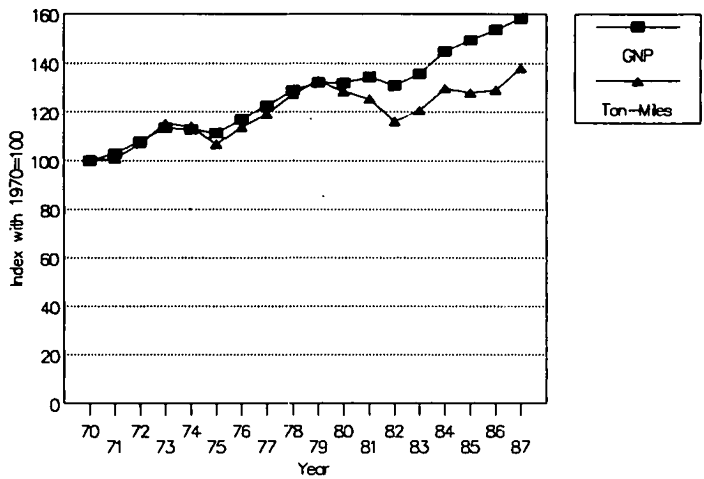

FIGURE 1 GNP versus freight transport.

The relatively slow growth in intercity ton-miles is an important trend, because it shows that the overall market is changing in an evolutionary, rather than in a revolutionary, way. In contrast, many service industries are growing rapidly in market segments that did not even exist 30 years ago. Some basic industries, such as petroleum production, are facing substantial absolute declines.

There was a time in the 1950s when the standard mode for transporting manufacturing output was rail carload. However, by 1970 completion of major portions of the Interstate highway system had made it clear that truck movement would replace rail as the standard for many shipments. With the passage of the deregulation-oriented Motor Carrier Act in 1980 and the Staggers Rail Act shortly thereafter, the shift to truck began in earnest (Figures 2 and 3). Even such traditional rail users as General Mills, which up to 1980 had routinely used rail for 75 percent of their moves, had switched to truck. By 1982 General Mills used trucks for 75 percent of their shipments.

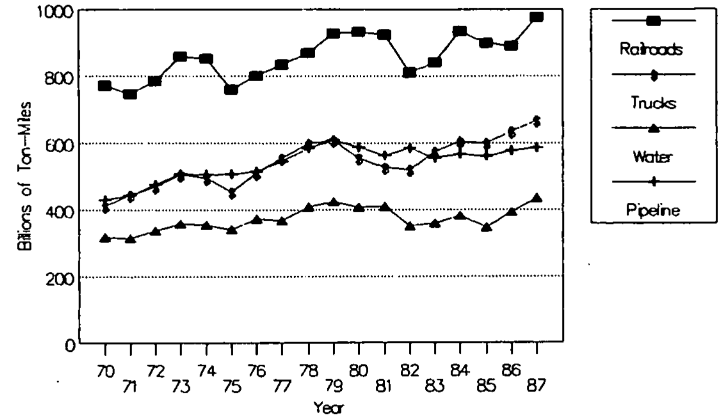

FIGURE 2 Ton-miles of intercity freight by mode.

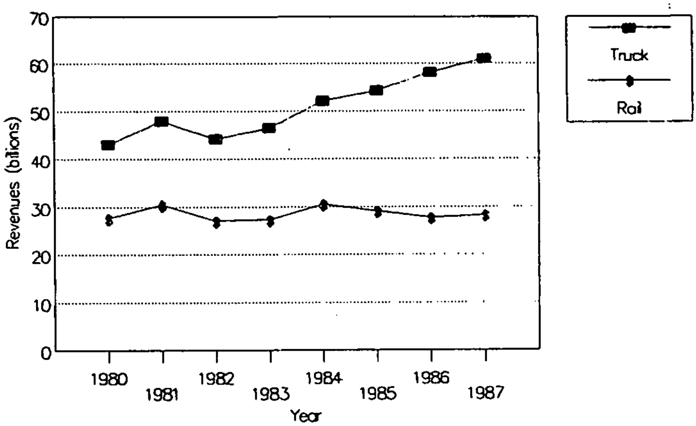

FIGURE 3 Freight revenues: rail versus truck.

This massive shift from rail carload to truck was not immediately obvious. It was obscured by the recessions of 1974 and 1981, which had been triggered by the fuel shortages of 1974 and 1978. The fuel crises had also reversed the long-term downward trend in the use of coal. The increase in rail coal movements tended to mask the loss of carload traffic in the overall rail statistics (Figure 4).

The recent shift from rail to truck is an important trend because it is the major competitive change currently confronting the industry. The results of this competition have had dramatic effects on the industry of today and will shape the balance of rail and truck services into the future. Indeed, many of the public policy calculations that will need to be made between now and the year 2020 will depend importantly on how successful the motor carriers are in continuing to divert traffic from rail to truck.

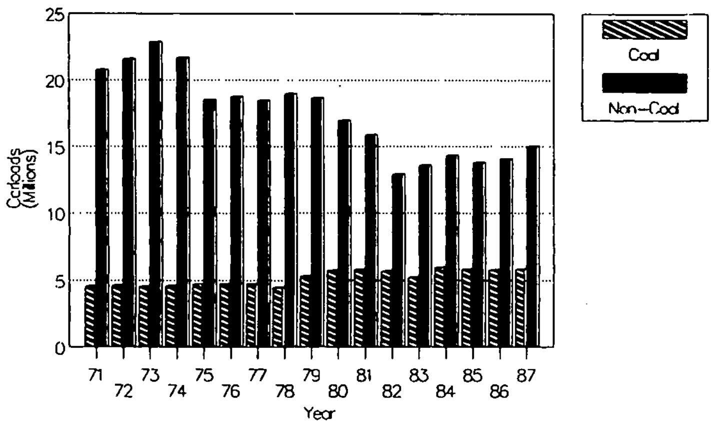

FIGURE 4 Coal and noncoal carloads, major U.S. railroads.

Today's Railroads

Products that need high levels of service have for the most part already moved to truck, and rail is left with the low-value, high-volume traffic such as coal, grain, and chemicals. The exceptions are automobiles and parts, some specialty chemicals, and intermodal traffic—which has grown so dramatically over the past few years that it occupies an increasingly important role in the long-run rail profit picture. Figure 5 shows the breakdown of overall rail revenues by commodity type.

Coal Coal traffic, which had been declining after World War II, had a resurgence after the second energy crisis, and is the principal rail commodity today (Figure 6). However, current low oil prices are again causing coal shipments to sag. Natural gas, for which both industrial and household

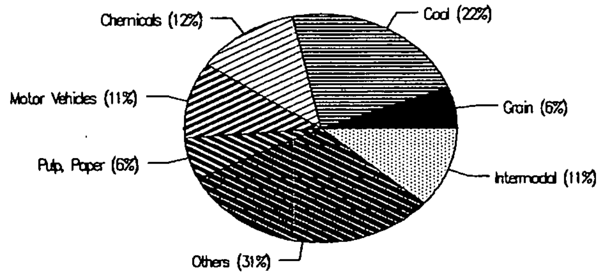

FIGURE 5 Rail freight revenues by commodity, 1986.

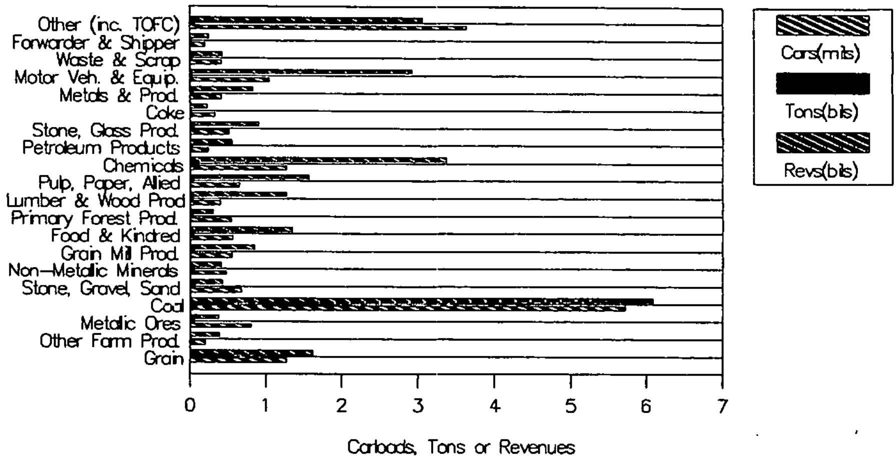

FIGURE 6 Rail freight commodities, 1986.

demand has grown as additional supply has become available, has become an attractive alternative because of environmental problems with coal. The most volatile component of coal demand has been export coal. Unfortunately, during 1981–1987, U.S. producers were effectively frozen out of the world markets because of the high relative value of the dollar. Figure 7 shows the recent trends in coal carloads.

Chemicals Rail is an effective way to move some chemicals. Hazardous materials transport by rail is safer than by truck and the necessity for storage at the destination tends to favor privately owned rail tank cars (Figure 8).

Grain Grain moves by both inland waterway and rail. When there are large amounts of export grain, the volumes carried by rail have been so large that

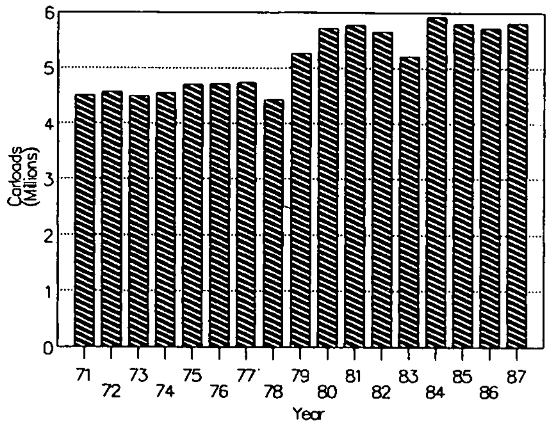

FIGURE 7 Carloads of coal, major U.S. railroads.

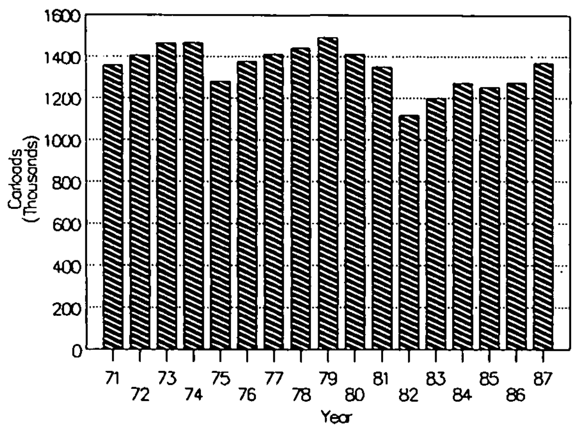

FIGURE 8 Carloads of chemicals, major U.S. railroads.

they create real movement problems. However, the amounts (and the earnings) tend to fluctuate from year to year. Like its impact on export coal, the relative value of the dollar has depressed world demand for U.S. grain (Figure 9).

Motor Vehicles Motor vehicles and equipment move in modest volumes in comparison with other commodities. The earnings, however, are substantial because of the uncommonly high revenues per ton. However, the automobile manufacturers have high demands for service, including a higher-than-normal

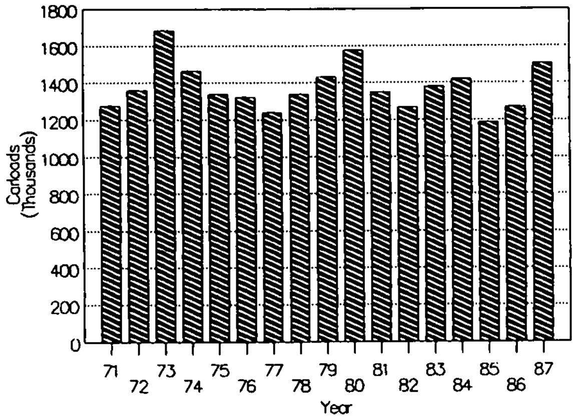

FIGURE 9 Carloads of grain, major U.S. railroads.

need for empty movement and the provision of special equipment and handling. Moreover, carloads of transportation equipment have been on a downward trend since 1970 (Figure 10).

Intermodal Commodities Intermodal traffic is especially important, because of the dramatic growth of import traffic in U.S. foreign trade and the emergence of double-stack technology to handle it. Although revenues are growing, profitability is still reported to be marginal. Intermodal movements

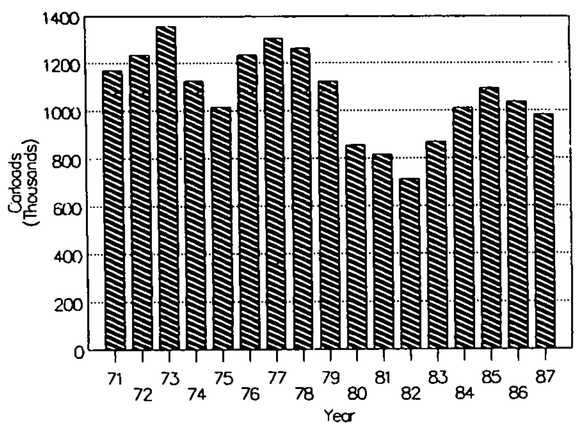

FIGURE 10 Carloads of transportation equipment, major U.S. railroads.

represent the cutting edge of the competition with trucks and consequently the hope for the growth of future earnings in the rail industry (Figure 11). Rail intermodal competition with truck is for medium- and high-value general freight shipped in truckload- or carload-sized lots to markets 500 to 2,500 mi away.

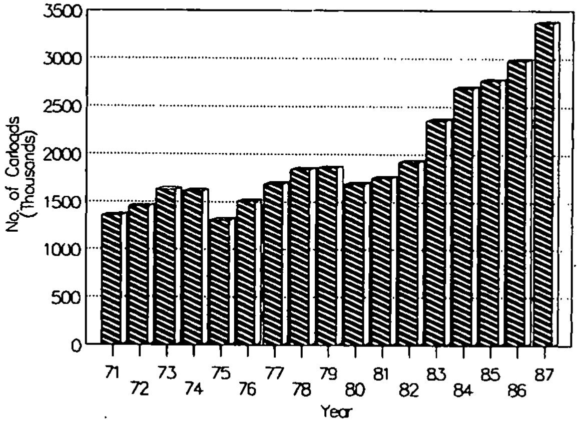

FIGURE 11 Intermodal carloads, major U.S. railroads.

Carload shipments have been eroding for years. Some of this traffic has undoubtedly moved to motor carriage, fueling the observed growth in the truckload sector. The balance of the loss in carload traffic has been diverted to rail intermodal freight. For a while, conventional trailer-on-flatcar (TOFC) service was extremely competitive with long-haul truck, especially for dense commodities and those that are not time sensitive. Recently, with the increases in truck sizes and weights, conventional TOFC has not fared as well in competition with truck. However, intermodal carloadings have more than doubled since 1980 (Figure 11), with much of the growth due to the surge in foreign trade. For a while imports were growing at 18 percent per year. Most of this import traffic moves in containers. For traffic destinations in the interior of the country, moves to major load centers, such as Chicago, are made by rail unit trains. Motor carriers are involved only in the drayage of the container to the ultimate receiver at the final destination.

Recent major innovations using double-stack containers have revolutionized the movement of maritime containers by rail. High-volume movements by unit train have line-haul costs of less than $0.50 per 40-ft container mile. Imbalances between imports and exports have led to a need on the part of steamship companies to return empty containers to the ports. Substantial rebates are sometimes offered to shippers who will fill the empty container with domestic freight bound for the port city or its environs. In those markets where empty containers are the most prevalent (from Chicago to the West Coast) the normal flow of domestic truckload traffic has been affected.

Today's Motor Carriers

The motor carrier industry as a whole is growing quickly, and at a rate faster than the rate of industrial production (Figure 12). There are four basic competitive segments within the trucking industry. These are the parcel carrier, the less-than-truckload (LTL), the private-truck, and the truckload segments. Specialty carriers are primarily identified with the truckload segment. The relative size of each of these segments over time has changed rather dramatically (Figure 13).

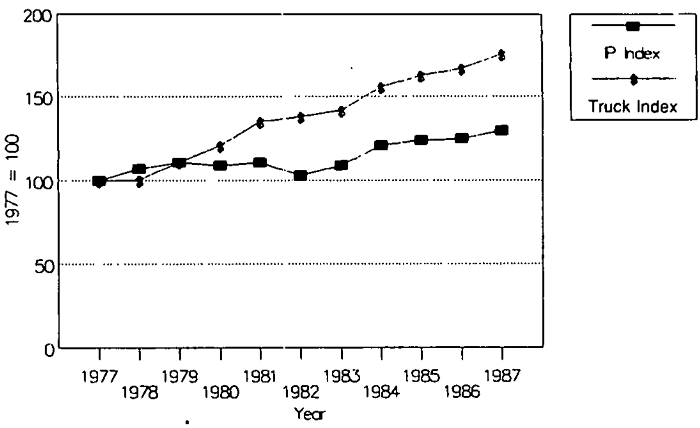

FIGURE 12 Truck revenue versus industrial production index.

Parcel Carriers The Interstate Commerce Commission (ICC) reports the activities of parcel carriers as part of the general freight segment, but they clearly belong to a separate segment. They are the largest carriers involved in general freight. Parcel carriers, dominated by United Parcel Service, are highly specialized and have grown rapidly. They are competitive with LTL carriers in the lower size ranges rather than truckload carriers. Parcel carriers use rail intermodal freight substantially in intercity trailer movement.

LTL Carriers The LTL segment is typically unionized and uses pickup and delivery vehicles to transport LTL-sized shipments from their origins through

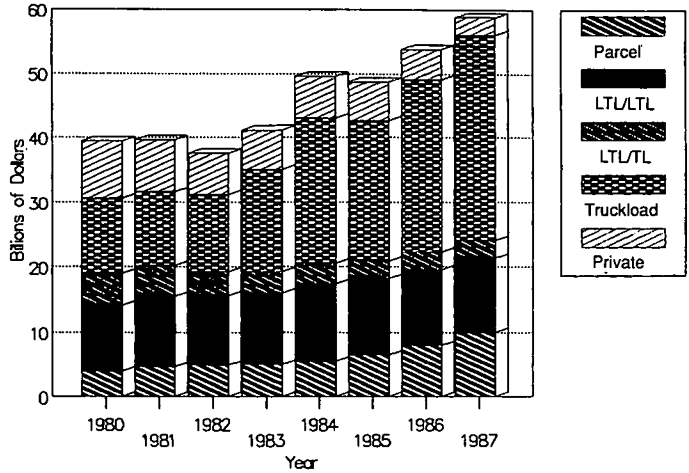

FIGURE 13 Freight bill for intercity trucking.

consolidation and deconsolidation terminals to their destinations on a typically extensive network of scheduled routes. The LTL segment contains the largest firms in the trucking industry, and its companies are the most well known.

Two types of LTL carriers are particularly successful at this time: large ($2 billion to $3 billion businesses) transcontinental carriers and regional carriers with very concentrated networks and high service levels.

Both types of carriers emphasize density on the traffic lanes that they serve. However, the geographical areas served by the two types are quite different in extent. At the time of regulatory reform in 1980 there was a full spectrum of LTL carriers, ranging from the largest, Roadway ($1 billion), to some with revenues of less than $1 million annually. Regulation had limited the growth of firms in the industry to only those that could be acquired by purchase or merger. With deregulation, the big firms invaded the territory of the smaller firms (as well as the territory of the larger firms) and took away their long-haul markets. Since then, the most successful carriers have been growing rapidly (25 to 30 percent a year). The key to success in the LTL trucking industry appears to be concentration by the carrier on achieving lane density within the market area. Those carriers that have not achieved density on their traffic lanes are foundering and it appears that they will eventually fail.

LTL carriers have historically carried a substantial amount of truckload freight. Before 1980 they held a significant, though declining, share of the truckload market. With the changes that have occurred in the relative economics of the LTL sector vis-à-vis the truckload sector and in the pricing structures of the two segments, LTL and truckload services have become two virtually independent markets, though they remain competitive. Because of their higher cost structure, LTL carriers can compete only for incremental traffic used to fill empty backhauls. As a consequence, the amount of truckload freight carried by LTL carriers has declined dramatically (Figure 14).

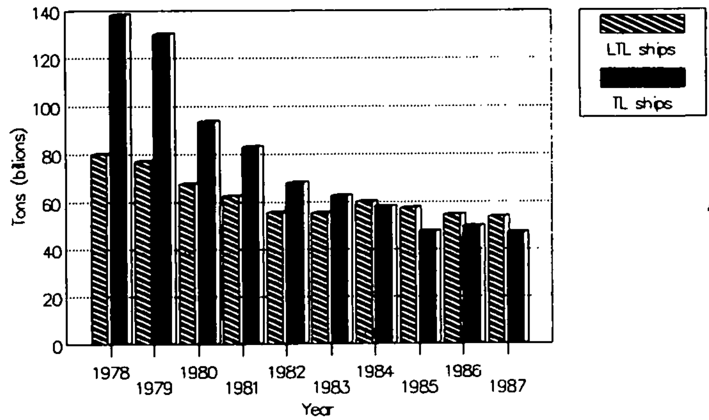

FIGURE 14 LTL tonnage for LTL and truckload shipments.

The LTL segment has suffered very badly, both during the 1981–1982 recession and since then. From 1978 through 1987 it lost 65 percent of the truckload tons shipped and 40 percent of the LTL tons. The loss of freight by the LTL sector was possible primarily because of the high level of LTL rates in the LTL tariffs published by the motor carrier rate bureaus. Separate rates may be filed independently or tariff rates may be discounted by individual carriers. When an LTL carrier wants to move traffic, the carrier's low short-term marginal costs allow bidding for the freight at rates that will capture it and still provide a contribution to overhead and profit. Rates that will allow the carrier to recover the contribution at fully allocated costs are typically uncompetitive. The only time that LTL fully allocated costs can be covered is when the shipper can find no truckload carrier to carry his freight and is forced to use the carrier of last resort—the LTL carrier—at the full tariff rate. It seems unlikely that LTL costs will change in the short term unless the differential in labor costs between union and nonunion drivers is reduced.

Specialty Carriers Specialty carriers abound in all segments of the trucking industry, but primarily in truckload shipping. Tank carriers, new-automobile carriers, heavy haulers, and cattle haulers all require quite specialized equipment and driver training. These carriers typically exist as separate companies or as independent divisions within a truckload company. Intermodal drayage is quite specialized in its own way, requiring rail-certified equipment, relatively short hauls, and a local pool of trailers. It is impossible to mix equipment, and driver experience within each of these sectors is typically very specialized. Competition is limited to other carriers in the same specialized niche. The specialized group is growing, but not as rapidly as the unspecialized truckload carriers.

Flatbeds, reefers, and household goods carriers are other specialties, though there is a cross-commonality with dry van carriers of general freight in each of the three groups. In addition, many of the dry van fleets are seeking ways to distinguish their service from that of the other dry van carriers. They are seeking marketing niches within which they can outperform other carriers and secure exclusive claim to a portion of the market. This may be done by providing special services (e.g., just-in-time shipments), regional or traffic-lane specialization (e.g., to and from the West Coast), or trailers placed for customer loading. Some degree of market specialization appears to be desirable in order to distinguish any truckload carrier from his competitors.

Carriers in specialty niches have grown at a rate only slightly higher than that of the industrial production index. For these carriers, length of haul is highly variable, depending on the type of carrier.

Private Fleets Many firms maintain private truck fleets to handle local pickup and delivery and to move shipments that require special service or handling. This private segment continues to exist today, though it carries principally short-haul loads. Some shippers found that a private fleet could handle long-haul movements on balanced and heavy traffic lanes at a lower cost than a common carrier.

After regulatory reform, a private fleet could request authority from the ICC to be granted a 48-state general operating authority. This allowed private fleets to become competitive with common carriers where this was desirable, or to become common carriers with their own authority when that appeared to be advantageous.

Since deregulation, however, long-haul private carriage has declined because of competition with long-haul regulated truckload trucking (Figure 15). Many companies appear to have abandoned their private fleets or downsized them drastically. Some have solved the increasingly difficult competition problem by acquiring authority from the ICC to become common or contract carriers. Because local carriage is primarily by private trucking fleets and the total freight market has grown, the dollars and tons handled by private carriers have still increased dramatically—by 44 percent since 1980.

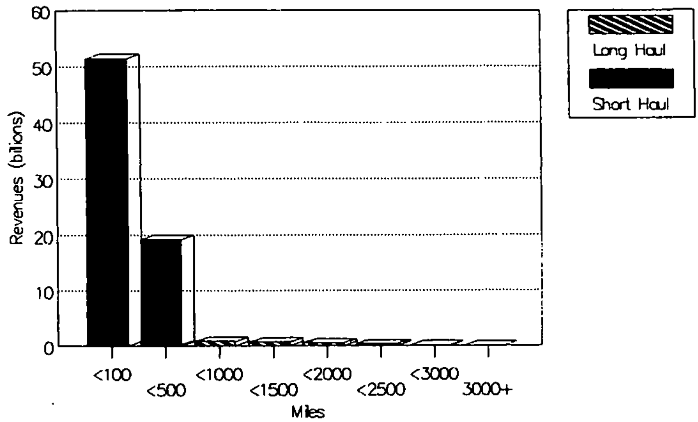

FIGURE 15 Private truck revenues by length of haul, 1987.

Truckload Carriers The truckload segment typically uses nonunion labor and carries shipments tendered by the shipper in full truckload lots directly from the point of origin to the final destination. Because truckload traffic was not historically the high-revenue segment of the freight market, such freight was left for the small carrier, who lacked the substantial investment in terminal facilities or pickup and delivery networks. Thus big carriers specialized in LTL traffic but handled truckload traffic as well, whereas smaller carriers were forced to carry only truckload freight. This characteristic of the industry persisted until 1980, when changes in the regulatory structure altered the rules of the game for acquiring operating authority. After 1980, truckload carriers began to grow rapidly, particularly in comparison with the LTL sector (Figure 16). This was remarkable in a freight market that had grown little since the late 1970s. Owner-operators were used to expand the fleet size.

The recession, which began to affect shipping dramatically by late 1981, caused a reduction in the amount of rail and truck freight carried of almost 25 percent before conditions began to ease in late 1983 and early 1984. Competition among carriers was intense. Logistics managers, pressed by upper management to realize the full cost saving promised by transportation deregulation, used their newfound ability to negotiate rates that pitted one carrier against another to secure the lowest possible cost for shipping. The losers were the owner-operators, who went bankrupt in droves. But for every bankrupt owner-operator, a new entrant, inspired by the dream of self-employment, bought the repossessed truck and filled the gap. The result was an era of low-cost trucking. In spite of continuing inflation, truckload freight rates did not rise. Shippers had a field day with all the truckload transportation services they could use at rock-bottom prices.

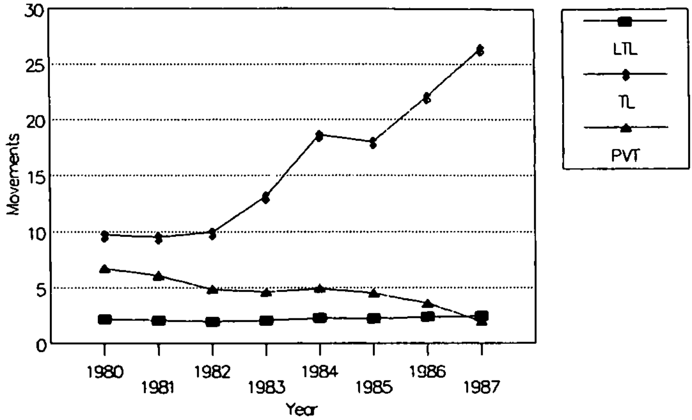

FIGURE 16 LTL versus truckload and private segments: number of loaded moves.

Although the truckload segment of the industry has never had extra-large firms like those in the LTL sector, two or three firms had already achieved considerable size before deregulation. Since that time a number of others have found that by managing costs aggressively and securing public financing, they can grow even more rapidly than other firms in the segment.

In late 1983, the amount of freight finally began to rise again, and the needed increase in capacity was met by a new type of truckload carrier, one that used company drivers (not owner-operators) and company equipment along with an extremely cost-conscious management style to dramatically reduce the cost of providing truckload transportation services. The capital to purchase fuel-saving equipment under very strict specifications was in many cases raised by public offerings of the carrier's stock, an innovation for truckload carriers. Interestingly, truckload rates generally did not rise to allow owner-operators to replace their equipment. Instead the growth in the industry was dominated by these new carriers, who added a great deal of the industry's new capacity at substantially lower costs than the marginal carriers, typically owner-operators.

The tremendous growth that has occurred in the truckload industry has set off a virtual scramble by various carriers to enter and dominate this market. It is useful to note that the rules of the game were changed by the Motor Carrier Act of 1980. There were also important shifts in the economic environment immediately before and after passage of the act. The act alone probably would not have produced either the speed or the magnitude of the changes that have been observed without the energy crisis, the inflation caused by it, the subsequent recession, the improvement in fuel efficiency of truck diesel engines, the legislation allowing larger truck sizes and weights, and the general overcapacity that existed in the industry at the time.

The most successful truckload carrier on the current scene is J. B. Hunt of Lowell, Arkansas. Profit performance has been good, growth has been outstanding, the balance sheet is strong, the management has been stable, and the company has recorded a solid performance for the last 10 years. It is viewed positively by shippers as an innovator by other carriers in the industry, and viewed as a good financial risk by investors, who like the high return on equity and the high price/earnings ratio achieved by the company. Certainly it must be viewed as the growth leader of the deregulated industry, growing from a revenue of around $10 million in 1977 to $286 million in 1987 and to projected revenues of $380 million for 1988. J. B. Hunt's management has indicated that it intends to be the first truckload carrier to record revenues of $1 billion a year, and it appears to be in an ideal position to do so. It has consistently recorded some of the lowest direct line-haul operating costs in the industry. Its large size and low costs give it a marketing advantage, even in a downturning economy.

Other carriers in the truckload group have also turned in performances that are outstanding. Several have return on equity that is higher than Hunt's. Others have briefly had costs per mile that are lower. Not all of those truckload carriers with high growth and low costs have the same operational philosophy as that reportedly used by Hunt, but most of them have a number of characteristics in common.

Revenues in the truckload segment have grown at a rate that is substantially higher than industrial production. This is due to the shift in traffic from LTL and private fleets, noted earlier, and to the diversion from rail carload that has occurred over the past 20 years and a possible shift from conventional TOFC over the past 3 to 4 years. Truckload is strongest in the medium- to long-haul markets (Figure 17). There is some short-haul intrastate traffic, but the amount is difficult to document and most of it is private carriage.

Outlook for the Transportation Industry

Reviewing current conditions and past history reveals that trucks have become increasingly competitive with rail, and intermodal rail traffic and truckload motor carrier traffic are growing rapidly at the expense of other, older segments of each mode, such as carload rail traffic or general freight carriers.

The preceding description has set the stage for consideration of where the freight transportation industry might be in the year 2020.

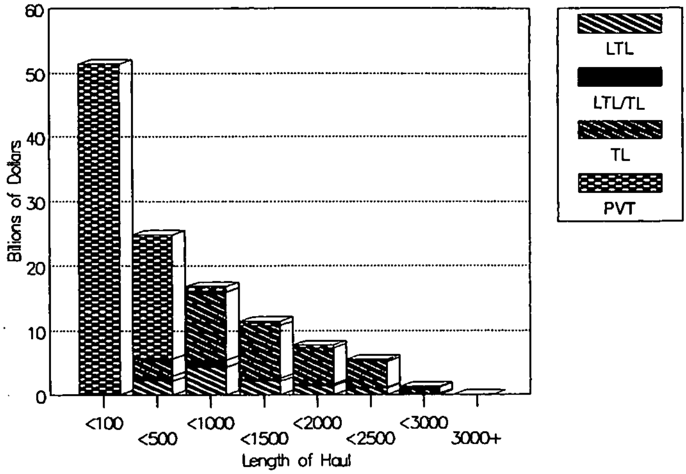

FIGURE 17 Revenues by length of haul, 1987.

Future Growth in Freight Markets

The current forecasts for the economy between now and 2020 have good news for the freight industry. Overall, the GNP is expected to grow more slowly than in the recent past. From 1974 to 1987, it grew at a 2.6 percent annual rate; in the next 13 years it is expected to average about 2.3 percent annually; it will trend down to 2.0 percent toward the end of the 32-year period.

If freight transportation continues to grow more slowly than the GNP, this outlook would imply a very slowly growing market. However, industrial production, in contrast to GNP, is expected to increase relative to the recent past, because exports and business investment are sources of future power in the economy, in contrast to the consumer-led recovery of the recent past. Industrial production should grow at 2.7 percent in the future in contrast to 2.6 percent over the last 14 years.

The continued power in industrial production should strengthen transportation markets. This trend is truly noteworthy, because goods have been a falling share of the GNP during the last 25 years. In the future the composition of the GNP will move toward goods and away from services (see Figure 18).

As a consequence of this revival of export trade, the manufacturing environment will experience significant growth, a by-product of which will be a surge in transportation. Truckload transportation will get a healthy share. Growth will boom until the next recession. At that time it is unclear what the final impact will be on truckload carriers. It is conceivable that the entire truckload shipping environment will benefit for some time to come.

Looking at particular markets for the most part reinforces this general optimism. Improvements in foreign trade have already begun. The change in

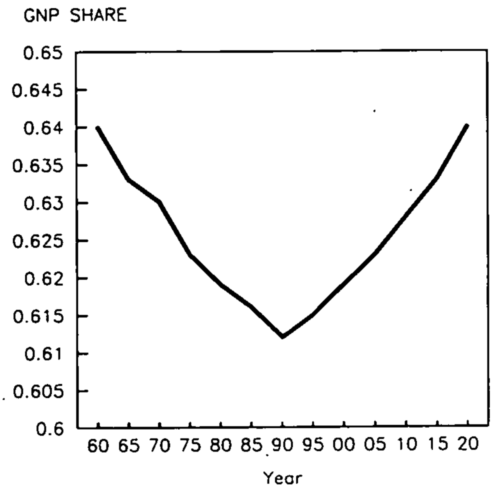

FIGURE 18 Demand for goods as a share of real GNP.

the value of the U.S. dollar has produced a surge of exports that has already begun to affect both rail and truck movements. Whereas during the 1980s approximately two containers of exports were handled for every three containers of imports, there is now a high likelihood that a balance in trade will be achieved in the near future. This will reduce the need to move empty maritime containers from interior points to port cities. If excess capacity in double-stack equipment exists and can be used for domestic movements, it may not make much difference in the competitiveness of truck versus long-haul double-stack rail. All long-haul movements may eventually have to be conceded to double-stack service. Meanwhile, the increased amount of freight moving in the United States as a result of the revival of exports will have good consequences for transportation generally and for the truckload trucking industry in particular. For every dollar of export goods, 25 cents is spent on the transportation of raw materials, semifinished goods, and components between the domestic manufacturers.

The coal industry has weathered a long storm and should, through productivity improvements and good management decisions, be well positioned for better times ahead. Competition from foreign countries will keep exports growing at a modest rate, but, overall, coal production in the United States is expected to grow at about 2 percent per year between now and 2020. Particular areas of transportation growth are the Powder River Basin in the West and the Central Appalachian region in the East.

Industrial production of transportation equipment, chemicals, and paper is expected to keep pace with the overall industrial production growth rate of 2.7 percent.

Outlook for Rail-Truck Competition

As has been indicated, truck-rail competition comes from several segments of the rail industry: rail carload, conventional TOFC, double-stack containers, and new intermodal technology.

Rail Carload Segment Rail carload traffic has been steadily declining for the last 10 years. One strategy used by the railroads to stem the tide, a practice known as rail transloading, appears to have the potential for slowing the decline in the use of boxcars. It is used when a large shipment of a heavy-loading commodity can be loaded directly into a rail car at the manufacturing plant and moved to a warehouse in the destination region, where it is "trans-loaded" into trucks for final delivery to a number of separate receivers. Short-term warehousing or light processing may also be performed at the point of warehousing. The concept is designed to serve manufacturers who ship truckload-sized lots to a number of receivers all located in the same region. For the shipper it offers an opportunity to "forward position" his inventory in a particular region only a short distance from the final user. Forward positioning of inventory can fit nicely with just-in-time processes. The major problem in applying the concept broadly is the lack of an entity to perform the consolidation-deconsolidation services, warehousing, and final truck delivery services. The railroad is in the best position to perform these services. Where individual railroads have taken the initiative, the concept has been successful. For bulk commodities such as chemicals, plastic pellets, and so on, it can offer large profit potential to both the railroad and the shipper because the cost by tanker truck can be relatively high.

Rail Intermodal Segment Rail intermodal shipping is the most potential threat to the future growth of trucking (and vice versa). There are several submodes, each with different characteristics.

TOFC. TOFC, using equipment 40 or 45 ft long and 96 in wide, is not competitive with truck, except for long-haul, heavy loading, and relatively low-value materials that do not require long drayage at the origin and destination. On dense, long-haul traffic lanes such as Chicago to the West Coast, there is still a substantial amount of conventional TOFC traffic, but it is steadily being converted to double-stack containers.

Several of the railroads have aggressively marketed short-haul TOFC service on an "expedited" basis in medium- to short-haul markets where the traffic densities should be able to support such service. Examples include Atlanta to St. Louis, Kansas City to Memphis, and Dallas to Chicago. They have used 45- and 48-ft-long, 102-in.-wide trailers; improved travel time; reduced ground delays; and cut prices in an attempt to build volume levels. There has been some success at building volume, but it appears that the service will not make a satisfactory return on the investment and will eventually be dropped.

Stack Trains. Stack train service has doubled every year since its inception and represents a major success story. The network of double-stack service is now quite extensive, connecting almost every major port with the principal inland cities (Chicago, New York, Detroit, Cleveland, St. Louis, Kansas City, Atlanta, Dallas, Memphis, etc.). The imbalance between imports and exports has led to rebates on sea containers to shippers who will use them for port-bound domestic moves. With the turnaround in foreign trade—exports increasing, imports slowing—this practice will become less important. In the meantime, however, American President Lines (APL) and CSX/Sealand are busy examining several of the larger third-party carriers, principally the potential to place 48- and 53-ft-high volume containers into service in the long-haul markets exclusively for domestic use. Long-haul truck markets to and from the West Coast felt increasing pressure from double-stack service for most of 1987.

The comparative economics of truckload trucking versus rail double-stack service is shown in Table 1. Line-haul direct costs favor rail double-stack service. The line-haul portion of long-haul moves costs about 39 cents per container mile. Lift-on and lift-off charges are around $170 per container. The limiting factor is the cost of drayage. In most drayage operations the moves are empty one way. This doubles the cost per mile. To overcome this limitation, careful coordination and planning are required. It helps if the markets will support dense traffic, because only one or two trailers a day to a given region are not enough volume to allow efficient handling, and improving the efficiency of drayage is crucial. APL has recently formed a new trucking subsidiary to handle its drayage.

The conclusion is that double-stack costs are substantially lower than those for truck shipment only on long-haul, heavy-density routes—Los Angeles to Chicago, New York, or Dallas, but not Chicago to Atlanta or to Kansas City.

TABLE 1 Cost Structure Comparison by Mode

MODE	TOFC/ COFC	OWNER-OPERATOR	TRUCKLOAD SUPERCARRIER	DOUBLE-STACK
LABOR COST	$0.07	$0.25	$0.21	$0.03
FUEL COST	0.07	0.17	0.11	0.06
PICKUP AND DELIVERY COST	0.25	0.00	0.00	0.25
EQUIPMENT OWNERSHIP COST	0.10	0.21	0.17	0.04
FIXED RUNNING COST*	0.09	0.14	0.12	0.05
TOTAL DIRECT COST	$0.58	$0.77	$0.61	$0.43
CIRCUITRY FACTOR	x1.15	x1.00	x1.00	x1.15
ADJUSTED COST	$0.67	$0.77	$0.61	$0.50
ADMINISTRATION, SALES AND MARKETING ETC. COST	0.20	0.24	0.18	0.16
TOTAL INDIRECT COST	$0.87	$1.01	$0.79	$0.66
DEADHEAD (EMPTY BACKHAUL) FACTOR	÷0.65	÷0.85	÷0.92	÷0.8
TYPICAL COST PER LOADED MILE	$1.33	$1.19	$0.86	$0.82

NOTE: All costs per trailer/container mile.
*Includes equipment maintenance, insurance, licensing, etc.

The long-term issue for trucking is the number of markets in which domestic stack trains will eventually be successful. The number is likely to be small, but even that may hurt the truck industry. In the markets between the West Coast and the Midwest, for example, the amount of double-stack capacity flooding the marketplace has depressed truck prices.

The phenomenally low cost of stack trains for the containerized movement of imports and exports has led intermodal operators and third-party shippers to explore the use of 48- and 53-ft containers for the movement of domestic freight in direct competition with rail carload, conventional TOFC, and long-haul truckload carriers. The results are only now beginning to be apparent.

The proportion of the total long-haul truckload market that is involved in the extremely long hauls (i.e., greater than 2,000 mi) is less than 12 percent. The danger to trucking comes in the 500- to 1,500-mi markets. More than 60 percent of the regulated truckload business falls in this category. Rail technology that is economically dominant in this length of haul could have a devastating effect on truckload markets.

New Rail Technology. New rail technology appears to have the potential to dominate the short-haul market—the RoadRailer (discussed by Sobey elsewhere in this report). The concept was originated in the 1960s by Robert Reebie, who obtained financing and built prototype trailers for testing. The concept worked well mechanically and was tested in several projects. For a variety of reasons, including the heaviness of the equipment, these tests were unsuccessful. Nevertheless, the concept has recently been revived with the advent of new, larger trailers and clip-on rail trucks. New tests by several of the railroads have demonstrated the feasibility of this technology for just-in-time shipments of automobile parts in racks. Other services are planned.

One innovative rail intermodal system using RoadRailers, being established by Mark 7 Transportation Company, will use 53-ft trailers in 80-unit trains originating in each of 10 major cities around the United States and broken up and reclassified over a hub center in Kansas City. This operation is backed by the Burlington Northern, Santa Fe, and Norfolk Southern railroads and will provide daily service between these cities and the West Coast. If successful, trailer-load service from Dallas to Minneapolis, Chicago, Detroit, and Cleveland will move through Kansas City in the same way that an LTL carrier might use a breakbulk terminal.

The potential for RoadRailers or similar technology has yet to be realized. The same problems will exist with drayage for RoadRailers that exists now for conventional TOFC. Circuity is also a problem. Out-of-route miles are expensive. For truckload trucking they cost around 70 to 80 cents per mile. For the RoadRailer they are reported to be less than 40 cents per mile. The next few months should give the answer. Over the short term, the major sources of competition are other carriers in the truckload industry.

Government Actions and Motor Carriers

Among the government actions being debated that affect the motor carrier industry are the following:

- Establishing uniform truck access to Interstate highways,
- Establishing uniform size and weight limits for trucks,
- Allowing large doubles on the Interstate system,
- Instituting bans on trucks in urban areas,
- Reregulating the trucking industry, and
- Adding major sections to the Interstate highway system.

All of the actions noted have been proposed at one time or another at either the federal or state level.

Uniform Truck Access An issue constantly being stressed by the industry is uniform truck access to the Interstate highways. Within some states access for 48- or 53-ft equipment to the Interstate system is restricted to within a very short distance from the interchanges. Connecticut originally forbade the use of 48-ft equipment throughout the state. Resolution of the issue has been on the agenda of the U.S. Department of Transportation for some time. It appears likely that it will finally be resolved and that equitable access to and from industrial sites will eventually be allowed.

Uniform Size and Weight Limits Trucks 53 ft long are likely to face the same access problems that have been found in the case of 48-ft equipment. Long-term resolution is likely to favor use of 53-ft equipment in all states.

Large Doubles on the Interstates A more fundamental question, and one of much greater economic significance, is the use of large doubles on the Interstate system. For states in the West, large doubles (i.e., two 45-ft trailers or two 48-ft trailers) are routinely allowed on the Interstates. Because they are not typically allowed on local roads, the company must maintain marshaling points at various interchanges along the highway. Large doubles have posed no particular safety or technical problems, though they have raised substantial consumer concern and opposition by groups such as the American Automobile Association. In spite of consumer concern, it is likely that legislation allowing their use in some restricted fashion will be enacted sometime within the next 5 to 10 years. If RoadRailer technology is successful or if there is another energy crisis, large doubles will be virtually assured. Congress has always leaned toward the slow relaxation of length and weight restrictions. There is relatively little technical problem with increased wear on the roads, but there will likely be increases in user taxes extracted from the industry if such doubles are allowed.

For large truckload motor carriers, the use of large doubles will be a boon. Although it would be necessary to retrain drivers and to relocate some of them, a regional structure is ideally suited to the development of load centers, or breakbulk terminals, using doubles. Double trailers are estimated to save between 30 and 40 percent of the line-haul, direct cost of movement. Large carriers using load centers will find large doubles extremely compatible with their current operations. In fact, even with doubles it may be desirable to use load centers more actively as a device to improve the use of equipment and the driver recruitment problem.

Truck Bans The increase in urban congestion throughout the United States has been exacerbated by the dearth of highway funding during the last few years. In the short run there will likely be an increase in public concern against the use of big trucks on urban freeways. This is likely to produce a rash of truck bans and hours of prohibition of truck entry onto freeways. In the long term, however, such actions are likely to help build pressure for an increase in funding of additions to the Interstate highway system.

Interstate Expansion. Because little funding has been devoted to major additions to the Interstate highway system in the last few years, it seems likely that new construction will be forthcoming in the near future. It could be accompanied by relatively large increases in truck user taxes. These should not have a major impact on competition within the industry. They will, however, increase competition across modes since an obvious quid pro quo for higher taxes is allowing big doubles. One possibility that seems likely is the construction of urban bypasses for trucks. Such truck-only or truck-dominated routes would greatly improve access to urban areas. Travel between them would also be improved for long-haul trucking. The trucking industry as a whole understands the importance of continued funding for the highway program and will almost certainly lobby in favor of additions to the system.

Reregulation Reregulation of the trucking industry is too speculative to comment on substantively at this point. The concentration of the industry that is occurring in the LTL segment of the trucking industry and the coming increases in the number of smaller firms that go bankrupt will almost certainly generate a backlash for reregulation. The same concentrating forces are present in the truckload industry that exist in the LTL industry, but at a very much lower level. It is conceivable that reregulation of the industry will be concentrated on the LTL sector exclusively. Given the substantial adjustment to the deregulated environment that has taken place since 1980, however, this almost certain reregulation of the industry will be extremely difficult to implement.

Government Policies and Railroads

Two policies are currently being debated that could affect the rail industry: (a) passing acid rain legislation and (b) repealing the Staggers Act.

Acid Rain Few now doubt that acid rain legislation is imminent—the questions are simply when and how much? The issue has been debated for so long and clouded by arguments from so many lobbyists from all sides that it now appears to be driven more by emotion than by analysis.

The most restrictive legislation now being considered would effectively be a mandatory scrubbing bill that would require massive capital expenditure by the nation's utilities to retrofit old plants, build new units, and increase utilization rates at scrubbed plants. Some coal markets would be destroyed and others bolstered, but most likely it would be a "wash" industrywide.

Repeal of Staggers Act The intent of Congress in passing the Staggers Act was to improve the financial health of the railroad industry by reducing federal regulation. There is some concern that captive shippers have not been protected, and some bills have been proposed to roll back some rates and make it more difficult to abandon unprofitable rail lines. Should the Staggers Act be amended, it would be more difficult for the railroads to respond to the competitive challenges of the motor carriers.

Energy Prices and Availability

Because of declining productive capacity, the United States will continue to grow more and more dependent on the Organization of Petroleum Exporting Countries (OPEC) and other oil-producing countries over the planning period, and fuel prices will rise more rapidly than in the recent past. If OPEC had shown itself to be a more cohesive group during the recent past, it might be reasonable to expect another energy crisis. However, public mechanisms for coping with the problem and public attitudes toward fuel conservation are substantially more mature at this time than they were at the time of the first or second crisis.

CONCLUSION

Between now and 2020, the economy will almost double in size, and, in contrast to the recent past, demand for rail and motor carrier transportation services should expand at least at that pace. This review of recent operating evidence suggests that a major unknown is understanding how rail-truck competition will be resolved over the time period and how some major public policy initiatives will unfold. The competitive and public policy issues will determine how different rail or motor carrier growth will be from the overall expansion of the freight market.

This review has focused on the physical volumes of freight moving on the U.S. rail and highway systems. Anticipating the business organizations that might evolve to handle freight is a separate issue, and changes are taking place in that area as well. For example, short-line railroads have emerged since deregulation: the large roads have spun off low-density lines into separate businesses that have reduced their labor costs and adjusted their overall cost structures. The concept of "total" transportation companies that might arise to utilize both rail and motor carrier modes is certainly on the horizon. Total logistics companies are another possibility. Even total transportation companies will have to decide how intensively to use rail and trucking, and those decisions will translate into the physical flows that are the ultimate concern.

ACKNOWLEDGMENT

Information for the table and figures used in this paper came from a variety of sources: *Transportation in America* (*1*); testimony of James Harkins, Director of the RCCC, before the House Committee on Public Works and Transportation oversight hearings on the Motor Carrier Act of 1980, March 16, 1988; Benjamin J. Ritchey, *Long Haul Truck Count and Gross Revenue* (2); working papers of the Intermodal Policy Study Group concerning the National Motor Transport Data Base, May 1988; and working papers reporting the results from Continuing Traffic Studies, developed by the various Motor Carrier Rate Bureaus.

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Respondents' Comments

ROBERT K. WHITFORD I would like to address the future in commercial freight from a slightly different angle. Events of the last decade or so, with double-digit inflation and deregulation, have caused and will continue to cause a marked shift in freight movements. Those shifts, from my perspective, are reflected in two questions:

1. How will shippers view and use transportation?
2. How will transportation respond to the needs of shippers?

To view 2020 freight movement and demand properly, we have to know not only where the population lives and works, but the type of work they are doing and what the economy looks like. One of the effects of moving toward a service economy is that goods will not move the way they are moved today. They will move in different directions. We will be importing more and exporting less. I would like to underscore two or three things alluded to by Roberts and Fauth that are an important part of this future orientation.

First of all there is the question of the businesses themselves. Roberts and Fauth discuss the question of transport modes, yet with deregulation we are finding that carriers are becoming more and more multimodal. CSX is a good example of a company controlling a variety of modes, including overseas shipping. We can call these companies "supercarriers." They are emerging at a rapid rate. What type of management structure they will have and how they will seek to invest capital are areas of research left for strategic planners. There are many issues around the mergers and the formation of major end-to-end carriers that must be solved.

Robert K. Whitford is Professor of Transportation at Purdue University. His past positions include visiting professor for interdisciplinary studies at Purdue's Automotive Transportation Center, Acting Director of the Transportation Systems Center, and manager of Advanced Electronic System Corporation and Guidance of TRW Federal Systems Group.

Second, there is a growing area of business in Europe called distribution companies. These companies manage for others all aspects of distribution, controlling inventory, warehousing, and transportation. The trade-off between inventory on one hand and transportation costs on the other has caused these management companies to move in and to manage all of it and save money.

The impact of the distribution on the manufacturing process, and vice versa, means that this third party is hired, gets involved in the company's planning but brings a very specific expertise of knowing how to warehouse, to distribute, and to transport the company's product. In fact, in this era of strategic planning, we are finding more and more companies that say they are manufacturing companies and not necessarily distributors. Thus, they look around for partners to help them in that respect.

In Europe a company called Franz Maas handles the entire incoming and outgoing distribution for their customers; they move all the goods from the suppliers, do the receiving, repack if necessary, and provide the preassembly storage and warehousing. The inspection and assembly are done by the production house.

On the outbound side, Maas does the distribution and transportation to the customers using 2,000 employees, a set of specialized resources including 105 centers located all over Europe, and about 260 trucks with over 1,200 trailers. You might liken this to an LTL company that turned their terminal into a distribution center with storage as well as consolidation capability. Maas has approximately 1.5 million ft^2 of modern warehouse space, and their sales in 1986 exceeded $200 million in U.S. dollars, with profits in U.S. dollars of about $15 million.

One company for which Franz Maas has provided services manufactures copiers, mainly for European distributors; they also market copier parts in other countries such as Mexico and Brazil. This company started with some 5,000 suppliers and over 20,000 different parts. Since Maas has handled their distribution (both the inbound materials management as well as the outbound), they have almost tripled their production with a lower labor force (185 employees rather than 200). Their inventory was reduced to 35 percent of the previous 1981 value and their transportation distribution costs were reduced to 60 percent of the 1981 value. This is a dramatic change, and by using computers and understanding what businesses they are working with, they have been able to find a market niche to provide these kinds of services, show considerable improvement to the company, and earn a respectable profit themselves.

Of course the flip side of this whole thing is that Franz Maas or any distribution company must get deeply involved in the manufacturer's operation, maybe too deeply for some of our companies. However, they work not only with the copier company, but with a truck manufacturer and two clothing companies. They are able to get their value added by working across the company products to consolidate and ship full trucks wherever they go.

Third, I would like to talk about the question of management information systems. We have heard very little about that, but we all have seen the dramatic impact that the computer has had over the last decade or two. That impact will continue and expand. The fact is that you can really cause an improvement in your production and in your shipment with a more in-depth use of computers.

One truck company has been working with a university on efforts to integrate the information technology into their strategic planning. In other words, training for use of the computer should be at the beginning of the strategic planning process.

Many of you know about materials requirement planning (MRP), which has been done by industry for a long time. An add-on to it, which incorporates MRP, is called distribution resource planning (DRP). This is an effort, through the computer and through a broad information base, to develop an overall plan for the improving productivity and operations of a given company. It is a key piece of software that will provide planning data for future distribution systems. It synchronizes distribution and production.

Another future development for commercial freight is in the area of facilitation. There are a number of third-party interchange systems being established that will provide interchange data to improve distribution. With proper security, suppliers, carriers, and manufacturing facilities can exchange production schedules, material status, location of shipped goods, and so forth, to implement their production and sales programs. For example, U.S. Customs is experimenting with on-line electronic data interchange (EDI) between several U.S. ports. Distribution centers and warehouses can have complete knowledge of inventory, production schedules for back order, estimates of stock out, and the like. Consolidators can determine how and where to consolidate to achieve the highest productivity in distribution.

Payments can be made electronically, market fluctuations can be observed, and management action can be taken based on better data and an improved understanding of the total system. Finally, management will have the best overview of operations that they have ever had.

I don't see this as a 2020 phenomenon; I see it as a 1995 phenomenon. Parts of it are in operation right now. The computer is going to continue to affect our ability to be productive and we need to use it to our best advantage.

Finally there are three other things with which commercial freight must concern itself: (a) What will we do about the sizable drayage costs over the next 30 years? It is the expensive part of any move and it must change dramatically to maintain cost-competitiveness. (b) Containerization is on the increase and needs to be addressed in terms of standard sizes and productivity.

(c) What is potential for railroads to regain some of the market share from trucks for the shorter hauls (500 mi)? Such potential might be captured as we set up hub centers and use new technologies like RoadRailers for lower-density routes.

ANNE STRAUSS-WIEDER I agree with Roberts and Fauth—given the current state of the freight transportation industry, it is as difficult to predict what the status of that system will be in the year 2020 as it would have been for a railroad analyst in the early 1900s to predict today's situation. I would like to offer a view of the future of commercial freight transportation based on the premise that the demand for freight is a derived demand, one that is based on the needs of the economic base being served, that is, the type of industries and population being served, and any constraints that may be imposed on the freight system.

Two major economic trends today are particularly shaping freight services:

- The advent of the global economy, and
- The rise of the service economy.

There is no question that the global economy is here. The production line for the Allante automobile stretches from Italy to Detroit. The global extension of production lines has already made its impact felt on domestic freight services. Domestic freight transportation companies (in particular, the railroads) are moving into the international arena. These transportation companies are "connecting" with the overseas plants to ensure the use of their domestic systems. Examples include CSX's purchase of Sealand and Conrail's establishment of an international sales unit. Likewise, international carriers are considering moves into the domestic transportation system to secure traffic. The globalization of the freight system is a trend that will continue.

Another outcome of the global business environment is increased competition and with that an increased need for businesses to compete through their product line and by watching their bottom line. Businesses are meeting this competitive challenge by using new technologies to make themselves more cost efficient, technologies like the computer, which allows them to link with their suppliers and customers in new ways and consider new options like

Anne Strauss-Wieder is Supervisor, Freight Research Section, Port Authority of New York and New Jersey. She is chairman of the TRB Committee on Freight Transportation Planning and Marketing.

reviewing their balancing of transportation and inventory costs—two major expenditures. One outcome of this has been the implementation of just-in-time delivery systems, which seek to minimize the amount of material warehoused by using more transportation services. This can translate into "warehouses on wheels," where the transit time is predictable and timed to feed into the production line.

This type of transportation system also requires the use of sophisticated goods-tracking systems so companies know where their items are. EDI may have begun as a marketing tool, but it is essential today and will remain so in the future. The year 2020 may see the standardization of these computerized systems.

The rise of the service sector has also meant change in the demand for freight services. Manufacturers produce widgets. Service firms such as insurance companies produce information. In terms of freight services, this translates into moving information, which is a time-sensitive commodity, and the materials used to produce the information—paper and office supplies. The need to positively, absolutely have it by 10:30 a.m. led to the spectacular growth of the overnight package delivery services. This industry is now in a maturing stage and facing competition from the facsimile machine and computer linkages. We may also see more of a paperless office in the future. Although there will always be a certain amount of legal and financial documents that will need to be transported, the demand for this type of movement may decrease.

The point is that different industries have different freight needs. They vary in terms of the quantity of goods that need to be delivered at a given time, distribution patterns, and delivery and in-transit times. Freight services will change as certain industries and others wane. Let me just mention a few other freight transportation developments that have occurred because of the changing needs of businesses and deregulation of the transportation industry.

There has been a great deal of technological development recently in freight transportation. We've seen the development and phenomenal success of double-stack trains, experimentation with RoadRailers, reassessment of permissible truck sizes and weights, and all sorts of lengths and widths for containers. This is happening because transportation companies, like other businesses, are competing through the products and services they offer and by paying attention to costs. This trend will definitely continue.

One-stop shipping—the growth of multimodal companies—is another outcome of this. Today, some businesses don't want to know the details; they just want to move their goods from point A to point B in X number of days for X amount in good condition. An example is the use of Federal Express—just get my package there by 10:30. Another form of one-stop shipping is the rise of transportation brokers who consolidate loads and broker space. These third parties allow smaller shippers to enjoy some of the advantages of large shippers. In both cases, the shippers don't worry about mode or route. And that has interesting implications for public- and private-sector operators of transportation facilities. Use of third parties is a growing trend and it implies that we have to rethink to whom we market these facilities.

Another related development is the changes occurring in the warehousing industry. Many forget that warehousing is an integral part of the freight system and that it is an area where tremendous change is occurring. Warehousing is now far more integrated with transportation. For example, two of the overnight package services have opened pick-and-pack warehouse operations near their hubs. Orders for parts are called in to the warehouse, and the parts are picked out and then shipped via overnight service, increasingly their customer base. Also, in an era of just-in-time operations, the use of warehouses has changed; they now emphasize service and the value-added items that come from temporarily storing goods in transit, for example, replacing damaged goods, repackaging items for retail use, and doing the finishing touches of the manufacturing process. These trends will also continue.

There are constraints that may affect the supply of freight services in the future. These include congestion, investment in facilities, human resources, and reregulation.

Congestion affects the predictability of travel time for trucks. No matter how goods move long distance, trucks are generally going to make the final delivery. We are not just talking about urban congestion, but also suburban congestion in areas of rapid real estate development. Congestion can be dealt with through a combination of techniques, including developing new routes (perhaps even ones that are exclusively for trucks) and encouraging public transit. The reality is, however, that no city in the United States has yet to develop an effective anticongestion program.

With respect to investment, our early 1900s railroad analyst would probably be looking at capital expenditures for building new routes and facilities. Today, looking toward 2020, we can anticipate the investment that will be required to maintain and update the freight system. This leads to an interesting situation that could affect the modes used and how they are used.

In terms of surface freight transportation, investment will be needed in both the roadway system and in the railroad track and signal system. The highways are maintained by the public sector and are also used by passenger vehicles. Investment in the railroad system would have to be done by the private sector. In this situation, to remain competitive, the railroads may look for new partners to help defray costs. As an outgrowth of the current situation in which railroads operate double-stack trains for steamship lines, in the future, railroads may increasingly make their track available for other companies and third parties to operate trains.

In terms of air cargo, there are already constraints on airport capacity that may shape future growth. Although air cargo is continuing to grow, it does compete with trucks domestically. On the international side, there is only a choice between air and sea. Certain high-value and time-sensitive goods will always use air, and these may be growth areas. But expanding on the "warehouse on the move" concept, ocean transportation may become an option for more commodities. The competitive position of the ocean carriers may also be helped by the expenditures currently being made by a number of ports in state-of-the-art facilities and infrastructure improvements like channel dredging. An example of this trade-off today is sea-air intermodal service in which travel time is traded off for a substantial reduction in transportation costs.

In terms of human resources, today we see a shortage of truck drivers and fewer students studying transportation and logistics. Although increased use of automation techniques and computerization may reduce some of the labor-force requirements, this will remain an issue to be addressed.

Regulation also looms in the picture. Deregulation brought radical changes to the industry. New regulations will clearly alter the picture for 2020. There are areas of concern that need to be addressed, including the movement of hazardous materials and truck safety. It is hoped that the public and private sectors can cooperate to resolve these issues.

Public and private cooperation will be key in shaping the freight transportation system in the year 2020. We will see increasing globalization of the transportation industry and a blurring in the traditional modal definitions. We can hope that 2020 will be as exciting to us as today's system would be for our 1900s railroad analyst.

John W. Fuller Change in freight transport has been plentiful. One can hardly recognize the railroads of today if one knew only the railroads of the 1950s or the 1960s. Today's motor carrier operations, as well, are vastly different from those of the 1960s and the 1970s. Roberts and Fauth believe that as we ready ourselves for the year 2020, the most useful thing we can do is to look at where we are now and how we got here.

I must say that my philosophy disagrees a little bit with that approach. We must constantly be aware of the difficulty of extrapolation. Merely looking at

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John W. Fuller is Professor of Economics and Geography in the graduate program in urban and regional planning at the University of Iowa, where he was Director of the Institute of Urban and Regional Research. He also served as Deputy Director of the National Transportation Policy Study Commission.

what has occurred over the past decade or so, to push us forward through the years, is a bit dangerous.

Nonetheless, the authors' background of the past few years is straightforward and perhaps not too surprising. They point out that since 1980 intercity freight ton miles have increased less rapidly than the gross national product, the rail share of freight has declined, recession and deregulation have had their impacts (the impacts one might expect on freight demand and intermodal shifts), we should pay attention to international trade changes, and domestic factors also have produced a decided imbalance of traffic in the United States, leaving a good deal of surplus capacity on outbound lanes.

What I found interesting was not so much the statistics in this recitation of what has occurred, but rather the changes that have taken place in the industrial structure within the rail and the highway modes. The authors say that there are only six Class 1 rail carriers remaining, there have been innumerable line abandonments, and there has resulted something quite new in rail transportation, which is a healthy short-line industry playing an important role in that particular kind of transport. It seems to me that not the least of that role is to provide an example of cost trimming, better labor relations, enlightened marketing, and general entrepreneurship that has long been missing in railroading.

The longer-term future of rail depends in part on the adoption of these kinds of new techniques and methods by the remaining major operators and in part on the demand for coal, grain, chemicals, and similar traffic. Railroads have to be successful competitors to survive, but they also have to be lucky recipients of continued demand from traditional customers. The authors, rather unfortunately, don't really place their bets on whether this advancement in rail transportation will occur or not, and they leave it up to us to decide whether there is going to be a continuing, meaningful rail industry to the year 2020.

The structure of motor carriage has changed even more dramatically than that of rail, in ways that were not well predicted before passage of the Motor Carrier Act of 1980 or even the first Surface Transportation Assistance Act. The less-than-truckload (LTL) carriers have established economies of density and scope that had not been anticipated; the surviving firms are large and nationwide in operation, or at least cover major regions of the country.

However, the role of the LTL carriers has diminished to a surprising extent. Truckload carriers have more than taken up the slack; they have grown greatly in size and profitability, and specialized truckload carriers, for example, J. B. Hunt, abound.

Major changes have likewise occurred in private carriage and in regard to owner-operators. Even in areas the authors do not cover, such as agricultural cooperatives and specialized agricultural carriers or commercial zone operators, the rapid change has been remarkable.

The reasons given by Roberts and Fauth for structural change involve some speculation, because the statistics gathered by the ICC are no longer produced or are no longer comparable. Part of the story has to do with the carriers' newfound ability to exploit market niches. Part of the change has come about because shippers now find that transport can better fit newly evolving needs, such as those for just-in-time service. Containerization of domestic and freight traffic has also changed patterns of transport supply. It seems to me, however, that the authors neglect the more generic reason for change—the newfound ability of carriers to be responsive to shippers and to make the managerial changes that reward them with new business. After all, the arguments for transport deregulation that relied on pointing out the higher rates of regulated carriers and protected markets were always a little bit suspect when it came to quantification.

Moreover, the quid pro quo in terms of stability, certainty, and higher quality of regulated service was worth the price to many transport users. The strongest argument for deregulation has to do not with lower prices for existing service, but with unleashing innovation, providing incentives for technological change, and new ways of operating. This is what we have found in the industrial reorganization of motor carriage.

When the authors forecast likely change based on the experience of the past few years, they narrow their discussion to a few developments that are already under way. One of these is rail double-stack service, which offers real competition to long-haul truckers. They conclude, though, that only a very few of the long-haul, most heavily trafficked routes, such as Los Angeles to Chicago or New York, will have successful stack trains. Even those important routes have only a small proportion of the motor carrier freight in the United States.

In the long run, another rail technology, the RoadRailer, offers to compete in the more important medium-haul market. Roberts and Fauth find it too early to tell, however, whether RoadRailers will be widely realized as a technology that is implemented by the U.S. railroads.

Some more important potential factors that could affect freight transport are changes in government policies. The policies discussed that I found particularly interesting are the establishment of uniform truck access to Interstate highways, setting higher truck size and weight limits, and instituting urban truck bans. Uniform truck access is much in the news, not to mention the courts. The authors believe that it is only a matter of time until 48- and 53-ft equipment will be provided, in their words, "equitable access to and from industrial sites." The results are assumed to be positive for truckers and shippers.

I find this short discussion of a complex issue unsatisfactory. To begin with, I would shift the emphasis to efficient rather than equitable access. If there were no question of resource allocation involved, I suspect the issue would have long since been resolved. But access involves the cost of providing and paying for facilities. Even if the geometrics of an access road are suitable for a longer semitrailer, extra operation of larger vehicles means that the road may be capitalized more quickly than its designers anticipated, and the extra funds needed for maintenance or replacement imply competition with other highway projects.

I have the same complaint with the discussion of longer combination trucks and other size or weight increases. We have a long history of making incremental changes in regulated truck dimensions in the United States. What I find indisputable is that the designers and builders of our highways did not have in mind vehicles of the sizes and weights that are now common. And they certainly did not anticipate the number of vehicle operations that now occur of these larger truck-tractor combinations. Yet the majority of our highway system is already in place and subjected to unanticipated traffic, and our highway pricing system, evolved as it has through compromise after compromise over the years, is not designed to cope with these unanticipated vehicles. The authors believe that the use of big doubles will be an automatic boon. It seems to me that this is an example of myopia resulting from viewing solely the demand for and operation of the vehicles without factoring in the provision of the highway facilities.

On the other hand, the authors do mention the possibility of urban truck lanes, and suggest that public concern over large trucks on urban freeways could lead to outright bans or hours of prohibition in a given area. In the long run, they believe such action would build pressure for more Interstates. Although this brief notice in the paper does show some attention to vehicle weight interactions and to the importance of public opinion, I find the analysis lacking.

Indeed, I find the lack of attention to the urban freight market in general to be most surprising. After all, the majority of trucking costs are incurred in urban movement. The United States is the most urbanized country in the world. And an ever-increasing proportion of our people live in urban areas. As we are all aware, urban and suburban congestion are key and continuing problems. Yet, this paper touches only lightly on urban impediments to the growth of highway freight transportation.

In this respect, we have heard earlier about air pollution problems, and I would point out the difficulties in Southern California that are accruing to trucking operators because of the special restrictions that are starting to be placed in the Southwest on the intercity freight and local freight movements.

I wish to leave the impression that I find this paper to be fact filled and with a great deal to say about recent developments in rail and motor carrier transport. It did not cover the competing and complementary modes of inland water transport and pipelines, nor did it deal with harbors or airports, although I suspect that the latter, perhaps, is not in many respects a serious omission.

I would have wished for more attention to the dynamic interaction between those who operate freight vehicles and those who set the infrastructure policies or manage the highway systems. Freight demand is influenced by highway pricing and rail taxation, but demand is even more strongly at the mercy of the levels of intrastructure service that society determines to provide.

I suspect that freight transportation in 2020 will most importantly depend upon the ability to attain what are viewed as reasonable compromises in case after case, as the years go by, between freight operators and the public providers of highways in states and localities throughout the nation.

FRANK WILNER My first thought on the paper by Roberts and Fauth is that it has to have a "handle with care" label. Its projections are based on extrapolation, and we all know that the future is subject to technological, economic, and political changes, and we have no idea what those changes are going to be.

There is no question that deregulation of all the modes—railroads, motor carriers, and airlines—has given us an outstanding array of price service options, but I think it is absurd to worry about who is going to win or who is going to lose within the modes.

A contradiction struck me: The authors believe that double stacks will consolidate their dominance in a few long-haul heavy-density markets and that RoadRailers might make major inroads in the 500- to 1,500-mi markets. They also say that 53-ft trucks and double bottoms are likely to be granted nationwide access in 5 to 10 years and that expanded truck routes in urban areas are likely to deal with congestion. I don't think we are going to have the first two and the second two simultaneously. It is more likely that one set is going to prevail or the other set is going to prevail. The determinant, I think, is with the rail industry—whether we are able to bring our costs under control—and the second determinant is really how we treat highways in the future. Who is going to pay for those highways?

Certainly the railroad labor negotiations that are going on right now are going to determine the ability of the railroad industry to compete and whether

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Frank Wilner is Assistant Vice President for Information and Public Affairs with the Association of American Railroads. Before joining AAR, he was Director of Transportation for the state of North Dakota.

there will be future rail capital investment. The short-line question is very important, and labor is the fly in that ointment.

If we don't succeed in bringing those labor costs under control, we are going to have another massive going-out-of-business sale that is going to make our previous going-out-of-business sale look awfully small. We know right now that we can reduce our route structure by one-third and lose only 8 percent of our car load. So, there is a tremendous amount of room for us to divest in the rail industry.

The growth of double stacks is mostly the result of the cheap dollar that is allowing and encouraging imports to come into this country and the backhauls being purchased at lower prices.

If you look at the growth of the U.S. economy over the past 7 or 8 years, which has been absolutely phenomenal, none of it has been due to railroads. So whether 53-ft trucks get access or truck trains of unlimited length become ubiquitous is a function of highway safety. Unfortunately, politics too often drives the safety equation.

There is no question that the motor carrier industry, like the railroad industry, has the greatest incentive to operate safely. It is not a matter of putting new laws on the books; it is a matter of enforcing the laws that we already have.

Some tie the driver shortage to the safety question. They believe that we are going to take a lot of these drivers off the road who are unsafe and have multiple licenses, but having a single license may cause these drivers who weren't very safe in the past to get their act in order and to become safe in the future. There also is the question of paying more for drivers in the future. Perhaps, but advanced truckload carriers such as J. B. Hunt allow their drivers more time at home, and they have been able to retain and add to their driver force without having to pay them a lot more.

There is also the question of how we are going to pay for the highways. Without a doubt, this provides us with an excellent opportunity to begin to explore privatization and also to get the Highway Trust Fund away from the politicians. Why should the decisions on what concrete is going to be laid be made in Washington? Why shouldn't it be made by the people who actually pay the bill?

Strauss-Wieder said that no city currently has an effective solution to congestion. I would submit that the reason for that is that we haven't used market mechanisms. We don't force those who are causing the congestion to pay for the delays, even automobile operators in the morning in Washington, D.C. Everybody that gets on these Interstate highways is causing additional delay and creating costs for everybody else who is on the road, and yet we have made no attempt to impose a user-based system that would force the people that are causing the delay to pay for it.

I am certain of a few things; one is that there is going to be a lot more coordination between railroads and trucks. It doesn't necessarily mean that there will be wholesale purchasing of both of the modes—you only need that to happen a few times and it forces the other players to voluntarily coordinate. There is going to be a lot more pressure for all competing interests to gain what are going to be scarcer tax dollars.

Also, baby boomers are starting to reach their most productive years and are starting to gain political control. A wonderful book on this subject by David Boaz of the Cato Institute is called *Left, Right and the Baby Boom.* It points out that baby boomers tend to be very liberal socially, but when it comes to fiscal issues, they are extremely conservative and they are not satisfied with candidates on either the Right or the Left. Baby boomers may very well change the political focus in this country in the years to come. If that happens, there is going to be a lot less tolerance for subsidies.

However, put a warning label on what I am saying, because I am equally certain that public choice theory is very valid, and public choice theory makes it very clear that those with the most to win or lose, usually special interests, can exert a tremendous amount of force through their lobbying, a force far greater than their numbers.

There is no question that the future is uncertain, but only market flexibility is going to permit us to meet these challenges in the future, whatever they may be.

SESSION 6

Personal Mobility

Personal Mobility in the United States

ARLEE T. RENO

IN THIS ASSESSMENT OF the current and future status of personal mobility in the United States, expenditures on and current levels of personal mobility are identified, and the factors that will determine the limits on future demand for personal mobility are evaluated. The likely resources required to meet the needs for mobility are assessed along with factors that will limit the ability to meet personal mobility requirements. The conclusion contains suggestions for what should be done to preserve and enhance personal mobility in the future.

Major questions addressed are the following:

- What are Americans spending on personal mobility?
- What is the current level of mobility?
- How much are various modes used?
- What has been happening to speeds and congestion levels?
- Are growth rates for personal travel going to change?
- What should be done to maintain and enhance mobility?

The United States today enjoys the highest level of personal mobility in its history and the highest level in the world. Adults with driver's licenses average about 30 mi of local personal travel a day, and almost all adults have a personal-use vehicle available to them. Those without driver's licenses average about 10 mi of personal travel a day. The very high level of personal mobility is due primarily to consumer expenditures on vehicles for private use and partly to past expenditures for roads by government agencies and developers. Consumers' expenditures on personal transportation are about 20

Arlee T. Reno is currently Director of Transportation Studies at the Urban Institute. Before joining the institute, he worked as a transportation consultant with Sydec, Inc., assisting state and federal agencies in a wide range of analyses of revenue, finance, and highway and transit programs.

percent of total consumer expenditures, and consumers spend more on personal transportation than they do on food or on home ownership and rent.

Recently, personal travel as measured by vehicle miles of travel (VMT) of automobiles and light trucks has experienced enormous growth, which will become more moderate in the near future because of limits on motorization in terms of number of vehicles per adult and a decrease in the rate of growth of the adult population. Despite admonitions that past predictions of saturation of demand for personal automobile and light-truck travel did not develop, if income gains continue at their historic rates and are shared equitably among the populace, hard and absolute saturation levels are approaching and will be reached within 10 to 20 years. Only a fundamental change in technology resulting in much higher travel speeds will alter the approaching limits on VMT per adult.

Public agency expenditures for personal mobility have not kept pace with the growth of private expenditures for personal mobility. This imbalance appears to have created an opportunity to achieve very high levels of net benefits to the economy and society from increases in current levels of public expenditures.

CURRENT MOBILITY: LEVELS AND COSTS

The starting point for assessing personal mobility requirements is to determine the current status of personal mobility in the United States in terms of how much personal travel is consumed and how much that travel costs. This information is then related to desirable changes in the future. By almost every measure, residents in the United States enjoy a very high level of personal mobility and voluntarily choose to spend a very high proportion of their disposable income on it. Two questions are central to a determination of the current situation:

- What are U.S. citizens paying now for personal mobility?
- What are they getting for it?

Consumer Expenditure Survey data from 1985 indicate that 20.47 percent of expenditures by household consumer units was on transportation (*1*) and that the level of expenditures on personal highway transportation was greater than that for food or for renting or buying homes. Table 1 shows data on expenditures for transportation by income quintiles for U.S. consumer units. (A quintile is one-fifth of the total consumer units.)

TABLE 1 Expenditures on Transportation by Income Groups in the United States (*1*)

Income Quintile	First	Second	Third	Fourth	Fifth	All Units
Average Income	$ 3.463	$10.338	$18.131	$28.178	$54.215	$25.127
Avg. Expenditure	$11.006	$14.131	$19.183	$25.931	$42.374	$22.539
Avg. # Vehicles	1.0	1.5	1.9	2.4	3.0	1.9
% At Least 1 Veh	58	84	92	95	97	85
Vehicles/18+	.7	.9	1.1	1.1	1.3	1.0
Average Annual Expenditures						
Transportation	$ 1.860	$ 2.844	$ 4.261	$ 5.632	$ 8.459	$ 4.614
Vehicles	$ 677	$ 1.133	$ 1.902	$ 2.540	$ 4.056	$ 2.063
Gasoline & Oil	$ 538	$ 781	$ 1.011	$ 1.314	$ 1.578	$ 1.045
Other Private Vehicle Expenses	$ 509	$ 762	$ 1.126	$ 1.549	$ 2.258	$ 1.241
Other (Air.Etc.)	$ 136	$ 168	$ 222	$ 229	$ 568	$ 265

AVERAGE EXPENDITURES

Income Quintile	First	Second	Third	Fourth	Fifth	All Units
Percentages of Average Annual Expenditures On:						
Transportation	16.9%	20.1%	22.2%	21.7%	20.0%	20.5%
Gas & Oil	4.9%	5.5%	5.3%	5.1%	3.7%	4.6%
Average Annual Transportation Expenditures Per:						
Person	$ 930	$ 1.237	$ 1.704	$ 1.942	$ 2.643	$ 1.775
Person 18+	$ 1.240	$ 1.673	$ 2.367	$ 2.682	$ 3.678	$ 2.428
Person 18-65	$ 1.691	$ 2.370	$ 2.840	$ 2.964	$ 3.845	$ 2.884
Vehicle	$ 1.860	$ 1.896	$ 2.242	$ 2.347	$ 2.820	$ 2.428

The first row in Table 1 shows the average after-tax income for each quintile. It is important to note that the after-tax income of the lowest three quintiles is less than the money they are able to spend. It is really the second row, expenditures, that provides a measure of the resources that they have been able to apply to their needs. The third row indicates the average number of vehicles of all types owned. As shown in the fourth row, by the middle quintile, 92 percent own at least one vehicle, and for the top two quintiles the proportion with at least one vehicle is 95 and 97 percent.

The data on average number of vehicles per person and per person over 18 show the effects of increased income. At the highest income levels there is more than one vehicle per person over 18, and the average for all groups is one vehicle per person over 18. (The vehicles include motorcycles, campers, etc., as well as automobiles and light trucks.)

The percentage of expenditures on transportation and the proportions of transportation expenditures by subcategories within transportation are remarkably flat across income classes. The lowest-income quintile spends 17 percent on transportation and the others from 20 to 22 percent. The percentage of expenditures on gasoline, which should be most directly proportional to travel itself, is also relatively flat; only the highest-income quintile spends slightly less than 4 percent, and all other quintiles spend about 5 percent. Gasoline expenses per vehicle are flat across income classes. Because users of personal vehicles pay for the facilities they use out of the expenditures shown in Table 1, expenditures by public agencies for highways to serve personal mobility needs are included in the expenditures shown in the table. Total passenger transportation expenditures were just over $400 billion.

Table 2, from the 1983 Nationwide Personal Transportation Study (NPTS) (2), provides a more detailed breakdown for 1969, 1977, and 1983 on the number of vehicles for households with one adult, two adults, and three or more adults. (The 1969 figures are not comparable with those from the other years because only automobiles and passenger vans were included in the vehicle counts in 1969.) By 1983 a majority of all households had as many vehicles as adults, 9 percent of one-adult households had more than one

TABLE 2 Distribution of Households by Vehicle Ownership and Number of Adults in the Household (2)

	Percentage of Households		
No. of Vehicles	1969[a]	1977	1983
One-Adult Household			
None	56.2	39.2	34.0
One	42.3	53.2	57.1
Two	1.5	5.7	7.1
Three or more	0.0	1.9	1.8
Two-Adult Household			
None	12.4	7.5	5.8
One	57.3	33.1	29.2
Two	29.1	48.2	49.7
Three or more	1.2	11.2	15.3
Household with Three or More Adults			
None	8.2	5.9	5.6
One	32.2	15.9	13.5
Two	42.6	34.4	27.1
Three or more	17.0	43.8	53.8
All Households			
None	20.6	15.3	13.5
One	48.4	34.7	33.7
Two	26.4	34.4	33.5
Three or more	4.6	15.6	19.3

NOTE: Vehicle ownership refers to all vehicles owned by or available on a regular basis to the household.

[a] 1969 vehicles included automobiles and passenger vans only; 1977 and 1983 vehicles also included pickup trucks, other trucks, etc.

vehicle, and 15 percent of two-adult households had more than two vehicles. Thus, some households had more than one vehicle per adult.

Current Levels of Personal Mobility

What is the level of mobility of Americans today? There is so much anecdotal information and so many individual observations on this topic that one tends to lose track of the actual data sources. There is a reasonable amount of information available from the periodic Nationwide Personal Transportation Study, the decennial census, the yearly *Highway Statistics* of the Federal Highway Administration (FHWA), the yearly *National Urban Mass Transportation Statistics* of the Urban Mass Transportation Administration, and other sources. These sources provide current and time-series data on quantities of personal travel, speeds, modes of travel, and the characteristics of travelers.

Table 3, from the 1983 NPTS, shows average daily person trips, travel, and trip length by driver's license status and sex. Those with driver's licenses average about 30 mi a day of personal travel, and those without driver's licenses about 10 mi a day. Only about one-third of the personal travel is

TABLE 3 Average Daily Trips, Miles of Travel, and Trip Length (*2*)

	Men		Women		All	
Trip Purpose	With Driver's License	Without Driver's License	With Driver's License	Without Driver's License	With Driver's License	Without Driver's License
Average Daily Trips						
Earning a living	1.0	0.3	0.7	0.2	0.9	0.3
Family and personal business	1.1	0.5	1.4	0.7	1.2	0.5
Civic, educational, and religious	0.2	0.3	0.3	0.3	0.2	0.3
Social and recreational	0.8	0.6	0.9	0.5	0.9	0.5
Other	0.0	0.0	0.1	0.0	0.1	0.0
All	3.1	1.7	3.4	1.7	3.3	1.6
Average Daily Person Miles of Travel						
Earning a living	12.6	1.9	5.4	1.4	9.1	1.5
Family and personal business	7.1	2.0	8.6	3.8	7.8	3.3
Civic, educational, and religious	1.3	1.1	1.3	1.1	1.3	1.1
Social and recreational	10.9	4.8	12.3	3.7	11.6	4.0
Other	0.4	0.1	0.4	0.1	0.4	0.1
All	32.3	9.9	28.0	10.1	30.2	10.0
Average Trip Length (mi)						
Earning a living	12.0	5.8	7.4	6.3	10.2	6.1
Family and personal business	6.5	4.4	6.2	5.8	6.3	5.5
Civic, educational, and religious	6.8	4.2	5.0	4.0	5.7	4.1
Social and recreational	13.0	8.0	13.6	7.9	13.3	7.9
Other	7.5	5.9	7.7	4.0	7.6	4.2
All	10.0	5.9	8.4	6.2	9.2	6.1

related to earning a living, indicating that a great deal of discretionary travel is being undertaken. Men with driver's licenses travel more person miles than similarly qualified women but women with driver's licenses make more total daily trips and travel more non-work-related miles than similarly qualified men.

Variations in travel also occur by place of residence. The data in Table 4 show that central-city residents travel somewhat less than those in other parts of a Standard Metropolitan Statistical Area (SMSA), and those outside SMSAs travel about the same as those inside SMSAs, on average. A decline in average miles of person travel appears to have occurred for central-city residents from 1977 to 1983.

TABLE 4 Average Daily Person Miles of Travel, 1977 and 1983 (2)

	Inside SMSA				
Trip Purpose	Within Central City	Not in Central City	Subtotal	Outside SMSA	All
1977					
Earning a living	6.1	8.3	7.2	6.3	6.9
Family and personal business	4.3	6.0	5.2	6.9	5.8
Civic, educational, and religious	1.3	1.7	1.5	1.8	1.6
Social and recreational	7.2	9.2	8.2	7.9	8.1
Other	2.0	1.5	1.7	1.6	1.7
All	20.9	26.7	23.8	24.5	24.1
1983					
Earning a living	5.1	7.1	6.1	5.9	6.0
Family and personal business	4.5	6.2	5.5	7.4	6.0
Civic, educational, and religious	1.2	1.6	1.4	2.0	1.6
Social and recreational	7.0	10.9	9.2	8.8	9.1
Other	0.2	0.5	0.4	0.9	0.5
All	18.0	26.3	22.6	25.0	23.2

The proportion of total VMT that went to earning a living declined for all income groups from 1977 to 1983, as shown in Table 5. Family and personal business travel and social and recreational travel increased as a percentage of personal travel from 1977 to 1983, indicating that more discretionary travel was taking place even as work-force participation rates continued their growth. From 1977 to 1983, weekday person trips for earning a living declined from 55.5 to 50.3 percent of all 6:00–9:00 a.m. trips and from 37.9 to 31.1 percent of all 4:00–7:00 p.m. trips, indicating that much more non-work-oriented and presumably discretionary travel was occurring during peak periods (2). This increase in discretionary travel during peak periods appears inconsistent with a worsening traffic situation during these periods. However

TABLE 5 Distribution of Vehicle Trips, VMT, and Average Trip Length by Trip Purpose (2)

	Vehicle Trips			VMT			Trip Length (mi)		
Trip Purpose	1969	1977	1983	1969	1977	1983	1969	1977	1983
Earning a living									
To or from work	31.9	29.3	27.8	33.6	31.7	30.1	9.4	9.1	8.5
Work-related business	4.4	5.3	2.9	7.9	7.6	4.2	16.1	11.9	11.4
Subtotal	36.3	34.6	30.7	41.5	39.3	34.3	10.2	9.5	8.8
Family and personal business									
Shopping	15.3	18.6	20.0	7.5	11.1	13.4	4.4	5.0	5.3
Doctor/dentist	1.7	1.5	1.2	1.6	1.8	1.5	8.4	10.3	9.7
Other family/personal	14.0	14.9	18.3	10.2	12.0	15.5	6.5	6.8	6.7
Subtotal	31.0	35.0	39.5	19.3	24.9	30.4	5.6	6.0	6.1
Civic, educational, and religious	9.3	7.3	5.9	4.9	5.2	4.1	4.7	5.9	5.5
Social and recreational									
Vacation	0.0	0.1	0.2	2.6	0.6	2.1	160.0	77.9	113.9
Visit friends/relatives	9.0	9.3	9.9	12.1	12.1	13.5	12.0	10.9	10.8
Pleasure driving	1.4	0.5	0.4	3.1	0.9	1.1	20.0	14.1	22.7
Other social/recreational	11.9	12.3	12.1	15.3	13.7	13.3	11.4	9.3	8.7
Subtotal	22.3	22.2	22.6	33.1	27.3	30.0	13.1	10.3	10.5
Other	1.1	0.9	1.3	1.2	3.3	1.2	9.4	29.3	7.2
Total							8.9	8.4	7.9

bad things might have been for the average peak-period commuter, they were not bad enough from 1977 to 1983 to induce those making nonwork trips to alter the times at which they made those trips.

Personal mobility is highly oriented to the use of personal vehicles, which are responsible for the large majority of the trips for all local trip purposes. Table 6 shows the proportion of daily local person trips across modes by mode of transportation and trip purpose. Private vehicle driver was the means of travel for more than half the trips, and drivers plus passengers of private vehicles accounted for more than 80 percent of trips. Within the "other" category, which accounted for 12.9 percent of all trips, walking was the most common mode (8.6 percent of all trips), and bicycling accounted for only 0.8 percent of all trips. All forms of public transportation together accounted for 2.5 percent of trips, down from 3.0 percent in 1977.

TABLE 6 Distribution of Person Trips by Mode of Transportation and Trip Purpose (2)

	Mode				
	Private Vehicle				
Trip Purpose	Driver	Passenger	Public Transportation	School Bus	Other[a]
1977					
Earning a living	71.3	18.2	5.2	0.2	5.1
Family and personal business	53.0	36.2	1.6	0.1	9.1
Civic, educational, and religious	27.9	30.0	4.8	19.5	17.8
Social and recreational	41.4	46.2	1.5	0.3	10.6
Other	37.6	42.7	7.5	2.1	10.1
All	50.9	33.8	3.0	2.8	9.5
1983					
Earning a living	74.5	12.6	4.5	0.1	8.3
Family and personal business	57.5	30.4	1.1	0.0	11.0
Civic, educational, and religious	23.4	32.5	4.7	21.3	18.1
Social and recreational	40.1	41.1	1.6	0.3	16.9
Other	25.8	57.9'	0.8	0.4	15.1
All	51.8	30.2	2.5	2.6	12.9

[a]Includes airplane, bicycle, and walk trips.

Mobility varies substantially by age and somewhat by sex. Tables 7 and 8 (3) show the average local person miles of travel by age and sex in 1983. Those under 16 and women over 65 have about one-third the average person miles of travel as those 21 to 65. Women in each age category travel less than men.

The data in Table 9 show the change in transit's share of work trips for different markets of workers from 1970 to 1980. The most dramatic change was the decline in the share of work trips from central city to central business district (CBD) using transit, which went from 46 to 34 percent. There were declines across the board in the percentage of central-city residents using transit to all work-place destinations.

TABLE 7 Average Daily Person Miles by Age, Sex, and Mode (3): Ages <16 to 35

	Travel Day Trips (weighted) by Age and Sex					
	<16		16–20		21–35	
Mode	Men	Women	Men	Women	Men	Women
Privately owned vehicles	8.4	7.9	18.4	17.6	29.5	25.4
Public transportation	0.2	0.3	1.2	1.4	0.8	0.9
Other	1.5	1.8	1.8	1.0	1.7	2.5
Total	11.5	10.8	22.9	21.4	32.8	29.5
Unknown	1.3	0.7	1.5	1.4	0.8	0.7

TABLE 8 Average Daily Person Miles by Age, Sex, and Mode (3): Ages 36 to 65+

	Travel Day Trips (weighted) by Age and Sex				
	36–65		65+		Total, All Ages
Mode	Men	Women	Men	Women	
Privately owned vehicles	25.1	21.2	13.4	9.0	19.1
Public transportation	0.8	0.5	0.7	0.4	0.7
Other	6.6	2.5	0.5	0.7	2.6
Total	33.6	25.1	14.8	10.2	23.2
Unknown	1.1	0.9	0.3	0.1	0.9

TABLE 9 Transit Use in Various Markets in Metropolitan Areas, 1970–1980 (4, p. 102)

	1970			1980		
	No. of Workers (thousands)	Percent of Total	Percent Using Transit	No. of Workers (thousands)	Percent of Total	Percent Using Transit
Living in central city and working in						
CBD	2,641.2	6.2	46.3	3,082.4	5.5	33.4
Non-CBD portion of central city	15,473.8	36.4	17.3	17,720.2	31.7	13.1
Outside central city	4,479.2	10.5	9.8	4,801.8	8.6	5.5
Living in suburbs and working in						
CBD	1,117.6	2.6	32.8	1,861.4	3.3	32.1
Non-CBD portion of central city	5,623.3	13.2	7.6	8,546.8	15.3	7.1
Outside central city	13,158.8	31.0	4.4	19,954.6	35.7	2.1
Total	42,493.9		13.4	55,967.2		8.7

The focus on the suburbs was maintained, as can be seen from transit's share of about 32 percent of the growing suburb-to-CBD market and its smaller share of around 7 percent for trips from suburbs to non-CBD portions of central cities. However, transit's share for suburban commuters not going to the central city dropped to 2 percent, a relatively insignificant market share.

Travel Speed

Current trends in average travel speed are very hard to pin down because of conflicting data or conflicting interpretations of recent data. Reports giving the miles of roads on which level-of-service E or F is experienced appear to show that increasing portions of the highway system are operating at these levels during peak travel periods. However, according to the NPTS, the average commuting speeds increased in urban areas between 1977 and 1983, as shown in Figure 1, although travel times increased slightly also.

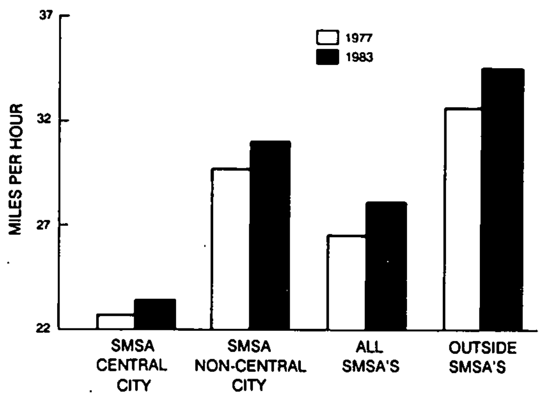

FIGURE 1 Changes in average speed of home-to-work trips by place of residence (*2*).

As with any other data, averages can mask a lot of important information. The nature of road systems is that speeds vary substantially by urban area and by corridor and facility. Although the increase shown in speed for work trips is partly due to shifts among modes and urban areas, and although slightly earlier data, such as those from 1975 and 1980 reported by Pisarski (*5*), also showed some increase in commuting time and in speed, it is clear that the situation has not yet reached the point at which commuting time is increasing substantially or speed is decreasing substantially.

Figure 1 shows that average home-to-work travel speed increased for residents of all types of areas from 1977 to 1983, during which time both average trip length and average trip time increased very slightly. Since 1983 the popular press has featured many reports about how much longer commuting is taking today. There have been no comparative data for the period since 1983. Speeds were significantly lower for those in central cities in 1983 (23.4 mph) than for SMSA residents outside the central city (31.0 mph) and for workers outside SMSAs (34.6 mph). Suburb-to-suburb commuting distances and times through 1980 were shorter than average commuting distances and times. The trend in locational choice for more of the population and jobs to be in the suburbs would have a positive effect on the average speed of travel, because these trips will be made at higher-than-average speed, including trips by central-city residents.

There is, however, no reason to be confident about speeds or commute times in the future. In fact, congestion can get a lot worse or a lot better very quickly, depending on the relationship between capacity and demand in a particular corridor.

Congestion Level

There have also been many recent reports in the popular press that congestion is getting worse. Table 10 shows data from 1981 to 1986 on volume-to-capacity (*V/C*) ratios, a primary measure of congestion, for various functional classes of highways in urban and rural areas compiled by FHWA from state sources and reported in FHWA's *Highway Statistics* (*6, 7*).

According to the FHWA data, *V/C* ratios were getting markedly worse on urban Interstates, urban other freeways and expressways, and rural Interstates, but there was little or no negative trend for the other functional classes. It must be noted that the FHWA data on which Table 10 is based are much more complete for the Interstates than for the other functional classes, so no conclusion should be reached that problems have not been getting worse for the lower functional classes of roads.

The NPTS provides data on average speeds by mode (2). Average travel speeds for daily trips in motorized personal-use vehicles ranged from 28 to 31 mph for automobiles and light trucks. Buses averaged 11 mph; elevated rail or subway, 15 mph; trains, 24 mph; and streetcars, 7 mph. Bicycles averaged 8 mph, and walking, 2 mph.

The low average speeds for transit modes indicate that they do not, in the average situation, offer mobility that is superior to that of personal vehicles. Transit's importance will remain in special places—very congested corridors where additional capacity by automobile would be difficult or impossible to achieve—and in special cases—to provide mobility for those who cannot or choose not to drive. Bicycling and walking do not offer very high speeds and

TABLE 10 Volume/Capacity Ratios by Functional Class and Urban and Rural Areas (6, 7)

	Percent with V/C Ratio 0.71 to 0.95		Percent with V/C Ratio 0.95 and Up	
Area and Functional Class	1981	1986	1981	1986
Urban				
Interstate	14.5	20.4	16.6	24.9
Other freeway/expressway	11.4	14.7	15.8	18.8
Other principal arterial	16.4	16.8	18.7	18.0
Minor arterial	11.7	9.8	11.3	11.2
Collector	4.5	4.1	4.5	3.4
Rural				
Interstate	2.3	5.9	0.6	2.9
Other principal arterial	2.7	1.8	1.6	1.1
Minor arterial	2.0	1.1	1.0	0.6
Major collector	0.6	0.2	0.7	0.1
Minor collector	0.1	0.1	0.2	0.0

are used for very short trips only. Bicycle trips average 2 mi, and walk trips 0.33 mi.

FACTORS DETERMINING FUTURE DEMAND FOR PERSONAL MOBILITY

Within the constraints of the travel technologies available today or likely to be in significant application by 2020, the factors influencing the demand for personal mobility through 2020 will be as follows:

- The driving-age population (those 16 years old and over);
- The average income per capita or per person of driving age in real dollars;
- The approaching saturation of personal-use vehicles per person of driving age, which is determined by the level and distribution of income;
- The travel speeds achievable with the technologies available;
- The level, type, and quality of investments in public facilities, primarily roads; and
- The spatial distribution of where people live and carry out their other activities among regions, urban versus rural areas, and urban areas of different sizes, and by location within each urban area.

These factors are termed the driving factors in personal mobility. The extent to which they can potentially change by 2020 will tend to limit personal mobility requirements. Situations can occur in which there are fuel or income problems that also limit personal mobility. However, the limits on the growth of the foregoing factors, other things being normal, will determine the limits on the growth of demand for personal mobility.

Driving-Age Population

Forecasts of population by age, race, and sex are made by the Bureau of the Census. The current projections for the driving-age population in the middle series (*8*) show growth from 185.4 million persons over 16 years old in 1988 to 234.1 million in 2020, an increase of 48.7 million or 26 percent. This results in an average rate of growth of only 0.7 percent per year for the next 32 years. By way of comparison, the driving-age population grew by 44 million, at 1.7 percent per year, in the 16 years from 1970 to 1986. Thus, the driving-age population will continue to grow, but at a fairly slow rate, and at a faster rate in the early part of the next 32 years than in the latter part.

Much of that growth will be among the older segment of the driving-age population, those over 65. The prime driving-age population, those who drive the most (ages 18 to 64) will increase only 1.9 percent per year from 1980 to 1990, 1.1 percent per year from 1990 to 2000, 0.8 percent per year from 2000 to 2010, and will have no growth at all from 2010 to 2020 (*9*). The low growth rate of the driving-age population will affect the demand for personal mobility by reducing that portion of the growth rate due to changes in driving-age population, which will change by 1 percent per year compared with what it has been recently.

Income per Capita

Income per capita in the United States grew by an average of 3.0 percent per year in constant dollars from 1960 to 1970 and by about 1.9 percent per year in constant dollars from 1970 to 1986. A continued growth of 2.0 percent per year to 2020 would result in an average per-capita income 96 percent higher in 2020 than it was in 1986, whereas it grew 104 percent in the 34 years from 1952 to 1986. How that income is shared among groups in society is very important, of course. If it is shared equally among the different income groups, the lowest quintile of the population in 2020 could be expected to have about the same average spending power as the medium quintile of the population does today, in which 92 percent of the households have at least one vehicle and for which the average number of vehicles is 1.9 per household (*10*).

Considering that there are some 3 million well-to-do households that do not own vehicles today, although these households can easily afford them, there would probably be about 5 million households and 9 million adults choosing not to have vehicles no matter what their income level. One would expect that these would be the elderly and those in New York City and other high-density areas, and that their travel needs would be met without household-owned vehicles. Those persons in institutions or who for other reasons are precluded from driving will not require a personal-use vehicle no matter what their income level. The remainder of all adults in a higher-income future can be expected to have vehicles available to them to satisfy their personal mobility needs.

Vehicles per Person of Driving Age

Saturation levels are being reached with regard to vehicle availability for adults, which means that future changes in miles of travel per adult will be the result of changes in settlement patterns, in the price of travel relative to other items, in work-force participation rates, and in levels of service on the road system. In 1987 there were 183 million persons 16 years old and older and 158 million light-duty vehicles (automobiles and light trucks) in operation, a ratio of 0.86 light-duty vehicle per person 16 and over. This was up from 0.81 in 1980 and from 0.72 in 1974. In the NPTS data for 1983, 5 percent of the vehicles available were other than automobiles, vans, station wagons, or light trucks, which are the only types included in the estimate of 158 million. However, these other vehicle types (motorcycles, motor homes, etc.) have low annual mileage and should be considered special-purpose vehicles rather than ones intended for local personal mobility.

Almost all light-duty vehicles are used for personal mobility at some times. However, there will continue to be about 10 million light-duty trucks whose primary purpose is nonpersonal travel, although a large number of these carry no products but are used for personal business during the week and likely for personal travel during nonwork hours. It is fair to consider almost all light-duty vehicles as serving some personal mobility needs.

Since many adults are too old to drive or are handicapped or institutionalized, it is reasonable to expect that saturation will be reached at a lower figure than one vehicle per adult. Perhaps the likely level will be about 0.95 light-duty vehicle per person over 16. This implies that the saturation level should have been only about 174 million vehicles in 1987, which is about 10 percent more than the actual amount, or about 10 years' worth of the average recent growth in the ratio of vehicles to adults. However, this does not take into account the observation that 9 percent of single-adult households have two or more vehicles and that 15 percent of two-adult households have three or more vehicles (although these counts include vehicles other than automobiles and light trucks).

If, all other things being equal, future households are all unconstrained by income and have 1.15 vehicles per adult, this could result in a saturation level of about 1.09 (1.15 times 0.95) personal vehicles per adult. Saturation is only about 10 years away if the level is 0.95, and 21 years away if the level is 1.09, dependent on the assumed income growth and income distribution. The contribution of increased motorization to VMT by 2020 is an additional 10 percent if the saturation level is 0.95, or an additional 27 percent if the saturation level is 1.09 vehicles per adult. The 10 percent would give a growth rate, on average, of 0.3 percent per year, and the 27 percent would give an average growth rate of 0.7 percent per year through 2020. Most of this growth would also take place in the early part of the three decades before 2020. Personal vehicles per adult has recently been growing at 1.4 percent per year, more than twice as high as the potential average growth rate through 2020.

Pisarski observed (*5*, p. 63):

> It has been traditional in transport forecasting to underestimate the potential for increase in vehicle availability. There was a time when the "reasonable upper limit" on vehicle ownership was one per household. When that was surpassed without diminution in the growth trend, one vehicle per worker was the next perceived "natural limit". Data presented in this study have shown that this ratio has also now been surpassed. The next "natural" level is one vehicle per licensed driver. Recent data indicate that this "limit" was surpassed in 1984 or 1985.

Although the level of one vehicle per adult is the next limit, it is of more basic physical significance than the others. One person can operate only one vehicle at a time. If there are additional specialty vehicles available, such as campers, motor homes, and motorcycles, these vehicles will be substituted for travel by the more usual vehicle (an automobile or light truck). Nevertheless, it is well to observe that the restrictions on vehicle use may be determined more by a person's choice of how to spend time than by other factors.

Average miles per vehicle has been very stable across many variables, as shown in Table 11, with little variation by year or by place of residence or number of adults or drivers per household. There is some increase in miles per vehicle with household income. Thus there is some reason to assert that if there is a reasonable limit on availability of vehicles, this will be related to satisfaction of all desires for personal mobility for adults within the constraints of the speed of travel.

The increase in miles per vehicle with household income can be estimated from the information in Table 11. The households with incomes under $10,000 averaged 7,963 miles/vehicle in 1983, those with $10,000 to $19,999 averaged 9,668 miles/vehicle, and so on. If it was assumed that the miles per vehicle for each household income category increased to the level of the next category, which would represent a doubling of income, and the miles per

TABLE 11 **Average Annual Miles per Vehicle** (*2*)

	1969[a]		1977		1983	
	Miles/ Vehicle	Avg. No. of Vehicles/HH	Miles/ Vehicle	Avg. No. of Vehicles/HH	Miles/ Vehicle	Avg. No. of Vehicles/HH
By Number of Licensed Drivers/HH						
One	n/a	1.5	9,868	1.2	9,319	1.1
Two	n/a	1.2	10,834	2.0	10,545	2.0
Three or more	n/a	1.1	11,256	3.0	10,752	3.2
Total	11,600	1.2	10,679	1.6	10,315	1.7
By Number of Adults/HH						
One			9,423	0.7	9,517	0.8
Two			10,785	1.7	10,303	1.8
Three or more			10,943	2.4	10,679	2.6
Total			10,679	1.6	10,315	1.7
By HH Income ($ 1983)						
<$10,000	7,095	0.7	7,964	0.8	7,963	0.8
$10,000-$19,999	10,854	1.1	9,954	1.4	9,668	1.5
$20,000-$39,999	12,200	1.5	11,163	2.0	10,791	2.1
$40,000+	15,000	1.9	12,048	2.4	11,544	2.6
Total	11,600	1.2	10,679	1.6	10,315	1.7
By Place of Residence						
SMSA, central city			10,460	1.3	9,553	1.3
SMSA, not central city			11,139	1.7	10,399	1.8
Non-SMSA			10,385	1.7	10,776	1.9
All areas			10,679	1.6	10,315	1.7

[a] 1969 vehicles included automobiles and passenger vans; 1977 and 1983 vehicles also included pickup trucks, other trucks, etc.

vehicle for the income category of $40,000 and up increased by the same amount by which it now exceeds the next lower category, the average miles per vehicle would increase from 10,315 in 1983 to 11,343 in 2020, a gain of 9.97 percent or an average gain per year of 0.26 percent per year for the 37-year period from 1983 to 2020.

Importance of Time

It has been established beyond doubt that time is a critically important element in determining levels of mobility. In a major cross-cultural study of the use of time in many countries, including the United States, time spent in travel for work and other purposes was assessed and the following conclusions were reached (*11*):

> Equally obvious is the fact that the quickest trips for equivalent commuting distances are accomplished by the automobile. But as we have already indicated, by far the most intriguing aspect of the trip to work cross-nationally is the relative constancy in average time allocated to this purpose across our sites in the face of the most complete variation in commuting technology. There seems to be a distinct preference toward using increased efficiency of transport to spread out in space, and modal distances to the workplace across our sites vary by a factor of fifteen or more, while time allocations remain in the average within an impressively narrow range . . . . Much of the same pattern of similarity holds for total travel as well as the trip to work.

It is thus reasonable to expect that in the absence of a technological change that brings a new level of available travel speeds to everyday travel, only fairly narrow variations in the average time spent in local travel are likely in the next several decades. This further implies that projections of vehicle miles of travel that imply enormous changes in the amount of travel time per person are likely to be merely nonsensical extrapolations of trends that were actually based on the absorption of a new and superior technology over time.

The superior technology can take a long time to be absorbed, as with the automobile, which required over a century to reach full absorption in U.S. society, and with the jet airplane, which will probably require over a half-century to be fully absorbed. Once the technology has been fully absorbed, if its performance charcteristics remain the same, the kind of strong exponential growth in use that characterizes the introduction and then the absorption of that technology will be dampened, and any further growth will be driven by changes in the numbers of users, not in the average use per person.

Travel Speeds Achievable with Current and Likely Technologies

The current vehicle-roadway technology is likely to determine travel speeds through the year 2020. Technological advances in vehicles should make them safer, more fuel efficient, and more reliable. Technological advances in pavement design and materials should reduce long-term pavement costs. No fundamental changes seem in the offing that would have the same kind of impact as introducing personal vehicle mobility at speeds more than twice those of transit systems.

Development Patterns

Future development patterns are covered in depth in the paper by Lowry in this report. In terms of the impacts of the development patterns through 2020 on personal mobility, the development that occurs is likely to be very similar to current suburban patterns, and will involve the same relative mobility requirements. In addition, most of what will be in place by 2020 is in place today. Future development patterns are therefore expected to result in average demand for personal mobility that is the same as the demand required by residents of suburban and rural areas today. The analysis earlier includes enough expansion of VMT to account for all the growth taking place in the outlying suburban or rural areas.

Development will have enormous localized impacts on congestion and on requirements for facilities. These issues cannot be resolved at the national level, but must be addressed in regional and local forums.

Summary

The three predictable factors that appear to define limits on future personal mobility demand for the nation as a whole are driving-age population, which will have an average annual growth rate of 0.7 percent to 2020; vehicles per person of driving age, which will have an average annual growth rate between 0.3 and 0.7 percent; and annual miles per vehicle as a function of income, which will have an average annual growth rate of 0.3 percent. Multiplying these growth rates yields an annual average of 1.3 to 1.7 percent growth due to these factors, with growth rates being higher earlier in the 30-year period.

FORECASTS OF FUTURE CONDITIONS

Most current forecasts at the national and regional levels predict that substantial growth in travel will take place through the year 2020, that congestion will be getting worse in the sense that more and more miles of highways will be operating at very poor levels of service (E or F) during peak periods, and that an even higher proportion of urban VMT will take place under congested conditions. FHWA projects higher percentage increases in hours of delay on freeways because of congestion in the suburban and rural portions of the metropolitan areas rather than in the central portions (*12*), specifically, increases in delay vehicle hours per year on urban freeways from 1985 to 2005 of 8.7 percent for outlying (suburban) areas, 11.3 percent for rural portions of the urban areas, and 7.9 percent for central portions of the areas. For signalized arterials in urban areas, growth in vehicle hours of delay is expected to be 6.5 percent per year in central areas, 6.2 percent in suburban areas, and 5.7 percent in the rural portions of those areas. For rural areas, although traffic volumes are projected to increase, *V/C* ratios will remain much lower on average than in urban areas. A high level of investment will be necessary in rural areas to keep levels of service from deteriorating.

Many of the forecasts of travel and traffic conditions made on a regional basis for metropolitan areas indicate that congestion will be getting worse. In Figure 2 (*13*), forecasts are shown for Northern Virginia of future peak-period VMT under congested conditions; these forecasts were made recently by the Metropolitan Washington Council of Governments, which is among the most advanced and professional of the regional agencies in travel forecast and analysis procedures. Peak-period travel under congested conditions is

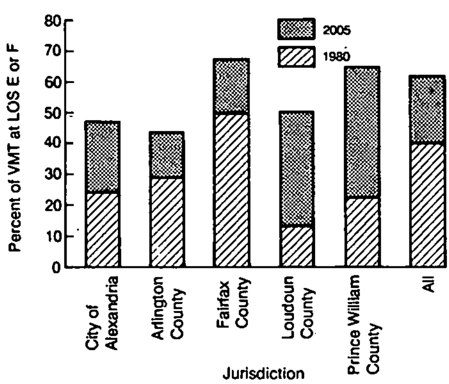

FIGURE 2 Percentage of total vehicle miles of travel operating at levels-of-service E or F (*13*).

expected to change from 39.3 percent of such travel in 1980 to 61.9 percent in 2005.

In the peculiar, backward-bending supply curve of highway transportation, as volumes rise speeds and throughput fall. When capacity is raised enough to get from the wrong side of that curve, where most of the travel time is spent because of delays, to the proper side of that curve, above 30 to 35 mph, there is a great deal of benefit for the traveler.

American commuters have now experienced periods when road capacity was expanding more rapidly and periods when it was expanding less rapidly. VMT did not increase more when road capacity was expanding compared with when it was more static. It is most important not to be led to believe that levels of service will be independent of the investments made. Conditions can be improved by adding capacity and by traffic engineering measures.

The FHWA forecasts of congestion levels do not take into account the limits on personal mobility described in the previous section. Using a method that involved forecasts of increasing VMT per licensed driver, FHWA prepared forecasts of automobile plus light-truck VMT that ranged from 1.95 percent growth through 2020 on the low side, 2.15 percent for the midpoint, and 2.56 percent on the high side (*14*). Growth rates in the FHWA forecasts also decline over time. Given the limitations on likely growth in speed, the FHWA forecasts imply that on the basis of the limiting factors discussed earlier, more time will be spent in travel than is estimated, and the limiting factors provide a better long-term perspective if technological change does not alter the speeds at which local trips can be made by the year 2020.

The substitution of slightly lower rates of growth through 2020 would tend to lower, albeit slightly, the rate of growth that FHWA estimates in the hours of delay experienced on urban freeways and arterials. The basic issue will still be to monitor congestion levels and to develop measures that will reduce congestion and bring about net user benefits.

Resources Required and Limits on Solutions

Resource needs are addressed by Stowers and by McDowell elsewhere in this report. The resources required to meet future personal mobility needs will be enormous. Even considering the future limits on increased demand for personal mobility and the consequent growth range of 1.3 to 1.7 percent per year, personal mobility will require by 2020 an increased annual consumer expenditure of 57 to 72 percent in real dollars over and above the expenditures of just more than $400 billion made by consumers today.

Table 12 (*15*) shows passenger and freight transportation expenditures for selected years from 1970 to 1985. The proportion of these expenditures to the

TABLE 12 Passenger and Freight Transportation Expenditures (*15*)

Type of Expenditure	1970	1975	1980	1983	1984	1985
			(In Million Dollars)			
PASSENGER TRANSPORTATION EXPENDITURES						
HIGHWAY PASSENGER TRANSPORTATION EXPENDITURES						
Auto Purchases and Ownership(1)	**$ 96,997**	**$156,550**	**$276,699**	**$339,842**	**$378,753**	**$404,252**
Local						
Bus(2)	$ 921	$ 2,349	$ 4,578	$ 5,708	$ 5,831	$ 5,905
Taxi	2,145	3,416	5,195	5,282	5,455	5,636
School Bus	1,219	2,174	3,833	5,200	5,800	6,100
Intercity						
Bus	799	1,016	1,709	1,965	2,035	1,989
Total Highway Passenger Transportation Expenditures	**$102,081**	**$165,505**	**$292,014**	**$357,997**	**$397,874**	**$423,882**
Air	10,565	17,792	38,135	42,754	48,061	50,687
Rail	464	924	1,953	2,172	3,493	2,316
Transit(2)	920	2,348	4,577	5,707	5,831	5,904
Water	287	294	303	420	472	510
Total Passenger Transportation Bill	**$114,317**	**$186,863**	**$336,982**	**$409,050**	**$455,731**	**$483,299**
FREIGHT TRANSPORTATION EXPENDITURES						
HIGHWAY FREIGHT TRANSPORTATION EXPENDITURES						
Truck Intercity						
ICC-Regulated	$ 14,585	$ 22,000	$ 43,000	$ 46,500	$ 52,100	$ 54,200
Non-ICC-Regulated	18,968	25,400	51,551	64,598	68,600	74,700
Truck Local	28,819	37,287	60,545	69,170	74,700	76,400
Bus	122	156	235	246	245	240
Total Highway Freight Transportation Expenditures	**$ 62,494**	**$ 84,843**	**$155,331**	**$180,514**	**$195,645**	**$205,540**
Air	1,171	1,838	4,013	4,959	6,016	6,743
Oil Pipe Line	1,396	2,220	7,062	8,302	8,693	8,290
Rail	11,869	16,509	27,702	27,325	30,549	29,150
Water	5,257	8,221	15,498	16,192	17,806	18,687
Other	1,791	2,208	3,153	3,253	3,426	3,337
Total Freight Transportation Bill	**$ 83,978**	**$115,839**	**$212,759**	**$240,545**	**$262,135**	**$271,747**
TOTAL TRANSPORTATION EXPENDITURES						
Total Highway Freight and Passenger Transportation Expenditures	**$164,575**	**$250,348**	**$447,345**	**$538,511**	**$593,519**	**$629,422**
Total U.S. Freight and Passenger Transportation Expenditures	**$198,295**	**$302,702**	**$549,741**	**$649,595**	**$717,866**	**$755,046**
Highway Freight and Passenger Transportation Percent of GNP	**16.6%**	**15.6%**	**16.4%**	**15.8%**	**15.8%**	**15.7%**

(1) Includes business expenditures for passenger cars.
(2) One-half of amount for "Bus and Transit" shown in source.
SOURCE: Transportation Policy Associates, *Transportation In America*, March 1987.

gross national product (GNP) has remained fairly constant at around 16 percent. If the economy grows at 2 percent or more and personal-use VMT at only 1.3 to 1.7 percent, consumers will be able to purchase even more luxurious and technologically advanced vehicles or to absorb much higher fuel prices within their transportation-related budgets without reducing their personal mobility.

The portion of consumer expenditure for mobility represented by user fees, which are used to develop facility improvements, should be set at the level that results in the lowest total resource costs (consisting of government expenditures, user operating costs, user time costs, and user accident costs) for the level of service that consumers are willing to support. Community and environmental constraints will mean that second-best solutions will often have to be calculated to many problems. Analysis is needed to develop a sound answer to the question of what actual public expenditures can be made that will have net benefits.

There is no answer to this today, so it is appropriate to continue the 2020 planning process through this and other conferences. A good answer can be developed. An off-the-cuff estimate of one and a half to two times today's levels of average user fees (raised appropriately among vehicle classes) appears reasonable.

CONCLUSIONS

Future increases in personal income will have a modest impact on demand for personal mobility beyond their impact on vehicle ownership levels. The analysis presented in this paper of factors determining the future demand for personal mobility indicates that an average annual growth rate of 1.3 to 1.7 percent in personal vehicle travel should be anticipated between now and 2020. Rate of growth will be higher than that in the near term and lower in the latter part of this forecast period.

The popular perception that local personal travel is becoming more difficult is not supported by data gathered in a consistent and periodic manner, such as the decennial census, the NPTS, or any other survey. This does not mean that the next census or the next NPTS will not show evidence of such increasing difficulty. However, more urban roadways are becoming congested each year, and a larger proportion of urban travel is taking place under congested conditions. Congestion can get better or worse fairly rapidly because of the nature of the relationship between a road's capacity and the throughput of vehicles at a given level of demand.

Increasing congestion levels are occurring at a time when there is preliminary evidence that the increased proportion of jobs in the suburbs is adding work trips that will be shorter on average than existing work trips, and that these trips may be on facilities that now have better travel speeds than the average for urban-area facilities. However, there is not likely to be much more capacity for growth in suburb-to-suburb travel before volumes on these facilities bring about declines in speed that will render suburb-to-suburb travel speeds similar to those for other trip patterns. Also, suburb-to-suburb trips afford less opportunity to achieve higher use of transit and ridesharing. It should not be expected that suburb-to-suburb work trips will be made with more than a 2 percent transit mode share or at an average automobile occupancy of more than 1.09 persons per vehicle.

The role of transit in total personal mobility throughout the United States will continue to shrink slightly from its 1983 share of 2.3 percent of local daily trips and 2.7 percent of local daily passenger miles, but this percentage vastly understates the importance of transit in serving trips at very congested times and for origins and destinations for which there may be few or no options to improve highway capacity. Walking and bicycling will continue to serve modest numbers of short trips. Walk trips averaged 0.3 mi and 10 min in 1983, and accounted for 8.5 percent of local daily trips and 0.3 percent of local daily passenger miles. Bicycle trips averaged 2 mi and 15 min in 1983, and accounted for 0.75 percent of local daily trips and 0.16 percent of local daily passenger miles.

This is a critical time for decisions that will affect future personal mobility. The private consumer has shown great willingness to pay for personal mobility of a high quality. Private consumers can, by themselves, make decisions on only a portion of the expenditures necessary to preserve and enhance mobility. Public agencies must make the decisions on the infrastructure improvements and maintenance programs that will support private mobility demands.

Because of the declining rate of growth of demand for personal travel, there is time to catch up with and resolve a larger proportion of current problems within resource levels that will be acceptable. Once the congestion problems have been resolved, a regularized pattern of expenditures will be sufficient to keep most of the road and transit systems at an adequate level of service.

The only reasonable public agency investment rule is to fund projects that return net benefits after allowing for public and private costs and both personal and freight transportation costs and user benefits. FHWA's analyses to support the 2020 program estimate that additional user benefits will continue to exceed additional public agency costs by very large factors for many succeedingly higher levels of investment (*16*). Even if only operating costs and accident costs are considered, the economy will be much better off at significantly higher levels of public agency expenditures.

Consumers do value time, however, and the amount of time they spend and the quality of time has to be considered in evaluating levels of mobility. This is not an objective factor; it may be that the increasing public preoccupation with traffic issues is related as much to the quality of time on congested roads, which is frustrating time to most people, as it is to the amount of time spent traveling, which is adjustable by choosing origin and destination patterns.

It is highly likely that after a wide range of sensitivity analyses by FHWA and the 2020 Consensus Transportation Program, it will be concluded that much higher levels of public investment are justified. On the basis of the high levels of benefits to costs that FHWA's analysis has already calculated, high net benefits should be achievable. Higher levels of public investment, funded by increased user fees, will make society better off. Lower levels of public investment would force consumers to try to buy the personal mobility that they want from a menu without a full list of choices. Public investment levels to support personal mobility must be in balance with consumer preferences.

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Florida's Challenge: Managing Explosive Growth

PATRICK J. MCCUE

FLORIDA'S POPULATION RANKED TENTH in the nation in 1960. In 1988 it ranks fourth. Over 12 million people reside in Florida today, and that figure is expected to rise to 15 million by 2000 and to pass 19 million by 2020 (*1*). In 1988, Florida was the annual vacation destination of 35 million tourists. By 2000, 60 million tourists are projected (2). Florida's manufacturing sector has grown 12.9 percent during the 1980s, whereas the rest of the United States experienced a 4.2 percent decline. A large portion of this growth occurred in high-technology industries, which have more than doubled over the past 10 years and now places Florida first in the southeast and seventh nationally. During this same period, Florida's service sector has grown at twice the national average and its retail sales industry approaches $110 billion annually (*3*). Florida's 35 million tourists contribute nearly $8 billion annually and represent the equivalent buying power of another 1 million residents.

CAUSES OF GROWTH

Florida's growth can be attributed to its climate, beaches, casual life-style, economic opportunities, relatively low cost of living, and low taxes. With the exception of climate, each of these attraction factors is either degraded or challenged by rapid growth, resulting in crowded beaches, polluted water, hectic life-styles, congested roads, increasing cost of living, and growing pressures for public infrastructure financed by higher taxes.

Patrick J. McCue is currently Director of the Division of Planning and Programming for the Florida Department of Transportation. His earlier positions include Director of Policy and Federal Programs at FDOT and staff member of the Association of American Railroads.

Nature of Growth

The magnitude and speed of Florida's growth constitute a serious problem that is compounded by the pattern of growth. Over 80 percent of Florida's population resides along the coast. The notion that Florida's coastline could be a continuous string of cities is becoming a reality. Just as significant, however, is the spreading out of Florida's cities. Instead of having several very large cities account for the majority of the state's growth, growth is occurring in many urban areas throughout the state.

Florida now has 22 medium to large cities of 50,000 or more, and by 2000 there may be as many as 30 such cities. This indicates that although Florida is rapidly urbanizing, it is growing out more than it is growing up. Although 20 percent of the cities in the United States had a decline in their populations in the 1980s, all cities in Florida continued to grow (*1*). The fastest growth of all, however, occurred in the suburbs. For many years, suburban growth meant residential growth. However, in the 1970s this trend changed with the emergence of large regional shopping malls in the suburbs. In the 1980s, perhaps the most significant development of all occurred: the explosion of offices, service jobs, and commercial business megacenters in the suburbs (*3*). Suburban megacenters are office developments of 2 million ft^2 or more, with thousands of employees. These centers, which are developing in many Florida suburbs, are attracting new business growth at a much higher rate than traditional downtown business areas. In the next 5 years, about 2 million ft^2 of new office space is planned for Orlando's central business district (CBD); however, this number pales in comparison with the projected 11 million ft^2 of new office space planned for the Orlando suburbs. The I-75 corridor through the Tampa region is one of the newest growth areas in the state. Proposed projects in this area total more than 40 million ft^2 of new office space. Again in comparison, projects proposed for downtown Tampa total only 5 million ft^2 of office space. This suburban office development is accompanied by an explosion of employment in Florida's suburbs. During the last 10 years, five new jobs have been created in the suburbs for every job downtown. This trend is occurring in a state where the downtown areas are still growing, which is contrary to the national pattern.

Suburban megacenters bring with them a host of new transportation problems. Because they are primarily designed for the automobile commuter, they cause severe traffic congestion on highways that were designed for rural use. They are also, for all practical purposes, inaccessible to pedestrian traffic and are very difficult to serve with public transit.

Florida's population is graying as well as growing. The age group who are 65 and over will constitute 20 percent of the population by 2000. Florida's experience with this elderly population will precede the national trend by approximately 15 years, so the demands and effective solutions tested in Florida will serve as a useful guide for the rest of the country. This group values recreational opportunities, has a greater need for access to medical services, is less tied to a work schedule for travel, has more discretionary income, enjoys privacy, and prefers rural settings. To them, crowded facilities and congested urban environments are not very attractive.

Florida's population of young families is also growing, attracted by job opportunities. These young families need educational services for themselves and their children to remain competitive in a technological environment and to become prepared to function in that technologically advanced future. Over 50,000 new kindergarten through 12th grade students enter Florida's schools each year, which translates into 100,000 more teachers and 933 new schools over the next 10 years to keep up with a 16.4 percent annual increase in enrollment (*4*).

For Floridians, life-styles are important. Going to the beach, walking, hiking, biking, and other outdoor recreational activities are strong attractions to the Florida experience. These life-styles require emphasis on sidewalks, hiking trails, bike lanes, green space, and urban open spaces designed to the human scale, which is contrary to the design standards guiding development of regional megacenters.

IMPACTS OF GROWTH

The impacts of Florida's growth are serious problems that, left unattended, will destroy those quality-of-life attractions valued so highly by Florida residents. The preference to live near Florida's Atlantic and Gulf Coast beaches is causing a boom in development along Florida's coastal zone. The growing congestion degrades the quality of life. Growing demands on natural resources are leading to water shortages, salt-water intrusion of the Florida aquifer, and environmental threats to wetlands. The growth in population has led to such a demand for new garbage sites that the legislature has mandated recycling and one firm has tendered a serious proposal to burn garbage in ships offshore. Drugs and street crime become important public issues. Prison overcrowding adds another burden to the infrastructure dilemma. Yet the tremendous growth of jobs, especially in the service sector, and the continuing perception that Florida's quality of life is preferable to that of other areas continue to attract more new residents. The most significant impact of growth for the public sector is the demand for new infrastructure: schools, water and sewage treatment facilities, public buildings, recreational facilities, prisons, and transportation—roads, transit systems, and airports.

Over half the roads in Florida's urban areas are congested and grow worse every year (*5*). In the rural and suburban areas the picture is better today, but suburban growth and emerging megacenters are creating new rural and suburban congestion problems. Suburban offices produce 70 percent more peak-hour trips than a regional mall, and as much as 1500 percent more trips than a subdivision (*3*). Congestion is clearly spreading in suburbia.

In efforts to streamline operations, railroads have abandoned almost 600 mi of line since 1980—about 900 more miles of additional abandonments are anticipated (*6*). Although creating some problems and dislocations, railroad abandonments provide corridors that may be of value to the public sector for other forms of transportation service. Some of these corridors offer the potential of providing relief of congestion on the state highway system.

Transit ridership has not kept pace with Florida's growth, and deficits have risen dramatically (*7*). Public transit works most effectively when it is serving densely populated downtown employment centers. A means must be found to serve scattered employment with public transportation. Public transit must find a way to serve downtown urban centers and suburban megacenters. New technologies must be employed in addition to the fixed-route systems of today. The Florida of tomorrow will almost certainly be unbearably congested without an effective transit mode.

Florida's civilian air traffic, combined with the greatly expanded military training operations over Florida, is creating serious congestion problems in the sky (*8*). These problems soon could lead to additional controls of air operations in Florida. The projected doubling of aviation activity by the year 2000 calls for significant airport improvements and the construction of new airports. If building started today, a new commercial airport might be operational by the end of the century.

Crowded skies, crowded roads, crowded cities and suburbs—can Florida meet the needs of a rapidly changing state?

The Florida Response

Public-Sector Tools

Bold public programs directed at guiding the nature, timing, and location of growth and adequate funding are prerequisites to reclaiming Florida's future.

The Florida legislature has repeatedly addressed growth problems over the last 20 years, creating water management districts, coastal zone management programs, environmental permitting agencies, and a local government planning process. In the early 1980s, a number of legislators became convinced that such efforts were failing because of two elements under their control: lack of a statewide, coordinated planning process and lack of a consistent set of statewide policies and goals. In 1983, 1984, and 1985, important pieces of legislation were passed aimed at correcting those problems. The legislative discussions about those proposed pieces of legislation quickly centered on a recognition that the public sector has few tools to address the impacts of growth. The primary ones that can be used are land use controls, water resource management practices, and provision of transportation services. A critical guiding principle of the new legislation has been the assumption that these public-sector tools must be tightly coordinated for growth management to work.

The growth management debate is now centered on implementation of statutes and funding, with funding being viewed as the remaining unsolved piece of the puzzle. Implementation of statutes has been delegated to state agencies and local government with legislative oversight. The attention of the Florida legislature has now turned to funding issues. To effectively use public-sector tools requires adequate public financing. For some time during the early growth decades of the 1940s and 1950s, it was argued that growth paid for itself. Many people believed that the new resident or business stimulated the economy enough through big ticket purchases—homes, cars, buildings—that growth was indirectly paying its own way. Also, many Floridians, and those new residents who came to Florida to escape high taxes, strongly resist tax increases. Thus, Florida currently ranks 37th in terms of total state taxes per capita (*9*). It ranks ninth in total budget expenditures of all forms, state and local; yet it ranks fourth in population (*10*). There is no state income tax or personal property tax, and real property (ad valorem) taxes are capped. Further, many local tax opportunities provided to municipal governments are not available to county governments in whose jurisdictions much of Florida's growth has occurred. In principle, management of growth cannot occur unless the public sector is adequately funded to provide needed infrastructure under policies and guidelines that serve the public interest. Thus the final piece for Florida's growth management puzzle is to provide sufficient funds for needed infrastructure improvements. The institutional and programmatic pieces of the puzzle are largely in place because of recent legislative actions.

Growth Management Legislation

In direct response to the growth issues discussed in the first section, the 1985 Florida legislature enacted the Omnibus Growth Management Act, which introduced a statewide coordinated planning process for state, regional, and local governments. The act amended various portions of existing Florida statutes and created several new statutes that established a planning process bringing together the many public and private interests that will shape Florida's future (*11*).

The process began in June 1984 when Florida passed the State and Regional Planning Act, which required the creation of the State Comprehensive Plan, adopted by the legislature (Chapter 187, Florida Statutes) in June 1986, in the form of 25 major goals and 364 strategically related policies. To breathe life into the goals and policies of the State Comprehensive Plan, state law requires the creation of consistent State Agency Functional Plans (Chapter 186, Florida Statutes), Regional Comprehensive Policy Plans (Chapter 186, Florida Statutes), and Local Government Comprehensive Plans (Chapter 163, Florida Statutes) that are each consistent with the State Comprehensive Plan. This network of coordinated planning products is the cornerstone of Florida's growth management process.

The principal focus of the growth management process is the legislative mandate for each local government to adopt a comprehensive plan and set of subsequent land development regulations. The Growth Management Act requires greater enforcement of local plans and consideration of capital facilities and the means to pay for them than did earlier comprehensive planning legislation. A major thrust of the new act is for localities to project their needs for roads, water, sewer, and other facilities and then to ensure that the facilities are funded and constructed concurrently with the growth that they serve. Once the local government plan has been approved by the state and adopted by the local government, communities may not issue building permits or adopt zoning changes that would result in reductions in level of service below adopted standards.

The state's land planning agency, the Department of Community Affairs, has developed guidelines for preparation of plans, including data requirements and rules for the presentation of goals, objectives, and policies. The guidelines require that each plan include implementation policies and a section on consistency with state and regional plans. Local government failure to adopt a comprehensive plan that complies with state requirements could result in the withholding of state funds, including transportation funds used to increase the capacity of roads, bridges, and other state-funded public facilities.

Through their Regional Comprehensive Policy Plans and Local Government Comprehensive Plans, regional and local governments are active partners in the growth management process. State agencies are also active partners through an Agency Functional Plan (AFP), which like the regional and local plan is to be oriented to policies devoted to helping Florida reach its State Comprehensive Plan goals and policies.

The Executive Office of the Governor reviews agency functional plans for consistency with the State Comprehensive Plan. Agencies must use their approved AFPs as part of the justification of their Legislative Budget

Requests. In essence, the AFPs become major tools ensuring that agency budgets respond to Florida's key issues as defined in the State Comprehensive Plan.

Anticipating the direction of legislative discussions of growth management, the Florida Department of Transportation (FDOT) initiated major changes to the Florida Transportation Code (Chapter 339, Florida Statutes) by outlining the purpose and contents of the Florida Transportation Plan (FTP). Portions of this document serve as the Department's AFP.

The Florida Transportation Plan (*12*), as adopted in September 1986, documents FDOT policies, directs programming and budgeting activities, and guides local and regional transportation planning. The FTP was developed in coordination with other state agencies, metropolitan planning organizations, and regional planning councils. Although the FTP is principally a policy plan, it does contain sections addressing practical implementation issues. A transportation mode section establishes level of service and ultimate through-lane standards for the state highway system, creating a threshold for a transition from highway improvements to other modal improvements in major state highway corridors. A transportation corridor designation and coordination section identifies transportation policies and corridors of major statewide and regional significance to focus planning, programming, right-of-way protection, and advanced acquisition within designated corridors.

Transportation as a Growth Management Tool

Although a wealth of information exists in Florida that explains growth management by discussion and example, a concise legal definition, especially as it relates to transportation system development, is not clearly stated in Florida law. FDOT reviewed growth management legislation and determined that five major issues can form the framework for transportation to serve as a growth management tool (*13*). These are

1. Providing infrastructure concurrent with the impact of development;
2. Coordinating state, regional, and local plans;
3. Attracting desirable development;
4. Encouraging development within urban areas and within transportation corridors; and
5. Protecting coastal resources.

Subsequently, growth management, as it relates to FDOT, was defined as (*5*)

> Implementation of state goals and department policies, objectives and standards to obtain maximum benefit from environmental, physical, social, and economic use of land by working with local governments to control the timing, nature and location of growth into preferred development patterns.

The types of highway projects that significantly affect land use patterns are those that provide substantially improved access. These types of facilities are (a) interchanges on limited-access facilities, (b) new highways and bridges to areas that currently have no or little access, and (c) substantially improved highways (e.g., unpaved to multilane roads).

Although major in scope, multilane highway improvements (e.g., two to four lanes) predominantly reflect traffic and land use demands. They are primarily a result of or a reaction to growth rather than facilities that guide or direct growth. "Access" is the key word relating growth management and highways. The three types of highway projects listed earlier significantly affect land use patterns by providing access to new areas. On the other hand, capacity improvements increase access to existing areas.

FDOT has a major responsibility to participate in growth management activities because (a) most major highways that provide new access are state facilities and (b) the department has statutory authority to construct, operate, and maintain the state highway system.

Major initiatives that FDOT is currently undertaking to implement growth management legislative intent include

1. Developing and promoting access control policies for the state highway system,
2. Promoting the state's interregional highway system to preserve and enhance interstate and interregional mobility,
3. Implementing minimum level-of-service standards for the state highway system,
4. Developing right-of-way protection procedures that the department will recommend to local governments to preserve and protect transportation corridors and rights-of-way,
5. Developing minimum standard Development of Regional Impact (DRI) and Local Government Comprehensive Plan transportation review and analysis procedures,
6. Promoting a partnership between the private and public sectors in funding transportation improvements through locally collected impact fees and other innovative financing techniques, and
7. Promoting consistency among the Strategic Transportation Plan, the Florida Transportation Plan, and the regional planning councils' Regional Comprehensive Policy Plans and Local Government Comprehensive Plans.

FDOT success in managing the state highway system is proportional to its level of participation in growth management activities that affect the system. Developing level-of-service standards and working with regional planning councils, metropolitan planning organizations, and local governments in using those standards within growth management efforts provided an early opportunity to become an active partner in the process. Although the impetus to examine level-of-service standards in Florida stemmed from growth management issues, the effort yielded other valuable benefits such as effective criteria to review development projects, development of measurement techniques of traffic flow [e.g., the 1985 Highway Capacity Manual (*14*)], and evaluation criteria of system operating conditions.

Level-of-service standards adopted by FDOT for the state highway system are contained in the Florida Transportation Plan (*12*). These standards have become integrated into FDOT activities with metropolitan planning organizations, regional planning councils, and other local governmental entities. They also are used by FDOT in the review of Local Government Comprehensive Plans and major site-development projects (e.g., developments of regional impacts) as they relate to the state highway system. The standards were based on three assumptions:

1. There is a direct correlation between urban size and public acceptance of some highway congestion as a trade-off for other urban amenities,
2. State facilities serve various roles (e.g., interregional mobility versus local access), and
3. Local and regional agencies must be active participants in level-of-service decisions.

The basic document for evaluating highway capacity is the 1985 Highway Capacity Manual (HCM) (*14*). With the assistance of William McShane, one of the principal authors of the manual, FDOT developed generalized average daily traffic volume tables for varying levels of service to complement the adopted FDOT level-of-service standards (*15*). These tables serve an urgent need of transportation planners by incorporating the 1985 HCM techniques in an easy-to-use format. They also provide practical measures that support the growth management concepts of urban infill and infrastructure concurrent with the impact of development.

High-Speed Rail Legislation

The Florida High Speed Rail Act (Chapter 341, Florida Statutes), enacted in 1984, will be a contemporary test of many of the leading concepts promoting public-private financing ventures and use of transportation as a growth management tool and in public-private financing ventures. The act created the Florida High Speed Rail Commission, charged with issuing requests for proposals and establishing termini and areas of the state in which the system will operate. It also empowered the commission to accept offers of property rights and to enter into joint development agreements with the franchisee.

In January 1988, the commission officially released its request for proposals outlining the requirements and guidelines for applicants interested in winning the franchise to build and operate this $2 billion to $5 billion high-speed rail system.

One unique feature of Florida's approach to high-speed rail service is the private-sector role in financing, building, and operating the system. In order to attract the best applicants, several financial incentives are awarded with the franchise. One is streamlined property development rights along the high-speed rail corridor in which both private and public properties have been donated or offered for stations, rights-of-way, or joint venture development. Another financing method under consideration is to secure tax-exempt bonding authority for the project. With these financial incentives and other private enterprise innovations, high-speed rail could be one of the largest private transportation and development projects in the state.

These incentives are balanced in the public interest by requiring compliance with state, regional, and local growth management plans as well as environmental impact considerations. In fact, the legislation requires state agency review of environmental and growth management impacts before award of the franchise.

Funding

Florida's legislative and other public leaders recognize that implementation of the innovative features of recent growth management legislation is tied to adequate funding. The funding issue has been addressed along two parallel but complementary tracks—local government funding and state funding.

Local government infrastructure cost through the year 2000 is estimated to be approximately $34.7 billion. This represents both existing needs ($16.8 billion) and new needs ($17.9 billion) that are unfunded with current sources at current levels. This $34.7 billion estimate translates into approximately $1.6 billion per year of additional revenues needed by local governments through the year 2000.

In 1987, the Florida legislature created the State Infrastructure Fund, which is subject to appropriation each year, to be used for numerous purposes including transportation. The fund was established at $500 million the first year. This level of funding, given the admittedly much greater needs, has led to considerable debate over spending priorities.

Local governments have continued to press for either fiscal help or relief from the rigid concurrency provisions of growth management. In the 1988 session, a strong effort was made to assign a major portion of the State Infrastructure Fund to local governments. Also, a number of proposals were made for raising broad-based funds for local infrastructure needs and for granting broader powers to county and municipal governments to utilize creative financing techniques (i.e., narrow-based fees and taxes). Among these proposals are removing referenda requirements for local-option sales taxes, passing a statewide local gasoline tax to replace local-option gasoline taxes (which vary from 4 cents to 11 cents per gallon), closing real estate transaction loopholes, increasing occupational license taxes, revising impact-fee taxes, permitting greater flexibility in the use of benefit assessment districts, tax-increment financing, establishment of municipal "reserve areas," and utility taxes.

Until the 1988 legislative session, state transportation funding in Florida was essentially a "pay as you go" exercise based mainly on the receipt of federal-aid transportation funds plus state revenues from a 5.7 cent/gal fuel tax and a portion of the motor vehicle license fees. However, some of these revenues are diverted for nontransportation purposes (education). FDOT has recognized for some time that adequate future funding of the transportation component of growth management will require a great deal more than this current system provides. The 10-year shortfall for state highway and public transportation needs is estimated at $25 billion in the 1988 Strategic Transportation Plan. The 1988 legislature responded to the FDOT initial proposal for financing the Strategic Transportation Plan.

MAKING THE MOST OF CURRENT OPPORTUNITIES

Strategic Transportation Plan

When Kaye N. Henderson was appointed Secretary of Transportation in January 1987, he promised to dramatically upgrade the state's transportation system. His first action to implement that promise was to initiate and personally direct an aggressive planning process that resulted in the 1988 Strategic Transportation Plan (*16*). The plan identifies bold, aggressive strategies, numerous reforms, and calls for a greatly expanded state highway system, improvements to public transportation systems throughout the state, and expansion and extension of Florida's Turnpike. The implementing strategies include improving employee productivity, increasing the production capacity of the department, reducing the time and cost of acquiring rights-of-way, and preservation and advanced acquisition of future transportation corridors. It also establishes working and financial partnerships with local governments and the private sector, identifies innovative financing solutions, and sets criteria for measuring FDOT success in meeting its new goals.

The plan is FDOT's answer to the challenges of Florida's growth. Implementing the transportation system called for in the plan, in close cooperation with local governments and the private sector, will result in a balanced, adequate system that will meet the intent of growth management. The Strategic Transportation Plan identifies needs over a 20-year planning horizon and documents near-term goals that must be accomplished. The most significant near-term goals are to improve productivity, increase efficiency, and establish and improve partnerships with local governments.

Improved Productivity and Increased Efficiency

Secretary Henderson has established a program based on the concept that "time is money" for FDOT to produce transportation products in half the usual time. The program seeks to double production (P × 2) while reducing the time to complete projects by half (T/2). Program activities include right-of-way acquisition, permitting, design, and construction.

The overall strategy for accomplishing program objectives recognizes that (a) additional agency costs associated with cutting project delivery time will be more than offset by relevant user savings and (b) "buying time" makes good sense from a benefit-cost standpoint.

The accelerated program is supported by a commitment from Governor Martinez to ensure full cooperation among "sister" agencies in state government. Programmatic elements require FDOT to

1. Fully examine all existing policies, procedures, and standards to ensure that they are up-to-date, streamlined, effective, and necessary;
2. Develop and implement a program to ensure more comprehensive and effective project management;
3. Identify and secure resources required to achieve objectives;
4. Implement new or innovative time-saving technologies, practices, and procedures; and
5. Mobilize and clearly focus the attention of all DOT employees on the goal.

Evaluation efforts to date have shown that with adequate resources and comprehensive, effective project management, delivery times can be reduced substantially. For example, time to complete major new highway and bridge construction projects should be reduced from an average of 9 years to approximately 5 years. Other major projects should be completed in 4 years instead of 7 years. These reductions can be accomplished within the existing framework of regulations affecting project delivery. Additional opportunities and related regulatory change will permit full achievement of T/2.

Intergovernmental Coordination

FDOT has assumed the role of serving as the primary advocate for building a transportation system that meets Florida's needs. This includes working cooperatively with other governments and the private sector to ensure proper alignment of jurisdictional roles and responsibilities for the transportation system.

In order to improve those working relationships, FDOT has assigned the following specific growth management responsibilities to the central office and to each of the district offices:

1. Expand and strengthen operations in urban areas;
2. Identify multicounty regions with common transportation concerns and initiate regional transportation planning and programming activities;
3. Work directly with local governments to develop and implement the transportation and land use portions of their comprehensive plans, including review of DRIs and other developments affecting the state highway system;
4. Work directly with urban areas to develop right-of-way protection procedures to preserve and protect transportation corridors and to develop comprehensive policies for the management of access to the state highway system;
5. Maintain productive working partnerships with local governments and their organizations (metropolitan planning organizations, regional planning councils, the League of Cities, the Florida Association of Counties);
6. Coordinate the FDOT strategic planning process with the metropolitan planning organizations' urban planning processes; and
7. Assist urban areas in the development of public transit systems and use transit service to relieve congested highway corridors.

Funding

Florida's Strategic Transportation Plan identifies aggressive strategies to improve FDOT productivity and efficiency; those actions are under way. Partnerships with local governments and the private sector are also being pursued to improve product delivery and to provide financing for certain projects.

Improved productivity and efficiencies are necessary to the accomplishment of the plan, which will require $25 billion in additional revenue to complete the projects in the first 10 years of the plan.

Potential revenue sources for the $25 billion shortfall have been identified (*17*). In general, the early years of the plan can be funded by bonding and moderately increasing some user fees. After fiscal year 1993, the plan requires additional financing and substantial increases in user fees.

Increased cash requirements total $4 billion during the first 5 years of the plan and $15 billion during the second 5 years. Because actual payments on contracts and other commitments are made over a number of years as projects are completed, the remaining $6 billion of the total $25 billion additional revenue will not be required until after fiscal year 1998.

The first year of the Strategic Transportation Plan is being funded through a combination of cost reductions and adjustments to the department's budget. During the first year, the department will also begin to expand and improve the Florida Turnpike, funded with bonds backed by Turnpike toll revenues.

Making New Opportunities

Broader Questions, Broader Answers

The public-sector side of transportation is facing major changes in the world in which it conducts its affairs. Although similar pressures are being experienced by the rest of the country, the magnitude and pace of Florida's growth give a sense of urgency to developing effective responses. In Florida, a key is the public unwillingness to allow transportation decisions to be made independent of land use decisions, and vice versa. The expansion of issues to consider in developing policy, setting priorities, and selecting projects is troublesome, because they are outside transportation agency control and require enormous man-hours of management time. As a state agency, FDOT's jurisdictional responsibilities overlap those of every jurisdiction in Florida. That makes the department the obvious choice to resolve issues in ways that have statewide application. The directions now are to develop and implement policies and programs that further the goals of overcoming jurisdictional barriers and to manage the state's transportation resources, not just to build them. Access management, corridor protection, transportation corporations, establishing a statewide turnpike system, and getting bonding authority are real FDOT successes in furthering those goals.

Legislative Initiatives

FDOT is responsible for the construction and maintenance of roads on the state highway system, which includes the power to establish and control connections to the system. During the 1988 session, the Florida legislature radically expanded that responsibility.

Until now, the FDOT process for regulating connections (driveways, etc.) to the state highway system has been constrained to the review and approval of permit applications for driveways, including proposals for construction, drainage, and basic traffic control. No attention has been given to maintenance of levels of service, basic roadway characteristics, or the potential impact of such requests on the future of that roadway. For the most part, local governments (cities and counties) have had little input to the department's access decisions.

The access management legislation (Senate Bill 1364) ensures that future connections to the state highway system will receive full review by all concerned parties and now includes participation by local governments. Such reviews will consider all factors that bear on both the current physical nature of the connection and the potential impact of the connection on that roadway's future as a segment of the state highway system.

The new law calls for FDOT to adopt, by rule, an access control classification system that will be used in evaluating proposed connections to the state highway system and will, in turn, become the major component of a new FDOT access management program.

Local governments may now, if they desire, adopt rules to become a "permitting authority" for administering access permits for segments of the state highway system within their jurisdictions. However, such local access management rules must be at least equal to or more restrictive than those of the department.

A local permitting authority can be established only by means of an interlocal agreement with FDOT. The minimum requirements for an agreement, as spelled out in the new law, provide for such items as notice to and challenge of intent by the department of a proposed permit. The department retains authority to close or change a connection. The law also establishes that changes to FDOT standards must be included in local regulations and stipulates that liability issues be addressed in the interlocal agreement. Additionally, such agreements can be rescinded or terminated by FDOT where local access regulations fail to meet FDOT standards.

A major item in the new law is the establishment of nonrefundable fees for connection applications. Such fees are to be graduated according to the nature of the proposed connection and will range from not less than $25 to not more than $5,000 per application.

Implementation of the bill is to be phased in over a period of years. By July 1, 1989, FDOT must have adopted procedures for the issuance of permits, modification of existing permits, and closing of unpermitted connections. Adoption of the access control classification system is required by July 1, 1990. By July 1, 1992, FDOT must have assigned an access category to each segment of the state highway system.

If Florida is to succeed in addressing the need for transportation services created by past, current, and future growth, the ability to protect and acquire property needed for transportation facilities must be enhanced and the coordination between governmental entities must be improved. One effective way to accomplish this is through the planning and development of transportation corridors to provide major transportation facilities consistent with growth projections and future land use.

The 1988 legislature addressed this major growth management issue by passing advanced right-of-way acquisition and corridor protection legislation that amends the planning requirements for the department and local governments to provide for increased coordination in planning and protecting the state's future transportation facilities, particularly those major facilities that are defined as transportation corridors. The legislation creates new mechanisms for protecting and acquiring rights-of-way to increase protection of all facilities and to allow earlier acquisition of property in transportation corridors.

Transportation corridors are "designated" by agreement between the department and local governments. The planning process leading to designation ensures that state and local natural resource and environmental agencies will cooperate in the review of corridors to assess environmental requirements. Each party to the agreement must use its authority and financial resources to protect and acquire needed rights-of-way within the designated corridors. Rights-of-way also may be acquired under the advance right-of-way provisions of the bill.

The advance right-of-way portion of the program allows the "necessity for the acquisition of property" to be demonstrated through the use of typical design or construction plans or profiles, and one or more of the following: anticipated trends in demographics and other growth patterns, land use and development patterns, traffic projections, expected utility needs, or future anticipated mass transit requirements. Actual design plans and profiles, project development and construction information, construction funds, or applicable permits are no longer necessary to initiate acquisition proceedings. Furthermore, FDOT may file maps of reservation for transportation corridors and for rights-of-way of transportation facilities within those corridors.

Governor's Task Force on Urban Growth Patterns

On May 25, 1988, Governor Martinez announced the creation of a Task Force on Urban Growth Patterns. The task force consists of 21 members representing private developers, local government, academia, regional planning councils, the state legislature, state agencies, environmental groups, and private citizens.

The mission of the task force is to facilitate implementation of the State Comprehensive Plan through development of strategies that encourage more compact urban growth and development and that discourage sprawling, inefficient development patterns.

The task force will attempt to identify the costs of urban sprawl and the savings that can be realized from reducing and slowing sprawl. The task force will also study existing state, regional, and local programs and processes to identify specifically where and how inefficient sprawling development is being encouraged and how those programs could be used, with or without modification, to encourage proper urban growth and development. The task force is to recommend new programs and policies that will provide incentives for more compact urban development and the reduction or elimination of urban sprawl. Major consideration will be given to the need for urban development to occur concurrent with the provision of adequate facilities and services.

The task force is to provide a final report with conclusions and recommendations to the Governor no later than January 15, 1989. The final report will include any proposed administrative actions, rule changes, and legislation. As appropriate, the task force can propose the use of pilot projects to test or document the results of proposed actions as an alternative to immediate statewide implementation.

Funding

FDOT offered proposals to the 1988 legislature to implement the first steps in financing the Strategic Transportation Plan. Since the first year of the plan was to be financed primarily from improved efficiencies and existing sources, no additional taxes were proposed this session. However, legislation introduced is intended to provide the vehicle for improving the management of the financial resources available for transportation from both the state and private sectors.

The funding legislation passed this session provides authority to bond toll revenues from Florida's Turnpike system for construction of new segments, eventually expanding the Turnpike into a statewide system of interconnected toll segments and non-toll limited-access routes. Ultimately, this is expected to generate $2 billion to $3 billion of construction money for the Turnpike system.

Approval was also given to place on the November 1988 ballot a constitutional amendment authorizing bonding of gasoline tax revenues for right-of-way acquisition and bridge construction. If the voters approve the amendment, $30 million from gasoline tax revenues would be used to back bonds that would raise $300 million during fiscal year 1988–1989. An additional $20 million would be authorized to support another $200 million in bonds during fiscal year 1989–1990. This bill would also allow bonding of future gasoline tax revenues in the event of a gasoline tax increase.

The Florida legislature, during its 1988 session, adopted the Florida Transportation Corporation Act (House Bill 621), which authorizes the establishment of transportation corporations under the control of FDOT. As nonprofit public charities, transportation corporations are exempt from state taxes. Such corporations will be authorized by FDOT and will be designed to assist with the development of roads on the state highway system provided such projects are included in the adopted 5-year transportation plan.

A transportation corporation can receive contributions of land and cash; acquire, hold, invest, and administer property; and transfer such property to the department for development of projects. The corporation can also work with landowners, local and state officials, and others to support, promote, and develop projects.

Other allowable activities of corporations include hiring administrative, legal, and technical staff; preparing exhibits, right-of-way documents, environmental reports, schematics, and preliminary and final engineering plans necessary for development of the project; and borrowing money.

Transportation corporations are prohibited from issuing bonds and from entering into contracts for construction. Corporations can make limited use of department facilities and resources; however, they cannot receive funds from FDOT except as specifically approved by the Legislature. Corporations would be subject to audit by FDOT and the state's Auditor General.

A transportation corporation can be dissolved by FDOT at the request of its members. Upon dissolution, all property of the corporation would be turned over to FDOT.

A Vision for the Next Generation

The Florida State Comprehensive Plan has a guiding philosophy of managing growth that advocates the use of infrastructure investments to direct growth in ways that will protect and improve the quality of life. It advocates a number of policies to coordinate land use, transportation, and other public facility planning to promote "more desirable" development patterns. Particular emphasis is placed on the use of multimodal transportation investments to promote compact, high-density development.

Multimodal transportation investments that cross multiple jurisdictions and integrate with effective land use controls are difficult to plan and harder to implement. FDOT is in a unique position to resolve the ensuing interjurisdictional and operational problems by exercising leadership, providing effective communication between jurisdictions, and developing workable solutions (political, financial, and technical).

Transportation planning is based on the relative transportation needs of current and projected land use patterns. In the future, transportation planning must also examine permitted and desirable future land use patterns, supporting implementing practices and procedures, and their effects on land use and transportation alternatives.

Suddenly everything gets very complicated. The major thrust of this "new approach" is that planning and implementation (or management) must be considered together and in an interjurisdictional and interdisciplinary environment. To be effective in such a complicated world requires good communication and tightly coordinated decision making. FDOT has set a strong course of direction in the Strategic Transportation Plan and through aggressive implementation of its goals and aims.

Transportation investment decisions will see some radical changes in criteria used to judge "sound investments." Projects will be chosen, at least partially, on the basis of their contribution to nontransportation, "quality-of-life" goals. Economic "feasibility" will include projected impacts of the transportation project on future land use patterns. Evaluation frequently will cross jurisdictional boundaries, leading to regional rather than local decisions. Ordinances, statutes, interlocal agreements and public-private contracts supporting the transportation investment will be essential criteria in every project. System management will be as important as system construction.

The ultimate questions remain unanswered. Can public investment policy significantly alter individual preferences for "inefficient" life-styles and transportation alternatives? Are sufficient incentives available to the public decision maker to bring about these changes without resorting to coercive methods? In a free society is it even proper for public officials to make such value judgments about private choices? This apparent conflict between individual preferences and the ultimate "social good" is the very heart of the growth management challenge. Public acceptance will be the key to the eventual success or failure of these efforts in Florida.

If Florida fails to effectively "manage" its explosive growth, the result will almost certainly be a continuing, possibly precipitous, decline in the general quality of life until Florida's life-style is no longer enviable and the incentive for growth is gone. The near inevitability of this projection causes the growth management initiatives now under way or under consideration to seem at once less onerous and more urgent.

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Respondents' Comments

Lester P. Lamm If transportation as a whole is ever going to get the necessary level of attention among competing priorities on the public agenda that it deserves, and thereby if transportation programs are ever going to be adequately financed, the quality of personal mobility has to continue to be of prime concern to U.S. citizens.

The research papers by Reno and McCue set the stage very well for thinking about future personal mobility. Reno assured us that with adequate attention, U.S. mobility will be better in the future than is now the case, and McCue tells how Florida has already recognized their problem and is beginning a series of state and local initiatives.

There is real reason for optimism as we look to the future. Our country has already met and overcome greater transportation challenges than we have before us now. Could anyone picture 35 years ago how our country could have accommodated more than a threefold highway traffic increase in 30 years and actually increased personal mobility? It is defeatist to think that some of the alternatives for taking care of problems are going to cause more problems.

I get very impatient with the statement that added capacity is going to bring more congestion. Does anybody think the $125 billion investment in the Interstate highway system would have been better public policy if those routes looked all week long the way they do at 6:00 a.m. Sunday morning?

This is Stage 2 of the 2020 process. Stage 1 began just about a year ago now with a series of public forums that have generated a lot of commentary on personal mobility. Representatives of highway users and others who you might consider on the receiving end of mobility agreed that travel is going to continue to grow. The American life-style did not develop by accident, and the next few generations seem quite comfortable with the suburban living arrangements with which they grew up.

Lester P. Lamm is President of the Highway Users Federation for Safety and Mobility. He was a career employee at the Federal Highway Administration, and served as its Executive Director from 1982 to 1986.

In effect, appointed and elected officials around the country are being challenged to do our part to make things better. Yet during the forum process, there were frequent pessimistic views of the future, or at least opinions that America in the future has to get individuals out of automobiles and freight out of trucks if there is going to be any change for the better. These comments often came from public officials who, from my way of thinking, ought to know better. Future public policy in transportation has to look more toward travel demand, that is, influencing mobility before it happens unchecked. Modifications that some of us are quite familiar with are going to have to spread much more fully around the country. For instance, promoting more efficient use of transportation facilities through HOV programs, transit improvements, flexible work hours, and so forth, has to be great public policy today and even better in the future.

At the extreme of demand management, however, I don't think our citizens will ever be ready for the really drastic changes such as congestion toll pricing or travel rationing. I think it would be a great indictment that both the transportation and energy planning processes have failed us if we are ever forced to get to these extreme measures. Does anybody really think that the country wants to limit growth to Florida or to the Southwest by doing something like rationing air conditioning? It is not going to happen through public policy, and yet we have heard that it could well happen because of environmental concerns.

Reno's look at the future began with driving-age population changes using census data. From this he concluded that today's growth in travel demand will slacken off measurably.

As our domestic population ages, and there is no doubt that it is going to, the economy will require just as many or perhaps even more person years of employment to support this aging population. In an ever more closely knit world community, doesn't a tight job market in one country cause changes in immigration policies and more immigration? If U.S. immigration barriers were lowered today, there is no doubt that there would immediately be a large population increment coming in from the rest of the world, not only the Third World countries but also a lot of industrialized nations where unemployment rates are three times ours. This was true in the last century as the United States accommodated an industrial revolution, a whole regeneration of our way of doing business, with input coming from the rest of the world. Jobs that we didn't even think of 100 years ago are today being taken care of by people who weren't in the country then.

Even given the indisputable principle of eventual saturation of vehicle ownership, as I look at trends in transportation planning, I think the most obvious is that planners have underestimated future travel demand. Obviously, we can't presume how the immigration laws are going to change or even that they are. But isn't it wrong to be thinking that there is only one alternative? I really believe that in our planning for 2020, we ought to have some sort of sensitivity analysis of what's happening to the U.S. population with travel demand, or at least set up alternative scenarios of what challenges we and the transportation planners that come later will face.

In any event, all of us have to agree with Reno's conclusion that this is a critical time for decisions that will affect future personal mobility. It is up to our generation of transportation professionals to make our decisions and make them in a timely manner, and with an assumption that our decisions very well are going to aid the nation's future economic health. Just as we today can't imagine an America without the Interstate highway system, do you want to look ahead and try to visualize the United States in 2020 if the only thing we have done in our generation is to close the remaining Interstate gaps?

ARTHUR B. SOSSLAU Reno's paper and his reference to Federal Highway Administration (FHWA) Working Paper 2 indicate the wide range in forecasts, depending on the assumptions made. Reno predicts the growth in vehicle miles of travel (VMT) to 2020 on the basis of the growth in driving-age population, vehicles per person of driving age, and annual miles as a function of income. He predicts a growth range of 1.3 to 1.7 percent a year. FHWA makes a medium estimate of growth at 2.4 percent per year to the year 2005 and about 1.8 percent per year from then to 2020. Their prediction is based on population by age and sex, licensed drivers per population, and VMT per driver.

It is interesting that although the variables used were very similar, the estimates result in a 50 percent increase according to Reno and over a 100 percent increase according to FHWA. My question is, Why is there such a difference and have you been able to test these methods to predict from the past to now? I think the data are there to do this.

I would like to take a look at VMT changes and system changes over the last 32 years, which is the same span of time between now and 2020. VMT grew from 560 billion to over 1.7 trillion vehicle-mi in the last 32 years. This growth rate averaged about 3.5 percent per year. If you think that VMT growth is slowing down, you have to consider that from April 1987 to April

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Arthur B. Sosslau is Vice President of COMSIS Research Corporation, with which he has been affiliated for 19 years. His previous positions include highway engineer with the Bureau of Public Roads, Chief of the Travel Demand Unit at the Tri-State Transportation Commission, and Manager of Applications for the IBM Service Bureau Corporation.

1988, the growth was still 3.6 percent. In the past 32 years, federal-aid system mileage grew from 726,000 to 847,000 mi, which was an addition of 121,000 on that system. The primary-system portion, including the Interstates, grew from 234,000 to 303,000 mi, a net addition of almost 70,000 mi.

If we use Reno's high estimate of 1.7 percent, VMT will grow about 70 percent in the next 32 years, from 1.7 trillion to 2.9 trillion vehicle-mi, a growth of over 1.1 trillion vehicle-mi. Although this is based on a rather low estimate of growth compared with the past, the absolute increase in VMT is about equal to the growth in VMT over the last 32 years. As has been mentioned a few times during this conference, looking at percentages can sometimes be misleading.

If we use the FHWA medium estimate, VMT will about double by 2020, and this is about a 25 percent larger growth in VMT than occurred in the last 32 years. So, you might ask, do we have to build as much capacity in the federal-aid system in the next 32 years as we did in the past, including something like an Interstate system?

Another factor that we might want to consider relative to VMT growth is the deterioration of system performance from the standpoint that it takes a lot less increase in VMT to change the level of service from C to D or D to E than it does to go from A to C. If we are already at a marginal level of service, the amount of VMT growth that makes things deteriorate a lot quicker is lower than it has been. We need to assess the effects of growth in these kinds of terms.

With regard to saturation levels for vehicles per adult, Reno postulates that saturation will occur at a ratio of about 0.95 to 1.09, maybe as high as 1.15. The ratio was 0.81 in 1980 and 0.86 in 1987. In 1980 the number of vehicles per household averaged about 1.6 across the country, and this resulted from about 13 percent of households with no vehicles, about one-third with one vehicle, one-third with two vehicles, and almost 20 percent of the households with three or more.

One should take a look at specific areas, because these variables are quite different by area around the country. In Simi Valley, which is in a county in Southern California, vehicles per household averaged 2.3 in 1980 as compared with the 1.6 across the country. Twenty-six percent of these households had three or more vehicles as compared with about 19 percent across the country.

If all of the United States were like Simi Valley, there would have been about 25 percent more vehicles in 1980. Simi Valley is an extreme, but Salt Lake City had 1.9 vehicles per household and 26 percent of the households with three or more vehicles.

Another interesting observation from the Nationwide Personal Transportation Study is that at a constant $30,000-per-year income, the number of households with three or more cars grew from 12 to 28 percent between 1977 and 1983. This happened in spite of the trend to smaller family size. So with higher incomes, the number of cars seems to be growing quite rapidly.

We all recognize that we need to make national forecasts; however, we also need to recognize that regions of the country—specific states, specific urban areas and so on—will grow significantly faster than others. FHWA estimates VMT to grow by about 50 percent by the year 2005, which is an annual growth rate of 2.4 percent. They predict that six states will grow by more than 3 percent per year, which averages to about 80 percent growth.

There has been and probably will continue to be significant growth and increasing congestion in suburban areas as indicated in a recent report, *Commuting in America*. Economic and demographic changes have turned up unexpectedly in the past, which has resulted in growth far greater than expected. In the last decade, commuting had an unexpected growth due to explosive growth in employment, especially women entering the work force. There has been a large increase in the purchase of vacation homes and the taking of more frequent but shorter vacations. If you look at the data, only 1 percent of all trips is over 60 mi, but that represents 17 percent of all travel. Imagine if that 1 percent went to 2 percent.

We tend to miss changes over time, but we need to look for them continuously. Over the years transportation planning has looked for limits on travel growth, and I believe our forecasts have tended to be on the low side. For example, take the number of vehicles. The first concern with saturation was in 1929 with the belief that the number of automobiles would not exceed the number of families, and now it is the number of vehicles per adult. We seem to believe that it is a lot safer and more prudent to be wrong on the low side ofour forecasts than to be wrong by being on the high side.

Obviously, we want to be right, but we look at the limits rather than the possible growth factors. The worst that can happen is that the forecast on the high side won't come true for an extra couple of years. If, for example, we consider Reno's 1.3 to 1.7 percent growth range, use of the high-value forecast for the period of 32 years when the low value actually occurs will require an additional 8 years to reach the forecast level.

PAUL N. BAY Several people have talked about the problem with using averages, and Lamm commented on the quality rather than the quantity of personal mobility. When you think about it, the very term "national averages" for personal mobility is a contradiction in terms. Personal mobility is just that, and there is a huge difference between averages and what happens to the individual. People may be traveling more but they are enjoying it less. Talk to any young mother who spends a great deal of her day chauffeuring kids around; the kids can't go down to the corner grocery store these days, because the corner grocery store is now a supermarket that is 2 mi away, and crossing busy streets on the bike won't work and so automobile travel is required. Take the young professional woman who takes transit from a park-and-ride lot to her job downtown but has to drop the baby off for child care first and worry about all the other things like picking up the cleaning and the laundry and stopping at the grocery store on the way home. She may have a car available, so transportation may be there, but I assure you, she is enjoying it less. Take my next-door neighbor, who recently swore that he would not buy a third car. Then after several nights of picking up his daughter at her job with Burger King at 1:00 a.m., he got a third car after all.

The fact is that in every poll taken in major cities around the country, transportation is very high on the list of problems people are concerned about, right up there with crime and taxes. Personal mobility is a big problem, and even if the numbers are indicative of the fact that we have to aggressively do things, we still have to deal with quality. I do not think that we have dealt with quality enough.

If there are problems in the suburbs, they are even more severe in the central cities. In Houston, where a large part of the population is Hispanic, there are neighborhoods that are largely Mexican or Salvadoran or Nicaraguan immigrants, many of whom do not read at all, even in Spanish, and are restricted to what is available by bus in terms of the job market.

You look at black teenagers with their huge unemployment rate and the fact that the jobs that are available to them are primarily out in the service industry in the suburbs. Did you know that the fast food industry has an annual turnover in employment of greater than 1000 percent? The jobs are there in the suburbs, but the black teenagers are not in the suburbs; they are in the central cities and how do you get them to the suburbs?

Personal mobility affects the future of a very large component of our population—the elderly. It has been commented that the population is aging.

Paul N. Bay is Assistant General Manager of Houston Metro. His past positions include city traffic engineer, San Mateo, California; Deputy Executive Director, Metropolitan Transportation Commission, Berkeley, California; and Executive Director, Division of Planning and Development, Tri-Met, Portland, Oregon.

The elderly have more and more difficulty driving or getting around. Where do they go? Where do they live? What are the mobility options available to them?

Again, in dealing with personal mobility we cannot just deal with quantity; we must deal with quality. We cannot just deal with national averages; we have to talk about specific segments of the market, specific components. There are things that transit can do better than anyone else, and there are things that transit shouldn't even try to deal with. There are things that the automobile, itself, will have to do in the future. But even there, we can do a better job that will involve managing growth and development, as Florida is trying to do.

We have to look at not only how much we pay and how we pay for our transportation, but what we pay in other than dollars in impact upon our lives and the way we work.

AVERY UPCHURCH The real basic issues in any community—whether you are a leader of a nation, a state, a city, a town, or a community—are education, transportation, and water. Just think, education, transportation, and water, and all three work together. Once you have those in place, the rest of the issues fall in place: quality of life, parks and recreation, economic development, and so on.

I listened to the Florida story and was very interested. There is one thing that I will assure you; you cannot build a 16-lane highway that is pleasing to the eye. I could turn to those in Florida and say, Why did it take you so long to do what you are doing? But at least they are doing something. We are trying to do something back in North Carolina that parallels this to some degree.

I agree that we do not need nor should we have to mandate driving habits, driving hours, and number of cars, but we are certainly headed there unless someone does something. Now, who is going to do something? It gets back to the elected official who has guts. He must have guts to the extent that there is credibility and perseverance. When I became mayor 4 years ago, we had no transportation program in a city that was reaching 200,000 people. We do have under way a program to build roads with threatening lawsuits and one lawsuit pending. I go to neighborhoods, and when I leave, we are friends and they understand why I am building roads because I tell them if we don't build the

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Avery Upchurch is Mayor of the City of Raleigh, North Carolina. He is currently President of the North Carolina League of Cities, Chairman of Triangle Regional Commission, and a Board Member of the National Association of Regional Councils. He is also currently serving on a 15-member Panel on North Carolina State Needs.

roads, we are going to limit the times that they can drive or we are going to refuse to let them drive. Then they understand.

It is going to take some people to tell the people why you must do it. The greatest thing that could happen in this nation today is to take the information we have heard here and then initiate a public works program like we have never seen before. Roads make money; they do not cost. This is a great conference if you are going to compare notes and plan. But when you leave here, some elected official—all the way from the county commissioner or city councillor, or mayor, or the President of the United States—must step out and accept the responsibility to say, this is the backbone of our nation—How do you get to grandmother's house? How do you get to jobs? How do you get to Florida? We need that opportunity to move around.

You must think about road building very seriously. You must protect the environment, protect our resources. You must find a way to make sure that the road is beautiful. I am trying to be very blunt and to the point in what we are faced with. We are faced with a decision. We are faced with the basics. We face this in every community in this nation because I have listened and I have observed.

The nation, as I say, revolves around mobility. If we cannot answer the need in this nation when the economy is good, how can we answer it any other time or when the economy is bad? Let's put into the reports and the solutions that someone must do something. We must have planners; we thank them for the information, but on the other side, someone needs to move forward and make sure that implementation takes place.

SESSION 7

New Technology and Communications

Advanced Technologies: Vehicle and Automobile Guidance

PETER G. KOLTNOW

IN THE RACE TO meet the highway needs of the future, there is a technological horse that keeps coming in last. But it keeps being entered, and it keeps coming in. The latest hot news is that it has moved from last to next-to-last, beating out congestion pricing as a technique to overcome urban congestion and accident problems. For those who have viewed congestion pricing as a way to improve mobility by taking the wheels off the wagon, this is good news indeed. The horse travels under the name Automatic Vehicle Control (AVC) and represents the culmination of long and noble technological bloodlines (*1*, *2*).

At one time the possibility of AVC—a condition under which the motor vehicle driver is essentially a passenger with voting rights—was attractive simply because the idea represented a luxurious state of advanced automotive technology. Today AVC is getting a close, hard look as a feasible long-term tool to meet a variety of transportation objectives. As the cost of congestion and accidents goes up, complex and expensive countermeasures become more realistic.

AVC has a number of potential operational benefits. They include

- Elimination of congestion on guideways,
- Improved trip-time predictability,

Peter G. Koltnow is a consulting engineer and Counselor to the President of the American Trucking Associations. Before his current position, he was President of the Highway Users Federation for Safety and Mobility. He has been active in TRB in many capacities, having served as Chairman of the Executive Committee in 1979.

- Increased vehicle capacity at lower cost than conventional freeways carrying manually operated vehicles,
- Elimination of traffic disruption from off-road incidents,
- Reduction in right-of-way requirements for new facilities, and
- Reduction of accidents stemming from driver error or impairment.

The basic approach of AVC is to replace a number of driver functions with sophisticated monitoring and control devices. Vehicle control is complex because the driving job is complex, including observations of the surrounding highway environment, operation of a vehicle's control system, adjustments to changing situations, and decisions about the path ahead.

At its most basic level, AVC can provide drivers with information and warnings generated by on-board equipment. It can also help driver control by adapting control functions automatically to outside conditions. It can intervene in vehicle control and ultimately take over the entire driving task.

Recent studies of AVC have looked at the technology, applicability, and institutional difficulties of automatic highways and what is called in Europe "automatic chauffeuring." Because of the costs involved, the primary application of AVC is seen in meeting the daunting increase in urban traffic congestion. The Federal Highway Administration has identified a growing number of so-called operational gaps in the urban Interstate highway system that are due to severe congestion, which is increasing at an alarming rate.

Traffic growth on urban freeways nationwide is growing from 6 to 7 percent a year. Motorist delay is growing even faster. Annual vehicle hours of delay are increasing by at least two to four times annual traffic growth. Annual congestion delay increases of 27 percent have been reported. About 40 percent of urban congestion is chronic and the other 60 percent is incident related. AVC is seen as affecting congestion in two ways: by providing increased capacity at a high level of service and reasonable cost and by reducing the likelihood of traffic incidents created by driver error.

Some federal observers believe that the urban congestion problem is essentially out of control in the 10 urban areas that have more than 2 million population; in these areas more than half the freeways, expressways, and arterials experience peak-hour congestion. By the year 2020 there are expected to be 21 areas of this size, subject to the same problems unless corrective action is taken.

AVC is seen as the evolutionary introduction of existing components. In the case of automatic chauffeuring, in which the system would operate on conventional roads along with unequipped vehicles, there is a set of required system characteristics, as follows:

- Capability to locate other objects, pedestrians, and vehicles;

- Responsiveness to the road geometry and traffic controls;
- Determination of distances to objects and relative speeds;
- Measurement of environmental conditions that affect vehicle control;
- Automatic steering, braking, and acceleration; and
- Utilization of route guidance and speed commands.

Automatic chauffeuring has received less attention in the United States than in Europe, perhaps because AVC here is seen as a powerful tool for adding high-speed capacity and a substitute guideway for some freeways.

Automatic highway systems, currently of the greatest interest in the United States, will rely on the integrated application of some technologies already in use, such as antilock braking systems, speed control systems, and some technologies undergoing intensive development, such as radar braking, automatic headway control, variable speed control, and automatic steering control.

AVC is considered by many to be the one opportunity to apply technology breakthroughs to growing traffic difficulties. There are various concepts for automatic highways. Some are based on palletizing, which is akin to a train on which captive vehicles are transported. The concept receiving the greatest attention from FHWA and others in the United States is a dual-mode system in which vehicles are individual, privately owned, specially equipped, and operable under automatic control on special guideways and under manual control on conventional roads. The strategy is to equip vehicles with as much control system as possible, simplifying the guideway system itself.

An automatic vehicle under this scheme would be operated manually by a driver until it reached a guideway entrance. Because automated highways imply an essentially fail-safe system, a quick electronic check would be carried out at the entry assembly point to ensure that the vehicle control systems are in full working order. The vehicle would transition to full automatic control and be merged into the guideway traffic stream.

It is said by many who are active in the AVC field that the technology is already available. It would be more accurate to say that examples of the required technology are in existence, but require extensive and expensive development and testing. Antilock braking systems and speed control, such as cruise control and governors, are in common operation. Further improvements are possible, but the devices are in accepted use in many places. All the other subsystems must undergo considerable improvement to provide the kind of reliability that automatic operation implies.

The objective of automatic braking, speed control, and steering is to permit a vehicle's lateral and longitudinal position to be under control at all times. The portions of the control system that are part of a guideway would be devices in guardrails or pavement that could be read by on-board sensors to guide lateral placement and passive or active road-mounted benchmarks to be sensed by a vehicle and compared with desired positioning by a signal transmitted to a control center.

In one form or another all the required technologies have had some real-world application. Radar braking is the subject of an upcoming California test. Radar control is certainly not unknown in military applications. A visit to a modern manufacturing plant will demonstrate automatic operation of forklifts that unload boxcars, route themselves and their cargos to desired destinations following electric guide paths, and then return to waiting bays. In a number of modern office buildings, rolling robots are used to distribute mail. A major automatic highway system project involving highway electrification is getting under way in Santa Barbara, California, using electric buses. Automatic steering has also been demonstrated in transit operations in West Germany and Australia.

Proponents of an aggressive program to develop automatic highways point to substantial capacity gains and improved levels of service as the chief justification. Safety benefits and lower right-of-way costs are also quoted. Studies carried out for FHWA indicate that although cost per lane mile for an urban automatic highway would be about one-third again as expensive as a conventional freeway, on an equivalent level-of-service basis the electronic guideway would be about 20 percent cheaper. Financial and social-psychological costs of equipping the vehicles themselves would be tempered if the components were introduced gradually as part of driver-aid efforts that would evolve over time. Whereas motorist information systems, autonomous navigation, and automatic vehicle location systems are considered likely to be in use within this century, automatic highways are not expected to appear until about the second quarter of the 21st century.

If current thinking holds sway, the first stage of deployment would probably involve automatically controlled buses in physically separated high-occupancy-vehicle facilities. Gradually greater automation of the facility would be developed, with manually operated private vehicles being replaced by automated private cars.

There is currently some difference of opinion about whether facilities should be fully automated on routes feeding central business districts or fast-growing traffic corridors farther from city centers. Given the early stage of AVC development, such decisions need not be nailed down for some time.

An early-generation automatic highway system based on automobiles only is estimated to have an operational capacity of 2,400 vehicles per lane per hour while maintaining a 25-mph advantage over conventional freeway operation at near-capacity conditions. This compares with a conventional freeway lane capacity of about 2,000 vehicles under good conditions. Future generations of automatic highways might be able to achieve capacities of 3,600 vehicles per hour (1-sec headways) at 60 mph. Such statistics should perhaps be considered desirable objectives rather than planned service standards.

Most of those who have given some thought to automatic highways come back to the position that the impediments to their development and use are more institutional than technological. A highway-vehicle system in which both public and private agencies share in moment-to-moment vehicle control conjures up interesting possibilities of liability and operational responsibility. Perhaps experience from other modes, such as air transportation, will provide some clues as to how responsibility is shared.

It is also the case that there is no focus yet for national agreement, even among technicians, on a schedule or plan for technological development. The Transportation Research Board is proposing that just such an effort be made to develop a basic scheme for the introduction of advanced technology, including automatic highways; for a body of research to permit evolution of advanced technology; for a program of analysis of the public policy issues involved in a new relationship between vehicles and highways; and for an independent review of the usefulness of advanced technology.

In addition to the institutional impediments that one can imagine, there is also a fair degree of inertia to overcome. Some observers of the current push to develop "smart" cars and highways believe that the underlying technology is a case of a solution in search of a problem. Until the problems themselves are better defined and the other alternatives evaluated, a real commitment to the use of the most modern technology for highway operations is likely to move forward only in fits and starts.

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Technology and the Future of Transportation: An Industrial View

ALBERT J. SOBEY

A COMPLEX QUESTION IS addressed here, one that is increasingly important for both the private and public sectors of the transportation community. In the past, new engineers and planners have been challenged to approach their responsibilities in innovative ways and to recognize that significant improvements in transportation systems will require the cooperation of all parties. This same goal applies today; the United States cannot afford to be trapped into a simple extrapolation of how things were done yesterday. This paper addresses the evolution of transportation; how technology will change what is moved, and how; how personal transportation needs may change; advances in transportation technology; where the energy will come from; and what is required to make the technology available.

Whether these new technical concepts will be implemented or not will depend on technical progress, the support of the transportation community, and the U.S. economic and business environment. For those who would like to pursue these questions in more depth, a complementary report is being reviewed for publication by the Eno Foundation.

Albert J. Sobey is currently President of his own consulting firm, Gemino Services, having recently retired from General Motors where he spent the majority of his career. His most recent position with GM was Senior Director, Energy/Advanced Products Economics.

Evolution of Transportation

This meeting on how transportation may evolve toward the year 2020 and the role of technology in that process is very timely. America has just entered what may be thought of as the fourth recent technologically driven revolution.

The First: the use of artificial energy to produce more (lower-cost) goods than was possible with human labor.
The Second: the use of mechanical transportation to move people and goods rapidly within and between cities and countries.
The Third: the use of the telephone and radio to link people (nearly instantaneously) across distances.
The Fourth: the use of computers to increase the ability to evaluate, regulate, and control processes and to reduce the need for human intervention.

Although the roots of the first technical revolution can be traced back to the discovery of fire and agriculture, there was little incentive to use power or mechanical devices as long as human labor and life were cheap. There have been other revolutions—in farming, in health and housing, in finance, and in government. Each of these could build on the increases in wealth, available time, or knowledge made possible by the earlier technical developments. A key was the acceptance of the idea that research and innovation could be beneficial to society. After that the technical revolution proceeded rapidly, from the invention of the steam engine to electrical devices to the silicon chip (*1*, *2*).

It is less than 35 years to the year 2020, and probably there will be capabilities by then that have only been hinted at. At the start of this century, few of the improvements that were to occur in the use of power, in transportation, and in communications were foreseen. Thirty-five years ago there was only a handful of digital computers. The 20th Century Limited and the Super Chief were still profitable passenger trains. There were no commercial turbine aircraft. Much of what is now urbanized was still farmland.

Most transportation technologies appear mature. The concept of railroad trains with flanged-wheel cars pulled by a locomotive is about 150 years old. The concept of the automobile, a road vehicle with four wheels, compliant tires, seats for two to six people, and propelled by an internal combustion engine, is 100 years old. Today the computer-control revolution is just beginning. Its ultimate impact on life and movement can only be guessed at.

Engineers have a reputation for underestimating how long it will take to do the things that they know how to do and overestimating how long it will take new technologies to mature and become available to the public. This conservative view of the future probably applies to other decision makers as well.

In looking forward to the year 2020 two time frames must be considered: what has to be done in the near future and what may be possible tomorrow. Near-term problems must be solved without building barriers to future beneficial innovations.

There has been a trend toward selection of technology that will provide specialized or individual services, for example,

1. The movement of goods has shifted from use of wagons and boats to railroads and to trucks or aircraft in 150 years, reducing both time and cost.
2. The journey to work has changed from walking to mass transit and to the personal car in less than 70 years as the service improved and real costs decreased.
3. Engineers have progressed from using slide rules to mainframe computers and to personal computers in less than 25 years as PCs became easier to use and the cost per computation decreased.

Transportation is seldom an end in itself; it is a service. Its future will be influenced by both technical and economic developments. In order to identify some future opportunities for improvements in transportation, there must be understanding of how new technology and economic and social developments will change where and how people and goods will be moved.

The movement of goods must be understood before the needs for the movement of people can be projected. Cities need an economic reason to exist and cities are where people find jobs. The growth (and decay) of cities will depend on the health of their businesses and industry. The changes in where the jobs are may be as important as how cars, trucks and roads are improved.

Reasons for the recent increase in international freight are known to all, such as the low cost of labor in newly industrialized nations and the inflated value of the dollar. There were technical factors also. Did the commercialization of the container ship make it significantly less costly for other nations to enter the U.S. markets?

The recent trends in international trade as a share of economic activity are nearly flat. Some think that trade could even decrease (in relative terms) after 2020 if the comparative advantage of some nations is leveled off by the spread of technology.

Technical progress will lead to major changes in the requirements for transportation of U.S. commodities, in particular grain and minerals. Not long ago, U.S. farmers not only fed the United States but also a large portion of the world. Many traditional food-importing nations—India, for example—have become self-sufficient. Developments in biotechnology should increase crop yields and reduce the requirements for fertilizers and pesticides. New types of food may appear, but there may be less shipment of perishables, even in the

United States, as farmers learn how to produce most kinds of foods in all parts of the nation (and the world).

U.S. consumer goods (televisions, videocassette recorders, microwave ovens, home computers) provide new services. The advances in manufacturing processes will make these goods available to the general public at lower real prices. Computer-controlled machines have been available for decades, but underused. The development of computer design and information systems will make it possible to produce a much greater variety of products. In principle, it will be possible to tailor each product or service to the customers.

Industry has had trouble in getting up to speed with the new manufacturing technologies. Some of the problems are due to underestimation of the potential of these new technologies. The most serious problem, however, may be the lack of experienced personnel who can make effective use of these technologies. U.S. industry faces a serious training problem. Many workers did not finish high school. There was little incentive to do so because they could make more as hourly workers in a factory than many college graduates. These employees must be retrained so they can operate these new machines if there is to be effective competition. Although this problem is serious in the automobile industry, it applies to much of U.S. industry as well.

The U.S. automobile industry is undergoing major changes as a result of foreign competition. The public perception of this industry is that it consists of General Motors, Ford, Chrysler and a few major suppliers, such as Rockwell and TRW. But to a surprising extent, the automobile industry is already made up of small companies. A study by the state of Michigan found that about half of the value added by the automobile industry in Michigan is produced by the more than 8,000 supplier companies with less than 250 employees each. More than 90 percent of the total jobs in the state are in companies with fewer than 250 employees (*3*).

On a national level, most of the new jobs have been in small companies. The Fortune 500 companies have lost jobs and probably will continue to do so. They must reduce both direct and indirect costs to meet international competition. The computer-control revolution will make it possible to reduce employment in U.S. manufacturing significantly.

Manufacturing facilities will be much smaller. Economies of scale in manufacturing are decreasing. Some industrial psychologists believe that the ideal size for an organization is between 200 and 400 employees. Many successful new companies appear to confirm this.

One result of the improvements in manufacturing processes and transportation is that industry, commodity producers, and manufacturing no longer need large-scale integrated facilities. In the future it will be possible to locate factories anywhere, even in places that are not yet cities. The point is approaching when big cities will no longer be needed to support big industries.

Most new plants and warehouses have been built in industrial parks, sometimes called research centers. Probably the majority of these do not have railroad access. The way freight is moved and the type of equipment used—that is, the freight transportation technology—are adapting to these changes.

The quantity of freight moved may not change much except to become more time sensitive. Deliveries will be made "just in time," to reduce inventory costs, cut waste, and make it possible to deliver the new products to the customers in a timely manner.

FREIGHT TRANSPORTATION TECHNOLOGY

There have been improvements in the technology of freight transportation, but the most significant changes, from the standpoint of service cost and efficiency, have been those made possible by the deregulation of the industry.

For truckers, deregulation reduced the cost of entry (formation of new truck lines) and eliminated the need for circuitous routing to comply with regulations. Equally important, truckers are now allowed to compete for loads to fill empty backhauls. The regulatory changes included increasing the allowable length of trailers and legalizing "double bottoms" (a combination truck with two trailers) on some routes. It will probably be possible to develop safe and stable triple bottoms, but they are unlikely to be widely accepted, unless benefits of using them can be demonstrated to the driving public.

Deregulation has not been as beneficial for the railroads, but consolidations and changes such as those that permitted long-term contracts have helped them remain competitive. Unfortunately, the railroads have a reputation for poor service and high variability of delivery time. Many shippers will pay truckers 25 to 50 percent more for what appears to be the same service as that the railroads provide because trucks usually deliver on time.

Boxcar service has been decreasing steadily. General Motors, as the largest user of boxcars, began to wonder if it could be the only user. Piggyback, or trailer-on-flatcar (TOFC), service grew at the rate of 14 percent a year in the 1970s and early 1980s, but has leveled off in the last few years. GM looked for other approaches and, in cooperation with several railroads (in particular the Burlington Northern), was able to demonstrate the benefits of Road-Railers, an adaptation of old technology. RoadRailers, sometimes called "carless piggyback," consist of semitrailers with two sets of running gear, steel wheels for operation in trains, and rubber tires for operation over the road to plants and warehouses (Figure 1). The slackless coupling all but eliminates

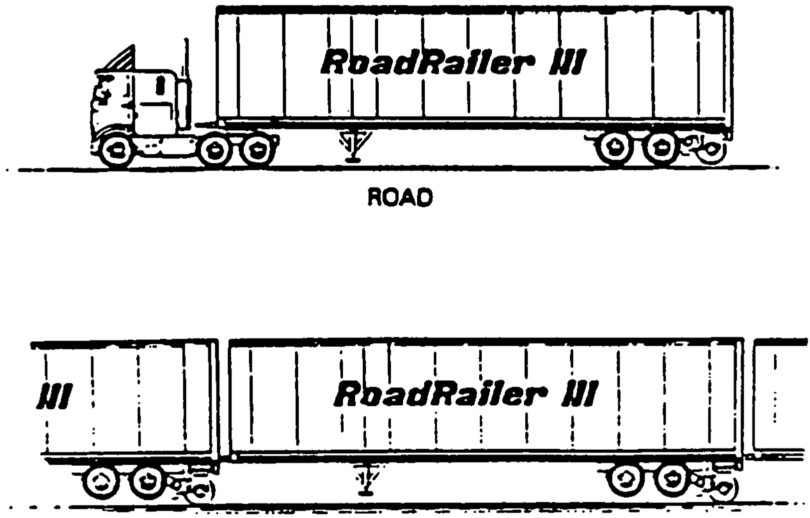

FIGURE 1 New approach in freight transportation, the RoadRailer.

buffing (load caused by starting or stopping of a train) so the RoadRailers are only slightly heavier than comparable highway trailers.

The light weight and low drag of RoadRailers provide exceptional performance. After a demonstration run from Chicago to GM's Van Nuys plant in California, in which the time nearly equaled the old passenger train times, the fuel economy approached 26 trailer miles per gallon of fuel. This is only one-fifth of what a truck would require. Their stability and air suspension provide a very smooth ride. The cargo will need less bracing (cans of water have remained full on trips from Detroit to St. Louis). RoadRailers can operate at much higher speeds than those of conventional rail freight equipment, limited primarily by the locomotive power, wheel track dynamics, and train scheduling.

This concept has the potential to nearly double the movement of time-sensitive goods by rail. This would be the equivalent of attracting nearly 20 percent of the long-distance (over 250 mi) intercity shipments back to rail. Also, RoadRailers should divert some heavy loads from the highways and thus reduce road and bridge damage. They could justify another look at some branch lines. Large cities could provide dedicated freight access for RoadRailers over otherwise underused rail rights-of-way, thus reducing traffic congestion. In any case these rights-of-way, many of which are being abandoned, are irreplaceable resources and should be preserved.

Other technologies that promise to improve the competitive performance of railroads significantly include logistics and train scheduling and operating control systems. Although not as dramatic as new rolling stock, logistics and train dispatching and management systems could reduce trip duration by several days by decreasing (and ultimately eliminating) missed connections. The reduction in shipment time may attract nearly as many time-sensitive shipments to rail as would the RoadRailer or its analogs. These systems will use already demonstrated technologies.

Air freight is frequently overlooked because the tonnage is small. Potential advances in technology and equipment could make air freight the largest revenue-generating freight service. Pipelines now move the majority of liquid and gaseous fuels and some solids. Coal pipelines require near-constant loads (averaging 70 to 80 percent of capacity) to be competitive with coal, but they are less expensive to build and additional coal pipelines may be constructed when the coal-hauling railroads approach physical (or acceptable) capacity.

It should be pointed out that not all new technologies find a market, even if they promise significant cost and performance advantages. For example, the market for surface-effect ships has not materialized. These ships were designed to take advantage of the lift available from forward motion close to the water and were expected to find a place between displacement ships and air freight because of their significantly higher speeds (60 to 80 knots).

MOVEMENT OF PEOPLE

Modern cities were made possible by the transportation revolution. First came the horsecar, then the streetcar, and more recently the personal car and the expressway. These innovations made it possible for people to separate their living and working environments and for them to reach an increasing number of opportunities—jobs, friends, stores, and so on. As Mel Webber pointed out a decade ago, an automobile user can reach more than 30 times as many jobs, stores, or friends (in an acceptable time) as could our great-grandfathers, who had to walk or depend on animal transport. Automobile drivers can get to nearly four times as many destinations in an acceptable time as can those who must use public transit.

The needs and objectives of personal transportation are different from those for freight; comfort and time are even more important. Personal transportation will benefit from new technology also, within some socioeconomic constraints; for example, most people have two budgets for their personal transportation: financial—families spend a relatively fixed share of their disposable income on transportation—and time—people spend a relatively constant portion of their time in travel.

In the United States the first transportation budget (financial) averages 12 to 14 percent of disposable family income. Most is spent on purchasing and using automobiles (gasoline, insurance, etc). Travel time, the second budget, averages from 60 to 80 min a day. Although there are extreme personal variations, this relationship is remarkably consistent in industrialized nations. Travel in developing nations takes slightly longer (*4, 5*).

In the United States between 40 and 50 percent of personal travel is for work-related purposes. This percentage decreases with increasing family income. Other purposes, including trips to stores, church, doctors, and so on, account for about one-third of urban travel. Pleasure and intercity travel make up the remainder. Total personal travel is a function of demographic trends, size of families, and the number of two-worker households. Many studies indicate that the demand for personal travel becomes saturated as family income increases above the median level.

Work travel patterns will change significantly as commercial and industrial facilities become smaller and more widely distributed, but total travel time will probably remain constant. There may be fewer large business centers. The head offices may remain in New York City or other financial centers, but the regional offices may be thousands of miles away, even in other nations. Effective communications systems will make it possible to locate more, smaller offices where they are accessible to the most customers (and employees) (*6, 7*).

Since the 1950s there has been a major change in how people shop. In the 1960s and 1970s, the central business districts were challenged by the shopping centers. In the next step, the shopping centers may be challenged by electronic merchandising. What form this will take is not yet clear. One way may be for neighborhood electronic stores to provide a full line of merchandise. The customer could go into a booth, select a suit or dress, see on the full-size screen how he or she would look in it, review a number of colors and options, make a choice, and place the order. The measurements will be taken unobtrusively in the booth. The goods will not be produced until they have been ordered. There will be less warehousing, but probably more home delivery (*8*).

Why could one not use a home computer, telephone, and television in the same way? One probably will, for staples and standard items, but the neighborhood merchant would display more options. Equally important, shopping will remain a social experience. The neighborhood store would become the neighborhood center. In addition to selling goods, it could serve beer and pretzels or wine and croissants, depending on the neighborhood. Recreation facilities might be provided as well. Ideally these store-centers would be located within walking distance of the customers. This may provide an incentive for some cities to rethink their zoning rules.

Personal Transportation Concerns

The automobile has been the dominant mode of urban transportation for decades, but society faces some significant problems with this mode, for instance, traffic congestion and transportation for those unable to drive or who cannot afford automobiles.

Traffic Congestion Traffic congestion is getting the most attention. Recent studies by the Federal Highway Administration estimated that, nationwide, traffic delays will increase from about 2 billion vehicle-hr in 1985 to nearly 8 billion vehicle-hr by 2000, or nearly 10 billion person-hr if it is assumed that there are only 1.2 persons per car. This is equivalent to the economic output of nearly 5 million people (assuming a 2,000-hr work year). This would still be a small portion (approximately 10 percent) of the total time spent commuting to work. More than 80 percent of the delays are in large central cities, but the congestion problem is increasing rapidly in small cities. Even in the large metropolitan areas, congestion is growing fastest in the outlying areas (*9*).

Better solutions are needed to the congestion problem than declaring all streets one way. Some promised ones include

1. Building more expressways,
2. Increasing the use of public transit or ridesharing,
3. Encouraging telecommuting,
4. Introducing innovative vehicles that take less space, and
5. Improving traffic signal controls and route guidance.

It is also possible that the problem may be self-limiting. When their commuting time exceeds their acceptable time budget, people may change their residence or job.

Building More Expressways. Some see congestion as an automobile problem and want to restrict the use of automobiles. Although not surprising, this is a misreading of the situation; it could be described as a version of the "kill the messenger" syndrome. Traffic congestion is the messenger; the message is that there are many unfilled transportation needs.

On the other hand, building more expressways does not appear to be an acceptable solution, either economically or socially. Opposition to new construction and to the perceived destruction of neighborhoods, businesses, or scenic areas is increasing. It is doubtful that many more miles of new freeway will be built, although many will be increased in capacity or number of lanes (*11*).

Increasing Public Transit and Ridesharing. Expansion of conventional public transit would be at best a marginal solution. The modern automobile-oriented city is costly to serve by public transit—residential densities are low, distances are long, and origin-destination pairs are highly diverse. In most cities the average passenger load on a bus is only 7 to 10 people. Expanded transit service will have difficulty in maintaining that level of ridership. The problems are compounded because public transit is considered to be the service of last resort in most cities.

But there may be a more fundamental influence. Transit use appears to be inversely related to quality of life and family income. Worldwide it decreases at a rate of about 5 percent for every 10 percent increase in per-person disposable income. On the other hand, if travel appears to be faster by transit than by car, it can attract many riders even at a higher perceived cost (*11*).

Technical improvements are possible. Much transit equipment, particularly for fixed-route systems, is at best a modern version of a concept first used in the early 1900s. New rail systems can have entrances nearly at street level. Lightweight and low-profile cars should make it possible to reduce the size of new elevated structures and tunnels and thus their cost.

In the 1960s GM devised what is now called personal rapid transit (PRT). In the PRT concept each vehicle provides direct, dedicated origin-destination service for a person (or group of persons) over a complex network of guideways. The demonstrations included what would (even today) be considered advanced technology: automatic controls, air bearings, linear motors, and magnetic levitation. Although PRT systems might attract riders, the costs of the guideways are thought to be prohibitive and probably politically unacceptable at this time. There has been little incentive to develop economically competitive transit equipment, a subject that may be worth revisiting (*12*).

Car- and vanpooling grew rapidly during the periods of high energy costs (1973 and 1980), but their use has decreased in recent years. It is difficult to find compatible people with similar origins and destinations and a willingness to compromise on their convenience. On the other hand, carpooling should be encouraged as one of the few ways to withstand another oil price shock.

Encouraging Telecommuting. Working at home, or "telecommuting," is expected to increase. Many people who have studied it are only mildly optimistic. There are serious problems with supervision and communications. Even if the number of people working at home does not increase dramatically, there probably will be small office centers where people, perhaps from different departments, or even different companies, can share facilities and equipment. This should reduce the average length of trips and spread out peak-time travel. The Southern California Association of Governments estimates that these changes could reduce freeway traffic congestion as much as 10 percent (*13*).

Introducing Innovative Vehicles. The use of innovative narrow vehicles is in keeping with the needs of automobile-oriented cities. GM started to study the design of half-width vehicles (two of which could operate side by side) in the 1950s. The technical feasibility of a concept was demonstrated by 1980.

GM calls these Lean Machines. They are articulated so that the passenger section (and front wheel) leans during turns, as a motorcycle does. Lean Machines are driven by the two rear wheels, which remain in contact with the ground. They can outcorner motorcycles and most cars. The use of three wheels enables them to be stable when stopped. There may be single- and two-passenger (tandem) versions. The passenger section could look like an aircraft cockpit, an enclosed motorcycle, or a small car. Lean Machines can have amenities like those of automobiles, even air conditioning (Figure 2). The compact body could be made as safe as a small car. They can provide exceptional performance. The version on display in the GM exhibit at EPCOT, in Orlando, Florida, should achieve more than 120 mpg at 70 mph, if allowed, and still accelerate from zero to 60 mph in less than 7 sec. They will be able to respond at least as rapidly in traffic as conventional automobiles (*14*).

The cooperation of the public sector will be required to obtain the full benefit of this concept. Lean Machines should probably be introduced first in selected areas where the benefits can be demonstrated and their operation monitored. It is necessary to know the critical number of these machines that would be required before traffic managers would be interested in adapting existing streets and providing narrow, low-cost bypass lanes and additional parking spaces. Several cities have expressed an interest in conducting such studies.

Improving Traffic Signal Controls and Route Guidance. Another way of reducing congestion would be to improve traffic data and control systems. New concepts, including route guidance and synchronized traffic signal controls to direct and expedite movements through congested areas, are being developed in Europe and Japan.

Studies show that the first trip to a new destination may be 40 percent longer than necessary. Even the typical work trip may be 7 percent too long, but the route chosen may be more scenic or less congested. Route guidance systems like those manufactured by ETAK, Inc., which have a map display to show the car's location and destination, can assist in reducing traffic congestion. These systems will simplify the problems of strangers, who depend on

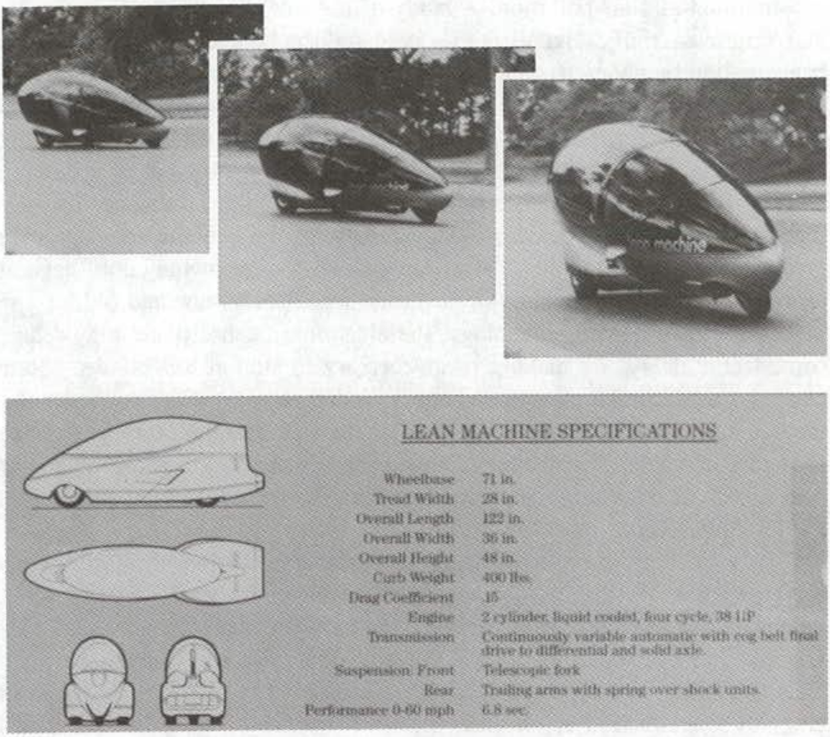

FIGURE 2 An innovative vehicle—the Lean Machine.

street signs that frequently are poorly located or vandalized. On particular expressways, there is seldom any margin for error, such as being in the wrong lane for a turn. The appropriate display methods (visual maps, symbols, or audible messages) require more analysis. Some psychologists estimate that less than half the population can read maps. A major complaint is that the most direct route is not necessarily the fastest (*15, 16*).

The only traffic status information service available to most city commuters is provided by local radio stations and traffic surveillance helicopters. It usually comes too late and is seldom sufficiently detailed to tell the driver how to avoid the problem. The car driver needs real "on time—on demand" information that will allow him to change course. Where are the accidents? How much time can be saved with an alternative route? The time to have this information is before the trip starts, when alternative routes can be selected, although the capability for midcourse correction is also important.

Traffic light synchronizing programs provide an opportunity for significant improvements in traffic flow and safety, as well as reductions in energy consumption and air pollution. A study of the Los Angeles basin estimated that improved traffic signalization could reduce both delay time and fuel consumption by about 10 percent. The benefits were approximated by use of the MOBILE 3 computer model, which indicated that by increasing the average speed from 15 to 19.6 mph, hydrocarbon emissions would be reduced 15 percent, carbon dioxide 20 percent, and NO_x by less than 5 percent. Unfortunately this model does not permit consideration of changes in delay time (stopping for lights, etc.) independently, so the benefits could be even greater. When implemented, these traffic flow improvements could have an immediate effect by reducing the trip time for all cars, new and old.

The use of a related technology, the electronic license plate, may reduce some traffic delays by making it unnecessary to stop at toll booths. (Some countries are testing these systems now.) Coded vehicles with known destinations could provide the data to reschedule traffic signal timing to meet changing demands in real time. These license plates could serve other purposes, such as recording time in parking lots. The charges could show up on the monthly Visa or other credit card bill.

The technology is available to display local information of interest to the driver, such as the speed limit and when an important traffic intersection is being approached. Concern over liability by both manufacturers and local governments makes it unlikely that this kind of service will be available soon. This capability will raise the issue of road pricing (which can be based on entry to a jurisdiction or on time of day) to reduce congestion during peak times. Effective public-private cooperation will be necessary for these services to become available to drivers. Implementing these systems will be controversial, with issues such as invasion of privacy being of increasing concern.

Implementation of improved traffic control technologies could attract some of the traffic from expressways back to the arterial streets. The problems may be more political than technical. People do not want heavy traffic going by their homes, and planners may want to encourage drivers to select other routes.

Driver augmentation systems can be developed incrementally, including collision avoidance, night vision, lane following, even adaptive speed controls, which change the setting of the cruise control with the local environment, weather, and posted speed. These systems can be implemented with little or no active involvement with the road. After enough confidence is gained in these technologies to understand their benefits and problems, it will be an easy step to automatic highways.

The following comments apply to the recent California initiative to study development of automatic highways for the United States,

1. The experiments must be well done. A serious accident will not only set the program back, it may close the doors permanently.
2. Automatic highways should not be addressed in isolation. A family of control systems should be anticipated, including driver augmentation for noncontrolled roads, traffic signal optimization, and real-time traffic data systems, all of which should be compatible.
3. Automatic controls may not permit a significant increase in lane capacity. The average driver provides less spacing between vehicles than could be used for an automatic braking system when all variables—weather, car conditions, etc.—are considered.
4. The emphasis should be on improving traffic flow and driver assistance; other attributes (if desirable) should be addressed separately. That way, if they become controversial, they will not delay progress in this vital area.

Unfortunately, liability problems may limit the adoption of some of these systems, a subject that requires additional consideration by both the private and public sectors.

Allowing Traffic Congestion To Be Self-Limiting. The last solution, allowing traffic congestion to be self-limiting, needs more study. The historic consistency of average travel times implies that there is feedback. People appear to relocate their place of living or working to keep within their travel-time budgets. How long it will take a trip maker to decide to relocate is unknown and probably subject to local variations, but between 1980 and 1984, half the people in the United States changed their place of residence. How much relocation will reduce congestion is admittedly speculative. There may be little apparent reduction if the average trip times still approximate the acceptable times, recognizing that time spent in delays is less acceptable than time spent time moving, even at slower speeds.

Service for the Transportation Disadvantaged. The second major urban transportation problem or deficiency is service for the transportation disadvantaged. This group is usually thought of as the elderly and handicapped, but a large share of the total U.S. population, about one-third of those between 20 and 65, who appear to be eligible for driver's licenses, are nondrivers. Some, although obviously not all, cannot afford automobiles. Of course, an increasing portion of the population will be elderly. In 1900 the average life expectancy was less than 50 years, by 1985 it had reached 75 years, and by 2020 it could easily be 85. Today very few over the age of 75 drive.

There may be several technical solutions to the needs of the transportation disadvantaged, depending on their ability, age, transportation objectives, and the community itself. Without going into great detail, three will be discussed:

1. Automobile controls for the handicapped,
2. Exoskeletons or servoactuated walking devices, and
3. Limited-performance neighborhood vehicles.

Automobile Controls for the Handicapped. The Japanese have a long-range goal of developing a system that will provide transportation for anyone from any place to any destination. When this goal is reached, the needs of the handicapped will be met, but this will probably be long after the year 2020. GM and other companies have developed automobile control systems that work well for some handicapped persons, but do not meet the needs of those that are not eligible for driver's licenses (the young, the infirm, or those convicted of driving while intoxicated), who depend on public transit, para-transit, or taxis. Frequently a trip will require a car and a family member as driver.

Exoskeletons or Servoactuated Walking Devices. An approach that is expected to be developed for the seriously handicapped is the exoskeleton, sometimes called the man amplifier. This will be a servo-operated, strap-on frame that enables the handicapped person to walk, climb stairs, and go anywhere a normal person would go. It eliminates the need for many of the prostheses now used to aid the handicapped. General Electric and Cornell Aero Laboratories demonstrated the concept for the military in the 1960s, but the electronics were too expensive and unreliable.

Limited-Performance Neighborhood Vehicles. Bill Garrison of University of California, Berkeley, among others, has suggested limited-performance neighborhood vehicles for those who cannot drive conventional automobiles. Such vehicles would enable them to get to neighborhood stores, doctors, churches, and so forth. They require no new technology, except perhaps avoidance systems to prevent them from running into a wall or a pedestrian. Electrical drives can limit speed (perhaps to 10 mph) while providing adequate power for acceleration and hill climbing. Their adoption will require the cooperation of local governments and equipment manufacturers as well as a new kind of driver's license. Several local governments have expressed an interest in at least studying these concepts.

Intercity Personal Transportation

The automobile has been the dominant mode of intercity transportation since the 1920s. It will continue to be preferred for the trips that can be completed in 1 day and for trips such as family vacations, which are in effect a series of 1-day trips.

Airlines will assume an increasing share of the longer trips, whether for pleasure or business. These trips will usually require use of a rental car for local transportation at the destination. The limit to the demand for economical intercity air transportation does not appear to be approaching, but there are constraints on both the air and land sides.

The technology to resolve the airside limits (route capacity) appears to be feasible. It can be based on extensions of military radar and control technology. Microwave landing systems can increase the capacity of existing airports, but if all of the latent demands for air travel are to be met, ultimately new, accessible airports will be needed. There will be pressure from the community to locate these away from the major metropolitan areas, a policy that would compromise the benefits that they would provide.

The landside problems, such as access to airports and objections to noise, are more serious. They differ in detail and magnitude from other traffic congestion problems. Some technical solutions, like use of Short Takeoff and Landing aircraft from feeder airports to bypass congested streets may be able to expedite passenger movement in large metropolitan areas. However, this solution will not help those who work at airports, who generate the majority of trips.

Frequent air travelers find the increasing delays, such as waiting for baggage or for a rental car, disturbing and costly. Perhaps there should be two classes of service—instead of conventional first class and coach, time-sensitive and service-sensitive classes. The first class would be for the business traveler whose time may be valued at hundreds of dollars an hour; the second would be for the person (or family) who does not travel frequently, usually for vacation or family business, and who is not familiar with locating services, gates, and so on.

Future use of high-speed ground systems now seems questionable, whether for airport access or intercity travel. The primary problem is the cost of the right-of-way. New technologies such as magnetic levitation and superconductor power to achieve higher speeds are not the solution. The ability to operate trains at speeds approaching 300 mph on standard rails has already been achieved. Frequency of operation is more important. The problem is that there are few routes with demand sufficient to bring the cost of operation (and amortization of the construction costs) to less than the cost of operating a personal car (or aircraft) for the same service. Perhaps high-speed ground passenger service would be economical if there were an existing right-of-way (with 4-ft 8½-in. tracks) that can also be used for high-speed freight service, perhaps with RoadRailers.

ADVANCES IN AUTOMOTIVE TECHNOLOGY

Transportation technology for all systems—cars, trucks, trains, and aircraft—will improve. The most important changes will not be those that the buyer sees but those that have to do with cost of manufacturing, quality of the product, its total life, and ability to meet air quality and other regulations.

Buying a car will continue to be one of the two major purchases that most people make (the other is buying a home). In the past, people tended to purchase the car that would meet an extreme combination of purposes, such as the once-a-year vacation trip and transportation for the Little League baseball team. This is giving way to having a variety of cars for different purposes. The light truck is growing in popularity as a passenger vehicle; it and the van (as a mobile living room) for families and friends are recent phenomena. In the future the variety of designs may increase; there may even be different styling and accessories for different parts of the country. Few automobile models will be sold in quantities of more than a few tens of thousands in a year.

A less costly variant of the "stable of cars," which is already common in some large cities, is to rent a special car for vacations (or to impress the mother-in-law-to-be). Purdue tested a car-leasing concept that may be attractive in high-density residential areas. The daily trip is made in the smallest car practical for that trip, leased from a pool that provides access to large cars and vans when needed. Innovations in leasing, when coupled with use of Lean Machines, could reduce the size of the average car used on urban expressways (*17*).

The automobile industry gives a lot of attention to determining how people select their cars. Profiles of buyers for various models are established, and performance, accommodations, and styling are directed at those buyers. Societal methodologies, such as Values and Life Styles (SRI International) can be used to estimate how buyer segments will change with time, income, education, and so forth (*18*).

Some insight into how buyers view technology is provided in a 1983 paper by Cheslow, which summarized what was then known about what people will pay for performance. He found predictions that people will pay from $15/mile per gallon (mpg) to $150/mpg for a more efficient car (an average of $45), depending on income, family size, and age. Customers would pay from $100 to $1,000 for 50 mi more range, which implies that avoiding gasoline stations is more important than fuel cost. This is not surprising, because most people pay more now for insurance than for gasoline. Apparently most car buyers will pay more ($45 to $500) to reduce the acceleration time from zero to 60 mph by 1 sec than for 1 mpg more (*19*).

There will continue to be improvements in the efficiency of U.S. cars. The primary ways by which this will occur are by

1. Reducing weight,
2. Reducing performance, and
3. Improving propulsion efficiency.

Before the first energy price shock in 1973, advances in engines, aerodynamics, and weight provided improvements of from 1 to 2 percent a year in gallons of fuel per mile, on a performance-corrected basis. This is a very different trend than stating the annual percentage improvement goals in miles per gallon, which implies that the improvements will get larger exponentially with time, a technological impossibility.

Reducing Weight

Since 1973 the majority of the improvements have come from weight reductions. However, the economic limit for weight reductions with existing technology is probably near. The increase in the cost of the car would probably be greater than the cost of the fuel saved over its lifetime at the expected price of gasoline.

Steel is still competitive with plastics, but plastics technology is developing so rapidly that lighter-weight, relatively corrosion- or decay-free cars with much longer operating life appear inevitable by 2020. Although plastics are (and will probably remain) more costly per pound than metals, many parts can be produced in one operation, thus reducing labor, scrap, and machining costs. Metals will be used where they have advantages, such as in engines and major structural elements. Ceramics will be used in the high-temperature zones of engines when they can be made without flaws and tested nondestructively.

Reducing Performance

Car designers can improve fuel economy by reducing performance. For example, a car may be offered with a choice of engines. A large engine that will accelerate the car from 0 to 60 mph in 8 sec will get 22 mpg. The small engine may provide 33 mpg, but will take 20 sec to reach 60 mph. The question of whether the fuel savings are worth the safety compromises (whether real or perceived) must be addressed.

Improving Propulsion Efficiency

There have been and will continue to be improvements in propulsion, but it is important to point out that the internal combustion engine is approaching its theoretical efficiency limits, defined by a French engineer, Carnot, 150 years ago.

The theoretical peak efficiency of an ideal thermal engine is about 60 to 65 percent (depending on the temperature at which the waste heat is rejected). The practical limit of spark-ignition piston engine efficiency is probably about 40 to 50 percent at peak power. Modern automobile engines deliver 30 to 35 percent efficiency at peak power. The peak cycle efficiency of the most modern combined-cycle stationary electrical power plants where size and weight are not limitations is about 55 percent. At low power, where automobiles operate the majority of the time, the delivered efficiency of 15 to 20 percent is close to the practical limits. It will be difficult to increase the average delivered engine efficiency by 10 percent. About 10 percent more may come from reductions in transmission and accessory losses, but these will come slowly. The difficulty (and cost) of improvements tends to increase exponentially as the theoretical limits are approached.

What about other kinds of engines? To be brief, gas turbines are excellent engines in aircraft, where they can run at near-maximum power most of the time. The Stirling engine has outstanding multifuel capabilities, but will probably be slightly less efficient (and more expensive) than internal combustion engines. The cost or availability of its fuel must offset the loss in efficiency and greater cost (*20*).

The electric battery car is another question. GM had a major program to develop and produce battery cars. It even announced a date for their production. At that time it was generally accepted that fuel costs would reach $3.00/gal or higher. The most serious problems with battery cars are their limited range (less than 100 mi per recharging) and costs. To be acceptable to the buyer, battery cars must provide advantages over other propulsion systems that could meet the same goals. The comparison with compressed natural gas (CNG) is illustrative. CNG costs less (per Btu) than gasoline and the technology is available. Existing cars have been converted to operate on CNG at a cost much less than that of a battery car. These converted cars have a range of over 100 mi. They use an embargo-free fuel. Yet there has been only a small market for them. It then became obvious that if a better good (a CNG-operated car) would not sell, why would anyone expect to sell many battery cars?

A super battery car (competitive in performance and cost with an internal combustion engine) will probably never be developed. The electrochemical series is well known. Some exotic batteries can theoretically provide higher performance, but they generally are now too expensive for passenger cars or require hazardous materials, or both.

Electric utility companies continue to be interested in battery cars, to use the excess generating capacity that now exists. However this surplus is expected to disappear by the mid-1990s. Actually, the utilities did not do as poor a job of projecting their demands as is frequently asserted. They did underestimate U.S. economic growth, a mistake many made. Electricity consumption per unit of the gross national product (GNP) increased during the two oil price shocks and is still greater (in kilowatt hours per dollar of GNP) than was expected in the early 1970s.

If zero air pollution is required, perhaps a concept that GM demonstrated in the 1960s should be reconsidered—a car propelled by stored thermal energy. Heated aluminum oxide pellets were used for the energy storage, and a Stirling engine provided the power. It had a range in excess of what can be obtained with current batteries.

The fuel cell is a potential battery-like propulsion system that should become real some day, although 30 years ago, it was believed that fuel cells were then only 5 to 10 years away from production. There has been recent progress, however. Because this is an electrochemical (not a thermal) process, it is not restricted by Carnot's limits. The process could be described as reverse electrolysis. Its output will be electricity, water, heat, and carbon dioxide (if a hydrocarbon or alcohol fuel is used). Experimental cells have demonstrated more than 60 percent efficiency during bench testing. In a typical duty cycle, a fuel cell could provide two to three times the range per Btu because, unlike an internal combustion engine, a fuel cell tends to have its highest efficiency at very low power, which is where cars operate most of the time (*21*). No one has built such a propulsion system, although all the required elements have been demonstrated. Cost projections indicate that it will be much too expensive for passenger cars or trucks, primarily because platinum is required for the catalyst.

New knowledge will be required to develop catalysts that use less expensive materials. As implied earlier, superconductors will probably not have much direct application in transportation, but the knowledge of electron transfer, which is being developed, may be very important in understanding how catalysts operate. Those who are following this technology are confident that solutions will be found, but it is impossible to project when. A goal of 2020 might be reasonable for initial production of automotive fuel cells. When fuel cell costs have decreased enough for them to be used in cars, most thermal power systems will be obsolete, not just those in trains, cars, and trucks.

ENERGY COST AND AVAILABILITY

Where will the energy come from? When people worry about shortages of energy, they usually mean petroleum products, but there are many other forms of energy, such as solar, geothermal, coal, and natural gas. The lessons of other energy shortages are sometimes forgotten. Oil got to nearly $100/bbl in the mid-1800s when whales became difficult to find. England learned to use coal to make iron after it had denuded its forests. When people learn how to use these resources economically, there should be no lack of energy to operate cars.

Even the petroleum problem is based on a special situation. The world has more than 70 years' supply of petroleum. Unfortunately, the majority of the low-cost crude oil supply is in the Persian Gulf, one of the most politically unstable areas of the world.

History has shown that it is essentially impossible to predict the specific price path for oil. It is driven by supply and demand (and politics). However, some lessons have been learned (the hard way) that can help in the understanding of how prices may change (22).

In the short term, oil prices respond to demand and willing supply, as does any other commodity. Unfortunately, the willing supply can be manipulated, as it was in 1973 and 1980. Prices could cycle from $10/bbl to $40/bbl in a year.

Over the longer term, oil prices should, on average, fall between upper and lower bounds, which can be described (*23*):

1. The lower bound will be affected by the marginal cost of the next barrel of oil outside the Middle East [or the Organization of Petroleum Exporting Companies (OPEC)], estimated at $7/bbl to $12/bbl by some oil company economists.
2. The upper bound will be affected by the revenue of the oil-producing nations. Above some price (estimated at $30/bbl to $40/bbl), the revenues of the oil-producing nations will drop as people turn to other energy forms or conserve.

Before 1973, many authorities thought that oil consumption would be independent of price. Fortunately that turned out to be a myth. The short-term elasticity is debatable, but is probably in the range of −0.6. This implies that people will reduce their gasoline consumption by 6 percent for every 10 percent increase in price. The long-term elasticity may be −1.0. In other words, people may budget a constant amount of money for energy and change their transportation plans to stay within their budget.

There are several ways to extend the supplies of U.S. petroleum (*24*). These include

1. Improving production and finding more oil,
2. Mandating savings, and
3. Developing alternative fuels.

Improving Production and Finding More Oil

The importance of improving oil production technology is illustrated by the fact that there are more than 300 billion bbl of oil in U.S. reserves that cannot be produced profitably (at current prices) with existing technologies. If one-third of this reserve could be recovered, it would meet the total U.S. oil need for nearly 40 years. Estimates of the approximate length of time by which U.S. reserves can be extended by various technologies include

- Improvements in exploration: 5 to 15 years,
- Carbon dioxide injection: 6 to 8 years,
- Liquefaction: more than 20 years, and
- Refining heavy oil and tar sands: more than 30 years.

The question is, at what prices will oil recovered by these recovery technologies be competitive with other fuels? Carbon dioxide injection is estimated to cost about $8.00/bbl and liquefaction chemicals may cost $20/bbl. Much of the known U.S. petroleum reserves will probably never be produced. There may be less costly energy sources, all costs, including environmental cleanup, considered (*25*).

Oil shale has not been mentioned. Although it is almost as large a resource as heavy oil, recovery is more expensive. The best use for shale oil (kerogen) may be to burn it directly in fluidized beds to generate electrical power.

Mandating Savings

In the 1970s some thought that enough energy saving could be mandated to make the United States relatively energy independent. In a 1979 study, Boyd (*26*) indicated that the combination of all feasible proposed mandates would reduce oil consumption between 7 and 8 percent. This is the same level of saving that would have been achieved by an $8.00 increase in the price of a barrel of oil. Since 1979 many of the savings proposed (such as having the utilities switch to another fuel than oil) have been made.

One mandate, which is still on the books, the Corporate Average Fuel Economy (CAFE) standards, has been a source of problems for the automotive industry. CAFE led to premature introduction of technologies and diverted resources from more productive activities. The psychological problems may have been the most damaging. The concentration by GM engineers and management on attempts to meet these standards may be one of the reasons for GM's loss of market share. Meeting customers' needs and improving quality were still considered, but of necessity with less emphasis than would have traditionally been expected, which is not surprising, because it was considered a criminal offense not to plan to make the standards.

One of the rationalizations for setting these standards in the 1970s was that controlled gasoline prices gave buyers the wrong signals. This argument no longer applies, because price controls were lifted years ago. People have argued that between 1978 and 1985, CAFE was meaningful, but in those years buyers preferred energy-efficient cars, even at a sacrifice of seating capacity and performance, because they believed that oil prices would increase, almost without limit.

The effort to set these standards might be justifiable if CAFE provided significant benefits, in particular extending the life of the U.S. oil resources. But the point of diminishing return is approaching. An improvement in fuel economy of 1 mpg will extend the life of the proven oil reserves from about 9 years to about 9 years and 2 months. Even if this were wrong by a factor of 10 or more, other solutions would still be needed. Another argument against CAFE standards is that the benefit provided by reducing the international balance of payments about one-third is due to the cost of imported oil (*27*).

Developing Alternative Fuels

The last solution mentioned is the use of alternative fuels. The fundamental question is not how to extend the life of U.S. oil resources, but how to provide economical fuels for transportation (*28*).

Some alternatives are available today; natural gas, for example, is the lowest-cost fuel available (even when road taxes are paid), which is why more natural gas is expected to be used. A major problem is the limited range (about 100 mi between refueling) of CNG vehicles. There are no factory-built or original equipment manufacture (OEM)-supplied vehicles (conversions cost from $1,500 to $1,800). The cost of existing compression equipment appears to be too great for profitable retail sales. There are more than 400,000 vehicles capable of operating on CNG in the world, the majority in northern Italy. In New Zealand approximately 10 percent of the gasoline-powered vehicles have been equipped for CNG operation. There are only about 30,000 converted vehicles in the United States, mostly in California and in utility fleets. Russia has recently announced its intention to adapt a large portion of its vehicle fleet to operate on CNG (*29*).

Except in the industrial nations (and some island nations), natural gas supply is not a problem. Some authorities, such as Henry Linden, formerly of the Gas Research Institute, believe that the world has several times as much energy in natural gas as in petroleum. Many oil exploration companies were disappointed when they discovered gas instead of oil in developing nations, because it has little value in these countries and is difficult to transport. Both the oil companies and the countries are looking for ways to export this resource.

The alcohols (ethanol and methanol) are good fuels, and politically popular—perhaps too much so, because the automobile industry does not yet have confidence that it can provide the same engine life using methanol as its customers have come to expect. Methanol may be the preferred fuel for fuel cells. It can be disassociated easily into hydrogen and carbon dioxide. Methanol may be the best way to store and ship the hydrogen that some advocates think will be the fuel of the future.

The lowest-cost alcohols are those made from natural gas. To determine when they would be economically competitive with petroleum-derived fuels, data on the costs of serial production of methanol plants were obtained from the company (Davy McKee Corporation) that has designed or built the majority of methanol plants in the world. These data indicate that in the United States new plants to make methanol from natural gas will provide an acceptable rate of return on investment (ROI) (15 percent) when the retail price of gasoline exceeds $1.50/gal (and is expected to stay there) (Figure 3).

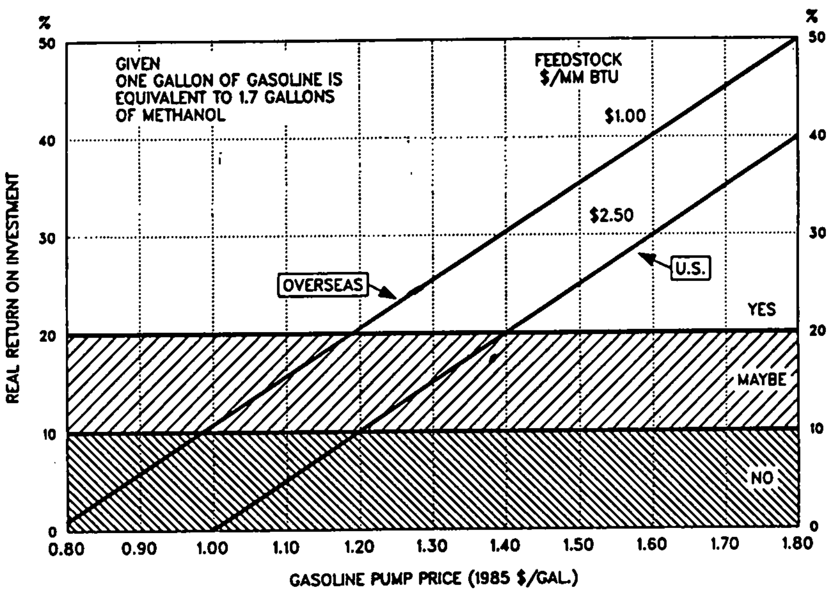

FIGURE 3 Methanol economics.

It is doubtful that anyone will invest in U.S. methanol facilities, for two reasons:

1. OPEC could drop the price long enough to bankrupt the producer.
2. Methanol can be produced at a lower cost in many nations that do not have a domestic market for natural gas.

Alcohols are being promoted as environmentally superior fuels, but the advantages, at least in internal combustion engines, are marginal. These fuels are biodegradable and can be made from many kinds of feedstocks, including coal and biomass. It has been suggested that alternative fuels could be a byproduct of new families of "safe" nuclear power plants (fission or fusion). If problems with CO_2 and the greenhouse effect are taken seriously, nuclear, solar, biomass, and closed-loop geothermal fuels may be the only acceptable primary energy sources.

Ethanol is usually made from biomass, by a much more expensive process than that used to make methanol from natural gas. Ethanol can also be made from natural gas, and other processes are being studied; as a result, the automobile industry cannot yet limit its options to a single fuel (*30*).

The transition to alternative fuels, if economically driven, should start before 2020 in the United States. There will be a period of overlap with the phasing out of petroleum-derived fuels when oil exploration and production cost more than manufacturing the alternatives, perhaps by 2050.

The transition should start sooner in oil-poor nations, which could detach them from OPEC. It has already in Brazil, but the cost of sugar-cane-derived ethanol deprives them of the economic benefits when oil prices are low. The use of alternatives in oil-poor nations would be beneficial to the United States and other developed nations, because it would help reduce world demand and cap world oil prices (*31*).

AVAILABILITY OF ADVANCED TECHNOLOGIES

When will these new technologies be available to the general public? That depends as much on the business environment as on their technological and economic feasibility.

- The concept must be technologically and economically feasible.
- There must be a large enough market to justify the investment in development and manufacturing facilities and to make a profit.
- There must be benefits for the purchaser or consumer.
- There must be public acceptance.

The acceptance of technological change requires more than economic feasibility. The changes must improve the operation and the economics of the equipment or provide new services for the user. The manufacturer must not only have confidence that the new technology will work, but also that it will work in the consumer's hands, be attractive to the customers, and meet safety and environmental regulations. The product must be able to be sold profitably in competition with other products that will be available by the time the new product reaches the market.

For industry, this means the economic life of the trucks or rolling stock, which includes not just the purchase price but life-cycle costs, including maintenance, operating costs, and the residual value at the end of the life cycle. For personal transportation, this means that the new technologies must fill a perceived need. They should provide economic advantages, an image, or new amenities.

Meeting these requirements gets to the core of the economy and how innovation by small (and large) companies is encouraged or discouraged. That is a topic for other discussions and other times, but there are a few major points to emphasize:

1. The incentives of the private and public sectors are very different.
2. The American public is increasingly resistant to change, even when it benefits the majority.
3. Regulation, however well intentioned, restricts progress and frequently does not achieve the intended results.
4. The increase in litigation, for whatever cause, is a threat to the nation's economic well-being.

Private- and Public-Sector Incentives

The introduction of a product or service in the private sector requires that the sponsor believe that he will earn more from that investment than from other investments. There are risks in innovation and technical development. The rewards should increase with the risk. The availability of capital to start a new company and the "bridging" capital to expand the business to meet growing markets is dependent on U.S. economic progress and such things as the capital gains taxes and antitrust laws. The U.S. legal devices to provide protection during the development of a new product include patents and the limited-liability corporation and bankruptcy laws, but in the increasingly challenging business world, these may not be enough. Joint preproprietary research organizations have been established for the electronics industry and may soon develop in other technical areas (*32*).

In the public sector, the ability to satisfy the local electorate is a necessary, but not sufficient, criterion for sponsoring an innovation. Industries' view of public-sector incentives is that they tend to discourage risk taking. A failure may end a public service career; a success may have only subjective rewards.

Fortunately, there are many innovative state and local government officials. Many states are creating institutions to sponsor the transfer of technology from the universities to the private sector. A notable example is the Michigan Strategic Fund, which sponsors centers of excellence for transfer of technology from the universities to industry. It has created a number of new financial instruments to help innovators obtain needed financing.

Some local governments have banded together to create risk-sharing institutions (like the Innovation Groups in Florida, California, Virginia, and five other states). Their members test innovations in the operation of their governments and encourage the development of new technology for cities (remote meter readers, police devices, etc.) by private companies. Some of the member cities have worked with GM in the past to study the future needs for energy and transportation. Several have expressed interest in cooperating in the development of requirements for new vehicles (e.g., the Lean Machine) and services (R. Havlick, Florida Innovation Group, Tampa).

The difference in viewpoint of the private and public sectors leads to suspicion of motives on both sides; sometimes they do not appear to speak the same language. The introduction of new technology (such as driver assistance systems or new vehicle categories), which combines the interests of both, is a particularly complex problem. Although the public and private sectors have tended to view their responsibilities separately, it has been encouraging to see offers by state and local governments to work with industry to explore new transportation concepts and services.

Resistance to Change

As a people, Americans are increasingly resistant to change. Historically, improvements in the quality of human life have been due to the use of new technologies, starting with the domestication of plants and animals. More recent developments include harnessing energy, moving people and goods effectively, communicating and expanding knowledge, and controlling the environment. The services available today to all our citizens were not even dreamed of by royalty 100 years ago.

The GNP is an incomplete measure of the quality of life, but in GNP terms, the U.S. economy must grow about 2.0 to 2.4 percent per year to stay even, considering the increase in population and the investment in education as well as the more experienced work force, which will expect higher incomes.

Many people appear to be antitechnology, afraid of progress, or at least technologically uninformed. They must be convinced that technical progress will benefit them or their children and grandchildren. The reasons for their worries are understandable. Mainly, they are concerned about careless use of technology; less well articulated may be concern over its deliberate use as an agent of control, hence the concern over privacy.

Of course, progress will cause change, which in turn implies injury to someone (what Schumpmeter called "creative destruction"). This can be costly to workers and professionals who have invested time in jobs or education.

Failure of Regulation to Achieve Intended Results

In an effort to address these problems equitably and to ensure that people have a voice, a paper-work mountain of rules and regulations has been created—a mountain that must be climbed by any and every major technical development. These rules can undoubtedly be justified individually, but collectively they stifle progress. Peter Goldmark pointed out that it took him longer to get a permit to deepen the main channel in the New York harbor than it took to build the Erie Canal.

Increased Litigation and the Economy

A symptom of the growing resistance to risk taking is the increasing propensity to sue, for actual or perceived injuries. It is difficult to estimate the total social cost, but liability actions are inhibiting the introduction of new products that would create jobs. Innovative companies find it difficult to get liability insurance. But insurance is only a symptom of the underlying problem. There appears to be a belief that there should be an absolutely safe environment, which of course is impossible.

The increasing rate of liability awards should be a subject of great concern to any one interested in technical progress. Although the data are incomplete, the potential upper limit of the cost can be estimated by using accident data from the 1985 National Research Council study on injury in America. If everyone who was injured sued and was granted the average award, the total could substantially exceed the GNP. Fortunately the majority of those injured are willing to accept responsibility for the accident and elect not to sue (or did not know that they could).

The injured have a legitimate reason to seek compensation if the injury was not their fault. Courts appear to be more than willing to find someone, usually a large company with deep pockets, to pay the expenses (plus a little more), whether the company could have prevented the harm or not. One of the arguments is that large awards lead to improved, safer products. Although hard to prove, this is probably wrong. Over one-fourth of the price of a stepladder is reputed to be the cost of liability. Ironically, many of the things being inhibited could reduce injuries and hazards. For example, it is dangerous to test a product to destruction because the data may be used against the manufacturer in a liability suit. Yet if this is not done, the accuracy of the design and potential problems or opportunities for design improvements will not be found. The perception of placing a company or product at risk may be more costly to society in lost opportunities and jobs than the actual liability awards.

Even advancements that are demonstrably safer may not reduce accidents or their severity. For example, air bags could increase car fatalities if people think that air bags alone provide as much protection as seat belts. Mandating a specific technical solution may discourage experimentation and innovation. There may be more effective ways to reduce injuries than either air bags or seat belts. There is evidence that improving an intersection that has had a disproportionate share of accidents may not reduce the number of accidents in the community. They may "migrate" to other places. Some of the most hazardous-looking intersections and streets, such as are common in Europe, are actually the safest, if only because people are more careful (*33*).

Safety is one area in which the benefits of technology are difficult to establish. The difficulty in assessing the benefits is illustrated by the formula developed in the 1940s by Smeed at British Road Research Laboratories. He correlated automobile fatalities (by nation) with automobile ownership. His formula appears to account for the majority of the differences in traffic fatality rates among the nations of the world. The annual fatalities per car varies from one for 25 cars (Liberia) to one for 4,300 cars (Norway and Japan), a ratio of nearly 175 to 1. The United States has one fatality for 3,030 cars. The implication is that car ownership (people per car) is a surrogate for wealth, quality of life, and the value placed on human life.

When the ratios were recalculated in 1983 (using the constants Smeed derived in the 1940s), it was found that the actual fatalities in one-third of the nations fell with 10 percent of Smeed's formula projections. Less than than 15 percent of the nations differed by more than 50 percent (a "corrected" spread of 3 to 1 versus 175 to 1 for the raw data). The actual U.S. fatalities were only 12 percent below the projection. All nations have access to the same technology today; thus it should not account for the difference (although it may account for the residuals from Smeed's formula). Any projection that comes this close after 40 years requires study. Is this a real or an accidental correlation? If real, should Smeed's formula (or an update) be used as the base against which to measure improvements in accident rates (*34*)?

Need To Bridge Gap Between Public and Private Interests

There are conflicts between public and private interests: government laws, precedents, and regulations that inhibit change versus government investments to encourage technical progress. Government sponsorship of basic research and development is necessary for the creation of new knowledge. But even this can be counterproductive if not effectively managed. Government intervention in the development of commercial products has frequently delayed their commercialization and may result in wasted resources. On the other hand, there are many fields in which government support is necessary. This is particularly true with those products for which the government is the primary customer (military, transit, etc.) or where the time horizon is very long (catalysts for fuel cells, etc.). Industry will probably be increasingly reluctant to invest where it cannot create (and protect) a proprietary position that may have market benefits.

New public-private institutions may be needed to develop and implement technical solutions to transportation needs when the interests of the two sectors overlap, such as the systems to provide real-time traffic data, synchronized traffic signal systems, or automatic highways. Two of the best models for this kind of cooperation still are the National Advisory Committee on Aeronautics (NACA) and the Farm Agents. NACA had an effective committee structure of users, manufacturers, and researchers who could advise on what work was justified and who had the knowledge required to transfer the results to the consumers.

CONCLUSION

There are many exciting transportation technologies and concepts. Innovative use of old technologies, such as the RoadRailer and the Lean Machine, can change how people and goods move. Increased use of new technologies, such as route guidance systems and traffic signal synchronization, can improve traffic movement, reduce fuel use, and improve air quality.

By reducing trip times the new systems will change how cities evolve and how people travel. New propulsion systems and alternative fuels will reduce the economic problems inherent in continued dependence on oil from the Middle East.

These opportunities should be approached as systems: cars, highways, energy supplies, and traffic controls all interact. For example, it may be more cost-effective to spend national resources on the development of improved traffic controls or alternative fuel resources than to invest in more exotic vehicle technology.

To make the correct decisions it is necessary to understand the transportation market and how its needs will change. Some fundamental questions need to be answered, for example,

- What premiums will shippers (or travelers) pay for service?
- How will advanced computers and communication technologies change the need for and use of transportation?
- Will industry (and jobs) continue to move to the suburbs and small cities?
- Is the apparent elasticity of transit use to disposable income real? If so, is the approach to public transit correct?
- Is travel time self-limiting? Will people relocate to avoid congestion?
- Can innovative vehicles be used effectively to ameliorate traffic congestion? How can government aid in their implementation?
- Is there adequate government and industry support for advanced traffic control systems? If so, how will the public liability problem be resolved?

A better understanding of these and similar topics is needed. In some cases it may be necessary to create new industry-government partnerships to identify the problems, seek opportunities, and provide the information that decision makers (and the public) will need to make informed decisions.

Advances in vehicle and infrastructure technology will make it possible to improve how people work, live, and move. Whether they are taken advantage of or not will depend on the ability of the public and private sectors to work together.

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Respondents' Comments

DANIEL BRAND This session is the only one for display of some the supply-side options in what is otherwise a firehouse of demand data. As such, these two papers bear a large burden at this conference.

The technological fix to our transportation problem is not going to be easy. This is not the 1950s when, as Alan Altshuler has said, freeways were the new technology. The question then was not whether to build them but where to put them.

The press picks up fast on technological fixes. The June 13 *Business Week* cover story on smart cars consists of seven or eight full pages of information on what we are doing and talking about. It says, "Coming soon, everything from video navigation to collision avoidance. Your new car has more computing power than a PC." "Smart Cars" is the name of the story and at the end there are a couple of pages on "smart streets," which Koltnow discussed here.

Sobey calls the fourth technologically driven revolution in transportation the use of computers to automate some or all of the driving functions. In a capital-short society, we can't afford to overbuild. We need much more understanding of the interactions of supply and demand, capacity, and operational control before we invest lots of money in anything. So, we have to plan smarter even before we operate smarter.

It may be, for example, that the highway guidance systems described by Koltnow will provide as much benefit from the information they give to drivers on their expected trip times as their benefit from shortening trip times. Highway route guidance systems may cause as much demand reduction in response to congestion as they provide effective network capacity increases. That is to say, the contribution to travel time savings to congestion reductions will be about the same from each or they will operate somewhat in parallel.

Daniel Brand is Vice President for Transportation with Charles River Associates. A professor at Harvard and senior lecturer at the Massachusetts Institute of Technology, he has served as Undersecretary of Transportation for the State of Massachusetts. He is the current chairman of TRB's Committee on New Systems and Technology.

That is, if in the short run we provide drivers with these systems, with accurate information on travel conditions in real time, in the long run we will probably wind up influencing land use location decisions and this will bring about a much less painful supply-demand equilibrium, which will be the individual traveler's contribution to solving our highway congestion problem.

Congestion avoidance systems can bring the true cost of the trip to bear on an individual's travel decision, at least the true time cost. Of course, congestion pricing—letting travelers pay the true cost of the capacity they use at any given time—would complete the equation. However, there is always resistance to this. Nevertheless, highway route guidance systems promise to remove time unreliability from its present prominent place as a highly valued cost of travel in the individual's travel decision.

There are clearly many important research issues for TRB to grapple with as they plan smarter before we operate our systems smarter. Sobey says we need better solutions to the congestion problem. He proposes five possible ones, which go from adding more conventional expressway capacity to introducing innovative vehicles that take less space (GM's Lean Machines, for example) and improving traffic signal controls and route guidance.

I am skeptical about Lean Machines. In mixed traffic small vehicles don't increase throughput at intersections. If anything, they decrease it because of their reduced acceleration and performance. GM's machine is supposed to have high acceleration, but that may not be consistent with the market for small vehicles. On hills or congested freeways, variation in vehicle performance reduces throughput because the vehicles can't maintain the close spacings. Indeed, if acceleration and top speeds of vehicles really vary from the norms of the traffic streams, there will be real safety concerns.

Finally, there is an important step in automation short of automated highways that should be part of the dialogue, and that is dual mode (which used to be called automated guideways back in the salad days of transportation research). We will always be limited for economic reasons in automating the line-haul portion of trips, just as we are limited today in the mileage of planned expressways. Automation of driving will always be limited to those congested areas in which it is necessary to reduce travel costs, including social costs.

The easiest way to provide the door-to-door transportation service enjoyed today for the bulk of our urban trips will still be to rely on manually driven vehicles. Dual mode would provide automated control in a carefully controlled environment. It may well be cheaper and more reliable to put complex control systems in a friendly centrally maintained facility than in everyone's car. You spend money on automation only where it is needed, for capacity and other reasons.

In summary, there certainly are some exciting technological options on the horizon. We are only beginning to think seriously about applying the computer chip revolution to surface transportation, and we have a lot more thinking and experimenting to do.

DARWIN G. STUART I would like to highlight four or five elements from these two wide-ranging papers. In focusing on these elements, I am reflecting the following perspectives.

I have only dealt with passenger transportation in urban areas, particularly the larger, faster-growing urban areas. Within those urban areas, the opportunity or need for significantly increasing route capacity, on a site-specific basis, is my primary focus. One of the concerns that has come out of some of the generalized, national-level data presented earlier in this conference is that such data gloss over area-to-area differences. Particularly on a site-specific basis, this may hide some of the significant opportunities I believe are emerging for automated guideway transportation as a serious alternative for solving route capacity problems.

I think it is still an open question whether there is a significant role for either automated highways or automated guideway transit over the next 30 years. We should therefore renew our efforts to look at these options seriously.

In pursuit of that overall conclusion, I think a first supporting highlight involves projections of seriously increasing urban traffic congestion, highly variable among specific urban areas. Within the faster-growing areas, and particularly in their suburbs, as we have heard from others here, congestion is growing quite rapidly. Our overall goal for dealing with this problem is to increase the person-carrying capacity, particularly of existing routes, but of new routes as well. Person-carrying capacity, involves both individual vehicles and the routes themselves.

There are a couple of basic options. One is to place more emphasis on group travel, both transit and ridesharing in carpools, vanpools, or buspools, leading to more passengers per vehicle. A second broad option is to simply increase the lane or route capacity of existing facilities by using high-occupancy-vehicle (HOV) lanes, exclusive bus lanes, or the like. HOV lanes, together with group travel options, offer one promising way to achieve higher person-carrying capacity with manually operated modes. The automated modes that

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Darwin G. Stuart is Manager of Strategic Planning with the Chicago Transit Authority. Before joining the CTA, Stuart was a transportation consultant for Barton-Aschman Associates, Inc.

Koltnow discussed, both automated highways and automated guideway transit, represent the other, longer-term end of the spectrum in terms of expanding route capacity to deal with corridor congestion.

Over the 30-year time horizon addressed at this conference, other alternatives to considering ways to increase person-carrying route capacity are to prepare for curtailment of demand or to reallocate demand from portions of urban areas that can no longer handle it to other areas that can. This suggests a growing philosophy of congestion acceptance by the traveling public in which significantly decreased service quality and ultimately decreased personal mobility become the norm. The result is a degraded quality of life.

Sobey and others at this conference have mentioned fixed daily travel time budgets that seem to have held over several decades. Perhaps over the next 30 years such budgets will be seriously threatened by degraded personal mobility as their length is necessarily expanded and/or trip flexibility and opportunity are reduced.

The second highlight I would like to address perhaps deserves more attention at this conference than allowed by program constraints. What is public transit's role in solving increased corridor congestion problems? In general, the challenge to public transit is continually to improve its average travel times, particularly within those corridors and major activity centers in which it can surpass the automobile's degraded performance associated with higher congestion.

The high-density, high-congestion corridor, in which express transit service can offer a workable alternative, then poses a challenge to provide a sufficiently improved service. In major activity centers, there is also an opportunity (with significant center growth) for supplemental internal circulation-distribution systems to provide a transit option that expands short-trip mobility.

In general, to achieve these kinds of service improvements in travel time for transit requires exclusive rights-of-way. HOV lanes, of course, are one such option. Other capital investment in fully and partially grade-separated transit systems, such as light rail, are being implemented in several urban areas, with others in the planning stage. These also begin to provide the same kind of improved transit service needed to meet corridor congestion needs.

In general, public transit can improve line capacity with changes in vehicle size, shorter headways, and, under higher demand conditions, platooning or entrainment. There is a lot of flexibility open for transit to meet increased corridor demand as an option to the automobile. The challenge is to provide a broader range of competitive modal options that can better match increased and more serious highway congestion in major travel corridors.

A third highlight picks up what I believe were points in both of the papers in this session—the difficulty of implementing any significant technology advance, particularly automated guideways for either highways or transit.

The limited success with which I am familiar indicates that an inordinate amount of time and skill is necessary in dealing with local elected officials to get them to buy into technology advances. This selling challenge offers a major stumbling block that we need to spend a lot more time with if we are going to see such advances. This applies, I expect, to both the small private vehicle concepts—the Lean Machine and the neighborhood car mentioned by Sobey—as well as automated grade-separated guideways.

Sobey stressed that there are few incentives for technology advance. We are instead faced with regulatory, legal, and fiscal barriers, and a general conservatism on the part of local and state government toward new technology. There is really a challenge for us to do an effective educational and promotional job with local government officials and state elected officials to convince them that there are significant economic advantages and benefits, and significant real and perceived travel needs, that must be addressed.

One of the issues here, for those technology options that have higher front-end capital costs, is to stress life-cycle cost analysis as the basis for justification. This leads us to a point that Deakin made, namely, that long-range planning, which has been dormant, is one of the stronger, more logical ways to make these points. At a systems planning level, we need perhaps some increased activity to expand the vision of local elected officials to get them to take new technology options more seriously, rather than making project-by-project, short-run decisions.

In Chicago there is currently a planning effort that gives an example of some of the issues of getting local elected officials on board. In the Chicago Central Area, an interagency study is now examining local distributor options for increasing the ability to move around within Chicago's rapidly expanding core.

The success of light-rail transit in several urban areas, such as Portland and San Diego, has led to a certain "fashionable" nature for that particular option. Partly because light rail has been successfully sold as a conventional option in some of the other faster-growing, low-density regions of the country, among elected officials and the private sector in Chicago a sort of present bias exists that at-grade light rail (streetcars) is good enough. There is a reluctance to seriously consider grade-separated options, which implies new technology options as well, because of higher capital costs, and particularly because of the need to rely on private-sector dollars.

There is a feeling among those involved in this project that we don't want to scare off the private sector by giving them options with the high front-end capital cost of grade-separated systems. There is a resultant conservatism and a willingness to settle for at-grade light rail.

My own view is that in the long run, light rail entirely at grade will be a serious mistake in the Central Area of Chicago, an area measuring 3 mi by 1½ mi. We are not talking about a four-block CBD distribution segment for a corridor line-haul light-rail line, in which the last four blocks downtown are really incidental to the performance characteristics that are critical to regional mode-choice decisions.

For a distributor system responsive to the scale of Chicago's Central Area, grade separation versus at-grade operation is a major choice. The higher speeds and service levels offered by grade separation, particularly for those thousands of distribution-circulation trips over a mile in length, afford a service difference that in the long run is worth serious consideration in terms of justifying the higher capital costs of grade separation.

We are struggling locally to get new technology taken seriously as an option. I think these are some of the reasons. This leads to a fourth highlight—new technology implementation is also going to require much more public and private cooperation, mainly from the private side, than in the past.

Sobey mentioned that several years ago he was involved in a form of automated guideway transit planning called personal rapid transit (PRT), and concluded that it was politically and fiscally unacceptable at that time. I believe we are now at a point where we should rethink those kinds of conclusions, and perhaps launch a more intensive R&D effort in these areas.

The regulatory and business environment to encourage innovation still isn't there, particularly in urban transportation. Renewed efforts by the private and public sectors are necessary both for small private automobiles and group travel modes, automated or not.

Sobey also mentions examples of innovative state and local government activities in California, Florida, and Virginia. These examples are the seeds of the cooperative local leadership that we sorely need. We must publicize these examples as having led to technology innovation success stories, and use them to best advantage as good examples of the role of the private sector in successfully moving ahead in new technology.

Koltnow cited the main impediments to implementing new technology as not technological ones at all, but institutional. Here again we get down to involvement by the private and public sectors as well as convincing local elected officials to buy into the long-range potential of new technology.

It seems to come down to selling both the private sector and elected officials on the benefits of new technology. In dealing with both of these decision-making markets, we must argue persuasively for the long-range view of the benefits of expanded capacity and new technology service gains in major travel corridors—the gains of higher productivity from existing as well as future transportation infrastructure.

G. SADLER BRIDGES These two papers are quite different, yet in some respects quite alike. Both papers are similar in that they concentrate on the automobile as the most important form of personal transportation for the year 2020. Many futures conferences have devoted their time to discussing mass transportation, personal rapid transit, high-speed rail, and similar technologies. I think it is a tribute to the practicality of these papers that they have avoided discussion of those technologies and have said that the future is going to be a great deal like the present. Changes will or may take place. However, to a large extent the year 2020 will find those of us still here driving automobiles. They may be "lean" cars powered by fuel cells or they may be controlled in guideways. But the important point is that automobiles will provide the preponderance of personal transportation; neither author foresees that a new technology will take the automobile's place.

The views of both authors have been affected by inflated presentations of future technologies such as helicopters and personal rapid transit. Sobey correctly points out that the computer society has not yet brought about significant cottage industries that show promise for reducing transportation. Koltnow gives us a good description of automatic vehicle control (AVC), but I don't think that he views AVC as being the future.

I agree with the authors that the year 2020 will not be different from 1988. The greatest benefit of the automobile is its flexibility. No other futuristic form of transportation can compete with the automobile on this point. Although other modes can get me to work and back, they do not allow me to stop off and purchase a piece of lumber for a repair project at home. No matter how fast an airplane or high-speed rail system gets me to a city, it is quite likely that I will need an automobile in order to conduct all of my business in that city.

Nevertheless, although I may believe that the automobile is the personal transportation of the future, I do not think that it or its operation will be the same as it has been in 1988. My field is research, and I cannot bring myself to believe that we will not take advantage of the technologies that are available to us. The year 2020 is 32 years away and we should not believe that 2020 will be more like 1988 than 1988 is like 1956. I suggest to you that automobiles differ in more than style; certainly both our urban and intercity transportation systems are different. In 1956, the Interstate highway system was only a piece of legislation, and urban freeways were in their infancy. A modern urban freeway bears little resemblance in design to those early freeways.

Sobey made several interesting predictions, many of which are outside my expertise. I have no ability to evaluate their probability of occurrence;

G. Sadler Bridges is Deputy Director of the Texas Transportation Institute. He has had over 16 years of experience in the transportation field, which includes rail, air, public transit, waterway, and pipeline systems.

however, they do make for some interesting changes in the transportation system. He stressed world-wide production of goods, smaller manufacturing facilities, and greater variety of consumer goods. Obvious changes will be required in goods movement transportation for all of these, and each of the changes translates into more frequent, more flexible, more timely, yet smaller shipment sizes. These changes will cause the future of railroads to be in RailRoaders, according to Sobey. These more diverse manufacturing points also translate into changing patterns of personal transportation. If manufacturing moves overseas, jobs will be lost here. Will those jobs be gained in transportation? In global corporations transportation may become more logistics rather than facilities and modes. Sobey indicated that jobs will be less oriented to large urban areas, with the implication that travel in smaller urban areas may become the problem of the year 2020 rather than travel in larger urban areas as it is in the 1980s. Will the greater variety of consumer goods result in replacement of trips to the shopping mall by trips by United Parcel Service or the pizza man? Will computer shopping permit more recreational trips? Is the future of shopping malls to become indoor sports arenas, not for professional sports, but for the amateur?

Perhaps Sobey's three predictions will contribute to the reduction of urban congestion in the 21 areas that FHWA predicts will be "out of control" by the year 2020, but create congestion in different forms or places.

Koltnow's paper is much closer to the transportation issues that I have knowledge of. He discusses automatic vehicle control (AVC) and the use of AVC to address the problems of urban congestion. I don't think he is completely committed to the position that AVC is the answer to urban congestion of the future. He does agree that it has some promise, should be investigated, and may, when fully developed, move more people past a point on a freeway in a given time, and I agree with him. But he has presented too narrow a view of AVC and urban congestion. I prefer to use the term Advanced Transportation Technology (ATT), which includes AVC as well as any technology that entails communication between the highway system and the vehicle.

I suggest that ATT, in addition to AVC, may contribute to reducing congestion. Many of those benefits do not have to wait until all vehicles and freeways are equipped with proper electronic packages. For example, President Eisenhower created the Interstate highway system in 1956 and by congressional decree it will be completed by 1991. Although 36 years was allotted to complete the Interstate system, many of those benefits were realized in the early years. The same situations will prevail with an advanced highway program. Complete automation of the vehicle and roadway is the goal of the program, but it should be recognized that milestones must be reached early in the program to alleviate urban congestion. Perhaps, for example, instead of completely controlling the vehicle, the system may "give advice" on routes to circumvent congested routes. Anything that can be done to increase or better utilize the capacity of the urban street and highway system will ease urban congestion. As Koltnow stated, rather than control every vehicle on a freeway, perhaps only vehicles traveling in special lane may be controlled. Special vehicles equipped with a collision avoidance system can operate much more safely even when mixed with manually operated vehicles. In this regard, our public transit systems may be the first to adopt the emerging technology.

I am convinced that one of the early gains in technology will come in the management of the urban traffic control system. Today traffic control is essentially a fixed-time system. It is true that strategies are changed for different times of the day, but this is largely changing from one fixed-time plan to another. I suggest that we could make better utilization of the street system if we would develop traffic control strategies that have knowledge of the actual arrival rate of vehicles at the intersections. Once those strategies are developed, just think how they could be improved if the vehicles could communicate their destinations to the controller. Could not the demand be better allocated to the system if the intersection controllers would communicate alternative route information to the vehicle? Benefits from these types of technologies could be realized if only a portion of the vehicles and controllers were equipped with electronics.

I have some problem with Koltnow's use of the term "radar braking." I suggest that "collision avoidance" is a better term and does not limit the technology to radar. There are some collision avoidance systems today that use radar, but I am not convinced that radar is the best technology. Although I am not an expert in radar, I have some trouble with a situation in which every vehicle emits a radar signal. This may avoid collisions with brick walls, but I doubt the ability of radar-equipped vehicles to clear a five-legged intersection. There are other technologies for robotic vision other than radar, including video systems that were used to dock space capsules by NASA.

I also have mixed feelings about in-vehicle navigation. Often this technology is limited to discussions of CRT maps visible to the driver. In view of Sobey's quote that over one-half of the population cannot read a map, there should be a better way of communicating position and course to the driver. For the half of the population who can read a map, I suggest we develop the collision avoidance system before we put CRT maps in the car.

Like both authors, I cannot answer the questions of liability in a system of private vehicles operating over public roads under a guidance system partially located in the vehicle and partially in the road. If we pursue the system, as I think that we should, perhaps the jobs lost to foreign manufacture will be gained in the legal profession.

I agree with Koltnow that there is not yet a focus for national agreement, even among transportation experts on a schedule or plan for technological development. However, I do think that ATT is in our future. Perhaps not all vehicles will be under automatic control by 2020, but at that time a greater amount of communication will exist between the roadway and the automobile. By 2020, we will have some of the benefits of technology assisting us in reducing congestion.

C. MICHAEL WALTON A couple of congestion-reducing options offered by Will Rogers about 65 years ago as he spoke on technology and congestion are "It is reported that in ten years, there will be an automobile for every man, woman, and child in the United States" and "Now all we've got to do is control the birth rate." Further, he suggested that one way to solve the traffic problem would be to keep all the cars that are not paid for off the streets. So perhaps there are some other options to be considered.

If we divide the operating environment of the transportation system into two categories, one would be vehicles (or vessels) and would highlight the technologies associated with guidance control and automation systems. This would include route guidance and communication techniques. The other, the highway or guideway infrastructure, would include technologies such as the AVC and some basic support systems (e.g., satellite reference systems).

Technology should advance efficiency or productivity goals and objectives, or both. However, ability to utilize the various technologies in ways that minimize a host of sociotechnical and related issues is clearly a formidable challenge. One is the benefit side of the cost-benefit equation. One of the more challenging aspects of technology is defining the benefits, which are often difficult and elusive to predict but imperative if we are to ensure that the technology will provide the expected results.

Another issue is the cost of bringing the technology on line. I would imagine that joint initiatives by the public and private sector involving government and industry will be a valuable arrangement for implementing technological advances. The transition period for associated with bringing the technology on line and the impacts on existing institutions and structured arrangements are critical elements that require considerable thought as we venture into new arenas of activity.

C. Michael Walton is Professor of Civil Engineering and Associate Director of the Center for Transportation Research at the University of Texas, Austin. He has been active in TRB both as a committee member and as chairman of study committees and special projects.

Another issue is "the process as a product." This concept may represent another expanding sector as we bring various technologies on line. There can be considerable effort to visualize and then orchestrate a process than can utilize the technology in a fashion to maximize the benefits while minimizing total costs, including social ones. This is a very challenging venture, with a treasure chest of opportunities.

Another objective to successfully visualizing and implementing various technologies is the importance of cooperative efforts on all fronts such as within individual state governments, between states, and between government and industry.

There are other issues, such as performance and safety. In regard to safety, there have been truck accidents attributed to a driver's inattention to driving while using an on-board computer.

There are issues of privacy and security, not only in the new ways and means of identifying and collecting data, but in the transmission of data and its use. Equity is a serious concern to all branches of the private sector. One must explore the effects on equity of any new technology used by government agencies to manage the private sector, such as the motor carrier industry.

I would like to introduce a program that is under way and is testing the feasibility of some selected technologies associated with a heavy-vehicle management system. It is the Heavy Vehicle Electronic License Plate (HELP) program, which involves cooperation between states and the motor carrier industry. The program began by focusing principally on technology but has gone beyond the original objective. What fostered this broadening of scope was the recognition of efficiency, productivity, and sense of opportunity. Principally, the representatives of the state transportation agencies were interested in more efficient ways of collecting data pertinent to highway planning and operations, such as maintenance estimates, pavement design inputs (axle loadings), and so on. The desire to reduce the cost of data collection is as important as the concern for data quality. The same technologies can assist in a number of highway agency tasks, including issuance of permits and hazardous materials movement.

The industry interests in this project are to stay involved so as to better understand the opportunities, if any, that might enhance their operations and their future. Some of the technologies used are automatic vehicle identification (AVI), automatic vehicle classification (AVC), weigh-in-motion (WIM), satellite reference systems, and on-board computers.

With regard to AVI, a $50 electric transponder for placement on vehicles is being developed. There has been some isolated testing of various arrangements using the transponder; the results suggest that most of the impediments are institutional and not necessarily technological.

The demonstration project for HELP, known as the Crescent, is about to begin; the technologies mentioned will be integrated and tested under actual operations. The demonstration project is to test the performance specifications that have been developed as a means of predicting satisfactory results in a larger-scale program.

An important next step, obviously, is not only to test the performance, reliability, and so on, but to design an integrated system consisting of equipment, data, and users that would facilitate an assessment of institutional arrangements that exist within and between states, at different levels of government, and within various elements of the motor carrier sector itself.

In other words, some of the factors being considered in devising the various system scenarios include the scope of the system, the relationship between government and industry sectors, the management of the data base, varying levels of communication, and whether the use of AVI on each truck should be mandatory or voluntary. These factors can be arranged in a number of ways to illustrate the challenges that are afforded in bringing any technology into an existing environment or operating system.

Review of the HELP program and Crescent demonstration project suggests that the implementation of technology is truly challenging, with potential opportunities of significance. It has been encouraging to see opportunities surface and be examined during the deliberation of the HELP program. It has shown that we must have participation between government and industry and joint initiatives between the public and private sectors. Regional efforts, such as those of the National Governors Association (NGA), may have considerable merit for programs like HELP. Government, industry, and university cooperation in research are paramount to a successful venture.

SESSION 8

Resources and Institutional Arrangements

Organizing and Funding Transportation for 2020

JOSEPH R. STOWERS

THE 2020 CONSENSUS PROGRAM is one of the most important decision-making processes in a generation in the transportation field. It is critically important that it be done well and that the results be a product that sets the stage for building, operating, and managing the best possible system for the next century, not just one that is an acceptable follow-on to the Interstate program for all interest groups participating in the 2020 process.

Setting the planning horizon 30-plus years in the future was an excellent idea. It allows freedom to think creatively and to avoid being overly distracted by passing issues of the 1980s. Lessons from the past and from current trends are necessary, but it must be recognized that 30 years will certainly bring dramatic changes that are difficult, if not impossible, to foresee. Wilfred Owen put it well in a presentation to the American Association of State Highway and Transportation Officials (AASHTO) in 1987. He said (*1*):

> Visualizing the transportation future is risky business, and the speed of change in recent years is making things worse. People are not comfortable with change, and history explains why. For sixty-eight hundred years following the invention of the wheel, humanity made almost no progress in transportation. People kept pushing and pulling wheeled carts, or getting animals to help. But once the railroads introduced a mechanized means of transport, the rate of change picked up. It was only 80 years from the railway age to the motor one, 40 years from the motor age to the age of commercial flight, and 20 years from the air age to the first travels in space. The 33 years that the 2020 program must anticipate seems like an eternity.

Joseph R. Stowers is President of SYDEC, Inc., a transportation consulting firm in Reston, Virginia. Before that, he was with the Office of the Secretary, U.S. Department of Transportation.

Too many transportation planners are inclined to see the future as an extrapolation of trends. That is what they do, basically, when they prepare most of their forecasts for projects. It is a mistake to apply the same thought process in planning the program for 2020. Much of the future transportation system has already been built, and it is true that the system has a lot of inertia. However, that should not prevent fresh thinking about how to organize for a future that will certainly involve many important changes as well. A status quo arrangement should not be advocated without thorough consideration and evaluation of alternatives that arise from new opportunities and new perspectives.

It was also an excellent idea to involve all interested groups from both the private and public sectors. This should help ensure the broadest possible support for whatever program emerges as the consensus from this process. However, the danger of ending up with a least-common-denominator program—one that is just acceptable to everyone—should be avoided. This danger is very real if each group approaches the effort as if it were a typical Washington negotiating process, trying to protect the interests of a constituency. There is a need to do far more than that—to participate creatively in bringing ideas and solutions from the best of each area involved. The challenge is to synthesize the best of these ideas and solutions into an imaginative program that will stimulate a new generation of transportation professionals.

Despite great accomplishments over the last generation, the old set of arrangements is showing signs of trouble. There are strains in some relationships. Some aspects of current programs have been discredited. A cosmetic approach in dealing with these problems will not provide a successful basis to get needed support for an expanded, long-term funding program.

This discussion is divided into two basic categories: (a) assessment of the current situation and (b) prospects under each of the two topics of this session: resources and organization.

RESOURCES

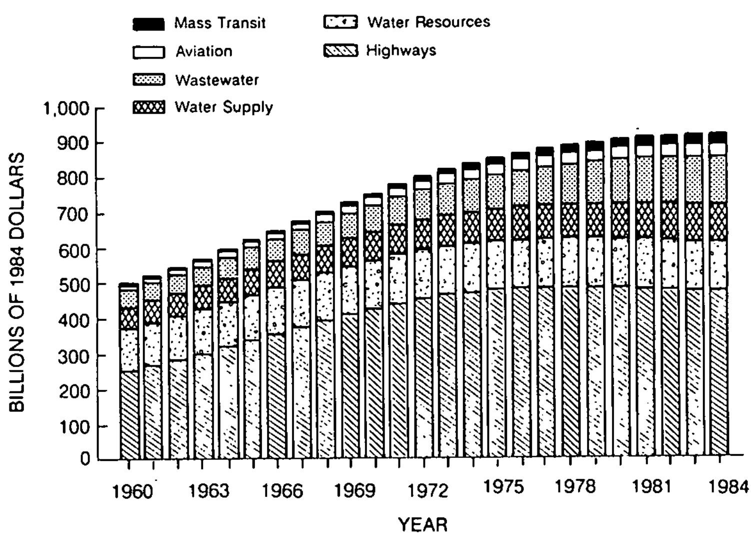
Assessment of Current Situation

In discussing resources, the focus tends to be on finance because of the importance of funding to all resources—land, labor, and capital. However, the components of resources all need some attention in the current situation. Thus this assessment will include recent trends in financial resources, condition of the system, resource allocation capabilities, human resources and understanding, availability of land, and highway user revenues.

Financial Resources As Figure 1 shows, U.S. Department of Commerce data for 1960 to 1964 indicate that net capital assets in transportation reached a plateau after several years of steady increase. Assets for highways reached a peak in the late 1970s and dropped off slightly in constant dollar terms in the early 1980s, whereas mass transit assets continued to grow, resulting in little total change over the last few years in constant dollars for these two modes combined.

Trends in expenditures by government (omitting private expenditures) portray somewhat more dismal trends, at least until the early 1980s. Figure 2 (2) shows that federal and other governments steadily reduced expenditures for highways for more than a decade. Total federal expenditures reached a peak in 1965 in constant dollars and then declined by about a third, whereas other government expenditures peaked in 1972 and declined more than 20 percent. As indicated in Figure 3 (*3*), these down trends in expenditures resulted in a more severe decrease in capital expenditures because of the priority given to maintenance and operation of the system. Capital expenditures for highways by all levels of government were almost cut in half between 1968 and 1982 in real terms.

The picture is much worse when expenditures are related to the growth of the economy as a whole, because the economy has grown steadily despite



SOURCE: U.S. Department of Commerce, Office of Business Analysis

FIGURE 1 Public works net capital assets, 1960–1984. (Solid waste net capital assets could not be shown on this graph; they increased from $0 in 1960 to about $2.3 billion in 1984.)

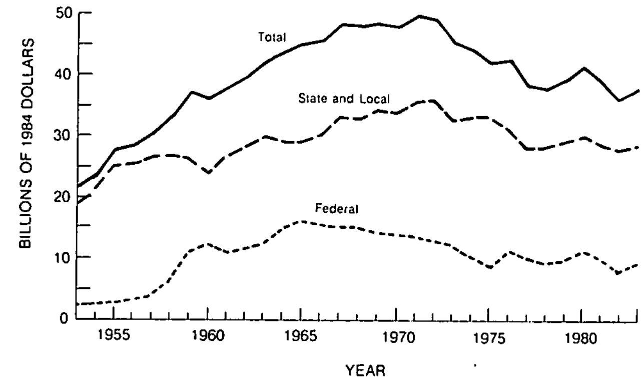


FIGURE 2 Public spending for highways by level of government, fiscal years 1953–1983 (2).

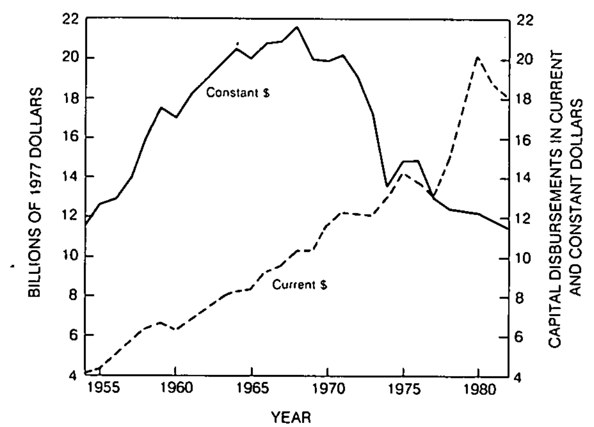


FIGURE 3 Capital expenditures by all levels of government for highways, 1954–1982 (3).

these substantial reductions in capital investment. However, this trend can probably not be maintained for long. Over the long term there has been a high correlation between transportation investment and the economic prosperity of nations. The current level of highway expenditures as a percentage of the gross national product (GNP) is well below that in several industrialized countries, including Japan, Austria, and Switzerland, which are far more rail-oriented (*4*, p. 126). Figure 4 shows that both total highway expenditures and total highway user revenues have recently dropped to about half the level of the late 1950s in real terms.

Condition of the System The average rating of pavements on the Interstate system declined steadily during the 1975–1983 period. As Table 1 (5) shows, the rating declined from 3.4 in 1975 to 3.3 in 1978 to 3.2 in 1983 for rural Interstates and 3.4 to 3.3 to 3.0 over the same period for urban Interstates. However, the picture was not as bad, at least in terms of pavement, for other

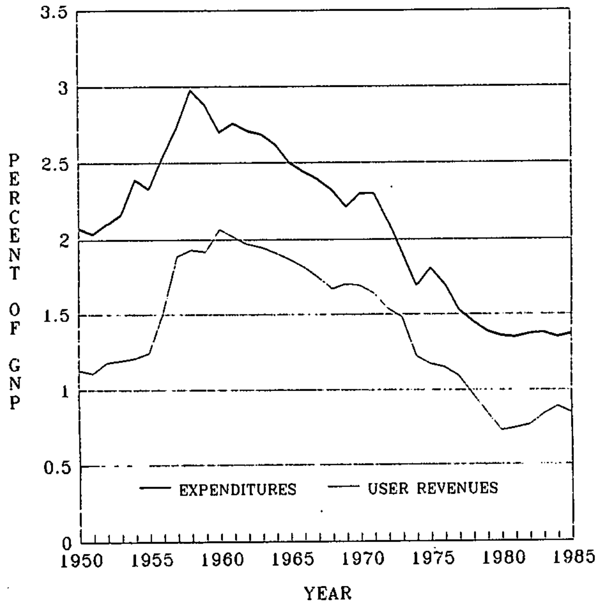


FIGURE 4 Trend of total highway expenditures and highway user revenues as a percentage of GNP. (Source: Sydec, Inc., based on data from FHWA and the Bureau of Economic Analysis.)

TABLE 1 Highway Pavement Condition by System in 1975, 1978, and 1983 (*5*, pp. 47–48)

	Average Pavement Rating		
Functional System	1975	1978	1983
Interstate			
Rural	3.4	3.3	3.2
Urban	3.4	3.3	3.0
Other arterials			
Rural	3.0	3.0	3.0
Urban	3.0	3.0	3.0
Collectors			
Rural	2.6	2.6	2.7
Urban	2.7	2.6	2.8
All systems	2.8	2.8	2.8

roads, which have either held their own on the average or improved slightly in the case of both urban and rural collectors. These data demonstrate that despite the major effort devoted to pavement rehabilitation and resurfacing under the Interstate program for resurfacing, restoration, rehabilitation, and reconstruction (4R), traffic volumes and axle loads are so high on these highways that the level of funding had to be substantially increased to maintain the average condition (*5*).

The generally negative trends described above have been reversed to some extent in the last few years as a result of federal revenue increases enacted in 1982. As a result of the nickel gasoline-tax increase and other measures, federal Highway Trust Fund revenues increased by about half from 1982 to 1985 in real terms. In large part as a response to the federal action, state expenditures increased by more than 20 percent in real terms over this 3-year period. State capital expenditures increased by about 30 percent.

Meanwhile, FHWA's report for 1985 on pavement condition indicates that substantial improvements were made in terms of average condition and the proportion of miles in poor condition since 1983.

These recent indicators of improvements are encouraging. However, there can be little confidence in future directions of transportation programs when annual appropriations are continually subject to political games and efforts to make the budget deficit appear lower by allowing the trust fund to accumulate unused highway user revenues (which are now at about the $10 billion level).

Trends regarding bridge conditions lead to mixed conclusions. The number of deficient bridges on all highway systems declined somewhat from 1984 to 1985, whereas the overall level of need increased about 5 percent in current dollar terms (*4*, pp. 38–44). When inflation is taken into account, little overall change is indicated. The credibility of the program, however, has suffered recently as a result of a few highly publicized bridge collapses and evidence that required inspections have sometimes been lax.

The clearest and most persistent trend is increasing levels of congestion throughout the highway system, but particularly in growing suburban areas and urbanizing intercity corridors. This has been a long-term trend because the growth in vehicle miles of travel (VMT) has greatly outpaced the rate at which capacity has been added. Table 2 (*6*) shows that congestion continued to increase on every functional class of highway even during the 1983–1985 period after both federal and state capital expenditures had started increasing again.

Although transit systems have generally improved in terms of quality of service, age of equipment, and accessibility for the handicapped, almost every measure of productivity has declined. Trips per bus mile decreased 0.8 percent per year from 1970 to 1983. Labor productivity fell from nearly 14,000 vehicle-mi per employee to less than 11,000 vehicle-mi from 1965 to 1983.

TABLE 2 Increased Percentage of Road Miles at High Volume/Capacity Ratio, 1983–1985 (6)

	Percentage of Miles with High V/C[a]	
	1983	1985
Rural		
Interstate-rural	3.8	5.3
Other principal arterial	3.7	4.8
Minor arterial	2.8	3.5
Major collector	0.8	1.0
Minor collector	0.1	1.0
Urban		
Interstate-urban	36.9	43.9
Other freeway or expressway	25.7	31.5
Other principal arterial	34.0	35.9
Minor arterial	20.0	21.3
Collector	7.6	8.7

[a] V/C ratios greater than 0.70.

Real costs per passenger more than doubled from 1970 to 1983 (7, p. 54). There is little hope of reversing these trends because of fundamental changes taking place in the restructuring of metropolitan areas. In most cases, stabilizing these productivity measures will be difficult.

Resource Allocation Capabilities One of the most discouraging trends has been the increasing political interference by Congress and others in the management of both the highway and transit programs. The worst examples are the recent rapid increases in the earmarking of appropriated funds for specific projects under the guise of demonstration projects in the case of highways and of new rail starts in the case of transit. This trend is disruptive to national investment decision making and creates a public image that both are pork barrel programs.

Ironically, this trend occurs at a time when both agencies have made significant strides in developing methods for rational investment analyses:

- The Federal Highway Administration (FHWA) Highway Performance Monitoring System (HPMS), which includes an analytical package for assessing various national program investment strategies in terms of benefits, costs, and other evaluation measures; and
- The Urban Mass Transportation Administration (UMTA) Procedures and Technical Methods for Transit Project Planning, which provide guidance for a systematic analytical approach to evaluating alternative investments at both the local and federal levels.

Both methods are imperfect. Elizabeth Deakin has noted several shortcomings of the HPMS, including omission of local streets and roads and lack of consideration of roads on new alignments, transit, transportation system management (TSM), and goals related to land development and economic growth (*8*, p. 17). Douglas Lee faults HPMS because it (*9*, pp. 4–5) "does not tackle directly the issue of existing segments that are not worth improving because of low traffic volumes." He also criticizes the system for not addressing the issue of what standards are optimal from a benefit-cost standpoint. (The user is apparently required to perform sensitivity analyses on standards to determine their effects on user benefits and highway costs.) UMTA's guidelines for evaluating transit investments have been criticized by the Congressional Budget Office (CBO) for failing to discount the time stream of benefits and costs to a common year (*5*, pp. 36–38). In a recent review of UMTA's guidelines, Sydec, Inc. interviewed most of those who have used the guidelines and reported numerous criticisms and several recommendations for improvements (*8*). Three shortcomings are stressed:

- UMTA should not insist on the use of a TSM alternative as the sole baseline for evaluating all alternatives.
- The evaluation is too restrictive in focusing on short-term benefits relating only to ridership and excluding such other important factors as equity, service to the disadvantaged, and long-range land use and system benefits.
- The single aggregate cost-effectiveness measure is inappropriate because of the obscure way in which it is defined and because of what is left out. (It is a composite measure based on several alternatives considered along a "frontier" ranging from low-cost options to most costly guideway systems.)

Another related problem that arose in some metropolitan areas in administration of UMTA's guidelines was lack of coordination between UMTA and FHWA when projects were being considered that potentially involved both programs. On occasion this has been a major obstacle to promising projects. This is but one of many areas in which different modes of transportation continue to be analyzed and planned separately, resulting in too many missed opportunities. What happens at the federal level is often repeated at the state and local levels because of the close interrelationships involved.

Human Resources and Understanding Shortcomings in human resources have long been a problem in the transit field because of its long-term decline; resources are becoming a serious problem in the highway field also with the aging of professionals who entered during the rapid-growth period of the 1950s and early 1960s. Because of demographic trends and the lack of major attractions in this field, young professionals are in increasingly short supply. To just keep up with the 1985 level (*9*), "the degree award rate would have to increase by 30 percent by the mid-1990s." A related problem is that many public-sector transportation agencies tend to focus their recruitment programs and their professional requirements for advancement too narrowly on civil engineering and exclude other disciplines that are increasingly important (e.g., economics, materials science, mechanical and electrical engineering, planning, and business). But even in the civil engineering field, the level of recruitment and professional training has dropped off in recent years, and future leaders are not developing at the rate of a few years ago.

Similarly, research efforts have diminished except for the Strategic Highway Research Program (SHRP), which covers just part of the spectrum of long-run needs in surface transportation. According to a recent General Accounting Office report, federal funding for transportation research declined about 40 percent in constant dollars between 1980 and 1987 (*10*). Figure 5 shows the trends during this period for all major federal programs.

A particular area that is getting less attention than it deserves is the development of evolutionary guideway technology, including technology for enforcement of high-occupancy-vehicle (HOV) lane use, coupling of buses in

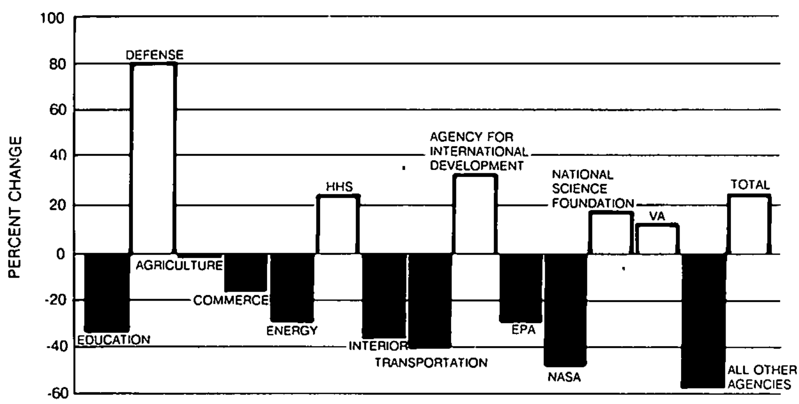


FIGURE 5 Changing priorities for federal R&D funding: percentage change in budget obligations for R&D, 1980–1987 (*10*). (Note: based on percentage change in constant 1980 dollars and not including departments or agencies with R&D budget obligations of less than $10 million. Source: Office of Management and Budget.)

trains, transition to guideway controls on busways and HOV lanes, as well as advances in existing forms of automated transit guideway systems. Discussion of R&D programs is somewhat tangential to the issue of resources, but not unrelated. Good R&D programs are important in attracting and improving human resources and in ensuring effective utilization of all future resources.

One of the more positive trends over the last several years has been a substantial improvement in the understanding of transportation as a result of cumulative experience and results from research. Better analytical tools have been developed for predicting responses to system changes of all kinds and for estimating the full range of important impacts. There is a wide array of useful models, software, documentation, and literature available for all professionals in the field. Much remains to be done to improve this material and extend its range of application, but it appears that the plateau that was the goal 25 years ago during the peak rate of expansion of the transportation system has been reached. However, on the down side, the transportation data base is currently suffering from cutbacks in budgets for the census and other data collection programs, including continuing planning programs. Unless this trend is reversed, the understanding and modeling capability will decline in the near future.

There is also a fairly good communications system for distributing material among professionals in the field. However, it consists of a complex array of channels and sources. TRB does a reasonable job of trying to keep in touch with all of them, but is not completely successful. There are still at least half a dozen organizations (mostly in the Washington, D.C. area) to canvass in any particular subject area if one wants to be sure to be abreast of current research and practice. Much more could be done to consolidate technical information systems and improve their accessibility, particularly for persons who are not experienced researchers, for example, practicing professionals and business people.

The need to improve communication with elected officials and other nonprofessionals with an interest in transportation is much greater. Everyone thinks of himself as knowledgeable about transportation, but the level of understanding is abysmally low in many important areas such as costs of construction and transit operations, traffic behavior under congested conditions, pricing and tolls, signalization and control systems, ramp metering, HOV performance and effects, and new automated systems. Much-improved communication is necessary to get the needed support for promising options.

Land The availability and cost of the right-of-way (ROW) for transportation improvements are much-neglected topics over the last several years. Much greater emphasis was placed on reserving the ROW in the 1950s and

1960s for Interstate routes and other planned freeways. In many metropolitan areas, the comprehensive, continuing, and cooperative (3C) process resulted in early reservation of the ROW for future highways for which no funding yet existed. In one community, an old outer beltway alignment became a major surface arterial 25 years later. At one time, the 3C process appeared to be working so well that fights over future highway alignments might never happen again. Then the process almost came to a halt and planned routes were often removed from master plans. Now the lessons of the 1950s and 1960s are about to be relearned in the response to rapid increases in congestion. Alignments for future roads and transit facilities are going to be increasingly costly and politically difficult to acquire.

Meanwhile, the ability to reserve the ROW has not improved. Requirements of the Environmental Impact Statements make it difficult, if not impossible, to use federal (and often state) funds for early ROW acquisition. No special programs exist for doing so. HOV facilities have been found to be among the greatest transportation resources wherever space for them can be found. Yet very little attention has been paid to the planning of future HOV facilities in corridors that have yet to become congested or to the need to reserve space in transportation corridors for other forms of future transportation technology.

User Revenues and Other Sources One of the strongest aspects of the highway program has been the dedication of highway user revenues through the federal Highway Trust Fund and through parallel funding mechanisms in most states. The trust fund has often been cited as a model financing mechanism for other public works programs because those who benefit most directly are paying the full costs of the federal program, because it has established program continuity on a multiyear basis, and because it has resulted in continuing support among those being taxed—including support for occasional tax increases to adjust programming toward prior levels. The trust fund also achieves support from economists, who argue that economic efficiency is achieved by having users subjected to the discipline of paying for the system based on their use of the system.

The highway program has also been credited with being innovative in the sense that changing needs have resulted in broadening and changing the assistance programs over time (5, pp. 73–75). Traffic safety, bridge reconstruction, rehabilitation of state and local networks, and rehabilitation of the Interstate system are cited as examples of how the program has responded to emerging needs. However, CBO notes that the addition of these new programs has merely resulted in diluting old programs because the number of funding categories has grown each time, whereas the revenues dedicated to the trust fund have generally remained the same and gradually shrunk in real terms.

The program has had its credibility greatly diminished lately as a result of the pork barrel approach being taken by Congress and mentioned earlier, and as a result of successful efforts to divert Highway Trust Fund revenues for transit and other purposes.

If the trust fund has merit because of the degree of discipline and economic efficiency that it fosters in program management, it also tends to discourage solid investment analysis for major projects or program components. The flow of revenues into the fund tends to be the controlling factor in determining the scope of the program and the targets that are set (e.g., completion of the Interstate system). Often no real economic analysis goes into even the most important of such funding decisions.

Cost-allocation studies have helped clarify the issues of what specific set of highway user taxes is most equitable. As a result of recent cost-allocation studies, federal highway user taxes have become somewhat more effectively distributed. Figure 6 shows an estimate of the trends in revenues obtained from major classes of vehicles during the last decade, with the biggest changes

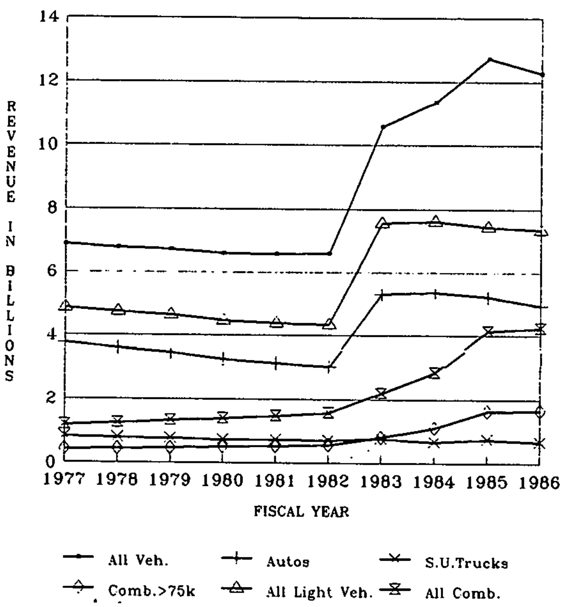


FIGURE 6 Trends in federal highway user revenue by major class of vehicle. (Source: Sydec, Inc., based on FHWA data.)

resulting from the nickel fuel tax increase in 1983, the 6-cent diesel differential increment in 1984, and the 2 percent increase in fees on new trucks and trailers in 1983. Figure 7 shows the same estimates of the trends in terms of percentage share of federal revenue. The share of taxes paid by automobiles, other light vehicles, and single-unit trucks has gradually decreased, whereas the share by combination trucks has doubled. The share paid by combination trucks registered at 75,000 lb or more has increased at an even higher rate (from 6.1 to 13.6 percent), primarily because of a more rapid increase in highway use.

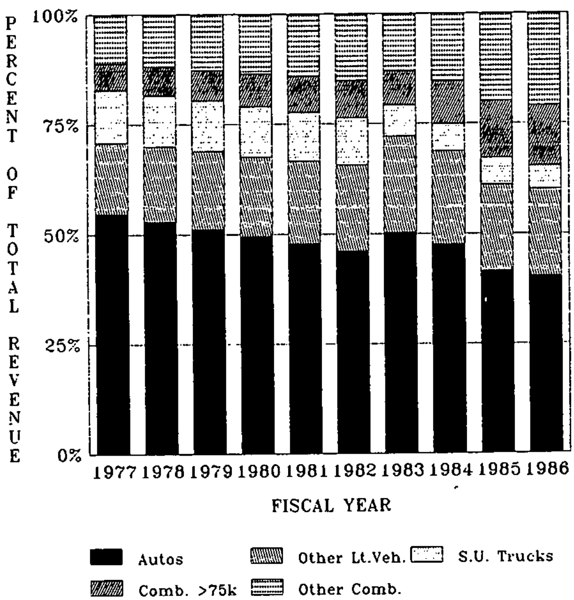


FIGURE 7 Trends in shares of federal revenue by major class of vehicle. (Source: Sydec, Inc., based on FHWA data.)

Continuing research by FHWA and others will undoubtedly result in further improvements in the understanding of the cost responsibility of vehicle classes and other categories of highway users. This will most likely result in further refinements of the linkage between cost responsibilities and user taxes, which will tend to improve the credibility and support for user-based financing of all highway programs.

But user financing is by no means the only game in town. Largely as a result of the decrease in the share of highway needs that have been met by the trust fund over the last few decades, increasing attention has been focused on other sources. The recent trend away from user-tax financing at all levels of government combined is shown by the following tabulation of change from 1978 to 1983 in highway receipts (*11*, p. 119).

Category of Receipts	*Increase (%)*
Road-user tax revenues	29.5
Tolls	24.7
Appropriations from general funds	49.4
Property taxes	42.1
Other and miscellaneous	72.0
Total current income	37.8

Receipts from the two specific nonuser categories (general funds and property taxes) grew roughly twice as fast between 1978 and 1983 as road-user tax revenues and tolls (which are more purely user charges). The even more rapid growth of the "other and miscellaneous" category epitomizes the search for new revenue sources in a period of shrinking traditional tax base.

The most intense recent consideration of alternative highway financing mechanisms occurred at AASHTO's Smuggler's Notch conference. For three days, 150 invited participants met to consider this subject, representing state highway and transportation agencies, legislatures, governors' and budget offices, universities and research organizations, highway development associations, and the private sector. Sessions were held on each of five funding mechanisms: user fees, nonuser fees, special-benefit fees, private participation, and debt financing. The findings of the conference, which are well reasoned and well substantiated in the conference report (*11*, pp. 4–5), are summarized as follows:

- User fees have been and remain the most promising and among the most equitable sources of highway funding.
- Nontraditional funding sources are a supplement to, not a replacement for, traditional sources.
- Weight-distance taxation can be a useful third structure tax when an equitable revenue base is shaped. The feasibility of such a tax at the national level is currently being investigated. Several states have weight-distance taxes, and efforts are being made to promote uniformity among them and other prospective user-states.
- Most nonuser fees are unstable; however, sales taxes pledged to specific transportation projects or programs offer potential revenues to states.
- Before general funds can be used effectively, a commonly accepted relationship between receipts and needs is necessary.
- It is reasonable to require developers to pay fees or make contributions such as donated rights-of-way for highway improvements that will benefit them.

- It is important to monitor developers closely and not to permit them to control priorities, standards, and decisions.
- In utilizing private participation for highway financing, highway agencies will be more likely to assume the position of facilitator rather than initiator.
- Highway programs can be expected to be more successful if they are presented as products of a process that combines sound engineering with sound fiscal management.
- Highway agencies could benefit by developing sound financial management plans, and highway managers could effectively spend more time doing financial planning.
- A marketing program that identifies a clear need, outlines a specific plan for meeting that need, and includes a highly visible campaign to promote the plan can be very useful in attracting needed program support.
- Highway programs could be better received if they reflected an awareness of the relationship to policy issues such as economic development and tourism.
- Highway personnel and developers could benefit from training seminars and a reference manual that defines terms, describes statistics and techniques of modern highway financing, and discusses overall strategies for seeking new sources.

A positive consequence of the financing problems that has occurred in recent years is the development of innovative approaches, particularly in private financing of highways, more sophisticated bond financing programs, and toll financing. Many of these efforts are documented in AASHTO's Smuggler's Notch conference report.

Despite these contributions, nonuser financing of highways has definite limitations in terms of both amounts and rationale.

Public-private ventures are not a reliable or predictable source of funding and have applicability primarily at the local level. They are more subject to changes in economic conditions than any other source. Under very favorable conditions and assumptions, they might generate as much as 1.5 percent of total receipts for highways (*12*).

Toll-road financing has seen a recent resurgence. However, projects now require much higher traffic volumes (as much as 100,000 vehicles per day compared with about 20,000 in an earlier period) or land value capture financing, because of higher costs and the competition of a more complete network of "free" roads (*13*, p. 5). There are relatively few opportunities for such projects nationally.

Privatization of highway and toll-road financing also often raises issues regarding distortion of priorities for use of matching public funds or tax subsidies, or conflict with the public interest with regard to some aspect of the design or alignment of the facility.

There is little argument in favor of nonuser financing of highways other than shortfalls in user taxes and political expediency. As documented in the federal cost-allocation report to Congress, direct nonuser cost responsibility is a small percentage of federal highway expenditures (*14*, pp. F-1 to F-35). The support for charging nonusers with cost responsibility for local access roads and streets is primarily a matter of historical precedent and expediency rather than any rational economic argument. Gary Allen put the case in stronger terms (*15*, p. 33):

> The most disconcerting aspect of the debate is the subtle, but forceful, suggestion that "innovative mechanisms" will be the savior of highway finance. The other side of the coin is the implication that user taxes will not work. This policy drift is unnecessary, notwithstanding its political expediency. It is inappropriate from an economic perspective. Of even greater concern, however, is the implication that somehow we can have highways without paying for them. In other words, we can have highways if property owners, developers, or consumers pay for them.

Finally, it should be recognized that the focus of attention on nonuser sources in the last few years is primarily due to two factors:

- Highway user revenues were tied to fuel consumption and other measures that were either shrinking or growing at rates slower than highway needs.
- Transportation officials and other interested parties did not make the case for increased user taxes effectively enough to Congress, the state legislatures, and other important decision makers.

Neither of these two factors should be presumed to continue in planning for the 2020 program.

Prospects

The prospects for achieving a high-quality long-range surface transportation program that meets the resource-related objectives of the 2020 program are not at all clear. Many of the trends and current conditions present significant obstacles. A critical factor in the likely success is the direction chosen by the leaders of the 2020 program. If others perceive the 2020 program to be narrowly defined in terms of the self-interest of the participating organizations, it is likely to fail. But if the program is perceived to be truly directed at achieving important societal goals, it is likely to succeed.

The involvement of such a broad base of interest groups can be an asset in helping to define a program that is perceived to reflect important societal goals. It is far less likely that a program will evolve that can clearly be identified with any particular narrow interest or professional discipline. However, the danger of developing a least-common-denominator program still exists. The process cannot be allowed to bog down and become nothing more than political bargaining over formulas for allocating funds. The process needs to be a creative, positive effort at achieving goals that are shared broadly as a society and that are achievable through transportation programs and through coordinated efforts with others.

To make this work, the goals should be as specific and clear as possible. They should not be a collection of every group's wish list. A few well-defined goals that are achievable should be the basis for clarity in defining the 2020 program, allowing more detailed program objectives to flow logically from these consensus goals.

In his closing remarks at the Smuggler's Notch conference, Tom Larson put it very well (*16*, p. 241):

> One of our underlying problems is that we don't have a complete understanding of what our product is. Our most visible product is the Interstate System, and we are in the midst of dealing with that now. But another issue is the process: how we talk about things is how we see them and how the public sees them. We keep saying our business is more money, and that is what people believe. We used to sell the Interstate System on the fact that it is vital to national defense, and that service would be better than ever—and that worked. Now there seems to be a growing mismatch between expectations and delivery, and people who have problems with what is delivered are more likely to litigate those problems. We have to articulate our product in new ways using new metaphors; then we will have a better chance of gaining support.
>
> Any leader has to have a vision. Unfortunately, our vision normally is that we know we have to meet citizens' expectations, whatever they are. Then we spend time strategizing how to extract more money from the population so we can satisfy our view of their needs. There are some real problems with this vision. We need to sharpen it, and we need to have a lot of dialogue about it.

It is hoped that the vision will begin to emerge from this conference, although not much evidence of it has been seen yet. The Smuggler's Notch conference did not set that as an objective and did not produce it. The three alternatives for 2020 defined and discussed in the report of the National Council on Public Works Improvement seem to be examples of what Larson says the problem is—different strategies for extracting more money from the population—rather than alternative visions of how transportation can achieve societal goals (*4*, pp. 88–89).

However, there is some material on alternative futures that deserves more attention. Robert M. Winick has transmitted some thoughtful comments to Lester P. Lamm on behalf of the American Planning Association (APA) Transportation Planning Division that stress:

1. Requirements for a successful 2020 planning process:
   - Transportation as a means, not an end
   - Transportation–land use relationships
   - Sound technical analysis and research
   - A cooperative, intergovernmental, public-private process
2. Issues, problems, opportunities, and relationships:
   - Having a transportation system that serves people
   - Serving people's activities at different land uses
   - Keeping different land uses as livable places
   - Funding responsibilities
   - Technological and institutional innovations
3. Defining alternatives for the transportation 2020 process:
   - More of the same scenario
   - Congestion-relief scenario
   - Acceptable-congestion scenario
   - Alternative approaches (based on investment strategies or levels, energy use, and metropolitan form and structure)

Some further thought should go into refining the options outlined by this group to incorporate the best ideas from the background discussion on the planning process and issues and opportunities. The two need to be brought together to work toward the objectives for this process.

Owen has articulated the clearest vision of what 2020 might be like as a result of an imaginative program that sees transportation as a key element in achieving societal goals (*1*). He emphasizes the use of emerging technologies and new organizational forms to achieve redesign and rebuilding of more livable cities and new communities along new high-speed intercity corridors. Even if there is doubt that all of his technological advances can be achieved by 2020, his approach is one that should be pursued to see where it leads in defining goal-oriented programs, including resource-allocation mechanisms and organizational relationships.

Deakin has defined three alternatives for future highway programs based on her review of discussions to date. Two of them have been put forward by representatives of major organizations (emphasis on a highway network of national significance and returning of lower-level systems to states). The third involves a major emphasis on economic and community development objectives (*8*, pp. 12–13). This third option is characterized as "defining a federal role centered on economic development and redefining systems—Interstate, urban, and rural." She describes the option as follows:

> Like the other options, the preservation of the Interstate system would be assured under this proposal. In addition, however, emphasis would be put on redefining urban and rural systems to better meet the economic objectives of each area. This option would eliminate the strictures and biases introduced by the current system definitions and matching funds rules, providing flexibility to use funds on cost-effective projects on any part of the urban and rural systems. Proponents argue that this option would permit operating strategies and network and corridor strategies to be effectively utilized, and perhaps could allow transportation and development to be linked more effectively. They also suggest that opportunities for introducing new technologies, and for developing proposals that the public would be willing to fund, are critical to the success of any future highway program and would be enhanced by this option.

Deakin goes on to review FHWA's estimate of the distribution of highway needs among the functional classes and concludes that the first two options would (*8*, pp. 13–15)

> substantially detract from the nation's ability to meet its highway needs. . . . Neither proposal offers a clear direction for the rest of the nation's highways. . . . The third option offers some hope . . . [and] assumes an aggressive attempt to increase funds for all highways, with a 'market pull' effect supporting the effort as the public sees opportunities for better transportation and a better economy. It is the most radical change of direction of the three options, but it also seems to offer the highest potential for benefit.

Deakin's third option is based largely on proposals put forward by Lawrence D. Dahms and William F. Hein. Dahms suggests that three programs be defined—Interstate, urban, and rural. The urban program should be very flexible and require a higher local match to ensure local commitment and responsibility. He sees the current system as forcing non-cost-effective expenditures such as widening of urban freeways, and calls for funding that will encourage more cost-effective solutions, such as developing complementary arterial systems, and improvements that are more sensitive to fragile urban environments. Hein argues that such a program requires support from the federal government because of its proven capacity to raise revenues and leverage state funds (*17*). He urges that state and local cooperation be required in defining networks, deciding where to encourage development, and establishing priorities.

The available objective evidence clearly points toward an economic warrant for substantially increased resources for surface transportation.

The National Council on Public Works Improvement, noting that national spending for public works dropped from about 3.8 percent of the GNP in the early 1960s to about 2.6 percent in 1985 (about one-third), concluded that a national commitment should be made (*4*, p. 2) "to vastly improve America's infrastructure. Such a commitment could require an increase of up to 100 percent in the amount of capital the nation invests each year in new and existing public works." Although the council reaches no specific conclusion on the amount by which highway expenditures should be increased, highway capital spending in 1985 was slightly more than half of estimated total public works capital spending by all levels of government combined.

FHWA's most recent analysis of national highway needs results in a finding that added expenditures are warranted in benefit-cost terms on each functional class for every level of higher expenditure analyzed (*18*, p. 9). Increasing expenditures from 10 to 30 percent above current levels yield benefit-cost ratios for the various functional classes that range from 1.9 to 9.6. Further increases to "full needs" expenditures yield benefit-cost ratios that range from 1.3 to 6.0. These expenditures are 128 to 159 percent above current levels (depending on whether or not "constrained" urbanized area routes are assumed to be widened in areas where abutting land development could make such widening infeasible). Some level of expenditures above these levels would be warranted in benefit-cost terms.

In FHWA's last major previous analysis of needs, current expenditure levels of $14.6 billion were estimated to have to be increased by 35 percent to maintain average 1983 physical conditions, by 113 percent to maintain average 1983 user costs, by 134 percent to satisfy "full needs" with constraints on widening, and by 203 percent if these constraints were omitted (*19*).

Several shortcomings of the FHWA needs study have been cited by different reviewers, but none of them lead to suggestions that these conclusions are off by an order of magnitude. They omit consideration of transit, TSM, and local roads and streets. On the whole, the criticisms would seem to point to an underestimate of the level that is warranted economically, and an even greater underestimate in the level of user-fee increases that are warranted. The only recent analysis that suggests a lower level was given by Arlee Reno in his paper for this conference. He analyzes factors involved in future mobility and concludes that FHWA's analysis implies more time being spent in travel than his analysis, which takes into account some limiting factors, such as increasing congestion. These limiting factors could result in a lower growth of vehicle miles of travel and hours of delay, and therefore could reduce some of the benefit-cost estimates. Nonetheless, Reno concludes that a level of user fees about one and a half to two times today's levels appears reasonable.

Almost everyone who comments on the subject concludes that more analysis is needed (particularly the analysts). It is hard to argue with that, but the range of uncertainty is probably not going to be narrowed down very much in the next couple of years, given the state of the art and the level of effort that is likely to go into the work.

A fairly simple but rational goal should be sought for future funding. It need not be the product of one grand benefit-cost analysis, but should reflect a consensus based on the best available evidence. A suggested target is to raise surface transportation expenditures back to the share of the GNP that they had in the late 1950s and early 1960s and to establish a user tax structure that would increase over a reasonable period to cover at least all of the federal and state share of those expenditures. Moreover, a policy should be adopted of providing local governments with the capacity for raising needed transportation revenues from a combination of user fees (including tolls) and other transportation-related sources such as impact fees.

Such a goal will be easy for the public to understand and can be readily related to economic and development objectives. Stating the goal in these terms should help devise a financial plan that will be less permanently tied to measures that will shrink over time in real terms. It could also help facilitate periodic adjustments as future analysis and trends suggest.

As was shown in Figure 4, this goal would require almost a doubling of current expenditures by all levels of government as a whole as a percentage of the GNP and almost a threefold increase in user taxes.

ORGANIZATION

Assessment of Current Situation

The federal-state partnership relationship in the highway program has been an excellent model that is often cited as an ideal for other programs. However, some aspects of this relationship began to deteriorate as the main focus of the program shifted away from the clearly defined goal of completing the Interstate system. In addition to the previously mentioned congressional interference in earmarking more and more funds for specific projects, this deterioration has been marked by occasional fights over individual, controversial Interstate projects and substitution transit projects, excessive involvement of largely unrelated political issues in the process of considering regular biennial authorizing legislation, and difficulty in getting agreement within AASHTO on allocation formulas and other policy matters.

Relations between the U.S. Department of Transportation (DOT) and industries involved in ground transportation have been poor in the past but have begun to improve in recent years. Some cooperative projects have been initiated, advisory committees have been set up or recognized to provide better communications, and FHWA has been reorganized to be better able to deal with industry-related issues. UMTA has placed major emphasis on private-sector involvement in its program and in all aspects of urban transportation.

In part because of reductions in federal funding and in part because of changing economic, demographic, and political conditions, the states have been playing an increasingly important role in transit. State financial support for transit has recently passed the federal level. Transit associations have been established within many states to share expertise and information and to address common issues at the state level. States have also become much more active in other ground transportation issues and programs, including preservation of rail services, short-line rail operations, acquisition of abandoned rail ROW for other uses, and commuter rail services.

Metropolitan planning organizations (MPOs) have been through an often-difficult shakedown period because of loss of federal support and deemphasis of their role in urban transportation decision making. Some have suffered badly or disappeared (in fact or in practical terms), but most have survived, often with modified programs as service agencies and consultants to local governments and others. The fact that most have survived has proven the validity of the concept of an MPO as a coordinating body among local governments and between local and higher levels of government. However, many metropolitan areas have experienced substantial losses in transportation planning expertise, data collection and information services, and most important, the quality of their transportation planning process. These areas are likely to have poorer future transportation systems as a result.

Direct relationships between the federal government and local governments (as distinct from MPOs) were once strong in the transit field when that program was housed in the U.S. Department of Housing and Urban Development. After UMTA was created in DOT in the late 1960s, the federal relationship generally shifted away from local governments to metropolitan transit agencies and MPOs. This period coincided with FHWA's increasing emphasis on improving and strengthening the MPO process, which was also generally the period of closest relationship between FHWA and local governments.

Local governments have increased their transportation responsibilities in many cases, generally because of rapid suburban growth and diminished federal and state resources. This has typically been accomplished in the absence of any significant leadership from national or state organizations or guidance on the various aspects of this effort (e.g., organizational models, financial or economic planning methods, user-fee tax mechanisms or powers, or transportation planning tools).

Transit agencies get very mixed reviews. The transit planning process has greatly improved, in large part because of the expertise and diligence of UMTA staff, but also because of the accumulation of expertise in agencies and consultants as a result of the large number of studies over the last 15 or so years. Excellent guidelines for these studies are now available, although much more can be done to improve them and provide documentation of good studies, as discussed in the Sydec review mentioned earlier. Transit agencies have introduced successful innovations in some areas, including timed-transfers and transit centers at major suburban activity centers or downtowns, paratransit services of various types, and programs of contracting for service to reduce costs and expand markets served. However, these innovations have involved only a small percentage of all transit agencies. Very few examples can be cited where transit agencies (or MPOs or others) have provided leadership in using transit to help shape land development as an element of local master plans or growth policy. A large number of opportunities to do this are being lost in rapidly growing suburban areas because of lack of leadership and lack of emphasis on this in current programs at all levels.

The basic structure of the discretionary transit capital grant program creates a strong incentive for transit agencies and other local officials to bias the planning process in favor of more capital-intensive rail projects. It also tends to create a contest between local agencies and UMTA staff over detailed assumptions and methods used in the planning process. This relationship will almost inevitably continue no matter how successful professionals are in improving technical aspects of the planning process. In fact, somewhat ironically, this federal-local contest itself has been a major factor in bringing about the continuing technical improvement of the planning process.

Private-sector involvement in transportation has been successful in several areas, although rhetoric on all sides is usually far ahead of performance. This is not too surprising, however, because experience and expertise are lacking in many areas. Good examples of recent successes include formation of active transportation management associations in several major suburban activity centers or downtowns, numerous examples of major negotiated agreements between developers and local governments to build road improvements and provide transportation management programs in return for development concessions, and many examples of increasing private-sector initiative in prodding government to improve the planning process and provide needed expansion of transportation programs. Several local governments have recently enacted or substantially increased impact-fee structures. However, the impetus has come primarily because of funding shortfalls rather than as a result of a rational planning process. The economic rationale for impact fees is not well understood by local officials or the public, and the transportation cost impacts of development have generally not been quantified to provide a sound economic basis for impact-fee schedules.

The federal government has not worked very effectively with industry in the development of improved technology, particularly in comparison with other leading industrial nations. The history of DOT's technology development process has been marred by great swings in orientation, magnitude, and emphasis, and has resulted in few, if any, notable successes. Program objectives have seldom been well defined or sustained over a multiyear period, and industry's counsel has not been sought on a sustained basis to help guide technology development.

Similarly, the federal government has not involved metropolitan transportation planning officials and professionals in helping to give direction to technology development programs. This should be an important interrelationship to ensure that new and evolving technologies are developed for actual important markets, as well as to help keep metropolitan planning officials and professionals much better informed as to what systems are likely to become available and thus to integrate this knowledge into their ongoing planning and decision-making processes.

Congress gets the worst marks for its recent performance. In addition to problems created by the "demonstration" highway projects and earmarking of specific local transit projects as discussed earlier, Congress has not given leadership in helping to evolve future programs or called for comprehensive planning of such programs. A main congressional emphasis in this regard has been to defend the existing program structure and funding from reductions and changes sought by the current administration.

Prospects

As in the case of prospects for future resources, the prospects for dealing with current organizational shortcomings and evolving an effective structure and set of relationships for the future very much depend on the choices made in the 2020 planning process for the post-Interstate program.

If it is decided to turn back some systems to the states, many of the most effective relationships and organizations that have been built up over the last several years will suffer and many opportunities for building on those relationships will be foreclosed. But the pattern will be very mixed around the country, with some states and metropolitan areas successfully building on good organizational structures and others (probably most) sliding backward. Similarly, if the direction is an emphasis on higher functional class systems as a national network and a deemphasis at the federal level on systems of local and regional importance, this will probably further harm MPOs, metropolitan transit agencies, associated relationships, and their planning and decision-making processes in most areas. State-federal relationships and many aspects of their programs, however, might be strengthened, at least as seen from the important perspective of those primarily interested in a strong national highway network.

On the other hand, a more ambitious federal program that seeks to achieve specific, carefully defined societal goals related to transportation, such as those discussed in relation to resources, will inherently face some new organizational challenges, as has been noted (*8*, p. 13). Renewed emphasis would have to be placed on MPOs or new forms of regional agencies in coordinating planning and decision making among local officials and between them and higher levels of government. New efforts would have to be made to transform many existing transportation agencies at all levels into organizations capable of managing more comprehensive programs. These challenges should be addressed as an important part of the 2020 process if such an ambitious direction is going to be seriously considered and ultimately selected.

The challenge of organization planning as a key element of the 2020 process differs from what happened at most critical decision points in the past. Only several years after the start of the Interstate program was much serious attention given to restructuring of federal organization, state highway and other transportation agencies, or metropolitan organizations. The only major historical precedent for coupling organization building with new national transportation programs was the federal requirement for creation of state highway agencies as a precondition for receiving federal-aid highway funds.

The responsibility for this organizational planning process should be a cooperative effort of the 2020 coalition, working with FHWA and Congress. On the basis of past experience, this process is not likely to be completed within a short time frame. After the first federal legislation implementing the Interstate system in 1954, at least 15 years was required to evolve the required federal, state, and local organizational structure. Therefore, it should be expected that a continuing planning and adjustment process will be needed over the next few years in order to achieve the framework needed for an ambitious 2020 program. The process will undoubtedly be more effective if this is recognized now and a continuing process is set up, rather than waiting until there is widespread dissatisfaction and the recognition of the need for organizing a new ad hoc response (as happened in the late 1950s and 1960s).

One of the organizational requirements of the new 2020 program is a de facto merger of ground transportation programs at all levels. Merging of the program planning process will not be sufficient, because experience shows that different funding mechanisms inherently lead to lack of coordination in project conception, design standards, and implementation. A merger at the federal level is critical because history shows that the flow of funding from the federal level has a great deal of impact on state and local organizational structure.

Merger of ground transportation programs always raises the fear that smaller programs will be gobbled up by larger programs. This can be prevented by mandates for proper representation in decision making and by well-conceived formulas that guarantee reasonable shares for transit and other local transportation needs. Experience also shows that some flexibility should be provided to shift some funds among program categories without having to overcome major bureaucratic hurdles. To ensure that allocation among program categories does not create significant distortions, regular periodic national needs studies should be conducted in cooperation with state and local representatives, using sound economic and community development criteria. These requirements and others discussed below should be built into the initial legislation and should be refined as necessary through a continuing 2020 planning process.

The 2020 planning process should begin now to work on quality-of-life criteria to guide other aspects of future program structure. These should be the driving forces in creating the organizational and funding structures for the urban and rural development programs. An element of these criteria should be a broader conception of environmental objectives. The emphasis should be on improving living and working environments through the planning and design process, rather than merely documenting the negative environmental impacts of projects. Considerations should extend to ways in which design standards for highways, streets, lighting, and other components of transportation facilities can be used to help create inviting pedestrian-oriented communities that are less dependent on the automobile.

Federal programs should be designed to foster competitive markets for services, products, research, and development wherever feasible, and pricing of services for users to encourage efficient utilization. This will require special efforts at recruitment, education, and training of staffs. Currently, there is a woeful lack of understanding of these market concepts and appreciation of their importance in promoting efficiency among transportation agency staffs at all levels.

Special efforts should be made in program planning to broaden recruitment, education, and training of transportation professionals beyond the civil engineering discipline and to include not only business and economics, but also mechanical and electrical engineering (critical in new technologies) and planning (critical in achieving community development goals). Career development in agencies should regularly include assignments that will foster appreciation for private-sector values, community development objectives, and other perspectives critical to success of the 2020 program.

To accomplish the evolution in transportation programs desired, the federal role should shift somewhat away from the details of program administration, leaving these to states, MPOs, and local governments, and more toward playing a leadership role in promoting innovation, conducting research, and fostering organizational development. To do so, much greater effort should go into technical assistance, training, and dissemination of research results and examples of successful practice.

RECOMMENDATIONS

The following recommendations are discussed according to their emphasis on programs, organization, or funding:

Programs

1. The 2020 planning process should develop a clearly defined set of goals for future transportation programs, and these should reflect broad societal goals relating to economic and community development.

2. Three major programs should be included in the 2020 program:
   - Interstate and principal arterials—emphasis on national economic development goals and use of new technologies to improve productivity, safety, and capacity.
   - Urban—emphasis on community development, quality of life, and integration with land development planning process, with flexibility in use of funds in terms of routes, and types of projects or services (transportation system management, parking management, transit, HOV facilities, new systems and service concepts).
   - Rural—emphasis on rural community and economic development goals, environmental protection, and mobility, with flexibility in use of funds as in the urban program.

3. Pricing of transportation services should reflect use of the system and marginal costs of providing the service, to the extent feasible, in order to foster efficient use of the system, equity, and credibility of the fee structure. New technologies and concepts for automatic billing based on use of the system should be fostered.

4. To achieve far better coordination of modes, surface transportation programs should be merged at all levels, not only in terms of the planning process, but also in terms of project conception, design standards, and implementation.

5. Transit and other elements of local interest should be protected by requirements for representation in decision-making processes and by categorical funding requirements, with some degree of flexibility in transfer of funds without the need to overcome major bureaucratic hurdles.

6. The current bias in the discretionary transit capital grant program in favor of costly rail projects should be eliminated by moving toward merger of programs, increasing of local matching requirements, and using a formula for much of the urban program, with incentives for productivity and performance rather than for running up capital costs.

7. Research and development programs should be increased in scope and level of funding. Leaders from industry, universities, the states, and

metropolitan areas should be actively involved in these programs to give better long-term guidance and to ensure that products are developed that have maximum utility in both the short and long term.

8. Programs should be developed to plan for and to reserve rights-of-way and space for future transportation facilities, including future HOV lanes, transitways and stations, highways, and new technologies.

9. Human resources for future programs should be developed by major new efforts in recruitment, training, education, and cross-fertilization of disciplines and experience in different working environments.

Organization

1. The 2020 planning process should include an emphasis on planning and implementing the organizational structure and interrelationship among all levels of government and between public and private sectors so as to carry out future surface transportation programs in the most effective possible manner.

2. The 2020 planning process should be planned to continue beyond the initial program development and legislative process, recognizing that periodic adjustments will be necessary in funding mechanisms, organizational structure, and scope of the programs.

3. The MPO process should be strengthened as a basis for the recommended urban program, with emphasis on flexibility of structure to reflect differences among states and metropolitan areas in constitutional powers and existing agency structures. New emphasis should be placed on community development and other program goals in developing guidelines for the MPO structure and process.

4. Consideration should be given to fostering the development of regional planning agencies as coordinating mechanisms for the rural program, according to the conditions in each state.

5. The 2020 planning process should recommend who should make each major type of decision under future programs. In general, decisions should be made at the lowest level consistent with the scope of concerns involved. In particular, Congress should not be involved in decisions regarding allocation of funds to particular projects, and the program structure should be designed to achieve this objective insofar as is possible.

6. The federal role should shift away from the details of program management, leaving these to other levels of government, and should shift toward a leadership role in promoting innovation, improving organizational structure, providing technical assistance, educating the public and elected officials, and disseminating results of R&D and good practice.

Funding

1. Capabilities for analyzing resource allocation options should be improved and utilized on a continuing basis within the 2020 process and within the ongoing programs at all levels. This should include periodic reviews of overall levels of funding and program category funding levels in benefit-cost terms as well as in terms of progress in achieving community development and other program goals.

2. A target should be established for overall national funding for surface transportation based on a consensus on the level that is optimal in objective economic terms, with appropriate consideration of other goals and constraints. A target of achieving and sustaining a fixed percentage of GNP is suggested, such as returning to the level of the 1960s, subject to periodic review.

3. User-based funding of highways should be established as the primary, if not the exclusive, basis for federal and state programs, and options for local user-based funding should be developed. Taxes and fees should be based on periodic refinements to cost responsibility estimates, and should be designed to grow with inflation in order to maintain overall funding targets.

4. Programs should be designed to create incentives for productivity improvements, for example, by making some portion of the funding allocation a function of performance measures and by establishing market mechanisms wherever feasible.

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Transportation Institutions in the Year 2020

Bruce D. McDowell

THE PRESENT IS A time of extraordinary change and uncertainty for transportation programs—a time to rethink transportation institutions as well as the related intergovernmental relationships and policy processes. Three major elements need to be considered:

- Changing roles of the three levels of government,
- The evolving intergovernmental planning process, and
- Shifting financial strategies and allocations.

Much of the current uncertainty in transportation programs stems from factors such as completion of the Interstate highway system, the waning of national commitments to urban policy and mass transportation, and deregulation of air, rail, and truck transportation. National visions for the future of these modes are becoming increasingly blurred. The question is whether such visions can and should be regenerated or whether state and local governments should be encouraged to strike out on their own to a much greater extent. Basic political values as well as transportation demands are wrapped up in the answer.

This paper approaches the rethinking of transportation institutions by examining the external forces that appear to be shaping existing transportation programs and future transportation demands and then by speculating about

Bruce D. McDowell is currently on the staff of the Advisory Commission on Intergovernmental Relations. His prior experience includes staff, National Council on Public Works Improvement, Metropolitan Washington Council of Governments, and Maryland National Capital Park and Planning Commission.

how future transportation needs might be repositioned in the political mainstream from their increasingly marginal location among public policy concerns. This analysis allows institutional implications to be drawn and played out among the federal, state, local, and regional units of government.

Obviously, there is no single answer to questions about shifting roles and responsibilities. This paper simply seeks to offer enough suggestions to stimulate a creative exchange of views on the major institutional issues. Where one comes out on the basic question of national purposes for transportation has everything to do with where one comes out on institutional structures, processes, and financial responsibilities.

EXTERNAL FORCES AND TRANSPORTATION DEMAND

A close look at current transportation programs and trends leads to the following conclusions: Current programs are finishing up and running out of steam. At the same time, however, transportation demands continue to grow and shift. The governmental response to these demands is losing ground in both the short and long run.

Disappearing National Purposes for Transportation

Many of the major national goals for transportation and other forms of physical infrastructure have been accomplished or have lost favor without being replaced with new ones (*1*, pp. 87–96). The federal government now seems preoccupied with national defense, the social safety net, and interest on the national debt—not with building the nation. Thus, the strong federal leadership in providing financial capital for public works, which had come to be expected during recent decades, has become uncertain in the 1980s. Some examples of disappearing transportation and related goals are discussed in this section.

Highways Federal-aid programs have built the secondary system of highways to "get the farmer out of the mud," the Interstate system to interconnect all the major metropolitan areas with modern high speed freeways, and the primary and urban systems to expand other high volume roads and bridges. These tasks, as originally defined, are virtually complete; the states are squabbling over the uneven distribution of remaining new construction funds, and no new vision has been agreed on to reenergize the program. Current activities consist largely of maintenance and minor extensions of the existing systems—hardly the stuff of political excitement and solid, long-term financial support.

Mass Transit Federal spending from the mid-1960s until about 1980 moved ailing private mass transit companies into the public sector and stabilized the quality and levels of their services. However, competition from automobiles remains fierce, public costs are high, and continuing federal capital spending is controversial. National purposes now are not as clear as before. Substantial budget cuts have been experienced.

Airports Federal airport programs since 1946 have assisted the planning and construction of a nationwide system of airports that serves virtually every significant travel destination in America.

Water Transportation In water transportation, most of the economical waterways and deep harbors have been developed by the federal government. Smaller ones remaining to be developed are considered to have less national significance and more localized benefits. Now they must be developed under new cost-sharing rules and strict environmental restraints, which make the task more difficult.

National Urban Policies National urban policies expanded during the 1950s and 1960s to integrate many transportation policies with goals for rebuilding the nation's decaying central cities, expanding the suburbs to satisfy pent-up postwar demand for affordable single-family housing, providing decent housing for low- and moderate-income families, and promoting comprehensive community development planning at the local, metropolitan, and state levels. However, most of the eight legislatively required national urban policy reports submitted to Congress by the presidents since 1972 have minimized the importance of such policies. Another one is due in 1988, and it is expected to do the same.

Arguments are frequently heard that

- National highway, airport, and transit goals have been achieved, along with the building of comprehensive community development planning capacities throughout urban America; henceforth it is up to the state and local governments themselves to operate and maintain these facilities and programs;

• National urban renewal and housing programs have been tarnished by imperfections that have dispersed natural neighborhood cultures, re-created low-income slums by concentrating assisted housing in too few neighborhoods, and become too expensive for the public sector to continue, and
• Federal assistance to the suburbs has created too much sameness and sterility, damaged the central cities, and weakened urban mass transportation.

Surveying such arguments in 1980, the President's Commission for a National Agenda for the Eighties recommended a shift in national purposes from those designed to assist places toward those that assist people (*2*). Reinforcing this thrust have been several initiatives in the 1980s to sort out the functions of government (*3*). In the process, place-specific programs generally have fallen into the "turn-back" column—appropriate for state and local responsibility rather than for federal responsibility. In addition, recent trends and proposals concerning privatization leave old programs in doubt (*4*).

Growth and Shift of Transportation Demand

Despite this atrophy of federal goals and programs, transportation demands are continuing to grow. In a study prepared for the National Council on Public Works Improvement by the U.S. Department of Commerce, industry use of infrastructure was conservatively projected to grow by one-third during the period from 1985 to 1995 (*5*). Much of this growth is in transportation needs—needs that are becoming much more sensitive as the just-in-time inventory practice spreads. At the same time, Federal Highway Administration (FHWA) projections to the year 2005 show urban and suburban congestion magnifying greatly unless major new initiatives are undertaken. In fact, FHWA expects (*6*, p. vi) "significant increases in vehicle delay" even with full utilization of . . . known transportation supply and demand management strategies, including TSM, new construction, 4R type improvements, improved organizational tools, and cooperative efforts in minimizing the impacts."

In addition to growth in overall travel demand the types and locations of demand are shifting. In particular, four major shifts have occurred since today's transportation systems were designed.

1. Jobs have moved to the suburbs and made cities where the highway and transit systems had assumed that there would be none. Suburban and rural roads serving those cities are inadequate (*6*).
2. Tremendous amounts of freight have shifted from railroads to highways. In response, the sizes and weights of trucks are increasing dramatically

(*7, 8*). In high-density freight corridors the mixture of larger and larger trucks, and more of them, with smaller and smaller cars is creating safety problems and making driving unpleasant. In rural areas the available roads often are simply inadequate, sometimes so much so that trucks must go the long way around.

3. The growth in air freight and in airport hubs for both freight and passengers is creating needs for better ground access and for redesign of airport and airway facilities and operations (*9*).

4. A small but significant number of major new travel destinations have emerged in the 40 years since the Interstate highway system was designed (*10*). These destinations include several new metropolitan areas, concentrations of seasonal population (resorts), transportation transfer points and access routes for trucks too large for existing roads, and some large military installations. Additional destinations like these are bound to continue emerging.

As these trends emerge, big changes are taking place among consumers in general and the traveling public in particular. They are moving upscale in large numbers and are looking for "niche" services that meet their own special needs (*11*). This challenges the concept that every highway should meet the needs of all drivers. Indeed, transportation markets are already beginning to fall into separate categories. For example, there are high-occupancy-vehicle (HOV) commuter lanes, parkways, truckways, toll roads, railroaders, express buses, shuttle buses, busways, traffic-free pedestrian malls, and so on. Consumers are sometimes willing to pay extra for these specialized services. It is not much of a stretch to imagine direct airline flights designed specifically to avoid hubs, or many other service enhancements that could come from increased market segmentation and special pricing (*12*).

As travel patterns shift, opportunities constantly arise to redesign portions of the transportation system for greater efficiency. For example, some important destinations on the Interstate system are now linked only by very circuitous routes (*10*, p. 29). Shortcuts might well be cost-effective. In addition, the most heavily traveled truck routes should probably have stronger pavements to keep them from wearing out so fast, whereas facilities with lighter use may not need to be built to full specifications at unnecessary cost.

Adjustment of Transportation Programs to Demand

The psychology of public works—transportation facilities chief among them—is that they are permanent. After they are built, they are there and tend to be taken for granted. But that psychology leads to a false sense of security. In urban and suburban areas the major arteries are clogging up and freeway systems may well become incapacitated unless they have the equivalent of a heart bypass. In rural areas the inadequate bridges that cannot handle large trucks are analogous to a series of small aneurysms that need to be reinforced if they are not to cause serious trouble in the future. Deregulation has led to the loss of many intercity and rural bus services, as well as many rail freight services and rail rights-of-way. The forces that are working on these transportation systems are very dynamic.

The contrast is striking between these dynamic forces and the perception that building on the transportation system has finished. That perception is powerful. The more that is built, the more that has to be maintained. Yet maintenance is being deferred, and huge liabilities are piling up for future generations without even realistic measurement or open debate. In addition, lack of concern with a public role in helping to smooth the flow of goods from one mode to another in interstate and international trade has even made obsolete the collection of data about where the goods are coming from and going, and by what means. Overall there are few new initiatives to maintain and upgrade current systems.

Another mismatch between needs and action stems from the fact that meeting transportation demands requires consideration of both land use management and transportation improvements. Although significant improvements have been made in recent years to strengthen this linkage in some localities, only a handful of states have become involved (*13*), and federal commitment to this effort has substantially declined. Overall, the linkage between land use and transportation decision making remains very weak.

To make matters worse, transportation finance is adrift. The primary source, of course, is the gasoline tax. The federal government has raised the rate only once in the 34 years that this tax has been used, even though it is a declining resource. As cars and trucks become more gasoline-efficient, less gasoline is used per mile of travel. Therefore, revenue shrinks each year in relation to the need for new roads and for maintaining existing roads. Of course, inflation eats away at this revenue also. Most states have increased their gasoline taxes since 1980 and local governments have increased their spending for transportation even more than the other two levels of government. However, the local money goes heavily for operations and maintenance. On the capital side, local governments have been relying more on local developers to contribute needed investments. Still, investment is declining rather than increasing (*1*, pp. 45–48). Demands are going unmet.

The development and application of new knowledge in the transportation field lag well behind the potential for cost-effective improvements in productivity (*1*, pp. 123–129). Improvements in existing construction materials and the development of new materials promise less expensive and longer-lasting pavements and structures. Several families of high-technology sensors are becoming available to help monitor the condition of pavements and structures much more cheaply, frequently, and accurately than is done now. Automated systems for using these condition data to optimize maintenance management can be expected to significantly increase the life of existing facilities. Better information on the performance of transportation systems can be expected to improve the precision and effectiveness of transportation needs studies, capital improvement programs, and budgeting (*1*, pp. 105–122). Transportation is the only public works field that has had any regular funding for research and development; however, it has never reached levels of priority even remotely like those of the space program, medicine, and defense. Mass transportation research has been cut dramatically in recent years, and technology transfer programs are well below the levels of a decade or two ago.

Finally, a shortage of highly qualified transportation engineers and managers looms in the near future. The Transportation Research Board documented the high percentage of state and local transportation engineers who will be retiring in the next few years, those who were hired at the beginning of the Interstate program and are coming to the end of their career (*14*). On top of that, engineering schools are now turning out fewer civil engineers, and curriculums have not been updated to reflect growing needs for expertise in maintenance and operations. Only a handful of schools offer public works management degrees.

The image of public works—like public employment in general—is not an exciting one that attracts "the best and the brightest" students and teachers. But it could be. A bigger R&D component and a bigger emphasis on innovation transfer could put transportation into the ranks of the high-technology professions, where it could compete more successfully for the talent that it needs.

Summary of Needs

It is clear from this quick review of the transportation field that the work is far from done. To summarize, it appears that a point has been reached at which the nation's transportation systems should be substantially redesigned to meet new needs and the opportunities that present themselves now should be taken to transform the transportation field into a more productive and attractive high-technology endeavor, staffed with some of the best and the brightest. Major features of the new design should include

- Overcoming urban and suburban congestion, including the creation of much stronger linkages between land use management and transportation improvement decisions;

- Meeting the needs of trucks;
- Tying in isolated destinations and shortcutting excessively circuitous routes;
- Utilizing or preserving for future use excess rail capacities and rail rights-of-way;
- Streamlining intermodal goods movements; and
- Providing alternative levels of service at commensurate prices.

REPOSITIONING TRANSPORTATION IN THE POLITICAL MAINSTREAM

Although transportation is still among the high priorities of state and local governments, it has lost ground at the national level. The question, then, is whether there are important national goals that can be achieved only by better transportation. Better mobility for its own sake does not seem compelling.

America's national purposes clearly include economic competitiveness, jobs, and a rising quality of life. Transportation is an important factor in each. National defense, of course, is another incontestable national goal, but it is, arguably, much less dependent on civilian transportation facilities than it was in earlier years. The nature of war has changed so much that the military must provide most of its own facilities for very rapid deployment of weapons and personnel during armed conflicts. This does not deny military requirements for moving materials, equipment, and personnel over the civilian networks during normal times (*15*). Some of those requirements are special, and they need attention. But it is more difficult now to imagine labeling as national defense requirements most of the currently needed highway improvements as was done when the Interstate system was initially authorized in 1956. In this age, the compelling rationale is that a country with a world-class economy and a world-class people, such as the United States, needs a world-class transportation network to keep it competitive.

Transportation policies have a great deal in common with several other types of national policies, which may offer pathways into the mainstream of the political agenda. For example, urban areas are the basic infrastructure of the national economy, and public works provide the physical infrastructure of urban America. So it can be argued that keeping urban America and the national economy healthy requires effective national urban policy. This reasoning recalls the origins of national involvement in mass transportation programs as a means of revitalizing the nation's cities. If urban and suburban congestion are allowed to squeeze the life out of America's cities, the economy cannot be expected to be healthy and internationally competitive.

The effort to rebuild national transportation policies might also benefit from association with national infrastructure policy. The recent report of the National Council on Public Works Improvement to the President and Congress has brought renewed visibility and media attention to overall public works issues (*1*). These issues include declining rates of capital investment, increasing amounts of deferred maintenance liability, the need to bill beneficiaries for the costs of improvements, and the need to squeeze greater benefit out of every public works dollar spent. These issues are all as vital to transportation programs as they are to other types of public works. Making common cause with others in the public works field may create the critical mass needed to push some of these issues into the national consciousness.

Another potential avenue into the political mainstream is industrial policy. Transportation is a significant cost in the production and marketing of most products and services. Although these costs may not be the biggest, they often are significant at the margin. Comparative efficiencies in transportation can make a difference in ever-tightening competitive situations. Congressional resistance to industrial policy may be weakening, if trade policy can be taken as a sign.

A final consideration in moving into the political mainstream is the need to overcome disillusionment with government. The general public and elected officials need assurance that additional spending will bring service improvements. New facilities are not always synonymous with cost-effective improvements in services. Better operations and maintenance may be more beneficial, but capital investment generally receives greater attention in the typical planning, programming, and budgeting process. The information available to planners and decision makers too often does not describe potential benefits and the performance of existing and proposed facilities, equipment, operations, and maintenance procedures. Demonstrating the potential for better services at fair prices will go far in building public support. This will require greatly improved accounting for both benefits and costs, and a direct link between these two sets of accounts.

Institutional Implications

Meeting emerging transportation demands and repositioning transportation issues in the political mainstream will require a number of institutional changes. These will involve adopting new national goals, tapping consumers' pocketbooks more effectively, accelerating the pace of innovations, and reinvigorating intergovernmental partnerships.

Adopting New National Goals

Clearly a new set of transportation goals, including new national goals, is needed. The federal government needs to continue its involvement in transportation programs for two fundamental reasons.

- First, interstate commerce—a constitutionally enumerated federal responsibility—is more important than ever and is increasingly taking on international dimensions as well (*16*). And it depends on efficient transportation.
- Second, the reality of the American federal system is that responsibility for getting things done tends to sink to the local level whereas the ability to raise funds tends to rise to the state and federal levels. Every tax, borrowing, and spending limitation known to man can be found externally imposed on local governments, yet they still manage to raise half of all the public works funds spent by government. The other half is split fairly evenly between the state and federal governments and is spent primarily for construction. Recent experience is that states compensate for federal spending cuts only partially if at all (*17*). So a major reduction in federal spending most probably would strain local budgets more and almost certainly would reduce current levels of service. Even if federal revenue sources were turned back along with program responsibilities, as proposed by some, resulting changes in the distribution of funds would create serious issues among the winners and losers (*18*). The fact is that the transportation function is highly intergovernmental, and for any one of the partners to pull out would be very disruptive.

Tapping Consumers' Pocketbooks

Highways traditionally have been financed largely by the gasoline tax. Other transportation modes more recently have been moving to cut their ties to the general fund. At the federal level, an airports and airways trust fund was established in 1970. That was followed in the 1980s by the creation of new trust funds for ports and waterways, and by a new mass transportation account in the Highway Trust Fund to help support transit.

This is a fairly general trend at the state and local levels as well. Through the use of special districts, earmarked taxes, user charges, and developer exactions, increasing proportions of public works spending of all types are being funded outside the general fund. It makes sense to do so, especially now with growing deficit pressures and fading priorities for physical infrastructure. Even at the state level, physical facilities are not competing well for top billing. Issues like educational excellence are crowding them out.

At the same time, infrastructure services have the potential to be marketed as consumer goods. Americans are noted consumers; they think nothing of going into debt to finance consumption. Thus, the trick is to make them aware of their constant consumption of infrastructure services all day, every day, and to convince them that they are getting good value for their public works dollars.

This approach implies that public works and transportation agencies should reorient their programs to their beneficiaries. In business, the bottom line is profit; in public works and transportation, the bottom line should be cost-effective performance of services. Performance goals should be set openly with the beneficiaries, and progress toward those goals should be monitored regularly and openly. Such a process would move public works agencies closer to their customers and help make the "beneficiaries pay" principle work (*19*).

Of course, if this process is to work, the agencies will need much better data on the physical performance, levels of service, health and safety exposure, deferred maintenance liability, and economic performance of their systems (*20*). These data are needed by all federal, state, and local units of government that own, operate, build, maintain, or fund public works. They should be collected by the owning and operating units and shared with the other units involved in planning and providing intergovernmental financial assistance. For these data to be useful by all of the parties involved, of course, standards for data collection and reporting need to be agreed on.

It is difficult to imagine these data standards developing in such a way as to produce reliable national data without involvement of the federal government. They should be built on the good work already begun in the Section 15 transit reports and the Highway Performance Monitoring System.

Accelerating Innovations

Another role that the federal government seems uniquely qualified to play is to institutionalize a stronger long-term commitment to transportation innovation (*21*). America's spending on transportation R&D is low compared with that of other nations and other industries. U.S. spending is also concentrated too much on short-term projects and on improving existing construction materials. Longer-term projects to develop new materials, sensors that could revolutionize condition surveys, improved maintenance management systems, and better benefit and cost accounting systems should not be left out. It takes the behind-the-lines position and superior staying power of the federal government to wait out the results from such long-term projects.

Reinvigorating Intergovernmental Partnerships

Intergovernmental partnerships are essential to meeting current and future transportation needs. Yet there are plenty of rough spots that need smoothing out. Each level of government has something the others need for the success of their own goals. For example, a review of current lead roles in transportation programs reveals the following lineup (*1*, pp. 75–80).

Federal Government The federal government plays the dominant role in planning, setting standards for, and providing capital financing for the Interstate highway system and in operating and maintaining the nation's airways, harbors, and inland waterways. It also takes the lead in capital financing of mass transit and many smaller airports.

States States now play a dominant role only in non-Interstate federal-aid highways. Although the states own, operate, and maintain most of these highways (both Interstate and non-Interstate), as well as some other highways, that mileage accounts for less than one-fourth of all roads. The states' dominance in federally aided non-Interstate highways (supported significantly by the state gasoline tax) is eclipsed in most states by the much greater mileage of local road systems. The major exceptions are Alaska, West Virginia, Delaware, Virginia, and North Carolina, where state ownership accounts for 85 percent or more of the total road mileage in the state. On average, states spend approximately 80 percent of all their infrastructure monies on roads.

The state role in mass transit is increasing. States like Maryland, Virginia, New Jersey, and New York actually operate mass transit facilities, and most states make financial contributions to local programs. Overall, state contributions (capital and operating) to mass transit exceeded the federal government's contributions in 1987, and the gap will widen in fiscal year 1988 under the federal budget approved in December 1987.

Local Governments Local governments generally dominate the provision of local roads (accounting for 76 percent of all roads), mass transit, airports, and certain landside facilities at water ports. Exceptions include the use of special districts (as noted below), the provision of local roads by a few states (as noted above), and federal dominance in the capital financing of transit (as noted above). In addition, key local roles often are shared with the private sector. This includes an important private role in funding, operating, and in some cases owning streets and roads, airports, and water ports.

Local governments also hold almost all land use controls. Although the states provide these powers to local governments, the states help to exercise them in only a few cases. This situation means that, under current procedures, local governments (cities and municipalities) are the only units holding the powers necessary to synchronize the provision of public works with the pace of land development.

Independent Special Districts and Authorities Independent special districts and authorities provide some public works in all states except Arkansas and Hawaii (22). Some of these units are agents of the state, and others are agents of individual localities or regional groups of jurisdictions. Among the facilities provided are airports, highways, mass transit, and water transport. These special units were being used more in every state in 1982 (the last year for which data are available) than in 1972 for all of these categories. However, special units for highways and water transport are found in fewer than half the states.

Even among states that use independent special districts and authorities, such units spend more than half the capital used at the state and local levels in only two functions: transit and water transport. The proportion of these capital outlays spent in any given state by these units varies widely.

These statistics understate the role of special districts because they do not count "subordinate" units classified by the U.S. census as being under the control of general-purpose governments. According to one estimate, the bonded indebtedness of these subordinate districts equals 62 percent as much as the debt of the independent ones, and even that estimate is an undercount because of incomplete reporting.

Metropolitan Areas In metropolitan areas, where all these roles come into closest contact with each other, it has long been recognized that some formal mechanism is needed to help align the goals of all the actors. The mechanism chosen was the metropolitan planning organization (MPO). According to the theory, there should be a single MPO in each metropolitan area recognized jointly by the U.S. Department of Transportation (DOT), the state or states involved, and all the local governments in the area. The purpose of these MPOs is to draw up coordinated transportation plans for all the modes synchronized with the pace of development in the region and orchestrate agreement among all the land management authorities and transportation providers to make their decisions in accordance with the plan.

From 1962 until 1980, DOT followed this theory. It focused its highway and transit planning funds into these organizations in every metropolitan area throughout the nation as well as its airport planning money in many cases. It was joined by the U.S. Department of Housing and Urban Development (HUD), which put land use planning money into most of the MPOs on a regular basis. The Environmental Protection Agency (EPA) added regular air quality planning money in the 1970s. In addition, the states sponsored and actively participated in the MPOs, and agreements were signed with virtually all the local governments in each area to get their participation.

Then a substantial degree of disillusionment set in. The issues of coordination were large and contentious; the political clout of the MPOs was weak. There appeared to be a serious mismatch. The MPOs had no authority to fund projects. The states held that key power, with federal and local decision makers playing significant backup roles in many cases. The MPOs had no authority to regulate air quality. Again, the states were the key actors, using federal guidelines, and local officials had backup roles. The MPOs had no authority over land use either. That power was very jealously guarded by local governments, and only a few states dared to tread into that thicket. The MPOs began to be viewed as toothless tigers.

HUD declared that it had helped to set up the MPOs and that its help was no longer needed. EPA refocused its attention toward the seat of regulatory power in the states. DOT was left pretty much alone in supporting the MPOs. Its planning assistance money stretched thinner and thinner as the number of metropolitan areas grew following the 1980 census and as DOT struggled to offset some of the loss of land use planning money from HUD. The result was that DOT cut back its planning requirements to focus mostly on the larger metropolitan areas with populations over 200,000. It also focused more on the key state decision-making role and allowed MPOs to be less than areawide if the governors and local officials decided that was best. Some MPOs splintered into subregional organizations. The states did not step forward to maintain the original concept or to strengthen the roles of the MPOs. Efforts to strengthen the very weak linkage between land use and transportation decision making were pretty much abandoned by the federal, state, and regional players.

The MPOs, in general, have become poorer and less planning-oriented. Their agendas, in most cases, have become more locally oriented. Instead of preparing regional plans, they concentrate on maintaining data bases, providing technical analysis, and performing a variety of services requested by local governments. A 1984 survey of local officials, prepared by the U.S. Advisory Commission on Intergovernmental Relations, revealed that most believed that the MPOs should be doing more planning and coordination, but that they should not be given decision-making powers (*23*).

An Institutional Reform Agenda

These institutional implications suggest the following four major proposals.

New National Goals The federal government should adopt some new national goals for transportation. The most likely candidate is the upgrading of the current transportation system to world-class status as part of a larger priority to improve America's competitive position in world markets and to keep America's standard of living among the best in the world.

The prime concerns of the federal government should be to redesign current systems to adequately serve the new destinations that have emerged beyond easy reach of the Interstate system, to shortcut circuitous routes, to beef up the system as necessary to handle the growing needs of trucks, and to keep America's urban and suburban areas from strangling on congestion.

Redesigned Federal-Aid Programs The federal government should redesign its financial assistance programs to reflect the new system design. The new programs might be the following:

- A program of 90-10 grants for a new National Highway System for the Twenty-First Century based largely on the Interstate and primary systems plus logical extensions to meet the most critical trucking and urban-suburban congestion needs. This newly redesigned system of high-priority roads would be considerably longer than the current Interstate system but substantially shorter than the full federal-aid system. The routes would be largely planned by the states but approved by the federal government. New construction and allocations for resurfacing, restoration, rehabilitation, and reconstruction (4R) would be included.
- A local mobility block grant channeled through the states. No matching would be required, but a certain portion would be required to be passed through for local use in accordance with regional plans developed by MPOs and other planning organizations. Allocations would be based on established needs and the ability of state and local governments to support such needs themselves (a fiscal equalization factor). The funds could be used for any type of transportation, including streets, roads, highways, bridges, transit, railroads, airports, water ports, waterways, and intermodal facilities. Eligible expenditures would include construction, equipment, maintenance, and operations (perhaps with some general limits on the proportion spent for operations). Route selection and project approval would be a state-local-regional responsibility. Performance-based planning and regional coordination would be

required. Funding would be provided from portions of the four federal transportation trust funds: highway/transit, airport, port, and waterways.

This combination of funds and delegated authority would free up the federal government to concentrate on decisions of truly national importance, and would let the state and local governments allocate funds to meet their own needs most cost effectively.

Permanent Transportation Trust Funds The federal government should reenact its four transportation trust funds on a permanent basis and provide an annual process for reviewing rates of the dedicated taxes and fees supporting them so that they do not get far out of line with needs. These revenues should be considered beneficiary payments for services received, and they should be kept current. Funds should be reserved in the transit and airport accounts for discretionary grants to support a limited number of new starts of national significance. The airways account would continue to support the federal airways system. The major portions of the port and waterways accounts would support existing programs.

Expanded Research and Development The federal government should allocate an increased percentage of all four trust funds for R&D and innovation transfer programs. In addition to projects in the engineering and scientific traditions, priority should be given to developing a practical new "performance language" that would allow citizens, elected officials, managers, planners, and technicians alike, at all levels of government, to communicate knowledgeably about current and future levels of service, deferred maintenance liabilities, health and safety risks, costs, and economic productivity. Other critically needed innovations that should be pursued are politically acceptable techniques for more precisely synchronizing land use and transportation decisions and for improving the effectiveness of regional planning organizations without giving them the powers that others guard so jealously. It seems almost certain, if history is any guide, that these organizations will have to make their indispensable contributions to improved local mobility through the power of their technical analysis and their mediating skills.

Although the states could give regional organizations greater powers, and have done so in a few cases, that alternative seems especially unlikely with respect to land use controls. In that field, at least, any modification of local powers probably would have to be exercised by the state itself—another potential topic for research and innovation.

Federal support for regional organizations without state commitment to the concept was shown to be ineffective by the events of the eighties. Those regions that remained strongest as federal support dropped have been the ones with strong state support. In this and other federal initiatives to innovate, it is important to set the agenda and pursue promising projects in cooperation with all the parties who are essential to making the innovations work.

What Does the Future Hold?

Resistance to institutional change is legend, but changes like those suggested will occur. There is certainly no lack of important national goals to replace those that are disappearing. State and local governments are more capable partners in the intergovernmental system than ever before. The potential is great for technological and managerial innovations that promise productivity improvements in transportation. Consumers are demanding better services, and American consumers are willing to pay for demonstrated benefits.

The key to taking advantage of all these potentials is the development of the new language of public works performance mentioned above. It will allow getting close to the customers and convincing them that the benefits of proposed improvements will be worth the costs. It will allow issues like the growth of deferred maintenance liabilities to be described in terms as compelling as those like the unfunded pension liabilities of a few years ago. Annual reporting of such facts as changes in deferred maintenance liabilities, levels of service, health and safety risks, and productivity rates—enforced by improved asset accounting standards—will make government leadership more accountable and citizens more confident in the government.

If the possibilities that the future holds are communicated convincingly, the American people will demand and support the changes necessary to achieve excellence.

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Respondents' Comments

LAWRENCE P. DAHMS Institutional and resource questions are fundamental and, if answered correctly, can have the effect of making most other plans fall into place. Other subjects being considered at this conference are external to our control, so we won't be able to do much about them, but maybe we can do something about defining what the institutional and resource allocation arrangements will be in a post-Interstate period.

I liked most of McDowell's and Stowers' ideas very much. One of our problems is perception; we are still wondering what Congress believes and what the public believes. Does the public believe, as we in the profession do, that transportation is in trouble?

McDowell contrasted the realities of growth and the traffic demand that growth is causing versus the idea that the system is complete. Does that contradiction need to be emphasized? It seems to me that it does. The Interstate as narrowly defined may be complete, but beyond the Interstate, the job will never be finished.

McDowell observes that the federal government is backing away from financing transportation, and state governments are not picking up the slack; the result is a proliferation of local units of government. Let me add one more example to that trend. Proposition 13 was an antigovernment California phenomenon 10 years ago. What has been the result? In order to get more money for transportation, we have to create new institutions to sponsor the same tax with the requirement of only a simple majority vote. In my region, there are nine counties; three of them have added half-cent sales taxes for needed funds, but in each case had to create a new transportation entity. The Proposition 13 vote in the state for less government has instead fostered more government.

Lawrence P. Dahms is Director of the Metropolitan Transportation Commission. He has been acting General Manager of the Bay Area Rapid Transit (BART) in San Francisco; consultant with Arthur D. Little, Inc.; and Deputy Director of the California Department of Transportation. He has served on numerous TRB committees and is a past chairman of TRB's Executive Committee.

McDowell notes that mobility for its own sake is not compelling. From the point of view of building transportation systems, that is a good point. Transportation is not an end in itself. If we think of it in that way, we are tempted to unduly infringe on the community fabric and the environment and, as a result, lose support for transportation funding. But as a sales technique, mobility as an objective in its own right can be seen as a simple response to the congestion that is stirring so much concern today. Ultimately, we are going to have to have a fairly simple sales pitch, and mobility in its own right may represent a compelling idea.

What about the federal role, partner or turnback? Both authors indicate that there is economic justification for federal involvement in a continuing transportation program. The nation's economy is the sum of all of our community economies.

McDowell also notes the significance of revenue preemption by the federal and state governments:

> The reality of the American federal system is that the responsibility for getting things done tends to sink to the local level while the ability to raise funds tends to rise to the state and federal level. Every tax borrowing and spending limitation known to man can be found externally imposed upon local government, yet they still manage to raise half of the public work funds spent by government.

This is a profound statement. How we do things, whether ventures succeed or fail, ultimately depends on how they are financed. If we force local government into wrong ways of financing transportation, we are creating problems we haven't dreamed of yet.

What about our objectives? The authors noted some interesting objectives. We have to overcome disillusionment with government. You can't expect the public to support public expenditures if it thinks government is going to waste tax money. To overcome disillusionment, Stowers says, we must avoid pork barreling by Congress; it undermines credibility. He also maintains that needs studies will avoid misallocation of resources. A professional answer is inferred to substitute for the political answer of pork barreling.

I don't think that works. We delude ourselves into thinking we can avoid politics when asking Congress for money. Needs studies and cost-benefit analyses are not sufficient. A more substantial institutional response is needed. According to Stowers, the Highway Trust Fund provides a good foundation (a strong institutional example) but has disadvantages; "it tends to discourage solid investment analysis." Two points are relevant here.

First, it is not the trust fund concept itself that gets in the way of proper investment analysis; it is the way that it is administered. Every state has been encouraged to get a higher proportion of Interstate allocations by, in effect, gold plating Interstate projects and in turn maximizing the state-Interstate cost estimate (ICE). It is the perverse incentive built into the Interstate allocation process that encourages such behavior.

Second, the Interstate categorical limitations forbid any thought of seeking more cost-effective investments. Although the Interstate program is in many ways a model of how to get some things done, it has had some unintended and undesirable impacts as well, and this is one of them.

If we want government to have credibility, we have to build in the right kind of incentive systems, incentive systems that encourage cost-effective decisions, not incentive systems that encourage gold plating. What are the right incentive systems and how are we going to encourage a belief that government can do things right?

We can take factors like population, geography, and whatever else it takes to arrive at a political consensus to devise a formula to determine how the federal part of this program funding is to be distributed to states and to regions, leaving to each community the responsibility to make investment and project trade-offs absent the perverse influence of the so-called free federal dollar.

I am talking about political decisions. I am not talking about alternatives analyses and cost-benefit studies. They don't really matter. What really matters is having a place where someone is accountable for meaningful decisions. Some decision center must have a budget of X dollars, whatever it is. That entity can make bad decisions and spend too much money on certain projects but clearly at the cost of not having the same dollars to spend somewhere else.

Somehow or other we must devise a concept of delegating real responsibility and authority instead of having the situation that now exists, in which the game is to get the biggest project possible out of each of the federal funding categories and to avoid having to make prudent investment choices.

What proposals are being offered? Stowers has 19, and for the most part, I can support them. I support some of McDowell's proposals, but I have trouble with his notion that we are going to have a national highway system that is going to be a lot larger than the one we have now and that it will be separated from a local mobility grant. He argues for a partnership and then proposes a separation that is guaranteed to undermine any meaningful partnership.

His proposal would serve three of his objectives, that is, access to new destinations, building shortcuts, and serving truck traffic. But it would do so partly at the expense of addressing congestion in urban and suburban areas. Local government holds the sack for that objective and will continue to do so, because it will get the federal crumbs after the other three objectives have been served. We will be left with insufficient funds and a weakened partnership unable to adequately address the fourth objective, attacking congestion.

My conclusion is that it would not be difficult to find agreement on the fact that economic justification is basic to the continuing federal role, that we must rectify underpricing and underfinancing of transport or pay the price in congestion and inefficient production. We need a new vision and system definition in order to focus our work, to provide discipline, and in the process avoid pork barreling. Institutionally, we must recognize the diversity of our communities and mechanisms for serving them. A federal program is needed with the federal objective of serving our common interests and respecting our unique requirements.

MICHAEL D. MEYER I would like to commend the authors for good papers on a difficult topic. The institutional and funding characteristics of future transportation programs are critical dimensions of ultimate success (or failure).

Both authors begin their papers by examining the national trends that have influenced our transportation experience. Such a beginning to the papers is important because the political and social environment of transportation directly affects the nature of governmental programs designed to support our nation's transportation system. A good example of this influence is found in *Building the American Highway System*, by Bruce E. Seely (Temple University Press, 1987). To quote Seely:

> In rapid succession, the Depression, World War II, the postwar inflationary boom, and finally rationing during the Korean conflict imposed severe strains on the highway community. In only sixteen years, highway priorities shifted from building a primary system to providing jobs to conducting a very limited defense road program to building roads as fast as possible after several years of inattention amidst rapid inflation and materials shortages. . . . After 1940, urban planners; social thinkers; chambers of commerce; economists pursuing Keynesian theories of government spending; bureaucrats in departments such as State, Agriculture, and Interior; and advocates of other special interests such as utilities and labor all demanded voice in shaping policy.

Seely's conclusion was that political and societal exigencies greatly influenced the scope and magnitude of the federal role in transportation. It is likely

Michael D. Meyer is Professor of Civil Engineering, Georgia Institute of Technology. Before assuming this position in 1988, he was Director of Planning for the Massachusetts Department of Public Works. He is past chairman of the TRB Committee on Education and Training and currently chairs the Committee on Statewide Multimodal Transportation Planning.

that the same will be true as Congress begins to shape the next federal-aid transportation program.

Both McDowell and Stowers discuss the growing problem of suburban transportation, the changing scale and nature of commuting demands and patterns, the increasing significance of off-peak travel, and the use of urban Interstates to serve local travel demands. Experience in Massachusetts indicated that these are some of the most important characteristics of urban travel. Allow me to add some more factors that will likely become even more important in the future:

1. Greater attention is being given to the land use–transportation linkage, in particular, how changes in land use policies and regulations can be used to mitigate or avoid transportation problems.

2. Many cities have implemented regional freeway management programs, and many others are in various stages of planning. I predict that some of the most exciting transportation efforts in the United States during the next 10 years will be related to operations and system management.

3. The urban transportation problem is not likely to be solved with one modal strategy. Intermodal connections among automobile, transit, ridesharing, and intercity transportation will become more critical in the future.

4. As transportation congestion has become more commonplace around the country, more and more groups are trying to address the problem. This has made a publicly dominated, regionally focused transportation planning process less likely to respond to local needs. We will likely see in the future more subregional, locally initiated transportation planning.

5. A major objective of most political leaders is achieving economic prosperity for his or her constituents. The role of transportation in achieving this objective will become more important.

6. Walton commented earlier about the regional transportation system and how regional problems will likely require some states to work together on addressing these issues. I think goods movement is going to be such an issue. It is going to put a strain on our normal way of doing business at the local and regional levels.

7. As everyone at this conference has mentioned, the increasing importance of suburban transportation will force the transportation community to spend more time on this issue. I think the fundamental question not addressed in the papers is, What does suburban transportation mean to planning agencies? In Boston there are serious problems between dealing with the demands from the suburban communities and a regional point of view adopted by the regional planning agencies. Adopting a subregional focus and forming subregional councils are ways to deal with this. In connection with this is the question of what the private sector does, not from the point of view of

contributing money for improvements to the highway system, but from an institutional point of view. That is, what role do they want to play in deciding priorities in your particular areas? A lot of nonprofit corporations are being formed in Boston whose purposes range from encouraging ridesharing to lobbying state government for transportation projects.

The authors next discuss the options or implications of the external factors and forces that they defined: adopting new national goals, tapping consumers' pocketbooks, accelerating innovations, and reinvigorating intergovernmental partnerships.

I would like to have seen more justification for the recommendations in these papers: in McDowell's, the 90/10 percent program for a national system and in Stowers', an Interstate/urban and rural delineation of federal programs.

I do not necessarily agree with some at this conference that institutional concerns or barriers are problems. I think there's a real problem with the tone that we as transportation professionals use in dealing with the institutional and political environment. The institutional framework—organizational, procedural, and political—was put there for a purpose. We professionals are the ones that put the framework in place. We are the ones that people have trusted to make decisions, to establish frameworks, to protect society, if you will. I do not and have never viewed institutional issues as a barrier per se. I view them as a challenge. If they cannot be surmounted and if I did my best in trying, so be it.

The political environment is critical, whether we like it or not. The politicians are elected to make decisions, and I think we need to recognize that. We need to be careful about using such phrases as "political interference in the transportation program," which are found in these papers and which have been used throughout the conference.

Let me end with an analogy about the transportation program and how it has become very complex. The transportation program is like a canoe. Over time, more and more people have jumped into the canoe—the environmentalist, the developer, the businessman, and of course highway engineers and planners. So many people in the canoe creates problems. Problem one is that if you want to head in one general direction, you all need to be going in that same direction. Problem two is that the surest way of sinking is to pick a fight with someone in the canoe. There is an important lesson for transportation policy in this analogy.

JACK KINSTLINGER Both authors of the papers in this session agree that transportation programs are underfunded, and that there is little research and development and lack of technological innovation. Transportation agencies are experiencing a loss of qualified staff due to retirement. There is a fragmentation in responsibility for transportation between different levels of government, between public and private sectors, between modes, and among transportation, land use, and other types of infrastructure. As a result, many segments of our transportation systems are congested, unsafe, and deteriorating, and current investments are often not cost-effective.

Let's look at the overall environment in which the system operates. First, the taxpayers will never allow any public system to be as well funded and as effective as its advocates wish. Despite its many problems, transportation today is probably better funded, enjoys more support, and is more effective than most other public infrastructure systems in the United States. But the trends are unfavorable, and things will probably get worse before they get better.

Our problem is one shared by all public infrastructure and probably the public sector as a whole in this country, which is traditionally underfunded. Given the global responsibilities of the federal government such as defense, health, law and order, welfare, and budget and trade deficits, I believe transportation congestion and safety hazards will be viewed as low on the list of federal government priorities.

Therefore, we must ask whether the primary responsibility for expanding and maintaining our transportation systems should reside at the federal level or whether a significant responsibility should be shifted to states and local levels.

What has traditionally been the federal role in transportation and other infrastructure systems? Historically, it has been one primarily of start-up, to stimulate state and local investments, to set standards and goals, to help build the basic structure and thereby ensure that the needs of interstate commerce are met.

These federal responsibilities to a large degree have been met in the last two decades. Why did we look to the federal government to get us started on new transportation systems after the Second World War? First, state governments then generally lacked sophistication, and most were unresponsive to the urban needs. There was a lack of uniformity between the states in design and operating standards. There was a need for cross-subsidy between states to get

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Jack Kinstlinger is President of Kidde Consultants. He was Executive Director for the Colorado Highway Department and served the State of Pennsylvania as Director of Planning for the Department of Highways and Secretary for Planning for the Department of Transportation.

the basic systems built. I maintain that to a large extent these conditions no longer apply.

The continuing challenge is to preserve, improve, extend, refine, and fill gaps—a role that increasingly will have to be addressed by state and local governments, who are closest to the problem and can best determine mode-specific and site-specific solutions. The basic components of our transportation system were established recognizing that role, and some are functioning better than others. In a number of systems, particularly highways, the greatest means to expand and to improve are within our metropolitan and suburban areas.

Given the above, it is reasonable to conclude that the continuing federal role is to set goals and standards (with emphasis on defining minimally acceptable levels of transportation access, mobility, and safety), establish an information system, measure performance and identify unmet needs, support research and development that stimulate technological and managerial innovation, promote intergovernmental cooperation and ensure that current interstate transportation links are maintained in a good state of repair.

If the federal government were to assume this more limited role in transportation in the future, the bulk of federal transportation taxes would revert to the states if the states commit to certain conditions:

- Transportation systems must meet defined adequate levels of access, mobility, and safety, with a system of federal rewards for meeting or exceeding these levels.
- Distribution of funds between different categories and modes of transportation must be appropriate.
- There must be an adequate passthrough of funds to local governments and, where appropriate, transportation decisions must be made by intergovernmental forums involving appropriate elected officials.

The federal government would maintain a portion of existing transportation funding on a unified basis for research and development, rewards to the states for meeting defined objectives, data systems, training, and the repair and rehabilitation of key Interstate links of national significance.

State and local governments have matured sufficiently to assume the basic management of their transportation systems. McDowell noted that it has been generally recognized by many that place-specific programs, as distinct from people-specific programs, should fall in the turnback category appropriate for state and local responsibility.

It is at this level that transportation decisions can be linked to growth management, land use, other infrastructure systems, and environmental, social, and economic issues. Innovative financing, including toll roads, privatization, and public-private cost sharing, can best be negotiated at state and local levels of government.

Fred Miller As Director of the Executive Department for the State of Oregon with some responsibility over a number of state agencies, I qualify as an outsider to those in the transportation profession. I have some observations prompted by the papers presented here and by this role as an outsider. They relate to the groundwork you need to lay or things you have to do now if in fact you are going to arrive at an appropriate solution in terms of institutional constraints or institutional forums, or even kinds of funding.

First, we really do need a vision, something that represents new intellectual capital, and I am not sure that I have seen it yet. I don't believe, especially given the last round of tax increases, that there is a lot of sympathy for the transportation sector to be won by more needs studies or by not having broader visions, broader linkages to economic development, land use, and other issues mentioned here. There has to be a little sense of excitement.

My second point is that the transportation community, and in particular the highway community, doesn't get much sympathy for the fairly narrow objectives of the trust fund. They may be guarding the allocation formula within the trust fund or the federal, state, and local organizational relationships. We are watching people fighting over a pie that maybe isn't growing fast enough for transportation needs. Most other sectors, whether for human resources or higher education, feel as though they are still trying to pick out their salad while transportation is worrying about the dessert.

Third, one of the recommendations was to double the investment in public works. I think there is a perception that there has been an overinvestment in transportation. We argue sometimes that transportation is very important for economic development, and it is. But, that is sort of an argument on the average or a historical argument without looking at evaluating the next investments or without looking at investments at the margins.

Other sectors believe that they have been making greater sacrifices. They have had fewer resources over the last few decades than has transportation. Politically, again, this is a difficult road. You must show productivity increases and be accountable.

Interestingly, and this is really an extension of the same point, when I look at priorities, I am amazed at how similar priorities are from one state to another when you look at governors' agendas. Our governor's major priorities are related to children's needs, and that is clearly not unique among states. Crime and corrections are among the top two or three issues; education, mental health, and economic development are also there. Transportation issues have to be either on that list or linked to that list in order to be a popular

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Fred Miller is Executive Officer of the Executive Department, State of Oregon. He was Director of Transportation for the State of Oregon from 1982 to 1987. He has had a wide variety of teaching and other professional assignments.

investment for state legislatures or for Congress. When I go through that list, the only link I can find is economic development.

Our economy has been driven by major transportation investments, and they go at about 50-year swings. In the mid-19th century, rail drove the economy. If you take a few liberties and say 50 years later or thereabouts, there is the age of the automobile, and that drove the economy. Perhaps air and space are now driving the economy.

What is the next transportation investment that will drive the economy forward? I am not sure I see it. Until recently, there hasn't been nearly enough emphasis in terms of research, development, and productivity improvements. We may have missed an opportunity, because the next wave may well be microelectronics, communications, computers. Some of that can be substitutable for transportation. I'm not naive enough to think that all of it can.

If I were operating a transportation agency, what would I do in the fairly short run to try to establish a base to make sure that a 2020 program were acceptable?

I see a combination of organizational or institutional inertia that you can all address. Sometimes our agencies are perceived as (and actually do have) either too many people or maybe too much of an old guard that does not encourage new ideas or new approaches. Certainly that relates when I think about conversations with a number of transportation and highway agencies on the state level; some things could be done better.

There is not enough emphasis on improving productivity and, when there is a good idea out there, pushing it hard enough. The trust fund has been perceived as too much of an island, too much envied by other agencies, both at the state and national levels. There are things organizations can do to share the wealth a little bit. On the state level, there are ways to make programs available to others and to generate more support.

I really don't worry a lot about pushing on those kinds of organizations or institutions to change, because the institutional momentum is so strong in most of our agencies. So I think that you in management positions have great liberties to push a little bit and try new things without fear of great failure.

Both McDowell and Stowers mentioned attracting talent. That's obviously an important point, and organizationally you can structure some things that take advantage of talent. Looking for people with different backgrounds or new ideas and making sure the climate is right are awfully important in terms of the image on the outside of the transportation agencies, and what will be acceptable when you come up with a 2020 plan.

However, as you experiment with new and different things I would hate to see you discard some awfully good partnerships, whether the federal-state partnership or federal-state-local partnership, or some combinations. There are some real strengths to build on that I think you can capture.

If I were funding transportation right now, I would cough up some money to try different institutional combinations that make some sense and that people can learn from. There are some kinds of personality and structural relationships that make it easier in certain places. I would get behind that innovation so that in the future there will be other combinations and ways to do things.

The other change I would hate to see is giving away a federal trust fund. I think you have got to stick with the trust fund. Certainly some frustrations with how it is used relate to turnback proposals, and states have either constitutional or statutory constraints on the trust fund.

I would try to deal with other jurisdictions in terms of additional funding, maybe even put some trust funds in with some other kinds of funds to achieve this larger aim or larger goal that we are talking about. But we should hang on to the base in terms of preserving the system that is there, even if some can argue that there is an overinvestment. You still have to preserve what is there.

Last, I think there is a real duty to communicate broadly what is going well, larger goals, and maybe, as one of the authors mentioned, an industrialization goal on national competitiveness. I think you have to be perceived as players in a larger sphere. There needs to be a more statesmanlike approach to problems within the transportation sector and better partners. That would establish a climate in which an innovative 2020 plan could succeed. From my point of view, there is a real opportunity, but it is going to take some short-run work. It is not just a long-run planning exercise.

Steering Committee Biographical Information

THEODORE C. LUTZ, *Chairman*, is Business Manager for the *Washington Post*. He has a B.A. from Carleton College and an M.A. in public administration from Syracuse University. After holding positions with the Office of Management and Budget and the U.S. Department of Transportation, he became General Manager for the Washington Metropolitan Area Transit Authority. He was with WMATA for 8 years, and in 1984 he joined the *Washington Post*, first as Vice President for Personnel and currently as Business Manager. He is a member of Virginia's Commission on Transportation in the 21st Century and a board member of the Meyer Foundation and the Washington Performing Arts Society.

PAUL N. BAY is Assistant General Manager for System Development at Metro Transit Authority in Houston, Texas. He graduated from Stanford University with a B.S. in civil engineering and became a traffic engineer for Salt Lake City. Next he worked for the city of San Mateo, California, as a traffic engineer and then for the consulting firm of Wilbur Smith and Associates. He was Deputy Executive Director for the Metropolitan Transportation Commission in Berkeley, California, before becoming Executive Director for Planning and Development at Tri-Met in Portland, Oregon. Upon leaving Tri-Met he joined the Houston agency.

SUSAN C. CRAMPTON is Secretary of the Vermont Agency for Transportation. She graduated from the College of William and Mary and the School of Business Administration at the University of Vermont. A Certified Public Accountant, she was associated with the firm of Gallager, Flynn, Crampton and Company until joining the agency. She is Vice President of the Northeast Association of State Highway and Transportation Officials.

ROBERT W. CRANDALL is Senior Fellow in Economics at the Brookings Institution. He received a B.A. and an M.A. from Cincinnati and Northwestern universities, respectively. After earning a Ph.D. from Northwestern, he became Associate Professor of Economics at the Massachusetts Institute of Technology. He is a member of the American Economic Association.

EARL DOVE is Chairman of the Board of AAA Cooper Transportation. He has been with the firm for more than 30 years. Mr. Dove attended the University of Tennessee and received a B.S. in transportation. He serves as a member of the Executive Committee of the American Trucking Associations, is on the Board of Governors of the Regular Common Carrier Conference as well as Chairman of their Economic Research Committee, and is a member of the Board of Directors of the Alabama Trucking Association.

THEODORE J. HACKWORTH, JR., is a City Councilman for Denver, Colorado. He attended Denver University and held several positions in the area and in Montana until he became councilman 9 years ago. He is a past member of the Denver Public Schools Board and a member of the Denver Regional Council of Governments, with which group he served as both Vice Chairman and Chairman. He is a member of the National Association of Regional Councils and its incoming President.

WILLIAM J. HARRIS is Snead Professor of Transportation Engineering at the Texas Transportation Institute of Texas A&M University System. He was born in South Bend, Indiana, and attended Purdue University where he received his B.S. in chemical engineering and his M.S. in metallurgy. After earning a Ph.D. from Massachusetts Institute of Technology, he served as Executive Secretary of the Metallurgical Advisory Board, Assistant Director of the Battelle Memorial Institute, and Vice President of the Research and Test Department of the Association of American Railroads. He is Past Chairman of the National Materials Advisory Board and a member of the National Academy of Engineering.

LESTER P. LAMM is President of the Highway Users Federation for Safety and Mobility. He received a B.S. in civil engineering from Norwich University and did postgraduate work at the Massachusetts Institute of Technology and the University of Maryland. After serving in various technical and managerial assignments with the Federal Highway Administration, Mr. Lamm became

Deputy Administrator of FHWA and retained that position until retiring from federal service. He has been an active member of many professional associations and received many honors and awards during the course of his career, including the 1984 George S. Bartlett Award for outstanding service on behalf of America's highway transportation system—an award presented jointly by AASHTO, TRB, and the American Road and Transportation Builders Association.

LILLIAN C. LIBURDI is Director for Management and Budget at the Port Authority of New York and New Jersey. She has a B.A. from American University and an M.S. in engineering from Manhattan College. She has been in the transportation field since her first position, with the Washington Metropolitan Council of Governments, after which she was with the Port Authority and with UMTA. She is a member of the American Society for Public Administration and President of the Women's Transportation Seminar National.

KENNETH G. MCKAY is Chairman of the Charles Stark Draper Lab, Inc. He is a native Canadian, born in Montreal, and became a U.S. citizen in 1934. He graduated from McGill University and Massachusetts Institute of Technology and held positions with the National Research Council of Canada, Bell Telephone Laboratories, and AT&T before joining Charles Stark Draper Lab. He is a trustee of Stevens Institute of Technology, on the Board of Governors of McGill University, and a member of both the National Academy of Sciences and the National Academy of Engineering.

CHARLES L. MILLER is Director of the Arizona Department of Transportation. He received his bachelor's degree in civil engineering from West Virginia University and served with the West Virginia Department of Highways in many capacities, including Commissioner. Mr. Miller joined the Arizona Department of Transportation in 1984 as Assistant Director and has been Director since 1985. He is Chairman of the AASHTO Executive Committee.

GRAHAM T. MOLITOR is Chief Executive Officer of Public Policy Forecasting, Inc. He received a B.S. from the University of Washington in Seattle and an L.L.B. from American University. After serving as legislative counsel for the U.S. House of Representatives, he became involved in governmental relations, acting as Director and Assistant Director in that field for General Mills, Inc., and Nabisco, Inc., respectively. He is a member of the Washington Business-Government Relations Council, the Washington Industrial Roundtable, and the Advisory Board of New Marketing Technologies Monitor.

PETER A. MORRISON is Director of the Population Research Center for the Rand Corporation. He received a B.A. from Dartmouth College and an M.A. from Brown University and was an Assistant Professor at the University of Pennsylvania until joining the Rand Corporation. He is a member of the Population Association of American and is on their Board of Directors.

PHILLIP S. MYERS is Chairman of the Department of Mechanical Engineering at the University of Wisconsin, Madison. He graduated from McPherson College with a B.S. in mathematics and commerce and from Kansas State University with a B.S. in mechanical engineering. After receiving a Ph.D. in engineering from the University of Wisconsin, he joined the faculty, first as Assistant Professor, then as Associate Professor, and now as Chairman. He has received many awards and is a fellow of the American Society of Mechanical Engineers and a member of the National Academy of Engineering.

JAMES P. PITZ is Director of the Michigan Department of Transportation. After earning a B.S.C.E. in structural engineering from Marquette University and an M.S. in structural design from the University of Illinois, he joined the staff of the Illinois Department of Transportation. During his 16 years with the department he was involved in planning and program development in various capacities. He left the Illinois Department of Transportation to advise the Saudi Arabian government and the U.S. Treasury Department on intermodal planning and programming activities. He is a member of the American Society of Civil Engineers and the Michigan Society of Professional Engineers.

ROBERT H. SMITH is President of The Futures Group. Born in California, he attended American University's School of International Service and received a Ph.D. in political science from Temple University. After positions with the Westinghouse Corporation and Syntex Corporation, he joined The Futures Group, becoming its president in 1980.

William M. Spreitzer heads the Operating Systems Research Department at General Motors Research Laboratories in Warren, Michigan. He is a native of Michigan, born in Highland Park, and received a degree in aeronautical engineering from the University of Detroit. He has been with the GM Research Labs for more than 30 years in various capacities. Mr. Spreitzer was a member of the Committee on Transportation of the National Research Council's Assembly of Engineering and a delegate to the 1971 White House Conference on Aging. He serves on the visiting committee for the College of Engineering of the University of Pittsburgh and on the Transportation Development Advisory Committee of the Highway Users Federation for Safety and Mobility. He is a member of the Engineering Society of Detroit and the Society of Automotive Engineering.

John R. Tabb is Director of the Mississippi State Highway Department. After studying at Mississippi College, he was employed by the Highway Department and became Executive Secretary of the Mississippi Highway Commission. He has been a member of the TRB Executive Committee and is Vice President of AASHTO and Chairman of the Executive Committee for the Strategic Highway Research Program.

Carmen E. Turner is General Manager of the Washington Metropolitan Area Transit Authority. She attended Harvard University and received an M.A. from American University. During 25 years with the federal government, Ms. Turner held various positions, including Deputy Director for Civil Rights for UMTA and Acting Director of Civil Rights for the U.S. Department of Transportation. She has received honorary degrees from Southeastern University and Youngstown University School of Law, as well as achievement awards from DOT and UMTA. A member of the American Public Transit Association, Ms. Turner is past President and cofounder of the Conference of Minority Transit Officials.

Carl S. Young is County Executive for Broome County, New York. He graduated from Syracuse University with a B.A. in political science and has been in politics and education for the last 15 years. He was Broome County Legislator for four terms, and Majority Leader for three years. As a teacher in the City School District of Binghamton, he was honored as Outstanding Secondary Educator in America in 1974.

Participants

ADAMS, ROBERT G., Michigan Department of Transportation, 425 West Ottawa, Lansing, Michigan 48909

ADAMS, JOHN J., Ohio Department of Transportation, 25 S. Front Street, Columbus, Ohio 43215

AGNEW, WILLIAM, General Motors Research Laboratories, 30500 Mound Road, Warren, Michigan 48090

AL-SALEH, OMAR, Kuwait University, 9519 Bear Creek Boulevard, White Haven, Pennsylvania 18661

ALSTON, SHERRI, D.C. Department of Public Works, 2000 14th Street, N.W., Washington, D.C. 20009

ANDERSON, ANDREW B., Asphalt Institute, Asphalt Institute Building, College Park, Maryland 20740

AOYAGI, GORDON, Chief, Division of Transit Services, 101 Monroe Street, Rockville, Maryland 20850

ARCHER, JOHN, American Automobile Association, 8111 Gatehouse Road, Falls Church, Virginia 22047

AYELE, MOGES, Morgan State University, Cold Spring Lane and Hillen Road, Baltimore, Maryland 21239

BACKER, JOHN, Maryland Mass Transit Administration, 300 W. Lexington Street, Baltimore, Maryland 21201

BEACHEM, PHILIP K., New Jersey Alliance for Action, P.O. Box 6438, Edison, New Jersey 08818

BECKER, ROBERT W., New Orleans City Planning Commission, 9W City Hall, 1300 Perdido, New Orleans, Louisiana 70116

BENJAMIN, PETER, Washington Metropolitan Area Transit Authority, 600 5th Street, N.W., Washington, D.C. 20001

BENNETT, JOHN C., Booz-Allen & Hamilton, Inc., 4330 East West Highway, Bethesda, Maryland 20814-4455

BENNETT, JACK, U.S. Department of Transportation, Office of the Secretary, 700 D Street, S.W., Washington, D.C. 20590

BERRY, JUDITH, New Jersey Department of Transportation, 1035 Parkway Avenue, Trenton, New Jersey 08625

BERTRAM, BRUCE, Salt Institute, 206 North Washington Street, Alexandria, Virginia 22314

Bestgen, John G., Federal Highway Administration, Leo O'Brien Federal Building, Albany, New York 12207

Beury, Kim S., *American City and County Magazine*, 4425 A Forbes Boulevard, Lanham, Maryland 20706

Blake, Steve, National Association of Regional Councils, 1700 K Street, N.W., Washington, D.C. 20006

Bloom, Madeleine S., Office of Policy Development, U.S. Department of Transportation, 400 7th Street, S.W., Washington, D.C. 20590

Boske, Leigh, LBJ School, University of Texas, Drawer Y, University Station, Austin, Texas 78713

Bosley, John J., National Association of Regional Councils, 1700 K Street, N.W., Washington, D.C. 20006

Bower, Dwight M., Colorado Department of Highways, 4201 E. Arkansas Avenue, Denver, Colorado 80222

Bradshaw, Thomas W., First Boston Corporation, 12 East 49th Street, New York, New York 10017

Brahms, Thomas W., Institute of Transportation Engineers, 525 School Street S.W., Washington, D.C. 20024

Braun, Richard P., Center for Transportation Studies, University of Minnesota, Minneapolis, Minnesota 55455

Brennan, Tim, Pioneer Valley Planning Commission, 26 Central Street, West Springfield, Massachusetts 01089

Brooks, Walter R., New Orleans Regional Planning Commission, 333 St. Charles Avenue, New Orleans, Louisiana 70130

Bulley, William A., H. W. Lochner, Inc., 301 116th Avenue, S.E., Suite 490, Bellevue, Washington 98004

Bushey, Roy, California Department of Transportation, 1130 K Street, Sacramento, California 95807

Byrley, Charles, American Public Works Association, 1301 Pennsylvania Avenue, N.W., Washington, D.C. 20005

Carver, Caroline, American Traffic Safety Services Association, 4540 Jefferson Davis Highway, Fredericksburg, Virginia 22401

Casey, R. J., High Speed Rail Association, 206 Valley Court, Suite 800, Pittsburgh, Pennsylvania 15237

Chu, Sherwood C., MITRE Corporation, 7525 Colshire Drive, McLean, Virginia 22102

Church, C. David, Michigan Department of Transportation, P.O. Box 30049, Lansing, Michigan 48909

Cianto, Donald J., Institute for Global Democracy, 2618 32nd Street, S.E., Washington, D.C. 20020

Clark, Don, State Department of Highways and Public Transportation, 11th and Brazos, Austin, Texas 78701

CLARK, J. P., Federal Highway Administration, Room 312, Mohawk Building, Portland, Oregon 97204

CLAWSON, DAVID H., American Association of State Highway and Transportation Officials, 444 North Capitol Street, N.W., Washington, D.C. 20001

COLUCCI, ROBERT, New York State Department of Transportation, 1220 Washington Avenue, Albany, New York 12232

COVIL, JAMES L., Wilbur Smith Associates, P.O. Box 92, Columbia, South Carolina 29202

CRANDALL, DUANE L., Minnesota State Automobile Association, 7 Travelers Trail, Burnsville, Minnesota 55337

DAGGETT, TIMOTHY C., Dowty Aerospace Corporation, Sully Road, Sterling, Virginia 22170

DAVIS, ANDREW R., New Jersey Department of Transportation Department, 1035 Parkway Avenue, Trenton, New Jersey 08625

DAVIS, BRYAN H., Arkansas State Highway and Transportation Department, P.O. Box 2261, Little Rock, Arkansas 72203

DEAKIN, ELIZABETH, Department of City and Regional Planning, University of California, Berkeley, California 94720

DENHAM, EDWARD T., Florida Department of Transportation, Suwannee Street, MS 28, Tallahassee, Florida 32399

DIXON, ROBERT N., Richmond City Board of Commissioners, Room 605, Municipal Building, Augusta, Georgia 30911

DOMMERMOTH, RITA, Delaware Valley Regional Planning Commission, 21 South 5th Street, Philadelphia, Pennsylvania 19106

DOVE, S. EARL, AAA Cooper Transportation, P.O. Box 6827, Dothan, Alabama 36302

DOWNEY, MORTIMER L., Metro Transportation Authority, 347 Madison Avenue, New York, New York 10017

DULL, GARTH, Nevada Department of Transportation, 1263 S. Stewart Street, Carson City, Nevada 89712

DURGIN, DARRYL E., Minnesota Department of Transportation, Transportation Building, Room 413, St. Paul, Minnesota 55155

EDWARDS, HORACE B., Kansas Department of Transportation, Docking State Office Building, Topeka, Kansas 66612

EDWARDS, LAWRENCE K., Futrex Inc., 3507 Slade Run Drive, Falls Church, Virginia 22042

ELKINS, MARTY, National Conference of State Legislatures, 444 N. Capitol Street, N.W., Washington, D.C. 20001

FIEDLER, RONALD R., Office of the Secretary, Wisconsin Department of Transportation, Madison, Wisconsin 53707

FORTIER, DANIEL J., Metropolitan Area Planning Council, 110 Tremont Street, Boston, Massachusetts 02108

FRANTZ, ROBERT C., Maryland Department of Transportation, Baltimore/Washington International Airport, Baltimore, Maryland 21240

GARLIAUSKAS, LUCY, Maryland State Highway Administration, 707 Calvert Street, Baltimore, Maryland 21203

GAUDIO, STEVEN, Maryland Department of Transportation, M.S. 135, Baltimore/Washington International Airport, Baltimore, Maryland 21240

GEISSLER, ERNEST, State of Washington County Road Administration Board, 206 10th Street, S.E., Olympia, Washington 98504

GLASCOCK, LACEY A., Louisiana Department of Transportation, P.O. Box 94245, Baton Rouge, Louisiana 70804

GONSETH, AL, Port Authority of New York and New Jersey, One World Trade Center, New York, New York 10048

GOODMAN, LEON, Port Authority of New York and New Jersey, One World Trade Center, New York, New York 10048

GRAY, JOHN, National Asphalt Pavement Association, 6811 Kenilworth Avenue, Riverdale, Maryland 20737

GREER, ROBERT W., New Hampshire Department of Transportation, J.O. Morton Building, Hazen Drive, Concord, New Hampshire 03302-0483

GRENAGER, TROND, Kidde Consultants, 1020 Cromwell Bridge Road, Baltimore, Maryland 21204

GRENKE, WILLIAM C., Roy Jorgensen Associates, P.O. Box 3310, Gaithersburg, Maryland 20878

GRIEBEL, THOMAS, State Department of Highway and Public Transportation, 11th and Brazos, Austin, Texas 78701

HAACK, HARVEY, Pennsylvania Department of Transportation, 1200 Transportation and Safety Building, Harrisburg, Pennsylvania 17120

HAIFLEY, JOHN F., American Automobile Association, 8111 Gatehouse Road, Falls Church, Virginia 22047

HANSON, DANIEL J., American Road and Transportation Builders Association, 525 School Street, S.W., Washington, D.C. 20024

HARDY, FLOYD E., Georgia Department of Transportation, 2 Capitol Square, Atlanta, Georgia 30334

HARTMAN, RICHARD C., National Association of Regional Councils, 1700 K Street, N.W., Washington, D.C. 20006

HAWES, DAVID, Alaska Department of Transportation, Public Facilities, P.O. Box Z, Juneau, Alaska 99811

HAYWARD, JOHN, Michael Baker, Jr., Inc., 4301 Dutch Ridge Road, Beaver, Pennsylvania 15009

HEANUE, KEVIN E., Federal Highway Administration, 400 7th Street, S.W., HPN-1, Room 3212, Washington, D.C. 20590

HERMAN, WILLIAM I., Washington Metropolitan Area Transit Authority, 600 Fifth Street, N.W., Washington, D.C. 20001

HEY, JOHN, Iowa Department of Transportation, 800 Lincoln Way, Ames, Iowa 50010
HOEL, LESTER A., Department of Civil Engineering, University of Virginia, Charlottesville, Virginia 22901
HOFFMAN, KATHY F., California Department of Transportation, 444 North Capitol Street, N.W., Washington, D.C. 20001
HOJSAK, DAVID J., Department of Treasury, Office of State Planning, Trenton, New Jersey 08625
HOPE, MELISSA, WILC-AM, P.O. Box 42, Laurel, Maryland 20707
HUM, JOICE, Transport Canada, Place de Ville, Ottawa, Ontario K1A 0N5, Canada
HUMPHREY, THOMAS F., Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139
IGO, DONALD J., Office of the Secretary, U.S. Department of Transportation, 400 7th Street, S.W., Washington, D.C. 20590
JACKSON, IRA, City Council, City Hall, 68 Mitchell Street, S.W., Atlanta, Georgia 30335
JACKSON, LOWELL B., Federal Highway Administration, 400 7th Street, S.W., Washington, D.C. 20590
JENSEN, VOLMER, Federal Highway Administration, 31 Hopkins Plaza, Baltimore, Maryland 21201
JOHN, RICHARD R., Transportation Systems Center, U.S. Department of Transportation, Kendall Square, Cambridge, Massachusetts 02142
JOYNER, HARVEY R., Barton-Aschman Associates, Inc., 1133 15th Street, N.W., Washington, D.C. 20005
JUDYCKI, DENNIS C., Federal Highway Administration, 400 7th Street, S.W., Washington, D.C. 20590
KARPILOFF, DOUG, Port Authority of New York and New Jersey, One World Trade Center, New York, New York 10048
KEMP, JOHN B., Howard, Needles, Tammen & Bergendoff, 9200 Ward Parkway, Kansas City, Missouri 64141
KHAN, ATA M., Department of Civil Engineering, Carleton University, Ottawa, Ontario K1S 5B6, Canada
KIHL, MARY, College of Design, Iowa State University, Ames, Iowa 50011
KING, ROLLAND D., Battelle, 505 King Avenue, Columbus, Ohio 43201
KLEPNER, LAWRENCE H., Delaware Department of Transportation, P.O. Box 778, Dover, Delaware 19903
KNIGHT, DON, Transportation Alternatives Group, 1776 Massachusetts Avenue, N.W., Washington, D.C. 20036
KNOX, ROBERT G., Metropolitan Transportation Commission, Metro Center, 101 8th Street, Oakland, California 94607
KOCHANOWSKI, ROBERT, S.W. Pennsylvania Regional Planning Commission, Waterfront, 200 1st Avenue, Pittsburgh, Pennsylvania 15222

KOLTNOW, PETER G., 9210 Fernwood Road, Bethesda, Maryland 20817
KRANISH, ARTHUR, Trends Public Inc., 1079 National Press Building, Washington, D.C. 20045
LAHUE, SANFORD, American Concrete Pavement Association, 3800 N. Wilke Road, Arlington Heights, Illinois 60004
LEIPER, JOE, Port Authority of New York and New Jersey, 54 South, One World Trade Center, New York, New York 10048
LEONARD, KEN, Office of the Secretary, Wisconsin Department of Transportation, Madison, Wisconsin 53707
LEVI, PETER S., Mid-America Regional Council, 600 Broadway, Kansas City, Missouri 64105
LIBURDI, LILLIAN C., Port Authority of New York and New Jersey, One World Trade Center, New York, New York 10048
LIPMAN, DEBORAH S., Washington Metropolitan Area Transit Authority, 600 5th Street, N.W., Washington, D.C. 20001
LOCKWOOD, STEPHEN C., Transportation Alternatives Group, 1776 Massachusetts Avenue, Washington, D.C. 20036
LUTZ, THEODORE C., *The Washington Post*, 1150 15th Street, N.W., Washington, D.C. 20071
MACDONALD, LOUIS N., Federal Highway Administration, Region 8, 555 Zang Street, Lakewood, Colorado 80228
MARK, FRAN, Dutchess County Legislature, 22 Market Street, Poughkeepsie, New York 12601
MATTSON, CHESTER, Bergen County, Administration Building, Hackensack, New Jersey 07601
MCCORMACK, RICHARD A., *New Technology Week*, 627 National Press Building, Washington, D.C. 20045
MCCREADY, RONALD D., Puget Sound Council of Governments, 216 First Avenue South, Seattle, Washington 98104
MCDONALD, MARY F., Vermont Agency of Transportation, 133 State Street, Montpelier, Vermont 05602
MCINTYRE, GEOFFREY R., U.S. Department of Transportation, 400 7th Street, S.W., Washington, D.C. 20590
MCMANUS, GERALD, Bureau of the Census, U.S. Department of Commerce, SPC B-105, Washington, D.C. 20233
MCQUEEN, JAMES T., Federal Railroad Administration, 400 7th Street, S.W., Washington, D.C. 20590
MCWILLIAMS, RUTH T., Office of Transportation, U.S. Department of Agriculture, Washington, D.C. 20250
MELTON, DAN, Office of the Secretary, Wisconsin Department of Transportation, Madison, Wisconsin 53707
MENARD, JACQUES, Ministère des Transports du Québec, 700, Boulevard St-Cyrille est, Québec G1R 5H1, Canada

MENGHINI, LENO, Wyoming State Highway Department, P.O. Box 1708, Cheyenne, Wyoming 82002-9019

MERRELL, WARREN, Florida Department of Transportation, Haydon Burns Building, Tallahassee, Florida 32301

MERWIN, DON, *Highway and Heavy Construction Magazine*, 1350 E. Touhy, Des Plaines, Illinois 60017

MEUNIER, DAVID, Comité de Prospective des Techniques de la Route, 46, Avenue A Briord, BP 100, Bagneux, France 92223

MEYERS, PHILLIP S., University of Wisconsin, Madison, Wisconsin 53706

MICHAELS, RICHARD M., University of Illinois at Chicago, 400 S. Peoria Street, Chicago, Illinois 60680

MILLER, TOM, University of South Florida, Tampa, Florida 33630

MOLITOR, GRAHAM T., Public Policy Forecasting, Inc., 9208 Wooden Bridge Road, Potomac, Maryland 20854

MORRILL, RICHARD L., Department of Geography, 408 Smith Hall, University of Washington, Seattle, Washington 98195

MULLEN, PAUL F., Metropolitan Area Planning Agency, 222 Cuming Street, Omaha, Nebraska 68102-4328

MURPHY, JEAN, *Traffic World*, 1225 Eye Street, Suite 30, Washington, D.C. 20005

MURPHY, MARY K., Office of Technology Assessment, U.S. Congress, Washington, D.C. 20510-6942

NELSON, JOHN C., Port Authority of New York and New Jersey, One World Trade Center, New York, New York 10048

NORMAN, MARK R., Institute of Transportation Engineers, 525 School Street, S.W., Washington, D.C. 20024

NORWOOD, BLAKE, Planning & Research Branch, North Carolina Department of Transportation, P.O. Box 25201, Raleigh, North Carolina 27611

O'TOOLE, STEPHEN E., General Motors Corporation, 1660 L Street, N.W., Washington, D.C. 20036

OAKLEY, JANET P., National Association of Regional Councils, 1700 K Street, N.W., Washington, D.C. 20006

OUELLETTE, RONALD A., Eno Foundation for Transportation, 270 Saugatuck Avenue, Westport, Connecticut 06880

PAIGE, JOHN H., Northeastern Illinois Planning Commission, 400 W. Madison Street, Chicago, Illinois 60606

PARCELLS, HARRIET, National Association of Railroad Passengers, 236 Massachusetts Avenue, N.E., Washington, D.C. 20002

PARKER, ELIZABETH A., U.S. Department of Transportation, 400 7th Street, S.W., Washington, D.C. 20590

PARSONS, BOB, Institute of Transportation, University of California, Berkeley, California 94720

PATTERSON, PHILIP D., U.S. Department of Energy, 1000 Independence Avenue, S.W., Washington, D.C. 20585

PERRY, CRAIG D., Coming & Going, 6309 Pacific Avenue, Plaza Del Rey, California 90293

PHETO, BEVERLY A., Office of Management and Budget, Room 9208, Executive Office Building, Washington, D.C. 20503

PHILLIPS, DAVID K., Federal Highway Administration, 400 7th Street, S.W., Washington, D.C. 20590

PIERPOINT, JAMES B., ABC/Chilton Publishing CCJ, 570 National Press Building, Washington, D.C. 20045

POLLARD, WM. S., JR., University of Colorado at Denver, Campus Box 113, Denver, Colorado 80204

POLZIN, STEVE, Dallas Area Rapid Transit, 601 Pacific, Dallas, Texas 75202

POOLE, MARION R., Planning and Research Branch, North Carolina Department of Transportation, P.O. Box 25201, Raleigh, North Carolina 27611

PROTEXTER, AMY, South Dakota Department of Transportation, 700 Broadway Avenue East, Pierre, South Dakota 57501

RADOW, LAUREL J., American Public Transit Association, 1201 New York Avenue, N.W., Washington, D.C. 20005

RAY, GEORGE T., Alabama Highway Department, 1409 Coliseum Boulevard, Montgomery, Alabama 36130

REED, HARRY A., Arizona Department of Transportation, 206 South 17th Avenue, Phoenix, Arizona 85007

REITH, JOHN L., American Trucking Associations, 2200 Mill Road, Alexandria, Virginia 22314

RIGGS, ANNE S., Floyd County, P.O. Box 946, Rome, Georgia 30161

RILEY, HERB, Oregon Department of Transportation, Room 516, Transportation Building, Salem, Oregon 97310

ROBERTSON, RICHARD B., Federal Highway Administration, 400 7th Street, N.W., Washington, D.C. 20590

ROBINS, MARTIN E., Metropolitan Transportation Authority, 347 Madison Avenue, New York, New York 10017

ROMEI, MICHAEL L., Shell Oil Company, One Rockefeller Plaza, New York, New York 10020

ROSENBLOOM, SANDRA, School of Architecture, University of Texas at Austin, Sutton Hall 2.130, Austin, Texas 78712

ROSSI, LOUIS, New York State Department of Transportation, 1220 Washington Avenue, Albany, New York 12232

ROYER, ROBERT E., Oregon Department of Transportation, Transportation Building, Salem, Oregon 97310

Ruggieri, Raymond, Port Authority of New York and New Jersey, One World Trade Center, New York, New York 10048

Ryan, Dianne M., *Urban Transport News*, 951 Pershing Drive, Silver Spring, Maryland 20910

Sams, Larry H., North Carolina Department of Transportation, P.O. Box 25201, Raleigh, North Carolina 27611

Sanborn, Fred H., Michigan Department of Transportation, 425 W. Ottawa, Lansing, Michigan 48909

Schoene, George, District of Columbia Department of Public Works, 2000 14th Street, N.W., Washington, D.C. 20009

Schrantz, Roger, Office of the Secretary, Wisconsin Department of Transportation, Madison, Wisconsin 53707

Schultze, Richard, Miami Valley Regional Planning Commission, 117 South Main Street, Dayton, Ohio 45402

Schust, Sunny Mays, American Association of State Highway and Transportation Officials, 444 North Capitol Street, N.W., Washington, D.C. 20001

Schuster, Neil D., International Bridge, Tunnel and Turnpike Association, 2120 L Street, N.W., Washington, D.C. 20037

Schwarzhoff, J. Chris, U.S.D.A. Forest Service, P.O. Box 2417, Washington, D.C. 20013

Serianni, Nick, Florida Department of Transportation, 564 Haydon Burns Building, MS 57, Tallahassee, Florida 32399

Shaw, Peter L., California State University, 1250 Bellflower Boulevard, Long Beach, California 90840

Sherman, Reith, Illinois Department of Transportation, 2300 South Dirksen Parkway, Springfield, Illinois 62764

Sims, Jim, Los Angeles County Transportation Council, 403 W. 8th Street, Suite 500, Los Angeles, California 90014

Sinha, Kumares C., School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907

Skoutelas, Paul P., Port Authority of New York and New Jersey, Beaver and Island Avenues, Pittsburgh, Pennsylvania 15233

Slater, Rodney, Arkansas Highway Commission, P.O. Box 2261, Little Rock, Arkansas 72203

Slimmer, Dennis, Kansas Department of Transportation, Docking State Office Building, Topeka, Kansas 66612

Small, Douglas, United Parcel Service, 316 Pennsylvania Avenue, S.E., Washington, D.C. 20003

Spear, Bruce, Transportation Systems Center, U.S. Department of Transportation, Kendall Square, Cambridge, Massachusetts 02142

Spreitzer, William M., General Motors Research Laboratories, 30500 Mound Road, Warren, Michigan 48090

STEINMAN, CHRISTINA, Deloitte, Harkins & Sells, 1001 Pennsylvania Avenue, N.W., Washington, D.C. 20004

STEPHENS, SPENCER K., *Engineering Times Magazine*, 1420 King Street, Alexandria, Virginia 22314

STOCK, MARIANNE, New Jersey Transit, McCarter Highway and Market Street, Newark, New Jersey 07101

STOCKMAN, GERALD, New Jersey State Senate, 176 W. State Street, Trenton, New Jersey 08609

SWERDLOFF, CARL, U.S. Department of Transportation, 400 7th Street, S.W., Washington, D.C. 20590

THOMPSON, MARK W., New Orleans City Planning Commission, 9W City Hall, New Orleans, Louisiana 70116

THOMPSON, TED, New York State Department of Transportation, 1220 Washington Avenue, Albany, New York 12232

TOBEY, BRUCE M., Delaware Department of Transportation, P.O. Box 778, Dover, Delaware 19903

TOMINACK, JOHN I., Ohio County Commission, 1500 Chapline Street, Wheeling, West Virginia 26003

TOPERZER, WILLIAM G., Motorola Aieg, 4000 Commercial Avenue, Northbrook, Illinois 60062

TREGO, GEOFFREY G., Virginia Department of Transportation, 1401 East Broad Street, Richmond, Virginia 23219

TURNER, CARMEN E., Washington Metropolitan Area Transit Authority, 600 Fifth Street, N.W., Washington, D.C. 20001

ULBERG, CY, University of Washington, 4507 University Way, N.E., Seattle, Washington 98105

UNDERWOOD, STEVEN E., University of Michigan, 4417 EECS, Ann Arbor, Michigan 48109

VIVERETTE, CARLOS C., Wilbur Smith Associates, 110C Connecticut Avenue, N.W., Washington, D.C. 20036

VIVERETTE, GEORGE, American Automobile Association, 8111 Gatehouse Road, Falls Church, Virginia 22047

VOCCIA, JOSEPH, Illinois Department of Transportation, 310 S. Michigan Avenue, Suite 1608, Chicago, Illinois 60604-4205

WALKER, THOMAS, Wisconsin Department of Transportation, 4802 Sheboygan Avenue, Madison, Wisconsin 53707

WANG, ZHENQUAN, Embassy of the People's Republic of China, 2300 Connecticut Avenue, N.W., Washington, D.C. 20008

WARD, DAN, Iowa Department of Transportation, 800 Lincoln Way, Ames, Iowa 50010

WEANT, ROBERT A., Eno Foundation for Transportation, P.O. Box 2055, Westport, Connecticut 06880

WEBBER, MELVIN M., Institute of Urban and Regional Development, 316 Wurster Hall, University of California, Berkeley, California 94720

WEINER, EDWARD, U.S. Department of Transportation, 400 7th Street, S.W., Washington, D.C. 20590

WILKINS, WILLIAM M., Road Information Program, 1200 18th Street, N.W., Washington, D.C. 20036

WILKINSON, PAUL F., West Virginia Department of Highways, 1900 Washington Street East, Charleston, West Virginia 25305

WILLIS, DAVID K., Motor Vehicle Manufacturers Association, 1620 Eye Street, N.W., Washington, D.C. 20006

WITTENBERG, AVIVAH, EUREQUIP, 19, rue Yves du Manior, Vaucresson, France 92420

WOODLE, CLYDE E., Trucking Research Institute, 2200 Mill Road, Alexandria, Virginia 22314

YOUNG, JAMES, *Washington Letter*, 1225 Eye Street, Suite 30, Washington, D.C. 20005

YOUNG, FELICIA B., District of Columbia Department of Public Works, 2000 14th Street, N.W., Washington, D.C. 20009

YUNWEN, ZHANG, *People's Daily*, 3706 Massachusetts Avenue, N.W., Washington, D.C. 20016

ZERRILOO, ROBERT, New York State Department of Transportation, 1220 Washington Avenue, Albany, New York 12232

ZIMMERMAN, SAMUEL L., Urban Mass Transportation Administration, U.S. Department of Transportation, 400 7th Street, S.W., Washington, D.C. 20590

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Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

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