CHAPTER 2
Transportation and Society

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Introduction

Vital Role of Transportation

When talking about transportation we commonly use words like "circulation," "congestion," "flow," or "artery"—words we also use to describe how blood moves through the body. This usage is not surprising, since these are practical terms for describing flows in networks. But they also suggest a far more profound similarity: transportation is a vital function of human society, just as blood is essential to human life. Both blood and transportation move essential material. Blood carries vital oxygen to all the body's critical organs, and it moves waste material out. Transportation moves people and goods to different neighborhoods, cities, states, and countries; and it allows people in those various places to trade and do business together. Just as life depends on a healthy circulatory system—along with the other bodily functions—society depends on good transportation—along with other social systems.

The relationships between transportation and society are numerous, deep, varied, ancient, and complex. Any summary of them sounds trite. Everyone has had extensive personal experiences using transportation. Transportation has influenced each of our choices about where to live, spend vacations, shop, or work. So inescapable is the tie between transportation and society that, like gravity, we take it for granted and cannot imagine a world without it.

The very hugeness of the transportation system hides its interdependence with society. The transportation system is the product of many decades'—indeed, of many centuries'—prior investment decisions and location choices. At any point, the transportation decisions being made by governments, companies, and individuals—even those that are pivotal, watershed decisions—affect only the fringes of the overall system. The cumulative value of facilities and vehicles that already exist is far greater than the amounts dealt with in periodic transportation legislation or corporate investments in transportation. For example, recent estimates of the value of U.S. highway infrastructure are in the $700 billion to $900 billion range. The value of the associated vehicle stock, which in 1996 included some 136 million automobiles, 65 million light trucks, and 6 million heavy trucks and buses, is in the range of $1,200 billion to $1,800 billion. Taken together, highways and their vehicles are worth more than the entire federal budget. When the value of railroad, aviation, public transportation, pipeline, port, ocean shipping, and other modes of transportation are added in, the value of transportation facilities is probably two to three times the size of the federal budget, or around half of the gross national product (GNP). In contrast, total government spending on transportation in 1996, by all levels of government and on all modes of transportation, was about one-twentieth of this cumulative investment. The vast array of transportation facilities now in place is the product of investments made over the centuries. Like culture itself, the transportation resources available to any one age are not just a contemporary creation, but a legacy from many previous generations.

A System of Disparate Parts

Transportation is also very decentralized, under the control of many independent companies, government agencies, and individuals. In the United States, most roads are owned and maintained by governments—cities, counties, states, or in some cases the federal government. Rail and pipeline rights of way are usually privately owned and maintained. Airports and ports are usually owned by public or quasi-public organizations, but they usually contain facilities that are

owned by individual carriers. Both public and private organizations own terminals, stations, and other loading and interchange facilities. Vehicles and rolling stock are mostly owned by private interests—shippers, carriers, other companies, or individuals. The vast bulk of the costs of operating transportation systems are borne by these same private interests. Overall, the resultant character of the transportation system reflects all of these public and private interests, operating at different times and different places. Within this overall complex, most decisions are not aimed at changing the system per se. Rather, many local, regional, corporate, and individual actions end up shaping the system unintentionally as decisions are made to ship supplies, deliver products, boost profits, spur the economic development of a region, enlarge a port, eliminate a bottleneck, and the like. The resultant national transportation system is the product of countless separate decisions, most of which are made for other purposes. Government plans, programs, and regulations add a measure of structure and uniformity to this system; but a sea of unplanned, independent decisions continue to be major determinants.

The organizations and individuals who make transportation decisions naturally view the system with an eye to their own requirements. A major shipper may be preoccupied with getting better access to the nearest interstate route. A coastal city may place top priority on improving its port. A commuter in an urban area may care most about clearing up congested intersections on the route to work. A national provider of intermodal freight services may place terminal access issues high on the list. Such interests compete with each other: mode against mode, company against company, city against city, state against state, and so forth. Governments compete for public funds for system investments, and they compete to attract economic growth and jobs. Carriers and shippers compete for customers, for market share, for advantageous routes and fee structures, and for profits. All have a general interest in national transportation improvement, but their individual priorities are diverse and often conflicting.

As we look at transportation and society, it is important to remember that transportation is not a homogenous, fully planned system, but a resultant of diverse and competing forces. It is a huge system that is only partly planned and controlled by governments. It looks different when viewed from the perspective of each of the different public or private organizations whose decisions influence its shape. The discussion in this chapter cannot present all of these perspectives. Brevity necessitates several limitations. First, this discussion of transportation and society will be based predominantly on the United States. Second, while large regional and sectoral variations in transportation exist, this introductory chapter speaks mostly in terms of national averages. Third, to reduce a topic of this scale to a manageable set of themes and issues, omissions are unavoidable. I have tried to pick a few themes that affect both freight and passenger transportation in many regions of the country and that illustrate key connections between transportation and society. No two authors would necessarily agree on which key developments to select. My only hope is that the topics I have selected serve to illustrate how thoroughly transportation is embedded in the fabric of society.

Social and Economic Consequences

Virtually everything we do relies on transportation. Whenever we live through a transportation shutdown like a paralyzing snowstorm, carrier strike, or automotive breakdown, it forms a memorable hardship. We think back on it as an abnormal interruption of our interaction with the many activities, people, and places around which our lives revolve. We can cope with such disruptions for short periods, knowing we can repair the damage when things return to normal. Difficult as these outages may be, we see them as temporary abnormalities. But they are not. They are actually the normal, undeveloped state of things, absent the availability of transportation. Over the span of centuries, society and transportation have evolved, hand in hand, from periods when such hardships were permanent and unavoidable. Now we have come to expect a high level of transportation consistent with our advanced civilization.

Various writers have observed that transportation is a mirror of civilization. Centuries ago, the Abbe Reynal noted:

> Let us travel over all the countries of the earth, and whenever we shall find no facility of traveling from a city to a town, or from a village to a hamlet, we may pronounce the people to be barbarians.[1]

Many air travelers today, flying over remote regions of the globe where there are no roads, railroads, or other traces of transportation to be seen on the ground, have probably made similar observations. Civilized society depends upon

[1] Henry Parnell, *A Treatise on Roads* (London: Longman, Green, Orme, Brown, Green, and Longman, 1833), p. 2.

communication, organization, trade, surplus and specialization, security, and protection of personal freedoms. Transportation is intertwined with many of these components.

History offers numerous instances where transportation was essential in creating or preserving the social and economic order. The Roman road system is celebrated for consolidating administrative control over conquered territories, British naval power supported the growth of the empire, and building the transcontinental railway opened the U.S. west and helped create a union of states. Throughout the developmental years of the United States, transportation investments and their effects have spurred economic development and political integration. Albert Gallatin, Secretary of the Treasury, proposed the first national set of transportation projects just 31 years after the nation began. In 1807, when describing how his planned improvements would affect the newly formed nation, he wrote:

> No other single operation, within the power of government, can more effectively tend to strengthen and perpetuate that union, which secures external independence, domestic peace, and internal liberty.[2]

Trade between different regions is vital to economic development and directly dependent on transportation. Adam Smith, the father of economics, wrote in *The Wealth of Nations:*

> Good roads, canals, and navigable rivers, by diminishing the expense of carriage, put the remote parts of a country nearly on a level with those in the neighborhood of a town, and they are, upon that account, the greatest of improvements.[3]

From the ancient world to modern times, the fortunes of nations hinged on their access to resources and markets. Natural resources had little use until freed by transportation; crops in remote areas had little value until nonlocal markets for them opened up. Economic comparative advantages, which lie at the heart of modern advanced economies, could not be realized until transportation systems opened the door to regional trade, then national trade, and now global trade. A surge in transportation development made the industrial revolution possible. The development of waterways, canals, roads, and railroads opened up the vast interior and western parts of the United States. Countless local histories provide dramatic illustrations of the sudden rise in the value of crops, resources, and land as transportation access improved.

The British economist A.J. Youngston observes that the vital significance of improved transportation to economic development is "one of the few general truths which it is possible to derive from economic history."[4] In developed nations today, it is easy to overlook this rare "general truth." Yet the vital linkages between transportation and economic development are just as strong today in the global economy as they were when trading with a neighboring village was at the cutting edge of economic growth.

The U.S. Transportation System in the 1990s

Passenger Transportation

Much of our personal travel now occurs in trip chains—trips in which we string together a series of different, possibly unrelated purposes. For example, on the way home from work, a driver may begin the commute home, stop at the day care center and pick up the kids, continue on to the grocery store and dry cleaners, and then drive home. While it is not always possible to separate travel for one purpose from travel for others, recent statistics do show that we make more than half of our trips for personal business of various kinds. About one trip in five is made to go shopping, and about one in four is made for other family and personal business. (Table 2–1.) One in six trips is made for social and recreational purposes, about half of

[2] Albert Gallatin, *Report of the Secretary of the Treasury on the Subject of Public Roads and Canals,* 1808 (Reprints of Economic Classics, Augustus M. Kelly, 1968), p. 8.

[3] Adam Smith, *The Wealth of Nations* (1776).

[4] A. J. Youngston, *Overhead Capital: A Study in the Development of Economics* (Edinburgh: Edinburgh University Press, 1967).

which are to visit family and friends. Work trips also account for about one trip in six. Travel to church and school accounts for about nine percent of all trips.

The average American household spent more than $12,000 on transportation in 1996. About $8,000 of this was spent directly on fares and automobile-related expenses. Another $4,000 was spent indirectly for freight bills embedded in the price of purchased products.

Not surprisingly, the largest category of expenditures trace from our heavy use of automobiles. Cars and trucks cost the average household about $2,600. (Figure 2–1.) Gasoline and oil cost the average household a little under $1,400 per year; and repairs, parking, and storage cost a little more than $1,400 per year per household. Altogether, auto-related items cost the average U.S. household $6,693 in 1996.

Table 2–1 Personal Travel by Purpose of Trip: 1995

Purpose of Trip	Percent of Person Trips	Percent of Person Miles
Work	17.7	22.5
Work-related	2.6	5.8
Shopping	20.2	13.5
Doctor/Dentist	1.5	1.5
Other Family and Personal Business	24.2	19.9
Church and School	8.8	5.7
Visiting	8.2	11.2
Other Social and Recreational Business	16.7	19.5
Other	0.2	0.4
Total	100.0	100.0

Source: *Our Nation's Travel: 1995 Nationwide Transportation Survey, Early Results Report,* U.S. Department of Transportation, Washington, D.C.: Federal Highway Administration, September 1997, p. 11.

The average U.S. household spent an additional $1,300 per year for airfares, bus and transit fares, and other forms of for-hire transportation. About $600 of this was spent on airfares, and about $200 was spent on local bus and transit fares. (Figure 2–2.)

Over and above these direct expenditures on transportation, the average household spent an additional $4,700 per year for freight transportation. Many of these freight expenditures are hidden from consumers because they are built into the cost of final goods and services, but by any measure transportation is a key item in family budgets. Transportation expenditures, both direct costs and those passed along in the cost of goods purchased, account for more than one-third of median household income in the United States. For comparison, the average household spent about one-third of its budget on housing, about one-seventh on food (at home), and about one-twentieth on entertainment.

Freight Transportation

When it comes to moving goods, trucking is the dominant mode from an economic standpoint. More than three out of every four dollars spent moving goods go to pay for trucking. This massive industry employs nearly 2,300,000 truckers and truck

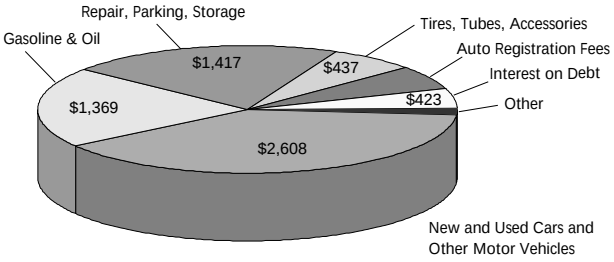

Figure 2–1 U.S. Total Expenditures per Household Related to Automobiles and Other Motor Vehicles, 1996.

(Total auto-related expense per household: $6,693.)

Source: *Transportation in America: 1997,* Lansdowne, Va.: Eno Transportation Foundation, 1997, p. 42.

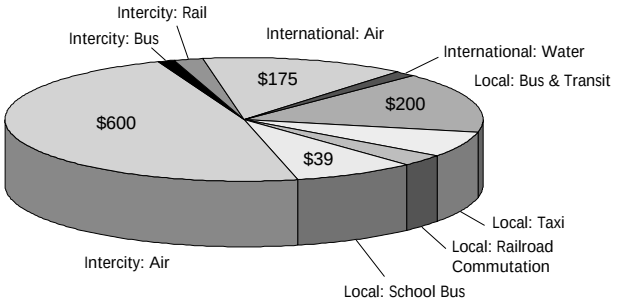

Figure 2–2 U.S. Total Expenditures per Household on For-Hire Transportation, 1996

(Total expenditure on for-hire transportation: $1,255 per household.)

Source: *Transportation in America: 1997,* Lansdowne, Va.: Eno Transportation Foundation, 1997, p. 42.

terminal workers—a workforce twice as large as that of the airline, bus and subway, and taxi industries combined. The second largest freight mode, from a revenue perspective, is the railroad, which generates only about one-tenth the revenues of the trucking industry. Out of the $467 billion that the United States spent on freight transportation in 1996, 7.5 percent went into rail freight, 5 percent into water transportation, and 4 percent into air transportation of goods. (Figure 2–3.)

Financial statistics do not do justice to the massive physical quantities of material carried by pipeline, rail, and water transportation. These modes carry more than half of all freight ton-miles. They haul heavier commodities than trucks, as well as move them greater distances. Nationwide, rail carries 40 percent of all freight ton-miles, trucks carry 27 percent, and water carries 14 percent. Nowhere is the contrast between physical volume and transport revenue more striking than in the case of pipelines. Oil pipelines received only about $8.6 billion of revenue in 1996, less than one-fortieth the revenues of the trucking industry, yet they carried more than half as many ton-miles as trucks. (Figure 2–4.)

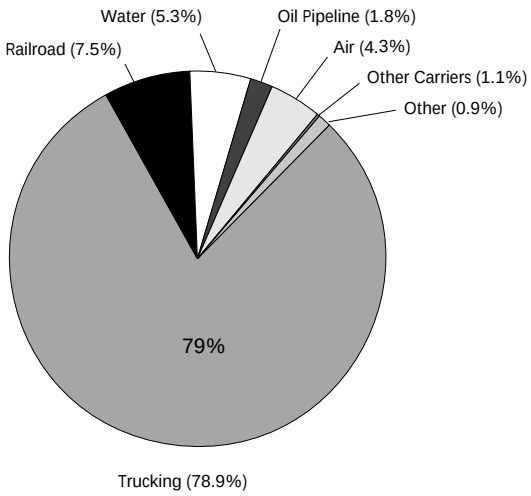

Figure 2–3 Percent of Freight Transportation Expenditures in the United States by Mode, 1996

(Total expenditures by all freight modes was $467 billion.)

Source: *Transportation in America: 1997,* Lansdowne, Va.: Eno Transportation Foundation, 1997, p. 40.

Economic Stakes in Transportation

Large investments have created a massive physical plant and vehicle fleet. Americans now own more than 200 million cars and light trucks—roughly one for each person sixteen years and older. There are nearly four million miles of roads in the United States, about half of which are paved. There are 136,542 miles of railroad track, 25,777 miles of navigable waterways, and more than 200,000 miles of petroleum pipelines.

This extensive system is financed by a combination of private and public investments. The transportation carriers invested $21 billion in new plant and equipment in 1994—$4 billion of this in air transportation, $7 billion in rail, and $10 billion in truck and other transportation. The manufacturing industries invested another $23 billion in transportation—$16 billion of this in motor vehicles and $3 billion for aircraft. Overall, the private sector invested more than $65 billion in new transportation plant and equipment in 1994. These numbers reflect only a subset of total transportation investments, since much of this investment is embodied in warehousing and plant improvements; and the transportation component cannot be isolated.

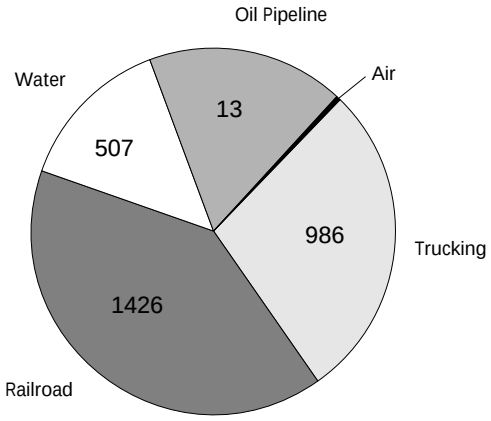

Figure 2–4 Ton-miles Transported by U.S. Freight Carriers, 1996.

(Total ton-miles by all modes was 3,563 billion.)

Source: *Transportation in America: 1997,* Lansdowne, Va.: Eno Transportation Foundation, 1997, p. 44.

Governments at all levels also make major expenditures for transportation. The federal government spent $35 billion on transportation in 1996, of which $20 billion was for highways and $8.5 billion for airports and airways. State and local governments spent an additional $111 billion on transportation, of which $93 billion was for highways. These massive expenditures represent both investment in new facilities and operation and maintenance of existing facilities. (Table 2–2.)

Transportation and Economic Growth

Many industries are vitally dependent on transportation. Better information on these dependencies became available in 1998 with the introduction of the transportation satellite accounts, which extended the U.S. input-output accounts to reflect transportation more accurately. These accounts show that the largest users of transportation in the United States in 1992 were manufacturing ($102 billion, 19 percent), services ($64 billion, 12 percent), construction ($52 billion, 10 percent), and wholesale and retail trade ($52 billion, 10 percent). These accounts show that transportation contributes 5 percent of the total value added to the U.S. economy.[5]

Transportation is used by all sectors of the economy, and the nation's gross expenditures on transportation are huge. Altogether Americans spent $1,263 billion on transportation in 1996, which represents nearly one-sixth of the GNP. As apparent from the similar growth patterns of the GNP and transportation spending since 1970, growth in transportation has generally paralleled growth in the GNP, although transportation expenditures trailed off a little in recent decades, relative to the GNP. (Figure 2–5.) Improvements in transportation productivity and logistics have helped to reduce this fraction, and such improvements are vitally important to economic growth. Over the years transportation expenditures and the GNP have grown side by side.

There are obvious ties between transportation spending and measures of overall economic activity, such as the GNP. Freight volumes are a rough but useful barometer of production. Every unit of economic output embodies transportation inputs that were made to get raw materials into production and to deliver finished products to consumers. When more goods are produced, transportation volumes are higher.

Table 2–2 Government Expenditures for Transportation Services and Facilities, 1996

(Millions of Dollars)

Mode	Federal	State and Local	Total
Airways	$ 6,935	-0-	$ 6,935
Airports	1,597	$ 7,251	8,848
Highways	20,186	93,255	113,441
Rivers and Harbors	1,032	1,925	2,957
Railroads	2,266	120	2,386
Transit	2,643	8,440	11,082
Total	$34,659	$110,990	$145,649

Source: *Transportation in America: 1997*, Lansdowne, Va.: Eno Transportation Foundation, 1997, p. 73.

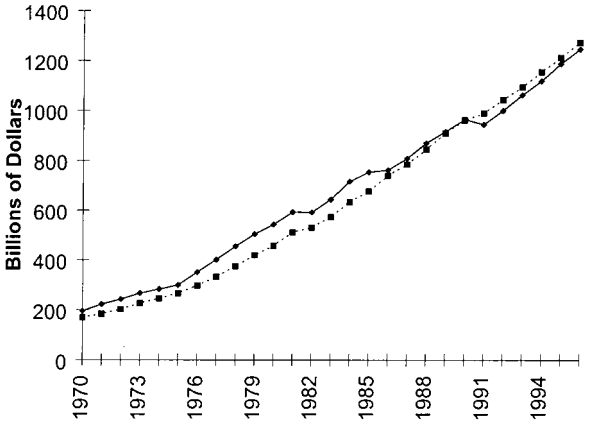

Figure 2–5 Total Transportation Bill Compared to the GNP

Legend: Solid line represents the nation's transportation bill
Dotted line represents one-sixth of the GNP

Source: *Transportation in America: 1997*, Lansdowne, Va.: Eno Transportation Foundation, p. 38, 1997.

Passenger transportation volumes are also tied to overall economic activity. Business trips and travel to work are directly tied to economic well being. Personal consumption of transportation for recreation, family visits, shopping, and many other purposes is also influenced by economic conditions. Thus both passenger transportation expenditures and freight transportation expenditures grow and shrink with the overall economy.

But transportation does not simply mirror the economy: transportation investments can also cause economic growth. A recent analysis of the nation's investment in highways and its economic performance found that the net social rate of return from transportation investment ran as high as 30 to 40 percent each year, well above the average return on private capital investments.[6] During the 1950s and the 1960s, the years when the nation began constructing the interstate highway system, the economic return from highway investment ran about 35 percent—more than double the rate of return that private capital produced during this period. At this rate, transportation investments paid for themselves in

[5] Bingsong Fang, Xiaoli Han, Ann M. Lawson, and Sherlene K.S. Lum, "U.S. Transportation Satellite Accounts for 1992," *Survey of Current Business* (Washington, D.C.: April 1998), pp. 16–27.

[6] M. Ishaq Nadiri and Theofanis P. Mamuneas, "Highway Capital and Productivity Growth," *Economic Returns from Transportation Investment* (Lansdowne, Va.: Eno Transportation Foundation, 1996).

three years in terms of overall economic growth. In recent years this return has fallen to around 10 percent, which is about the same as the return on private capital. Investments in facilities of national significance—ones that increase the capability of the overall network—show a return around 16 percent, still above the rate of return on private capital.

The transportation investments with the highest returns appear to be those that can produce what are called "network" effects. Network effects, as opposed to local improvements, raise the potential of the system as a whole. Increases in network capability benefit everyone linked to the network, even those located at points far removed from the point where improvements are made. For example, a strawberry grower in California and a restaurant diner in New York may benefit from highway improvements in Nevada. Unfortunately, network effects tend to be eclipsed by the site-specific, local benefits of new projects when alternative policies are weighed and when political decisions are made about new programs. Elected officials are keenly aware that building a transportation facility in a region brings very tangible, immediate benefits in terms of jobs, access, and land values. These site-specific benefits are an important consideration to the communities involved, but it is their expansion of the transportation network that brings most of the economic benefit.

Possible Changes in the Future

Transportation is thoroughly integrated into society, and its priorities and goals shift as the needs of society change. While history suggests that there has never been a civilization nor an age that did not rely on transportation, it also shows that the nature of that reliance has been very different from age to age and place to place. Even in the relatively short span of the automotive age, transportation priorities and concerns have changed repeatedly, echoing society's evolving concerns. "Getting the farmer out of the mud" was a rallying cry for surface transportation earlier in the century; then came construction of a coast-to-coast system of high-speed, limited-access highways; and recently demands have been increasing to integrate transportation more effectively with environmental, safety, and developmental goals. As transportation professionals plan and build for tomorrow, their work will be most valuable if it is able to anticipate how society's expectations will shift. With continued growth in population, affluence, and technological progress, tomorrow's opportunities and problems may well be different than today's. The continued emergence of the global economy, the aging of the baby boom, and many other foreseeable and unforeseen factors will shape the future of transportation.

More than ever, the private sector will influence this future, as transportation incorporates more communications and computational capabilities, as transportation operators provide overall logistics capabilities, as industries become more dependent on just-in-time distribution systems, and as deregulation of transportation moves from the national to the international sphere. No one can predict how these issues will play out, nor how the private sector will address them. Everyone engaged in transportation faces many unresolved issues and uncertainties, and each has developed working assumptions to draw upon in the face of speculative matters.

In the remainder of this chapter, I discuss several emerging developments that could redefine the linkages between transportation and society, especially as this affects issues faced by transportation planners working for public agencies. Fundamental shifts in technology, competitive structure, and regulatory frameworks may also greatly shift the complexion of transportation industries in future years, and planners in private companies may face a different set of issues as well. No one can confidently predict the public attitudes, laws, regulations, and methodological resources that will attach to them in the future. As unpredictable events unfold in the decades ahead, many areas will pose special challenges for planners. Eight of these are singled out for consideration here:

- development of intelligent transportation systems (ITS) and automated highways,
- continued worsening of traffic congestion,
- a growing focus on operational efficiency and potentially on congestion pricing,
- the explosion in information technology and its implications on where and how we work and travel,
- mounting concerns about global warming,
- growth in intermodal transportation,

- the severity of traffic safety problems,
- changing public expectations of transportation.

Intelligent Transportation Systems

Technological Potential

The dramatic strides that have been made in computing and communications capabilities are just beginning to find their way into the automobile and driver markets. We are occasionally reminded that there is more computer capacity on a new car than there was on early spacecraft, yet much of this remains invisible to drivers as it regulates a variety of engine, braking, and emissions control functions. Automation also has the potential to revolutionize features of automobiles and highways in ways that directly affect drivers. Navigation, crash avoidance, data on road and route conditions, information on roadside businesses and attractions, automation of driver functions, and many other potential applications are still in their infancy.

Today, many of the component capabilities are available off-the-shelf for other uses. For a nominal price, you can buy a CD-ROM with every street in the country at your neighborhood computer store. Spend a little more and you can buy a cellular telephone for your car or a global positioning system (GPS) unit that triangulates its location by beaming signals to satellites for use on your boat. Adaptive cruise control, which sets your car's accelerator based on the speed of the car in front of you, is now an option on some new cars. Field demonstrations of the automated highway system have shown that fully automated longitudinal control, obstacle detection, overtaking, and platooning are now possible. The capabilities of the Internet continue to surprise us week after week; and as communications and computing continue their rapid strides, the day is coming when every car will have Internet access supporting a wide array of services.

Picture yourself in the year 2050 (or could it be as soon as 2020?) as you are driving on the interstate from Atlanta to Miami, when you decide to make a local detour for food and scenery. You push a button on your on-board computer. Based on your exact location on the map, which is sensed using on-board GPS devices, the computer determines your location. It combines this information with its Internet listing of area restaurants and attractions, and on your on-board display it suggests two or three routes with good restaurants. You click on the one you want and the vehicle drives you there automatically on the shortest, least congested route. This is not far-flung science fiction: every feature of this is technologically possible today, much of it is now economical, and the costs of the more exotic features are dropping rapidly. Not only might you, as a future driver, be willing to pay for such capabilities, but every business that has ever paid for a billboard, a listing in the yellow pages, an Internet site, or a tourist magazine will have an interest in seeing these capabilities developed as well. With more than 200 million vehicles in the fleet, any device that can penetrate this market faces immense potential, so that device manufacturers will be driven to do the research needed to perfect new capabilities and make them economically competitive.

Organizational Implications

Realizing the potential for increased automation in the highway system will take many years. The vehicle/highway system is immense, involving roads, signals, vehicles, signs, markings, and communications systems under the control of many thousands of separate government units, private manufacturers, and other interests. There are immense problems of coordination, standardization, liability, and privacy that remain to be resolved. Just as it took the automobile itself many years to progress from being an expensive luxury to an everyday necessity, so too will it take decades before advances in communications, computing, and sensing become standard features in vehicles.

Government programs are helping to spur developments and channel individual advances to fit into a coordinated whole. The Joint Program Office for Intelligent Transportation Systems at the U.S. Department of Transportation and Federal Highway Administration is developing a system architecture that balances the needs for interoperability and standards with the need for incentives that stimulate private investment.

The business interests in introducing new sensing, communications, computing, and navigational capabilities to the auto fleet are so huge that these developments are likely to occur sooner or later. No one can predict with confidence which devices and capabilities will catch on and when they will catch on, just as an observer of the fledgling automobile industry in 1895 could never have predicted what the nation's highway system would look like in 1920 and beyond. But can anyone doubt that the leap in technological potential that is evident today in communications, computing, and sensing is at least as great as the invention of the automobile, or that its consequences on the interaction between society and transportation will be any less profound?

As highways become more technologically advanced in their interaction with vehicles, this could transform the private and organizational roles in surface transportation. If we ever reach the stage when drivers are not needed on portions of an automated highway system, will there be any distinction between public transportation and taxi service? Between taxis and rental cars? If these distinctions blur, so too will the organizational lines between many existing public agencies and private companies.

Amidst this rapidly growing technological potential, the role of public agencies could shift from being primarily providers of infrastructure or providers of specific services to being operators of the system. This trend is already emerging. In the case of highways, for example, back in the 1960s and 1970s public agencies concentrated on providing new capacity—interstate highways and other system expansion. In the last decade more and more attention has been focused on maintenance and preservation, as well as on improved traffic management. With the advent of automated highway capabilities, public agencies will increasingly be engaged in information flows, operational management, correcting system malfunctions in real time, and planning for operational improvements. The disciplinary skills needed for these roles, as well as the operational mentality, are different from those needed to plan and build new facilities. One of the biggest challenges to today's professionals in transportation agencies is to augment their own strengths to anticipate tomorrow's operational needs.

Congestion

History

Just as new transportation capabilities have made modern lifestyles possible and have contributed to economic growth, the erosion of transportation capabilities through congestion could undo those advantages. Everyone complains that congestion is bad; but behind this apparent common complaint there is little agreement about what congestion is, how it can most appropriately be measured, how much is tolerable, how to value its cost, which averages to use, and how to characterize the duration and extent of the problem. The severity of congestion depends on definitions, statistics, behavioral tolerances, personal values, social expectations, and comparisons; and these elements are poorly understood and not systematically accounted for.

Congestion is not a creation of the automobile age, but it has been a feature of urban living for as long as there have been cities. The poet Juvenal gives us a vivid description of what it felt like to be a common citizen on the streets of Ancient Rome, crowded with people and freight:

> One needs to have a lot of money to sleep in this town …The vehicles moving down the narrow, winding streets, the quarrelsome crowd refusing to move on …The rich man, when called away on business, will have himself borne through the crowd, which opens to make way for him; he will make swift progress over everyone's head in his vast Liburnian litter. As he goes, he will read, write, sleep within…And for all that he will arrive before us. In my case, the human tide in front of me prevents me from hurrying; the hastening throng behind me is thrusting into my back. Someone shoves an elbow into me; another man gives me a nasty jolt with a long beam. Here's a fellow also set on giving my head a whack with his joist and yet another with his mighty cask…A wagon is coming forward with a great bulk of timber swaying about on it; a second is loaded with a pine trunk. These are threatening the crowd as they swing in the air…[7]

[7] Raymond Chevallier, *Roman Roads* (University of California Press, 1976), pp. 67–70.

The discomfort and dangers experienced on Rome's crowded streets led Julius Caesar to issue a traffic ban in an attempt to tame the streets. Caesar's edict ordered unnecessary vehicles off the streets during daylight hours:

> …no one shall drive a wagon along the streets…where there is continuous housing after sunrise or before the tenth hour of the day, except whatever will be proper for the transportation…of material for…public works, or for removing from the city rubbish…[8]

Apparently, Caesar's ban was but one of many such edicts, which suggests that this type of instrument was not very effective or not able to accommodate the many exemptions that were essential for public health and safety and for religious reasons. It appears that congestion continued in Rome, as it did in many other European cities, as population grew and particularly after private horse-drawn vehicles came into fashion centuries later. Traffic jams are reported in Renaissance Paris, and Victorian novelists describe hordes of workers crowding bridges into European cities following the industrial revolution. Photographs of New York City and other major metropolitan areas in 1900 show streets clogged with horse-drawn vehicles, pedestrians, and parked and loading vehicles. Throughout history, the size of the city, the location of activities within cities, and the regulation of public space have all been driven in part by congestion.

Measurements

At present, highway traffic congestion imposes severe costs in the form of traffic delays, schedule slippage, in-transit inventory costs, production interruptions when inventories fail to arrive when needed, wasted time for deliverymen and salesmen, wasted time to schedule in allowances for traffic uncertainties, wasted fuel, and environmental damage. Such costs are difficult to estimate, but rough estimates place them at several hundreds of billions of dollars per year in the United States.

The yardsticks used to measure congestion are varied and the ones that are most applicable to one situation are inadequate for addressing others. One recent review recommended that congestion should be measured by various yardsticks for different purposes. For example, travel time is a good measure for analyzing short roadway sections, total delay is appropriate for long sections, and the delay ratio is a good tool for corridor analysis. Depending upon the purpose, useful yardsticks also include differences in travel time, travel rate, delay rate, relative delay rate, and various other indices and measures.[9]

Traffic engineers have traditionally used a ranking system called the "level of service" to characterize flow conditions along a route segment.[10] Under this system, level of service A is defined as free flow, where the speed of an individual vehicle is controlled solely by the desires of the driver and the prevailing conditions. Progressively worse conditions are defined by levels B, C, and D. The worst is level of service F—breakdown conditions—where uniform moving flow cannot be maintained, causing a temporary reduction in capacity as queues build. The level of service definition has been very useful over the years, but there is growing recognition that it is not able to make the distinctions necessary to help set priorities for today's congested facilities. The worst condition, level F, might refer to a temporary snarl or a major standstill. It might refer to a five-minute jam when a shift is over at a big plant, or it might be a four-hour tie up on the regional beltway. Level F is a broad label that encompasses conditions that are disparate in severity and duration, and a more refined yardstick is needed to distinguish the levels of severity now experienced in long-term tie ups. Such disruptions are increasingly common, and their alleviation is a key concern in developing transportation and land use policies suited to crowded metropolitan areas. As will be discussed in Chapter 7, planning practices are now changing to address the duration of severe congestion.

[8] Dora Jane Hamblin and Mary Jane Grunsfeld, *The Appian Way: A Journey* (New York, N.Y.: Random House, 1974), p. 170.

[9] Tim Lomax, Shawn Turner, and Gordon Shunk, *Quantifying Congestion, National Cooperative Research Program Report 398*, Vol. 1, Final Report (Washington, D.C.: Transportation Research Board, National Research Council, 1997), p. 5.

[10] *Highway Capacity Manual—Special Report 209* (Washington, D.C.: Transportation Research Board, National Research Council, 1994).

Trends

Overall, most Americans probably sense that congestion is getting worse, but this is difficult to prove with statistics. Data on average commute times suggest possible worsening. The average commuting time rose by 40 sec. during the 1980s, according to data from the 1990 federal census, and from 21.7 min. in 1980 to 22.3 min. in 1990.[11] Similar results are reported by the "Nationwide Personal Transportation Survey." This survey found that the average commute time increased from 18.2 min. in 1983 to 19.7 min. in 1990 to 20.7 minutes in 1995. But do these longer commute times show that congestion is getting worse? Not necessarily. This same survey also found that because of a trend toward longer commutes, the speed of work trips actually increased from 28.0 to 33.6 miles per hour between 1983 and 1995.[12] The commuters surveyed were traveling greater distances at higher speeds—hardly proof of worsening congestion! Homes and workplaces are increasingly located further and further from urban central business districts, so that the trip time data for 1983 and 1995 partly compare trips in different parts of the metropolitan area. That is, the speedier trips at the later date include more travel at the distant fringe of the area, where streets are often less heavily used. Such a comparison does not really say anything one way or the other about the change in travel time for trips along the same routes.

From one year to another, traffic increases, more lanes and roads are added, and people and businesses move. Roads that are clogged with traffic are often prime candidates for improvement, and relocation decisions are often based on ease of access. An increase, or a reduction, in average commuting times in a region might reflect changes in congestion along specific highway segments; or it might reflect growth of population or jobs in less congested parts of the region, with no improvement at all in the trips that were used to compute the base year number.

For making year-to-year comparisons of congestion, one ongoing longitudinal study developed a useful index for comparing conditions over time in fifty urbanized areas in the United States.[13] This index compares actual traffic density to congested traffic density on a combination of freeways and principal arterial streets, computed at various intervals since 1982. Based on this index, traffic congestion appears to be getting much worse in most of the fifty areas studied. Between 1988 and 1994, the greatest increases occurred in Salt Lake City, Utah, where the congestion index increased by 31 percent; Columbus, Ohio; Cincinnati, Ohio; Charlotte, North Carolina; Detroit, Michigan; Minneapolis-Saint Paul, Minnesota; and Baltimore, Maryland, where the congestion index increased by 15 to 20 percent. Only five of the fifty urban areas studied showed decreases in the congestion index between 1988 and 1994, and none of these decreases was greater than 5 percent.

Tolerance

Surrounding all the ambiguity involved in the measurement of congestion there lies an even vaguer set of issues in depicting society's tolerance of congestion. There is no standard or uniform expectation of how much congestion is acceptable. Public tolerance for congestion varies from place to place and time to time. People from large metropolitan areas are often amused when they visit smaller communities and hear the locals complaining about congestion. Residents of small areas look with disbelief at the traffic snarls suffered by their big-city friends, and they ask why anyone would suffer such inconvenience. Incidents of "road rage" and aggressive driving could be interpreted as a sign that more drivers have reached their boiling point with congestion, but such behaviors could just as well be attributed to many other causes.

Congestion that was unacceptable in one era may be tolerated in another. Changes in technology have been accompanied by shifting expectations. Widespread development of limited-access highways has increased our familiarity with, and expectation of, free-flowing traffic. Air conditioning, stereo systems, and cellular telephones have added to motorist comfort and productivity; and in the process they may have tempered the irritation of congestion. For example, calls from car phones can greatly reduce the anxiety and disruption of plans caused by traffic delays. Car phones and faxes allow work and personal business to proceed in spite of congestion. As auto-based communications and information-processing capabilities increase to embrace more of what is now possible via the Internet, auto occupants may have many ways to use their time fruitfully; and this could diminish their sensitivity to congestion.

[11] Alan E. Pisarski, *Commuting in America II* (Lansdowne, Va.: Eno Transportation Foundation, 1996), p. 91.

[12] *Our Nation's Travel: 1995 Nationwide Transportation Survey, Early Results Report* (Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, September 1997), p. 11.

[13] Tim Lomax and Gordon Shunk, *Urban Roadway Congestion—1982 to 1994* (College Station, Texas: Texas Transportation Institute, 1997).

The transportation of goods, and all the economic interests associated with having timely delivery of inputs and efficient distribution of products, are also being threatened by congestion. At a minimum, congestion adds to shipping cost by requiring more driver time, by increasing in-transit inventory costs, and by reducing the efficiency of vehicle use. The delays and uncertainties associated with shipping over congested routes also add to the cost of production, and they erode the advantages of just-in-time delivery systems. Many companies attempt to escape the problem by rescheduling trips outside peak hours, by using nighttime pickup and delivery, or by shifting to less congested modes of transportation. Such shifts also add to the cost. Just as the construction of the interstate highway system made a substantial contribution to national economic growth, growing congestion on that system and other important routes could undo the network benefits that have been achieved and adversely affect national economic performance.

All in all, highway congestion is bad and likely to get worse. History offers few if any useful remedies for congestion. New technology, demand restrictions, pricing, and increased telecommuting could help. The search for solutions that are attuned to society's priorities will be a major thrust of transportation policy in the coming years; yet any attempt to support this debate with systematic data runs into statistical variations, inadequate definitions, and behavioral uncertainties. Congestion varies by time of day and from neighborhood to neighborhood; and broad averages cannot capture these differences. It varies in duration and severity, and no index or average can fully characterize its effects. Our tolerance for congestion is tempered by our individual day-to-day experiences and expectations. Our sensitivity to congestion depends partly on how comfortably and productively we can pass the time while stuck in traffic.

In future years, planners will find that congestion, which has always been an important concern, takes on added urgency and forces consideration of a broader range of policies and attitudes. This will require planners to develop more systematic characterizations of congestion and its costs. It will force increased planning attention to focus on the management and use of existing systems.

Operational Efficiency and Congestion Pricing

Economic Rationale

Introduction of ITS, lanes for the exclusive use of high-occupancy vehicles, rush-hour use of shoulders, ramp metering, intersection improvements, and other innovative techniques will make ever greater contributions as communities struggle to make efficient use of resources. In the face of growing congestion and a diminishing physical and political ability to add new system capacity, public policy will increasingly focus on improving the efficiency of system operations.

Operational efficiency has always been a concern of transportation agencies, but current constraints are increasingly leading to consideration of operational policies whose public acceptance is uncertain. Measures that physically or economically restrict travel have been notoriously slow to gain public acceptance, and most of the limited use of traffic demand management has come only when conditions were drastic and construction remedies were not feasible.

Economists have argued that the efficiency of highways could be much improved by setting prices to cover the marginal costs of a trip. Similar peak period pricing has been used effectively by airlines, transit systems, electric companies, and many other industries. A similar concept might be useful for roads. Prices could be set in such a way as to reckon in the time costs of the trip—both those borne by the traveler and those imposed on other travelers. Such "congestion pricing" goes beyond peak-period pricing (which simply refers to any peak premium) by calculating the peak premium at a level high enough to deter traffic and maximize system efficiency. This pricing policy would set high charges for road use on congested roads during rush hours and lower charges at other times and places. While the prospect of very high road-user fees may have been prominent when policies of this sort have been considered, recent variations of the concept such as "value pricing" place more stress on positive aspects like reduced off-peak fees or availability of revenues for other transportation purposes.

Societal Concerns

In spite of the economic arguments in support of congestion pricing, no U.S. cities have tried it. This lack of application probably stems from many causes, among them concerns about the associated administrative costs and difficulties, the possibility of adverse effects on poor persons, the apparent inequity of charging a fee for use of roads in addition to collection of fees for road construction within the Highway Trust Fund, and adverse public reactions to what might be seen as an unpopular tax or restriction on personal freedom. To many, the ability to move, like the ability to breathe, is so fundamental that it should not be made available to people with means and denied to those without. They see the road as more than a physical facility: it represents freedom of mobility and equality of access to modern society. It is seen as a basic right.

Throughout much of history, this distinction was very real:

> To the citizen of the twelfth, the fifteenth, or even the eighteenth century, the King's Highway was a more abstract conception. It was not a strip of land, or any corporeal thing, but a legal and customary right…What existed, in fact, was not a road, but what we might almost term an easement—a right of way, enjoyed by the public at large from village to village, along a certain customary course, which if much frequented, became a beaten track.[14]

This concept of a road has an egalitarian ring—an entitlement independent of economic class or social station. Any road user fee tends to run against this sense of entitlement. Congestion pricing, which is explicitly designed to be an economic barrier, poses a greater threat than gas taxes and conventional tolls, which merely recoup direct construction and maintenance costs.

Recent Changes

Nevertheless, a few cities around the world have turned to policies akin to congestion pricing, notably Singapore, Kuala Lumpur, Oslo, Bergen, and Trondheim. Will such policies become acceptable elsewhere? While much of the emphasis of public support for surface transportation in the past has been on adding new capacity, recent decades have seen more attention being given to nonconstruction measures that will improve system efficiency, such as traffic signal synchronization, incident management systems, traveler information systems, and ramp metering. As these capabilities are applied and congestion remains, consideration may move on to pricing measures.

Over and above philosophical arguments about the fairness and appropriateness of congestion pricing, one of the difficulties in advancing this concept has been the high administrative cost and difficulty of collecting the tolls. This obstacle is fading fast as the capacity to collect tolls in less burdensome ways has made huge advances in recent years via electronic toll collection.

The vast majority of U.S. roads are free of toll, supported by fuel taxes and other user fees paid to states and the Federal Highway Trust Fund. These fees are then returned to road users through various highway programs. In this financing environment, congestion pricing has appeared alien and threatening. But this resistance could fade with the introduction of HOT lanes—lanes reserved for high-occupancy or toll-paying vehicles, which are now being introduced in a few U.S. cities. The operators of HOT lanes impose substantial tolls for peak-hour travel. Experience along SR 91 in California, the earliest of the HOT lanes, shows that drivers are willing to pay rather than drive on congested alternate routes. Experiences like this could erode the resistance to congestion pricing that has been evident in recent years.

The ability to add new highway capacity is already severely restricted by budgetary constraints and public concerns about the environment, visual blight, and the quality of life. It will become evermore restricted as open space becomes scarcer and scarcer, and as esthetic, developmental, and environmental priorities continue to gain added force. This will lead to increased priority on achieving maximum system efficiency, forcing greater consideration—in concept at least—of measures such as congestion pricing, which have not been feasible in the past.

[14] Sidney and Beatrice Webb, *English Local Government: The Story of the King's Highway* (London: Longmans, Green and Co., 1913), p. 5.

Several parallel developments make reconsideration of pricing timely. As the technologies of ITS continue to advance, electronic identification of vehicles is becoming much more widespread, making congestion pricing more feasible administratively. As HOT lanes are built and operated, this form of economic demand management appears to be gaining public acceptance. Such developments suggest that congestion pricing, which has long been the very benchmark of political impossibility, is becoming less impractical, alien, and threatening than it was in the past.

Actual applications of congestion pricing will probably continue to be scarce, but planning consideration of demand restrictions, modest peak-period price premiums, and other pricing measures will be increasingly common. Consideration of such alternatives involves far more than technical issues: it raises the specter of consequences that clash with deep-set cultural attitudes, notions of fairness, and expectations of basic rights. Resolution of these matters will require new levels of public and political participation in planning.

Communications as a Substitute for Transportation

Communications Changes

The explosion in communications and computing capabilities has fueled a series of forecasts that these technologies will replace the need for travel. These predictions have been prompted by communications improvements in long-distance services, conference calling, videoconferencing, email, the Internet, file sharing, and facsimile transmission; but the anticipated substitution of communications for transportation has not materialized…yet. Certainly, more and more workers are finding that they can telecommute effectively. The business press and technical experts alike foresee continued expansion in computing and communications capabilities, and further sharp reductions in their costs. As a result, the substitution of communications for transportation, which has thus far mostly eluded us, finally appears to be on the brink of making substantial changes in how people work, leading to shifts in where they live and work, and when and where they travel. Already, one report indicates that about eight percent of all workers—or about 11 million people—now telecommute in one form or another.[15]

Transportation Implications

These shifts could have profound consequences on transportation. If significant numbers of workers are able to perform part or all of their jobs from their homes or other remote locations, this could reduce the number of commuting trips and business-related trips, as well as shift the times and places where such trips occur. It could allow small towns and distant suburbs to become viable places for telecommuting workers to live. Residents in all parts of the country, rural and urban alike, increasingly enjoy the same shopping opportunities, stock-market information and access, current news in electronic format, access to technical literature, and other benefits of the Internet. This ability frees self-employed and retired persons to choose their residence without regard to these amenities.

To the extent that people actually do shift location in response to these new communications capabilities, this could create radically different patterns of land use and transportation. Other forces, like proximity to schools, hospitals, churches, cultural attractions and the like will continue to weigh heavily in location decisions; but the rise of telecommuting could shift the balance by eliminating the importance of burdensome commutes, at least for those who can rearrange where work occurs. What might this do to the suburban boom of the past thirty or forty years? Census data show that although total population grew by 64 percent between 1950 and 1990, the number of people living in nonmetropolitan areas fell by 6.5 million; and the population of metropolitan areas increased by 33.8 million. Within metropolitan areas, the population of central cities grew modestly, by 45 percent between 1950 and 1990. The bulk of metropolitan growth—indeed of national growth—was in suburbs, which grew by 232 percent during these four decades. Freed from commuting constraints, this suggests that the newfound freedom offered by telecommuting might be to push the boundaries of suburbia still further out and to encourage satellite communities beyond the suburban fringes. These areas may now lie outside the reach of today's metropolitan planning.

[15] *Urban Transportation Monitor,* vol. 11, no. 14 (Fairfax Station, Va.: Lawley Publications, July 18, 1997), pp. 1–2.

Global Climate Change

Scientific Basis

Societal concern about the environment has become far more pronounced. All sectors of the economy—whether agriculture, manufacturing, mining, or transportation—and all aspects of environmental quality—noise, wetland preservation, hazardous materials, and air quality—are being reassessed in terms of these heightened environmental expectations, both in the United States and around the world. Increasingly, as with trans-national migration of acid rain, the issues are recognized to be regional or global in scope, giving rise to discussion of more broadly based environmental control strategies. Nowhere is this broadened concern more pronounced than in the case of emissions of gases that build up in the atmosphere and have the potential to alter climate around the world.

Huge uncertainties abound surrounding questions of when, where, and how much climate change will actually occur. There are many open disagreements about the climate models used to answer these questions. Experts' divergent predictions have spawned complex technical arguments and additional research. It is not always clear which is a balanced assessment, an alarmist exaggeration, or baseless optimism. But several key facts about global warming are well established. Anthropogenic emissions from mobile and stationary sources represent a small fraction—about 5 percent—of overall carbon dioxide emissions, the remaining 95 percent stemming from natural biogenic processes such as oceans, plant decay, and animal respiration. Various natural process absorb carbon dioxide at a somewhat greater rate than biogenic sources produce it, so that nature has a considerable capacity to accommodate human-generated creation of this gas. But the scale of human-generated emissions has exceeded this natural buffer in the last 150 years. The amount of carbon dioxide in the air has risen, as witnessed by measurements of cores from the Antarctic ice cap. This build up appears to be a result of the burning of wood, coal, and petroleum following the industrial revolution.

Transportation is a major contributor to greenhouse gasses. Vehicles emit large amounts of carbon dioxide, which is of particular concern to global climate change. In the United States about one-third of all anthropogenic carbon dioxide emissions are from transportation vehicles, and transportation emissions have been increasing more rapidly than those of most other sectors of the economy. Transportation also produces methane, nitrous oxide, and other greenhouse gases. Transportation emissions are troublesome not only because of their large scale and rapid increase, but also because of the difficulty of controlling them. If international treaties to control greenhouse gasses are ever enacted, the U.S. transportation sector, which accounts for seven percent of carbon dioxide emissions from all sources in all countries, will certainly be a primary focus of attention.

There are scientifically sound reasons why increased amounts of carbon dioxide, methane, and other greenhouse gases, in conjunction with increases in other atmospheric constituents, can cause earth's temperature to rise. Actual temperatures have in fact risen during in the last 150 years, but they have not done so in a regular, steady way. There was a sharp drop in temperature in the 1900s, a steady increase from 1910 to 1940, a cooling trend during the 1950s and 1960s, and a rising trend from 1970 on. On average, the temperature on the planet has increased between 0.5 and 1.0 degrees Fahrenheit over the last century. Whether or not the build up of greenhouse gasses has contributed to this pattern is uncertain, as is the extent and timing of their effect on future climate conditions.

Because carbon dioxide lasts for 50 to 100 years once it is formed, the long-term cumulative effects are worrisome. But their effect on global climate is hotly debated. The actual temperature increases of the last century are less than those predicted by most mathematical climate models. A variety of natural and anthropogenic causes make predictions difficult. Human-caused depletion of stratospheric ozone and increases in smog may retard global warming. Shifts in ocean currents, the jet stream, precipitation levels, snow cover and cloud cover, and volcanic eruptions affect the link between increased carbon dioxide levels and earth's average temperature; and temperature effects vary widely from one region to another.

As a result, predictions of future global warming and its effects stir up divergent reactions, ranging from alarmist to defensive. The Environmental Protection Agency predicts temperature increases of two to six degrees Fahrenheit by the year 2100. If this occurs, it could increase global precipitation, cause intense rainstorms, and increase the sea level along most of the U.S. coast by two feet. Global effects of this scale would bring severe economic and social consequences,

especially in places like Bangladesh, with much low-lying land and limited economic resources. The amount of attention given to global warming by nations around the world is increasing, and these must deal with vast disparities in responsibility for current emissions of greenhouse gases, as well as the potential for development in other countries to exacerbate the problem. The United States now emits more than one-fifth of total global greenhouse gases. Per capita, China, Brazil, Mexico, and India emit far less, but as these countries adopt the automobile on a large scale it will add materially to global totals. International deliberations on global warming struggle to balance the disproportionate responsibility that industrial nations have for current emissions and the key role that developing nations will play in future emissions. Negotiations on international agreements to control emissions of greenhouse gasses reflect this divide, and the associated political sensitivities drive the responses of both industrial and developing nations.

Transportation Implications

As of this writing, the United States has not ratified an international treaty that would limit its overall emission of greenhouse gases, nor does it appear that it is likely to do so in the next several years. As alternative international arrangements have been discussed, these have led to the consideration, in concept at least, of policies to control greenhouse gases, including across-the-board measures such as carbon taxes, sector-specific regulations similar to the corporate average fuel economy standards applied to U.S. automobiles, and voluntary measures such as ride-sharing. Domestic and international policies might also entail emissions trading arrangements, whereby sectors or nations that cannot economically achieve their own targets are able to buy credits from others who have surpassed their targets. Within the transportation sector, decreases in greenhouse gasses might come from improvements in vehicular efficiency, substitution of fuels, reductions in travel, shifts of mode, changes in location of activities, and many other changes. Major reductions would require substantial changes in these areas.

No one can foretell how scientific understanding of this issue will advance, how international policies will evolve to address the problem, or whether natural phenomena will occur to alter the picture. Nor can one predict the pace with which technological developments will yield highway vehicles with greatly reduced emissions of greenhouse gases. The transportation sector has already made huge gains in vehicular fuel efficiency and operational coordination. Recent automotive news has highlighted new cars now being produced and ones that will be available within a few years that have dramatically improved fuel economy—60 to 100 miles per gallon—with concomitant reductions in emissions. Widespread introduction of these vehicles could transform the complexion of the entire set of issues surrounding global warming. In spite of major uncertainties like future technological capability and the many difficulties of quantitative prediction, there is nonetheless widespread scientific conviction that there is a serious problem associated with carbon dioxide levels, and that it may be self-defeating to wait and see how bad it is. As best we know, the carbon dioxide produced today will be here 50 to 100 years from now. Reversing a pattern of high emissions will take many years as new vehicles, travel restrictions, or land use patterns are phased in. The complexion of the issue is sharply different from one country to another, and global solutions will require negotiation of new forms of cooperation such as emissions-trading agreements.

The difficult process of crafting a solution to this problem is only beginning. The stakes are immense. The problem is growing. Solutions are slow and may be distasteful. For example, efficiency improvements might impose a cost in terms of vehicular performance; fuel substitution might involve reductions in convenience, range, or performance; and demand management could impinge on personal mobility. Yet public concern around the world is growing and intensifying the pressures for a coordinated international approach to the issue. Political responses are limited by public awareness. Society's assumptions about unrestricted mobility appear to be on a collision course with global warming. If future events unfold in a way that forces governments to enact global protective policies to combat human-caused alteration of climate, this could lead to consideration of measures that are viewed as unacceptable today. Planning for this contingency will require new tools to evaluate a wide range of governmental policies relative to transportation, land use, and vehicular technology.

Growth in Intermodal Transportation

One of the fastest growing sectors of transportation has been intermodal freight transportation, which provides origin-to-destination services using a mixture of two or more modes but allows the shipper to contract for this on a single freight bill. All of us are familiar with the convenience of overnight package delivery services and know from experience how this service, which might have seemed exotic at first, has become an everyday business necessity. Much of our office paperwork moves this way, as do many of the ever-growing volume of items that consumers purchase from catalogs or over the Internet. In 1960, the United Parcel Service reported that it carried $5 million in revenues for its trucking operations alone. By 1970 this figure had risen to $420 million and by 1980 to $3,963 million. In 1996, the United Parcel Service reported revenues of $16 billion on these operations.

Businesses making large shipments also stand to realize substantial benefits from intermodal freight transportation. Containerization of cargo has made it possible to move material rapidly and economically among ship, rail, and truck. Intermodal services have grown rapidly in recent years, and further growth is expected.

Intermodal Policy

Government policy has long recognized the need to adopt a comprehensive, multimodal vision. This was the driving force for the creation of the U.S. Department of Transportation in 1966 and for many state departments of transportation since then. At the national level, one administration after another has issued policy statements calling for an integrated national transportation policy, not just a funding strategy for highways and transit but a set of laws and institutions that would move us from a world of mode-specific policies and plans into one where transportation by all modes was treated methodically in its entirety. As logical as this sounds, it has proven to be impossible to design a national transportation system or to delineate a clear set of multimodal priorities for the nation. The task has been illusive because of the massive scale and complexity of a national transportation system. There are so many competing objectives—economic, social, regional, modal, corporate, and programmatic—that the task defies central planning and administration. Historically, the parts of this system have been difficult enough to coordinate one mode at a time. The prospect of governments creating "command and control" structures to achieve modal coordination and balance has threatened all involved—all modal interests, private as well as public agencies, and shippers as well as carriers. As a result, the goal of an integrated national transportation policy has remained more rhetorical than real.

The last two authorizing bills for surface transportation—in 1991 and 1998—introduced a new approach to intermodalism. Rather than attempt to design and implement command and control plans for the entire transportation sector, these acts instead created financial flexibility for using highway funding to address interconnections to the surrounding transportation networks. They allow resources to be focused strategically on bottlenecks in the overall multimodal transportation system.

This strategy is far less ambitious than planning, building, and maintaining a national transportation system. It extends traditional highway program funding to make it eligible for use on "intermodal connectors" that allow these resources to be used on other nonhighway transportation system improvements, and it takes one step toward expanding the program focus to address the needs of the system as a whole.

Recent legislation has also increased the attention given to major transportation corridors, which will also lead to more multimodal and intermodal projects. Such incremental steps appear to be workable devices for growing out of the traditional mode-specific planning framework into one where multimodal issues receive greater consideration. This means that the work of transportation planners, which has mostly been for governments and largely focused on highway and transit matters, will increasingly have to address how the regional economy is affected by improved rail or port access links or by access to international airline services. It means that more attention will be given to freight transportation within metropolitan areas, that new ways will be found for public agencies to collaborate with private shippers and private carriers, and that public agencies will be called upon to go beyond facility planning and to devote increased attention to operational management.

Safety

Cost of Crashes

Societal concern about transportation is heavily centered around safety. Around the world, 500,000 people are killed annually in motor vehicle crashes and 15 million are injured.[16] In the United States, more than 40,000 lives are lost in highway crashes each year, more than 5 million people are injured, and 27 million vehicles damaged. The National Highway Traffic Safety Administration estimates that these crashes cost the country $150 billion per year in lost productivity, medical costs, legal and court costs, emergency service costs, insurance administration costs, travel delay, property damage, and workplace losses. Airline disasters anywhere in the world are lead stories in the news. Train derailments and multicar pileups make the national news. Every one of the people who die on U.S. highways each year are covered in the local news, as are numerous truck jackknife incidents and hazardous materials spills. Few, if any, citizens get through life without experiencing a crash firsthand or without knowing someone killed in a traffic crash.

Much has been done to improve highway safety. Cars have safety belts, air bags, and many other safety features. Roads are being built and retrofit to higher geometric specifications, to have safer guardrails, energy-absorbing crash attenuators, and many other safety-enhancing features. The effect of all these improvements is evident. The number of traffic fatalities per mile driven has been dropping continuously year after year. In 1975, there were 2.95 fatalities for every hundred million miles traveled. By 1995, that rate had fallen to 1.98 fatalities. But much remains to be done. More than one-third of all crashes are caused in part by alcohol impairment, and more than two-thirds of highway crash victims were not wearing safety belts.[17] Our driving behaviors do not appear to match our expressions of concern about highway safety.

If visitors from another century were to arrive suddenly in contemporary U.S. society, they would probably be astounded by our progress in reducing fatalities from warfare and sickness. They would probably also be stupefied at the death caused by transportation. But having grown up in the auto age, we have become numb to its grim statistics. We have heard over and over that highway deaths are the leading cause of accidental death in the United States and the leading cause of death—accidental or otherwise—for persons between 15 and 24 years of age. We have heard that the United States has had more people die driving on its highways than fighting in its wars. Six out of every ten children born today will be injured in a highway crash during their lifetime. Through repetition, statistics like this have become dull; but the awful reality they represent is known to each of us through personal tragedies.

Future Challenges

Safety will continue to be a paramount issue in transportation planning. The advances that have been made in driver behavior, vehicle features, and road design form a strong basis for further progress. The future will also bring new problems. For example, the baby boom starts turning 65 in the year 2011. In their retirement years they are apt to remain auto dependent. They will face health and medical conditions that make driving risky for them and others. These risks can be reduced with ample anticipation and planning. Automobiles can be designed to make controls more compatible with the needs of older persons, new crash-avoidance technologies can help, and crashworthiness can be adjusted to reflect the changing demographics. Highway, transit, and pedestrian facilities can be improved to make them safer for older people. Better training and medical assessment programs can be made available and affordable to post-stroke patients and other rehabilitating drivers. Alternative transportation services can be improved to make them more accessible to retirees. Crashes involving older drivers will become an increasing priority on the highway safety agenda.

Improving safety while enhancing mobility, personal freedom, efficiency, esthetic, and other transportation concerns is a continuous and ever-changing balance. Speed limits, safety belt laws, regulations requiring air bags, crackdowns on drinking and driving, and other steps to control this balance stir considerable public attention. As technology has advanced and public concern has mounted, public policies have continued to encourage further improvements in transportation safety. The American Association of State Highway and Transportation Officials recently prepared the

[16] Christopher J.L. Murray and Alan D. Lopez, *The Global Burden of Disease* (Cambridge, Mass.: Harvard School of Public Health, Harvard University Press, 1997).

[17] *Traffic Engineering Handbook*, 4th ed. (Washington, D.C.: Institute of Transportation Engineers, Chapter 2, 1992).

Strategic Highway Safety Plan, designed to reduce highway deaths by 5,000 to 7,000 by 2004, using cost-effective measures that are acceptable to the general public. It includes initiatives to improve driver behavior, such as graduated licensing for younger drivers. It also addresses special users, specifically bicyclists; vehicles, particularly trucks; highways (minimizing the consequences of leaving the road, better intersection design, and safer work zones); emergency medical services; and improved safety management systems.[18] The substantial improvements that are possible through improved sensing and greater automation of functions can accelerate the pace of safety gains; but they will also raise difficult new issues of technological dependence, liability, governmental roles, and privacy. Striking a new balance between transportation safety and other societal concerns will continue to be a top priority of transportation planning in the years ahead.

Public Expectation of Transportation

Accomplishment and Disillusionment

Because transportation and society go hand-in-hand, the aspirations of society become the aims of transportation. These aims appear to have been less clearly drawn in recent years than they were in earlier eras. Articulating those aims at this juncture poses a special challenge. In earlier eras, one or another social goal has been matched by an exciting development in transportation; and this has stirred public interest and support. At the turn of the century, crowded, noisy, and polluted cities made urban dwellers long for escape, just as streetcars and the automobile made their deliverance possible. In the 1920s, the backwardness and isolation of rural areas made "getting the farmer out of the mud" a priority; and this led to a policy that saw highways not just as a tie to nearby cities, but as a truly interconnected network that tied cities and regions together. The 1939 Worlds Fair portrayed an exciting vision of coast-to-coast, high-speed highways that would dramatically increase the range of places Americans could visit, live, and work. In the 1950s, the United States set out to begin construction of the National System of Interstate and Defense Highways, a project that dominated transportation policy through the 1980s.

Today, transportation rarely ranks at the top of the list of hot issues in public opinion polls. The facilities in place appear to be largely taken for granted. Many local projects stir considerable public interest, but a larger share of national attention focuses on social concerns like environmental problems, noise, and safety. No radically different new locomotion technologies are known to be hovering just around the corner. The transportation sector, which is more crucial than ever, seems to be perceived to be a mature industry with an unexciting future.

The creation of the interstate system during the past forty years left strong imprints on the U.S. economy and development patterns. It reshaped where we live, work, shop, and spend spare time. It ushered in a new era in the marketing of roadside services—fast-food, motel chains, and major merchandisers. It triggered substantial gains in economic growth and it facilitated population expansion and metropolitan growth that might not have been achievable without it. But in spite of such benefits, it is seen by many as a mixed blessing. Critics perceive that it did not solve congestion problems in urban areas nor make driving more pleasant. They feel it exacerbated air pollution problems, split apart cities, and disfigured countrysides.

Such criticisms may be valid for some parts of the system and not for others. Everyone living in the United States today has his or her own opinion about the value of the system. Much has been written about it. As major new road systems are planned in Brazil, China, India, and elsewhere in the world, the U.S. interstate experience is being mined for useful inferences. It is a big chapter in economic and social history that will be analyzed and debated for years to come. One recent book describes it in these words:

> 'O public road,' wrote Walt Whitman in oft-quoted lines, 'You express me better than I can express myself.' In building the Interstate Highway System, the American people expressed themselves in all of their glory, all of their virtue, and not a few of their vices. The highways show our grace and our vision, but they also reveal, at times, our

[18] *Strategic Highway Safety Plan* (Washington, D.C.: American Association of State Highway and Transportation Officials, 1997).

> impetuousness and our shortsightedness. They represent the height of American technology. They suggest all our dreams for what America might become—one nation, indivisible, bound for all time by concrete and asphalt strands. As so often happens, the dream played out differently over the four decades it took to build the Interstates, and we learned that the very roads we thought would unite us have sometimes actually divided us. Over the decades, the Interstates have reflected our shifting attitudes about technology, landscape, community, race relations, and the quality of our lives. Indeed, as our image of ourselves has changed from the one we had in 1956, so have our highways. In this way the Interstates have revealed our dreams and realities better than any of us could have predicted.[19]

There may never be a final verdict about whether there were better ways to deal with rising population, a growing economy, and the auto age. Nor will we ever be sure whether or not the shortcomings of the interstate system might have been better anticipated. Certainly the accomplishment was an unprecedented one, and one that produced immense economic benefits. It also taught us about limitations and unexpected consequences. In cycle after cycle, culminating with the building of the interstate system, we have found that a new road is not a permanent solution to congestion problems. We have learned that limited-access, high-speed highways may be efficient; but some scar the landscape and make bad neighbors for many.

Today our dependence on transportation is greater than ever. This dependence is growing daily, as metropolitan growth continues to push homes, jobs, and stores outward, and as we become reliant on catalog shopping, just-in-time production, increased recreational opportunities, international air access, and all the other social and economic changes that have accompanied the development of modern transportation.

Transportation programs reflect the growing diversity of society's needs and the desire to fit transportation more harmoniously into communities. The growing number of local-interest highway projects that have found their way into national legislation in several recent reauthorization cycles reflects the lack of a single, unifying vision behind the national highway program. This fragmentation, coupled with post-interstate understanding, could mark the beginning of a new era. The benefits that transportation can bring to society remain important, but public attention appears to focus increasingly on alleviating the costs imposed by the current system and extensions to it. Programs have been introduced to offset the negative effects of new transportation facilities and services and to pay for features that make projects more amenable to communities. An increasing share of funds goes into programs that improve how we integrate transportation with society's other goals.

Future Planning Challenges

For planners and other professionals working amidst these changing expectations, the shift in public expectations has sometimes been sudden and disillusioning. Seen only recently as the deliverers of mobility, speed, and efficiency that society wanted, the professionals who designed and built the interstate system are occasionally stunned to find themselves vilified for creating current environmental and urban problems.

Transportation plans, like any other plans, do not always end up as anticipated. But their unanticipated outcomes may point the way to future improvements. As public expectations about beautification, environmental quality, and safety have grown, planning has become more comprehensive. We now focus far beyond facility provision, increasingly addressing the challenge of system operation. We find ourselves increasingly challenged to work with new partners, new modes, new policies, and new social concerns, and to reconcile far-reaching public expectations. We know that no fixed set of disciplinary methods or professional tools can keep up with the challenge.

Planning will continue to be an evermore dynamic, pluralistic activity, responsive to the public and its elected representatives. It will be the voice for an ever-wider array of concerns, reflecting many complex links between transportation and society. We must continue to develop better ways to portray the full range of consequences of transportation actions and to describe how they affect each set of interests. We must work with more and more industries, companies, agencies, neighborhoods, and other groups with a stake in transportation matters. We must continue to

[19] Tom Lewis, *Divided Highways* (New York, N.Y.: Viking, 1997), p. 294.

synthesize all this effectively to support elected leaders in their search for solutions. As we look for a better match between the aspirations of society and the goals of transportation, we must reflect a seasoned understanding that political resolution of conflicts is the appropriate planning process, not an intruder into the realm of professionals. Our vision and our tools must continue to evolve to serve society's changing expectations.