THE CHANGING FACE OF TRANSPORTATION

U.S. Department of Transportation

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A Message from

Secretary Slater

As stewards of America's transportation system, the U.S. Department of Transportation remains vigilant in the face of change and visionary in preparing for the future. We know that to be effective, our transportation system must be international in reach–linking us to new markets and destinations around the world; intermodal in form–gaining from the combined strengths of the individual modes; intelligent in character–harnessing the tremendous power of technological advancement to expand our capabilities; and inclusive in service–moving all forward and leaving no one behind. Perhaps, above all, it must be innovative–creating a system that will grow safer and more efficient over time.

We also know transportation is about more than concrete, asphalt, and steel. It is about people and their daily lives. It is about their dreams and aspirations, their connection to the economy and to each other. Transportation is the tie that binds.

As we take stock of the challenges we face, the Department has embraced a decisionmaking process that ensures the public's interests are served and that the public and all other stakeholders are involved in the process. How is this process different from others before it? The key is a tenacious focus on outcomes–beyond inputs, activities, and outputs–and a commitment to measure our performance against the goals we set. We hold ourselves accountable, but our plans aren't prescriptive; they are inherently flexible. This means that we need high-quality, objective data to guide our programs and judge our success. In fact, Congress created the Bureau of Transportation Statistics as an operating administration within the U.S. Department of Transportation precisely for this purpose–to ensure the availability and reliability of relevant data for decisionmaking in transportation.

We are moving from strength to strength, taking our planning process to a new level with the assistance of both this document, *The Changing Face of Transportation*, and its companion document, *Transportation Decision Making: Policy Architecture for the 21st Century*. As a companion document, the *Policy Architecture* report will help translate the trends we see and the goals we set into choices that will guide decisionmaking for the next 25 years. Thus, we build on the foundation laid down by those who have gone before us, those who carved the path in *National Transportation Trends and Choices* 25 years ago.

I invite you to continue improving our nation's transportation system so that it will not only serve the needs of today's Americans, but tomorrow's Americans as well. Each of us has an important role in helping to shape and pave the way for the future in this, the new century and the new millennium. Together we will continue to provide the best transportation system in the world.

Rodney E. Slater
Secretary of Transportation

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chapter 1

Visions Past and Future

Our vision of transportation in this new century and this new millennium is shaped by the many successes of our past and a renewed commitment not only to meet but to surpass new goals, as we strive to obtain transportation excellence for all Americans. Today, under the leadership of President William J. Clinton and Vice President Al Gore, transportation has moved from strength to strength, and the U.S. Department of Transportation (USDOT) is poised to lead the transportation enterprise as we improve safety, expand mobility, support economic growth and trade, protect our environment, and support America's national security interests.

"If we make wise and informed choices today and in the years to come, we can make our communities more livable, give our citizens greater choice and mobility, protect our environment, and help create a truly global community. The 20th century was indeed a golden age for transportation; the 21st century can be an even brighter one."

William J. Clinton
President of the United States
May 15, 2000

A quarter century ago, William T. Coleman, Jr., the fourth Secretary of Transportation, opened a window into the lives of Americans that was extraordinary. He painted a picture of our society, of the ways in which we travel and interact, of our economic lives, of our safety and health, of our environment, and of our use of natural resources. And then he went even further. He used the knowledge of the past to look into the future, and he set about creating a planning and decisionmaking framework to guide that future. Over the next two-and- a-half decades, the document that outlined that framework would fade from view. But, remarkably, the future unfolded in many ways just as Secretary Coleman envisioned in the 1977 report, *National Transportation Trends and Choices* [USDOT 1977].

Eight USDOT Secretaries would stand watch as the future became reality. They challenged the Department and the transportation community to implement a new vision for transportation in the United States—to embrace higher safety goals, to champion deregulation and investment efforts, to pursue greater private-sector participation in meeting our transportation needs, and to adopt policies that enhanced the performance of the nation's transportation system. Among the Secretaries, Secretary Neil E. Goldschmidt continued efforts to deregulate the railroad and trucking industries as the Staggers Rail Act of 1980 and the Motor Carrier Act of 1980 became law. Secretary Samuel K. Skinner oversaw the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), a major surface transportation program, which also led to the establishment of the Bureau of Transportation Statistics (BTS) during Secretary Andrew H. Card's administration in 1992. And Secretary Federico F. Peña successfully worked with the transportation community to implement the provisions of ISTEA.

Today, Rodney E. Slater, our thirteenth Secretary of Transportation, has changed the face of transportation through visionary and vigilant leadership and by setting aggressive goals that will make our transportation system progressively safer and more sustainable in the face of change. Secretary Slater challenged us to expand our horizon by pursuing a transportation system that is more than just a physical infrastructure of concrete, asphalt, and steel; and in turn, he redefined transportation to be about people and their total quality of life. Through transportation, he created opportunities for us all to lead safer and more fulfilling lives. During his administration, several laws governing major transportation programs were reauthorized. These include the Ocean Shipping Reform Act of 1998 (OSRA), the Transportation Equity Act for the 21st Century of 1998 (TEA-21), the Coast Guard Authorization Act of 1998, which established the Marine Transportation System (MTS) initiative, and the Aviation Investment and Reform Act for the 21st Century (AIR-21). Also, during Secretary Slater's tenure, 38 new "open skies" agreements were signed with countries around the world, bringing today's total number of these liberalized aviation agreements to 52.

The Changing Face of Transportation, together with its companion document, *Transportation Decision Making: Policy Architecture for the 21st Century*, links past and present and then points us toward future successes. Both documents reflect the Department's determination to fulfill its Strategic Plan, its resolve to remain visionary and vigilant, and its intent to lead the way to transportation excellence in the 21st Century.

Under the collaborative and open leadership of Secretary Slater, today's transportation enterprise is leading America's great transition into the global economy. Today's decisionmakers persist in ensuring that our transportation system remains *international* in reach—linking us to new markets and destinations around the world; *intermodal* in form—gaining from the combined strengths of the individual modes; *intelligent* in character—harnessing the tremendous power of technological advancement to expand our capabilities; and *inclusive* in service—moving always forward and leaving no one behind. Our transportation system must also be *innovative* in scope—deriving every benefit from technology that enhances safety and makes our communities more livable.

Under the leadership of the Clinton-Gore Administration, we have made safety our top transportation priority. But today's USDOT is positioned to do much more; we must make the system even safer, we must improve mobility and accessibility, and we must protect our environment, while supporting our national security goals.

Box 1-1

Purposes of *The Changing Face of Transportation* and *Transportation Decision Making: Policy Architecture for the 21st Century, 2000*:

1. Present a blueprint to build a transportation system that goes far beyond the goal of safely and efficiently moving people and goods to one that improves our total quality of life.
2. Provide a vision to inform future decisionmakers and policymakers for the 21st Century—a vision that puts people first and strives to leave no one behind.
3. Show that aggressive "stretch" goals can be achieved through collaborative leadership that brings partners together to produce maximum results.
4. Estimate and illustrate the potential results of current policies.
5. Show the potential improvements from achieving the Department's Strategic Goals.
6. Illustrate record-level infrastructure investment that significantly improves the condition and performance of our nation's transportation system.
7. Forecast and show the impacts of policies on public safety, energy use, environmental enhancements, and technological advances.
8. Show the emerging trends in transportation demand and their potential impacts.
9. Encourage an informed decision-making process that draws on the best from all stakeholders at federal, state, and local levels, and from the private sector.
10. Facilitate a transportation system that is truly the "tie that binds" us together as a nation and connects us to the rest of the world.

Box 1-2

The Purposes of *Trends and Choices*, 1977:

1. Estimate and illustrate the potential consequences of policies.
2. Show that long-range consequences are considered in both substantive and resource allocation decisions.
3. Encourage a view of transportation as a means to broader national goals.
4. Promote a more informed public debate on transportation decisions.
5. Forecast and illustrate the impacts of policies on energy conservation, environmental enhancement, assistance to the transportation disadvantaged, and public safety.
6. Indicate the directions in which current and future transportation policies are taking us.
7. Initiate a planning process based on common time horizons and planning assumptions.
8. Encourage transportation performance measurement.
9. Facilitate federal decisionmaking with information on desired or probable directions.
10. Encourage careful evaluation of proposed regulatory actions.

Goals of *The Changing Face of Transportation*

The Changing Face of Transportation provides a historical perspective for policymaking. It reviews the major policy milestones of the past quarter century and the social and economic context for those milestones. Secretary Slater provides a logical foundation for making future policy choices and challenges the transportation enterprise to aspire toward higher marks of excellence, moving beyond what we think is possible and also thinking globally. Some future policy choices are apparent already and, as with the choices envisioned by former Secretarys of Transportation, undoubtedly many more will emerge as the future unfolds.

Today, we can look forward with confidence knowing that our transportation system reflects the remarkable achievements of the Clinton-Gore Administration in striving to meet our nation's transportation needs. Under their leadership, virtually every law governing major transportation programs has been renewed, including the Trucking Industry Deregulation Act of 1994, the Ocean Shipping Reform Act of 1998, the Transportation Equity Act for the 21st Century of 1998 (TEA-21), and the Aviation Investment and Reform Act for the 21st Century (AIR-21). These Acts provided record-level infrastructure investments, increased funding flexibility, expanded the proven strategies of public participation in the planning process, and affirmed this Administration's top transportation priority of improving safety and creating opportunities for all Americans. The ramification of this extraordinary era will positively shape transportation in the coming decades.

25 Years Ago . . .

Trends and Choices was developed at a critical time in our nation's transportation history. The United States had just experienced a major energy shock in 1973 and would soon experience another in 1979 due to oil embargoes by OPEC—the Organization of Petroleum Exporting Countries. Kindled by recent memories of long gas lines, a major concern about petroleum fuel was availability—perhaps even more so than price. But in the aftermath of the 1973 shock, the public had returned quickly to its old driving habits, almost as though nothing had happened.

A Chronology of Vision and Vigilance Under the Leadership of Secretary Rodney E. Slater

"As we look to the future, I am confident that we are truly in on the ground floor of a new age of prosperity for everyone. And the role of transportation in this age is to create the links that make it happen. Transportation is truly the tie that binds."

Rodney E. Slater
Secretary, Department of Transportation

October 2000

National Drunk Driving Standard – Confirming his consistent commitment of safety as the Clinton-Gore Administration's top transportation priority, President Clinton signed into law the "Department of Transportation and Related Agencies Appropriations Act, 2000." This Act provides critical transportation safety funding and contains a provision that will help set a national impaired driving standard at 0.08 Blood Alcohol Concentration, thereby reducing drunk driving on the nation's roads and saving lives.

USDOT Performance Report Rated the Best in Government by the U.S. Senate – The Senate Governmental Affairs Committee rated the USDOT's 1999 Annual Performance Report one of the best in government. The USDOT's Report was one of two agencies to be rated "A", out of 24 federal agencies. The Performance Report informs Congress and the public what USDOT is doing and how well we are doing in terms of our strategic goals under the Government Performance and Results Act (GPRA). In 1997, the USDOT's Strategic Plan and Performance Goals were also rated the best in the entire government. The USDOT plans to continue achieving improved results in safety, mobility, economic growth, human and natural environment, and organization excellence.

International Transportation Symposium – USDOT hosted the first International Transportation Symposium for world transportation ministers, industry leaders, academia, and the public to develop a bolder vision for a truly global transportation system and create the environment conducive to addressing the emerging challenges of the 21st century.

Open Skies – During the last eight years, the United States signed 51 Open Skies agreements with countries around the world. Under Secretary Slater's leadership, the United States signed 37 of these agreements, opening more markets and creating more opportunities for international air service than ever before.

July 2000

10th Anniversary of the Americans with Disabilities Act of 1990 (ADA) – In celebrating the 10th anniversary of the ADA, USDOT emphasized its commitment to envisioning accessibility as a civil right.

July 2000

First to Achieve EEO Goal – The USDOT became the first federal agency to achieve an important goal in equal employment opportunity complaint handling. DOT has eliminated its complaint backlog and has an aggressive compliance goal of zero backlog.

April 2000

AIR-21 – The 2000 Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR-21) substantially increased funding for aviation safety, modernization and stability of critical air traffic services, and airport development.

March 2000

New Generation of Vehicles – The Partnership for a New Generation of Vehicles (PNGV) program celebrated a milestone. The PNGV partnership, started under Vice President Gore in 1993, brings together the federal government and the U.S. auto industry. It achieved a major goal when the three big U.S. automakers started marketing hybrid-electric vehicles with very low emissions and fuel efficiency of up to 80 miles per gallon. Another Vice-President Gore initiative, "A Research Initiative for 21st Century Trucks," will build on the PNGV success by cutting fuel use and greenhouse gas emissions of delivery vehicles while improving the safety and efficiency of the nation's trucking industry.

February 2000

Moving Passenger and High-speed Rail into the Future – The Clinton-Gore Administration consistently supported a national passenger rail system to help meet our nation's growing transportation needs in the 21st Century. Critical funding was provided to help Amtrak achieve self-sufficiency, improve and increase the speed of rail service, and lay the foundation for high-speed rail corridors. Passenger rail service, including high-speed rail, will play a key role in meeting the nation's transportation needs and providing solutions to the effects of economic growth and urban sprawl.

January 2000

Motor Carrier Safety – The Department's newest agency, the Federal Motor Carrier Safety Administration was formed following passage of the Motor Carrier Safety Improvement Act and USDOT set a stretch goal to reduce the number of truck-related fatalities by 50 percent over 10 years.

December 1999

Aviation in the 21st Century Beyond Open Skies Ministerial – USDOT hosted an Open Skies Ministerial, attended by leaders from more than 90 countries, to expand and strengthen international aviation partnerships far beyond bilateral agreements. This ministerial promoted transportation policies that foster the Clinton-Gore Administration's goals for prosperity, stability, and democracy and was a follow-up to the historic meeting held in Chicago 55 years earlier.

September 1999

Africa-US Transportation Ministerial – USDOT hosted the first Africa-U.S. Transportation Ministerial for African transportation leaders to develop a vision of collaboration and partnership in transportation, safety, trade, and development.

Marine Transportation System Assessment – Secretary Slater submitted to Congress the first comprehensive assessment of the U.S. Marine Transportation System. This assessment was prepared by a congressionally mandated public- and private-sector task force under the leadership of the U.S. Coast Guard and the Maritime Administration.

July 1999

Order on Accessibility – A new USDOT Order on Accessibility was signed, stating that accessibility is a civil right. This Order and other activities put USDOT in the forefront of federal activities to lower barriers and obstacles to people with disabilities in their use of transportation infrastructure.

June 1999

Innovation in Transportation – Looking toward the future impacts of technological innovation in transportation, USDOT hosted the "Spirit of Innovation in Transportation" conference to foster a climate of ongoing innovation. Secretary Slater challenged the transportation community to work toward a transportation system that is innovative in scope, international in reach, intermodal in form, intelligent in character, and inclusive in service.

May 1999

Transportation and Community Livability – USDOT made the first awards under the new TEA-21 Transportation and Community and System Preservation program, established to enhance our understanding of links between land use and transportation. Under Secretary Rodney Slater's leadership, the USDOT has ensured that transportation programs support the Clinton-Gore Administration's community livability efforts. Such efforts include development of information on USDOT programs supporting livability, initiation of ONEDOT partnership efforts, and implementation of the Delta, New Markets, and Rural initiatives. The USDOT has used tools and resources to preserve green space, ease traffic congestion, restore a sense of community, pursue regional smart growth strategies, and enhance economic competitiveness.

March 1999

Transportation and Community Development – The USDOT showed strong commitment to new markets and emerging corridors and initiated major programs to use transportation in promoting economic development in the Appalachian region, the Delta region, and in Rural America. Although we have made progress in improving transportation in these underserved regions of America, more needs to be done so that no region in the country is left behind. Transportation could bring greater economic opportunity and improved quality of life to communities in these regions.

National Transportation Safety Conference – In partnership with the safety leadership of the transportation community, the USDOT hosted the first ever national safety conference involving all modes of transportation that had two significant outcomes on partnership and promise. The partners developed an aggressive safety action plan and committed to make safety their top priority to the American people. Safety is the USDOT's North Star by which we are guided and willing to be judged. The safety partnership was challenged to embrace safety as a promise we make and keep together. Progress has been made since this conference, including efforts to improve data for strategic and operational transportation decision, development and use of advanced safety technologies, and promotion and funding of enforcement of transportation-related laws and regulations.

continued next page

January 1999

New Rule Revising USDOT's Disadvantaged Business Enterprise (DBE) program – USDOT announced a significant new rule revising the Department's Disadvantaged Business Enterprise (DBE) program, a major component of the Administration's commitment to minority businesses. The new rule assures that help is extended to those businesses that need it the most. USDOT has one of the largest DBE programs in the federal government, thus ensuring minority and disadvantaged access to federal contracts.

December 1998

Western Hemisphere Transportation Partnerships – Secretary Slater continued the Clinton-Gore Administration's goal to promote free trade, economic development, and democracy throughout the Americas. Secretary Slater hosted a Transportation Ministerial for the 34 nations of the Western Hemisphere at which a two-year action plan was adopted to improve transportation safety and security, to continue the integration of transportation policies and programs across national and modal lines, and to enhance disaster prevention and relief.

November 1998

Marine Transportation System National Conference – Under Secretary Rodney Slater's leadership, the USDOT collaborated with other federal agencies and numerous private-sector stakeholders to develop a bold and comprehensive plan to modernize our nation's Marine Transportation System (MTS), as required in The Coast Guard Authorization Act of 1998. The MTS vision is to be the world's most technologically advanced, safe, secure, efficient, effective, globally competitive, and environmentally responsible system for moving people and goods by 2020.

OneDOT – Secretary Rodney Slater challenged the Department to reinvent our workplace culture to better serve the American people through teams that produce higher performance goals by working better together across all modes.

June 1998

TEA-21 – The 1998 Transportation Equity Act for the 21st Century (TEA-21) guaranteed a record $200 billion in surface transportation investment for highway safety, highways, transit, and other surface transportation programs for six years.

Transportation Infrastructure Finance and Innovation Act – Authorized under TEA-21, The Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA) provided direct loans, loan guarantees, and lines of credit to private and public sponsors of major surface transportation projects, epitomizing the importance of public-private partnerships under the Clinton-Gore Administration.

National Transportation Library – Embracing advances in information and communication technology, TEA-21 established the National Transportation Library within the Bureau of Transportation Statistics. The library, an electronic repository of materials from public and private organizations around the country, facilitates the exchange of transportation-related information. This Library will allow USDOT to meet emerging information challenges of the future.

November 1997

First Electronic Docket on the Internet – Secretary Rodney Slater broke new ground by unveiling the first electronic docket on the Internet to involve Americans in the governmental decision-making process. This improves access to government information, improves service to the American people, and makes government more efficient.

October 1997

Africa Transportation Initiative – Secretary Rodney Slater led the Clinton-Gore Administration's Partnership for Growth and Opportunity in Africa. USDOT promoted sustainable improvements in aviation safety and airport security, trade and market development, technical assistance and technology transfer, and human capacity building throughout Africa.

June 1997

USDOT Strategic Plan Rated Best in Government by the U.S. Senate – Under the leadership of Secretary Rodney Slater, USDOT's Strategic Plan 1997-2002 was rated the best in government by the Senate Governmental Affairs and Appropriations committees under the GPRA. The Strategic Plan sets aggressive performance goals in safety, mobility, economic growth, human and natural environment, national security, and organizational excellence; and it identifies measures to gauge progress. The Department increased its investment in America's infrastructure while reducing staffing.

May 1997

Garrett A. Morgan – Under Secretary Slater's visionary leadership, the USDOT started the Garrett A. Morgan Technology and Transportation Futures Program to enhance transportation education at all levels by leveraging the Department's current technology, education, and research program through public/private partnerships. Garrett A. Morgan (1877-1963) was an African-American inventor whose lifetime of contributions includes the invention of the traffic signal.

April 1997

30th Anniversary of U.S. Department of Transportation – The USDOT, celebrating its 30th anniversary, is positioned to remain more vigilant and visionary, committed to making the American transportation system safer.

January 1996

Intelligent Transportation Systems – Under Secretary Federico F. Peña, the USDOT challenged the transportation community to embrace advances in ITS technology to save time and lives and improve quality of life.

November 1995

National Highway System Designation – President Clinton signed the National Highway System Designation Act passed by the Congress, formally establishing the National Highway System (NHS). The NHS has focused federal resources on the most heavily used highways and on those that link other key elements of the transportation system, such as ports, international border crossing points, major airports, and public transit facilities.

April 1995

Transportation and Environment Policy Statement – Under the leadership of Secretary Rodney Slater, the Federal Highway Administration (FHWA) expanded the definition of environment far beyond "natural" and "scenic" to include the built environment, the cultural and social fabric of our country, our neighborhoods, and the total quality of life of all Americans. This was part of his overall vision to redefine transportation beyond public works of concrete, asphalt, and steel to one about creating opportunities for all Americans.

August 1994

Hazardous Materials Transportation Authorization Act of 1994 – This Act became law under Secretary Federico F. Peña and made the American transportation system safer by improving federal hazardous materials transportation provisions.

October 1993

The Federal Highway Administration – FHWA celebrated 100 years of service to the country. Record levels of infrastructure investments provided under the Clinton-Gore Administration have positioned the FHWA to continue to make our nation's highways safer.

August 1993

Livable Communities and Transportation – The USDOT announced the first Livable Communities grant to the Metropolitan Transportation Commission. The USDOT has continued to support communities by encouraging transit-oriented commercial and residential development and supporting improved access to transit service.

August 1993

Government Performance and Results Act of 1993 (GPRA) – President Bill Clinton signed the GPRA to require government agencies to develop three important performance measurement systems: strategic plans, performance plans, and performance reports. The USDOT aggressively responded with our organizational excellence goal, which advances the Department's ability to manage for results and innovation.

July 1993

The Americans with Disabilities Act (ADA) Key Station Compliance – This Act took effect and required all transit stations, unless granted extension by the USDOT, to be readily accessible to and usable by individuals with disabilities.

Source: U.S. Department of Transportation, December 2000.

Table 1-1

Forecasts Past and Future	1975 Actual	1990 Coleman forecast	1990 Actual	2000 Estimated	2025 Forecast[13]
Transportation Context					
Population (millions)[1]	215	247	249	275	338
GNP (constant 1975 $, billions)[2]	$1,598	$2,830	$2,409	$3,049	$5,486
GNP Per Capita (1975 $)[2]	$7,417	$11,457	$9,675	$11,087	$16,240
GDP (constant 2000 $, billions)[3]	NA	NA	NA	$9,942	$18,258
Passenger Transportation					
Passenger-Miles (billions)[4]	2,560	3,850	3,946	5,036	8,438
Passenger-Miles Per Capita[4]	11,881	15,600	15,847	18,313	24,979
Licensed Drivers (millions)[5]	130	161	167	190	243
Vehicles (millions)[6]	138	170	193	219	262
Freight Transportation[7]					
Total Ton-Miles (millions)	2,285,000	4,394,706	3,196,000	3,959,432	5,098,888
Rail*	754,252	1,845,777	1,033,969	1,416,446	1,484,802
Water (domestic ton-miles)	565,984	1,010,782	833,544	763,540	NA
Water (domestic and foreign tons)	1,695	NA	2,164	2,453	3,429
Truck (intercity)	454,000	703,153	735,000	1,130,132	2,121,837
Air	3,470	8,789	9,064	15,904	33,925
Pipeline	507,000	834,994	584,000	633,410	797,950
Safety[8]					
Transportation fatalities	49,214	45,500	47,248	42,600	40,300
Air Pollution[9]					
CO (millions of tons)	85.27	27.00	61.18	50.48	24.24
NO_x (millions of tons)	9.45	8.82	8.51	8.66	7.98
Greenhouse gas emissions[10]	350.00	NA	420.00	500.00	600.00
Energy[11]					
Btu[12] (trillions)	16,998	16,700	24,070	25,200	36,600

* The FRA forecasts a two percent average annual growth rate for the 2000-2025 period. This translates into 2.4 trillion ton-miles in 2025.

[1]Population projections are taken from U.S. Department of Commerce, Bureau of the Census, Annual Projections of the Total Resident Population as of July 1: Middle Series Projections for 2000 and 2025.

NA = not available.

The Clean Air Act of 1970 had introduced vehicle emission standards and local plans for meeting national ambient air quality standards to be administered by a new agency—the Environmental Protection Agency. The Federal Task Force on Motor Vehicle Goals Beyond 1980 issued a report in 1976 recommending fuel consumption standards for a new vehicle fleet while dealing with often conflicting requirements to preserve personal mobility, reduce emissions, and enhance safety. Many public research efforts were launched after 1973, focusing on alternative fuel technologies. It was for these reasons, among others, that a national document like *Trends and Choices* would have a special section devoted to the automobile.

Issues of expanding safety regulation and economic deregulation of common carriers for both passengers and freight were at the forefront of policymaking. American railroads were in serious difficulty with rates of return that, at best, did not permit adequate investment. Amtrak had been created in 1970 as part of a divestiture process. Conrail had just been created from a family of bankrupt Eastern and Midwestern railroads. Congress was also considering legislation to reduce the economic regulatory burdens imposed on carriers by the Interstate Commerce Commission (ICC), which oversaw rail, truck, and intercity bus activities; and the Civil Aeronautics Board (CAB), which oversaw air passenger and freight activities. The U.S. maritime industry was in a long decline from its once-dominant position in the world.

Thus, at the time *Trends and Choices* was issued in 1977, every sector of the transportation system faced significant challenges; however, unlike today, system capacity was not a major issue.

[2]Forecasts for GNP are based on 1975 through 1999 data, using log linear (Holt) exponential smoothing model, parameters optimized through SAS/ETS software.

[3]Forecasts for GDP are based on 1929 through 1999 data, using damped trend exponential smoothing, parameters optimized through SAS/ETS software.
[4]Forecasts are based on 1990 through 1997 data, using damped trend exponential smoothing, parameters optimized through SAS/ETS software.

[5]Forecasts are based on 1949 through 1998 data, using damped trend exponential smoothing, parameters optimized through SAS/ETS software.

[6]Forecasts for vehicles are based on 1990 through 1997 data, using double (Brown) exponential smoothing, parameters optimized through SAS/ETS software.

[7]Forecasts for total ton-miles are an aggregate of the individual forecasts by mode. Forecasts for rail ton-miles are based on 1990 through 1998 data, using damped trend exponential smoothing, parameters optimized through SAS/ETS software. Forecasts for water ton-miles are based on two forecast models: log damped trend exponential smoothing based on 1990 through 1997 data, and log simple exponential smoothing based on 1960 through 1995 data in five year increments; the two forecasts are combined with equal weights. Forecasts for truck ton-miles are based on two forecast models: linear trend based on 1990 through 1997 data, and double (Brown) exponential smoothing based on 1960 through 1995 data in five year increments; the two forecasts are combined with equal weights. Forecasts for air ton-miles are based on two forecast models: linear trend based on 1990 through 1998 data, and damped trend exponential smoothing based on 1960 through 1995 data in five year increments; the two forecasts are combined with equal weights. Forecasts for pipeline ton-miles are based on 1990 through 1997 data using log linear trend. All forecast model parameters optimized through SAS/ETS software.

[8]Forecasts are based on 1990 through 1998 data, using damped trend exponential smoothing, parameters optimized through SAS/ETS software.

[9]Forecasts for CO are based on 1985 through 1997 data, using log linear trend parameters optimized through SAS/ETS software. Forecasts for NOx are based on 1985 through 1997 data, using double (Brown) exponential smoothing, parameters optimized through SAS/ETS software. Forecasts for greenhouse gas emissions are based on expert opinion.

[10]Millions of metric tons of carbon equivalent, excluding bunker fuels.

[11]Forecasts based on 1990 through 1997 data, using double (Brown) exponential smoothing, parameters optimized through SAS/ETS software.

[12]Btu: British thermal unit.

[13]The 2025 forecasts are purely statistical. For sources of data used in these forecasts see page 1-32.

As the Last Quarter Century Unfolded . . .

Perhaps the centerpiece of transportation policy over the last 25 years has been the economic deregulation of aviation, trucking, intercity buses, railroads, and, recently, the ocean shipping industry. These actions produced profound impacts not only on the structure of these industries, but also—because of enhanced competition—on their performance rates, fares, and quality of service.

Airlines and railroads continue to experience major consolidations through mergers, alliances, and buyouts. Lowered entry barriers have allowed new small air carriers, thousands of small trucking companies, and regional intercity bus companies to offer services, and have brought about the resurgence of regional and short-line railroads. At the same time, enhanced competition within each industry has lowered fares and freight rates.

Growth brought about by deregulation has provided unprecedented levels of mobility and contributed to the enormous economic prosperity of the last decade. Since 1975, passenger-miles of travel have nearly doubled, just as economic production has nearly doubled over the same period. Yet the number of transportation fatalities continues to decline, and most measures of air pollution/emissions have declined as well. Energy use has risen; but with gains in energy efficiency, cars now get close to 33 percent more miles per gallon than they did 25 years ago.

Technology has played a critical role in enabling change. During the past quarter century, the aviation system has moved to satellite-based communications, navigation, and surveillance systems. Global Positioning System (GPS) technology has provided major advances in positioning accuracy for maritime shipping, railroads, and highway vehicles as well. Cars are no longer controlled by purely mechanical devices, as they were in 1975. Instead, microchips control many mechanical components. How much of this could have been anticipated?

"In 1970, U.S. per capita income was 31 percent higher than that of other major industrialized countries. By 1991, that difference had narrowed to only 10 percent. But with the dawn of the Internet Age, the gap has started to widen again—to more than 22 percent this year."

Michael S. Mandel
Business Week
Oct. 4, 1999

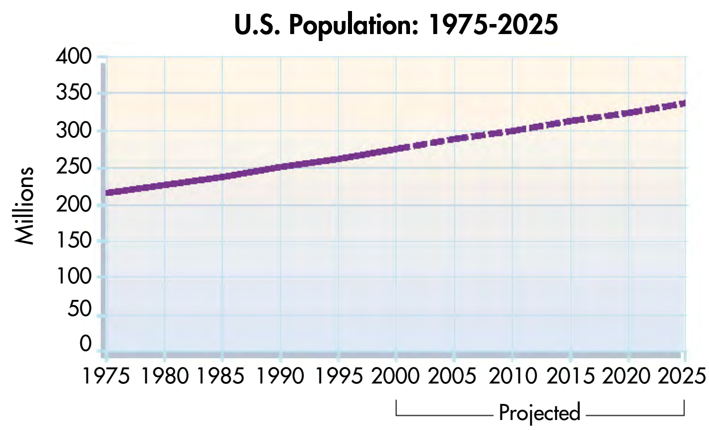
Forecasting

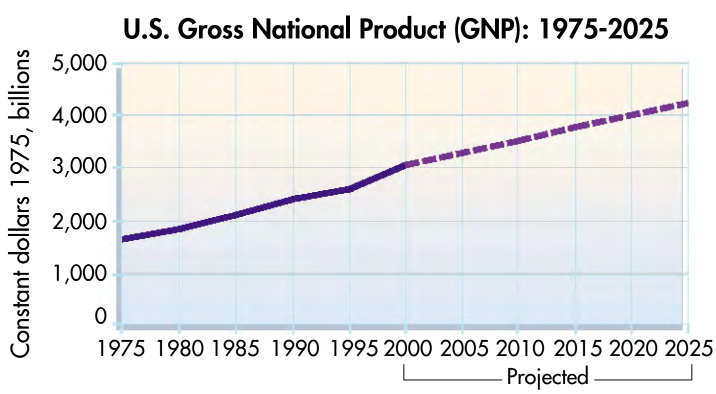
Even in the most tranquil of times, projecting trends into the future is an undertaking filled with challenges and pitfalls. Still, the forecasts made in *Trends and Choices* were fairly accurate. And history is instructive. The past suggests that most of the technologies likely to be deployed widely over the next generation are ones that either exist today or are under development. It is imperitive that we invest in research and development today to support future generations. Even while we might safely forecast that the pace of change will quicken, history cautions us to avoid assuming that futuristic visions will quickly become reality (table 1-1). The past suggests that public acceptance of new technologies or policies can play a major role in whether they are deployed or implemented. The past also has shown that many changes will be associated with *wild cards*—developments like wars, recessions, or other phenomena that we know might occur but which we cannot forecast with any confidence. Perhaps most importantly, through *Trends and Choices*, Secretary Coleman demonstrated that well-informed policy decisions can have important effects on the ultimate outcomes for transportation.

The Transportation Context

During the Clinton-Gore Administration, a steady growth in population and strong economic growth increased demand for transportation services. By 1998, under the leadership of Transportation Secretary Rodney Slater, Congress provided nearly $200 billion over six years in surface transportation investment, an increase of nearly $50 billion over previous funding (see box 2-1 in chapter 2).

In 1975, the U.S. population was growing steadily, with most of the increase due to migration, and the economy was picking up after a recession. The U.S. population stood at 215.9 million, the Gross National Product (GNP) was $1,598.4 billion, and GNP per-capita—a commonly used indicator of economic well-being—was $7,400 per person.





At the time of *Trends and Choices*, the U.S. population was projected to grow by about 0.5 percent compounded annually over the next 15 years to 247 million. Real GNP was projected to grow at a faster rate — by about 2.3 percent per year — to $2.83 trillion, or about $11,460 per person (in constant 1975 dollars).

By 1990, without any major social upheavals over that period, the population actually grew to a level almost exactly as forecast—to 249 million. But the nation's economy had been buffeted by another major oil shock in 1979 and had stagnated through the 1970s and 1980s. With high levels of inflation accompanying slow growth, economists came to call this unusual phenomenon "stagflation." GNP fell short of the projections by 15 percent—$2.41 trillion vs. $2.83 trillion projected in *Trends and Choices*. Real GNP per-capita fell short of the $10,000 forecast by Coleman for 1990.

Under the leadership of President Clinton and Vice President Gore, we have witnessed a continuing rise in population, still largely through immigration, and the longest expansion of the economy in our nation's history. Making up for the pause in growth during the 1980s, the economy has grown to an estimated $9.9 trillion in 2000, and per-capita Gross Domestic Product (GDP)[1] stood at about $36,153 thousand in 1998 or about $11,100 in 1975 dollars.

Over the next 25 years, the U.S. population is likely to continue growing at an average annual rate of change of about 0.82 percent, reaching a level of 337 million by 2025. But the age distribution of the population will continue to change significantly. The median age has risen from 28.8 in 1975 to 35.2 in 1999, and it is expected to reach 38.0 by 2025 [USDOC Census 1999]. These changing demographics will challenge transportation decisionmakers both directly and indirectly through the makeup of the workforce, consumer preferences for products and services, and the numbers of youthful and aging drivers, among other things.

Economic projections tend to be more near-term. But the Congressional Budget Office's estimates suggest growth in production at a substantially faster rate than population growth—about 2.7 percent compounded annually over the next 10 years [CBO 2000]. Projected forward, we might expect GDP to reach $29 trillion by 2025. In that event, per-capita GDP might well be close to 1.5 times today's level in *real terms*.

One facet of the trends in this period was the growth in workers that resulted from the baby boomers coming of working age from the mid-1960s to the mid-1980s and the growth in women joining the labor force. In the 1980s, more people were added to the labor force than to total population. Women's increasing involvement in the workforce shifted the historical pattern in which one-third of working-age women worked to one in which one-third of women of that age group did not work. By 1975, female labor force participation had risen to 47.3 percent; by 1998, it stood at 59.4 percent. It is to the great credit of the U.S. economy that the surge of workers found jobs in a thriving economy. Today, the ever-increasing demand for workers directly supports President Clinton's welfare reform plan, and an increasing number of welfare recipients are transitioning to the job market.

Transit ridership grew from 7.4 billion passenger trips in 1993 to 9 billion in 1999 – the highest level since 1964.

Population and economic production have always been important factors in shaping the nation's travel patterns. As population grows, travel generally rises proportionately. But changes in the age distribution, geographic distribution, and even immigration can affect travel volume and patterns as well. Economic well-being can brake or accelerate the use of the transportation system, while changing the mix of transportation modes or trip purpose. Also, internationally, population growth and globalization of the economy will amplify both trade and passenger flows. Thus, demographics and economics provide an important part of the context for transportation decisionmaking by individuals, government, and in private industry.

[1] Since 1992 the United States changed from GNP to GDP as the aggregate measure of the size of the economy to better reflect the domestic production capacity of the country. In 1992, U.S. GNP was $24,490 per capita in current 1992 dollars, while GNP was $24,447 per capita in current 1992 dollars.

Today, highway vehicle-miles traveled exceed 2.6 trillion per year and continue to grow. Transit ridership reached 9 billion in 1999, the highest in 40 years. Commercial airports handled more than 8.5 million flights, nearly double the number of flights handled in the mid-1970s. By 1999, U.S. domestic revenue passenger-miles had climbed to 473 billion and will continue to increase.

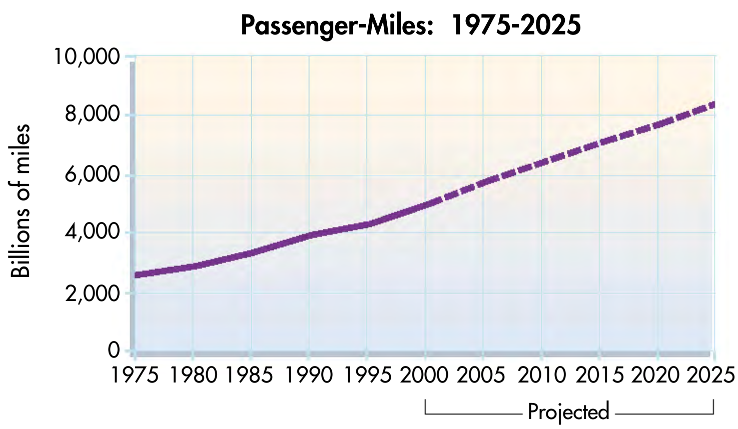
Increased demand for transportation brings increased safety, security, energy, environmental, and congestion concerns. The challenge will be to address these concerns while developing innovative solutions to ensure the free flow of goods and people within and among all of the various modes of transportation, to allow people to be even more productive with their time, to experience new things, and to always be connected.

Passenger Travel

In 1975, Americans used the automobile for more than 90 percent of their travel (by mileage), and travel by automobile was continuing to rise faster than the population was growing [USDOT 1977]. Therefore, it was natural that *Trends and Choices* would forecast what we would see by 1990:

- 50.4 percent rise in passenger-miles,
- 23.4 percent rise in licensed drivers, and
- 23.2 percent rise in the number of vehicles on the highways.

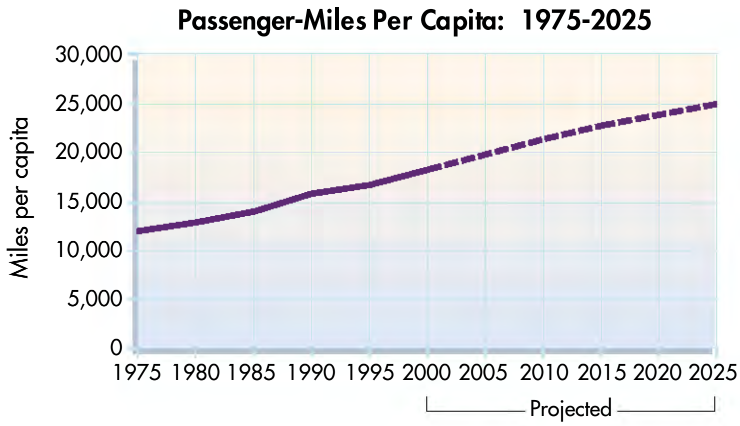
What is a little surprising is the accuracy of these forecasts even while the economy fell short of forecasts by 14.9 percent. Passenger-miles per capita, in particular, were almost exactly as projected. The number of licensed drivers grew to a level slightly (3.7 percent) more than projected. But the number of vehicles increased to an astonishing 193 million—23 million more than expected only 15 years before. The number of light trucks and sport utility vehicles (SUVs) alone grew by more than 23 million.

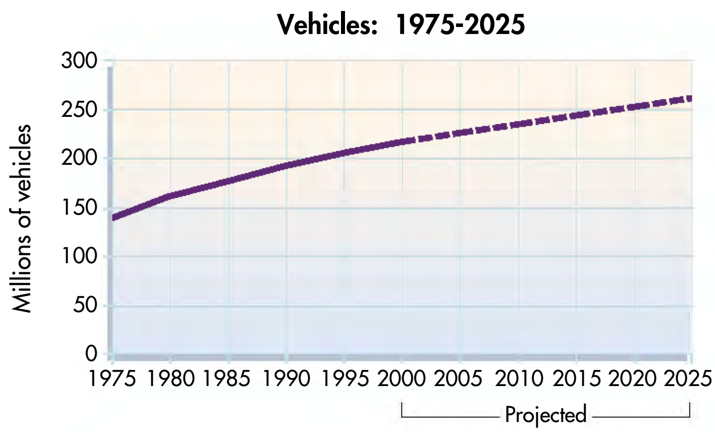


Evidently, the American fascination with automobiles was tied much more loosely to the economy than originally thought. And vehicles were starting to last longer, so even moderate levels of new car purchases inflated the national inventory. The increase in telecommuting, e-commerce, and other advances that can be a substitute for transportation will likely slow the growth in transportation demand. However, continued growth in the demand for transportation may result in more attempts to control demand through pricing, regulation, and other mechanisms.

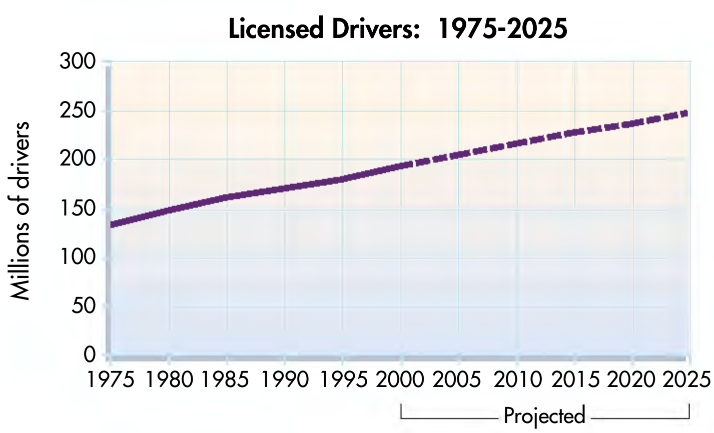
Over the past 10 years, passenger travel rose even more steeply than during earlier decades as the economy grew rapidly. Highway travel (as measured in passenger-miles) has continued to dominate—still accounting for 90 percent of travel—while air travel accounts for another 9 percent, and the other modes together account for the last one percent. Until the past decade or so, about every five years highway travel lost a percent of the modal share, while air travel gained a percent. Reasons for this shift include lower costs, faster travel, and an increased willingness to travel longer distances and visit more places.

The next 25 years present some real uncertainties. While vehicle miles of travel (VMT) certainly have risen over the last 25 years, today congestion presents a real challenge. Our strong economy has increased demand and created capacity challenges. Record-level investments have made funding available, but we cannot build ourselves out of this situation. We cannot build enough lanes or roads in most places where capacity is needed.





The current market share of transit—and its capacity in some geographic areas—is limited, and currently forms only a small part of the solution. Although transit ridership has been growing at a rate faster than automobiles in some urban areas, its full potential to ease congestion is yet to be realized. The market share of transit—and its capacity in some areas—must be expanded. The other main mode of passenger travel—aviation—is also beset by capacity problems, with significant public concern about flight delays and cancellations, even now. Three current options offer hope. First, Intelligent Transportation Systems (ITS) technology offers one option, as metropolitan areas across the country are actively deploying some of these technologies to improve the capacity of the highway system. Second, modernization of the nation's air traffic control system offers another part to the overall solution for transportation. Third, continued investment in airport capacity that will allow increasing aviation activity that is compatible with environmental standards.



For some time now, we have had the tools necessary to advance telecommuting. But, there may be some aspects of the way we work that are preventing greater market penetration. Recall that no less a visionary than Thomas Alva Edison predicted the demise of the conventional classroom with the advent of films and radio. As work is becoming more information- and innovation-oriented, team development is becoming more important. Systems are becoming more complex. As one is less and less able to master entire systems, trust is perhaps becoming more critical, and face-to-face contacts are needed to develop that trust. In fact, it seems that workplaces are beginning to pay more attention to "professional emotional" relationships. These take time and close interaction. We can support efforts to continue to increase telecommuting.

By 2025, travelers will have widespread, real-time access— any time, any place—to information of all types, such as transportation availability, geographic location, and operating conditions over various segments of a trip. Passenger-miles of travel will increase faster than the growth in travel experienced during the 1990s—from 5 trillion miles in 2000 to 8.4 trillion in 2025, provided that capacity issues can be adequately addressed. A corresponding rise in global travel will also occur.

Box 1-3

Forces of Change Affecting Commuting, Land Use, and Other Travel
(in this decade and beyond)

The Democratization of Mobility—Everyone can travel—the number of vehicles in the nation exceeds the number of drivers. Currently, the saturation in drivers licenses and vehicles is really the saturation of the white population alone. As affluence increases, more African-American, Hispanic, and Asian households will acquire both licenses and vehicles. This equalizing of mobility will be critical to both the ability to fully exploit job opportunities and to expand the ability to enjoy social and recreational opportunities.

Aging of the Population—As future numbers of older and retired people increase, travel patterns and levels will change as well. Travel in nonpeak hours may increase at a greater rate, relative to commuting travel, as the retired have more time for leisure activities.

Changing Immigration—With immigration returning to turn of the 20th century levels, immigrants will become a critical factor in future commuting patterns. In 1998, close to 60 percent of arrivals from abroad went directly to metropolitan suburbs, rather than the cities. While new immigrants may initially stimulate transit use over time, they may make other travel choices.

Growing Affluence— Rising incomes increase auto availability and use, trips per household, and average trip lengths. As the means to travel increase, people consume more transportation. With 70 percent of the nation's workers living in two-or-more-worker households, commuting trips become longer, more auto-centered, and more likely to be in a peak period. Household income levels of $25,000 appear to be the threshold for shifts to private vehicles for transportation.

Dispersal Technologies— Transportation services, both ground and air, have been a key factor in dispersing the population by making formerly remote areas highly connected to the rest of the country. Airport congestion will push development to areas with excess capacity. Airports will be the economic engines of the 21st century, not unlike the seaports and railroad stations at the turn of the 20th century. The Internet, computers, and future technologies will further loosen constraints on dispersal, expanding the freedom to work anywhere.

Source: Alan Pisarski, excerpts from speech to the "Road Gang," Channel Inn, Washington, DC, June 15, 2000.

There will be greater concerns for the safe mobility of older adults, who will make up one-sixth of the population. New technologies will be employed to keep them driving safely longer, as they continue to use the automobile as their main source of transportation. And more user-friendly, reliable forms of nondriving transportation will be perfected, providing older adults with additional options.

While traveling in the future will be different, the basic modes we use are unlikely to change. What will change are the characteristics of these systems, how we use them, and how we construct our daily routines, all of which will help enhance the quality of the transportation experience. Certainly, technology, automation, and the prospect for increased affluence will play major roles. And capacity is going to have to be addressed head-on, even if just to avoid constraining the U.S. economy.

With the unveiling of "Acela," Amtrak's new high-speed train service (with speeds reaching150 mph) in the Northeast Corridor, the interest in high-speed, rail-based ground transportation continues to grow. It is expected that by 2025 most of the corridors in the nation will have a high-speed train service. The advent of MagLev (magnetic levitation) over the next 25 years will present intercity travel times that will rival those of air travel.

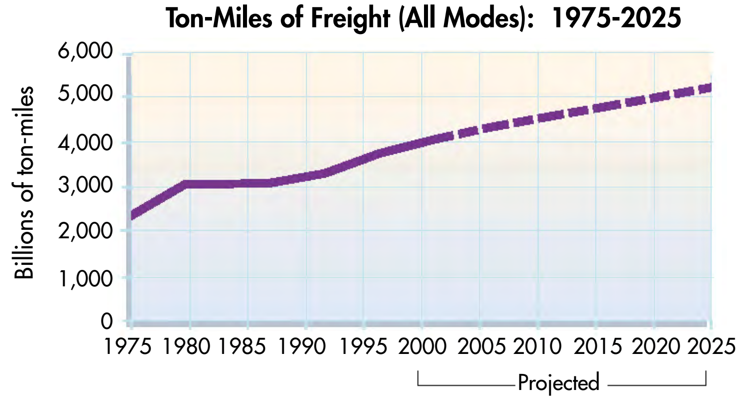
Increased use of ferryboat systems is being looked at as a measure to address congestion in major metropolitan areas like San Francisco, New York City, and Seattle. The U.S. Marine Transportation System (MTS) report, submitted by the USDOT to Congress in 1999, estimates very rapid growth of the high-speed passenger ferry industry. Ferries traveling up to 80 knots or more will be used to compete with other forms of transportation. The growth in the ferry industry is expected to continue over the next 25 years and will require improvements to the port infrastructure and a continuing focus on prevention programs to minimize risk to passengers.

Freight Transportation

In 1975, the U.S. economy was more product- and less service-oriented than it is today. The domestic transportation system handled about 2,285 billion ton-miles of freight—or a little over 1.4 ton-miles per dollar of GNP. Freight tonnage was split among rail (33 percent), water (25 percent), pipeline (22 percent), and truck (20 percent) by modal share; air transportation accounted for much less than 1 percent of ton-mileage. Over-regulation and energy costs were among the more visible issues. But the demand for freight transportation was growing rapidly.

Trends and Choices forecast 92 percent growth in ton-miles by 1990—even more than the 77 percent projected growth in real GNP. In fact, while GNP fell somewhat short of the forecast, freight traffic fell short even more. By 1990, real GNP was up about 50 percent while total ton-miles were up only 40 percent. Two important things were happening. The economy had cooled, and changes in the nature of U.S. production had reduced the overall tonnage for a given level of national output. In particular, the service sector of the economy grew disproportionately. Changes in the type of commodity moving (higher value-added-per-unit-weight commodities like computers, electronic equipment, and the like) might also have reduced the tonnage.

Ton-Miles of Freight (All Modes): 1975-2025



Trends and Choices overestimated total freight ton-miles by some 27 percent, but the modal split also shifted significantly and unexpectedly. Rail tonnage fell short of predictions by 44 percent, pipeline by 30 percent, and water transport by 18 percent. Trucking and air transport were slightly less than predicted. The large difference in the rail mode, in particular, is probably a reflection of the large increase in the price of petroleum that was expected but did not materialize, which would have made rail relatively more attractive compared to trucking.

Over the past 10 years, freight ton-miles have grown another 23 percent—just trailing the growth in the U.S. economy. Large increases in truck and rail freight together can account for this growth. Trucking, in particular, increased its modal share from 23 to 30 percent in just 10 years. By contrast, domestic waterborne transpor–tation declined fairly dramatically, from a 26 percent share to an 18 percent share. Pipeline transportation grew, but more modestly than other modes. Aviation grew by more than 70 percent. While it remains a very small part of freight transportation by tonnage, aviation accounts for about 30 percent of the value of U.S. merchandise trades, and this share will increase.

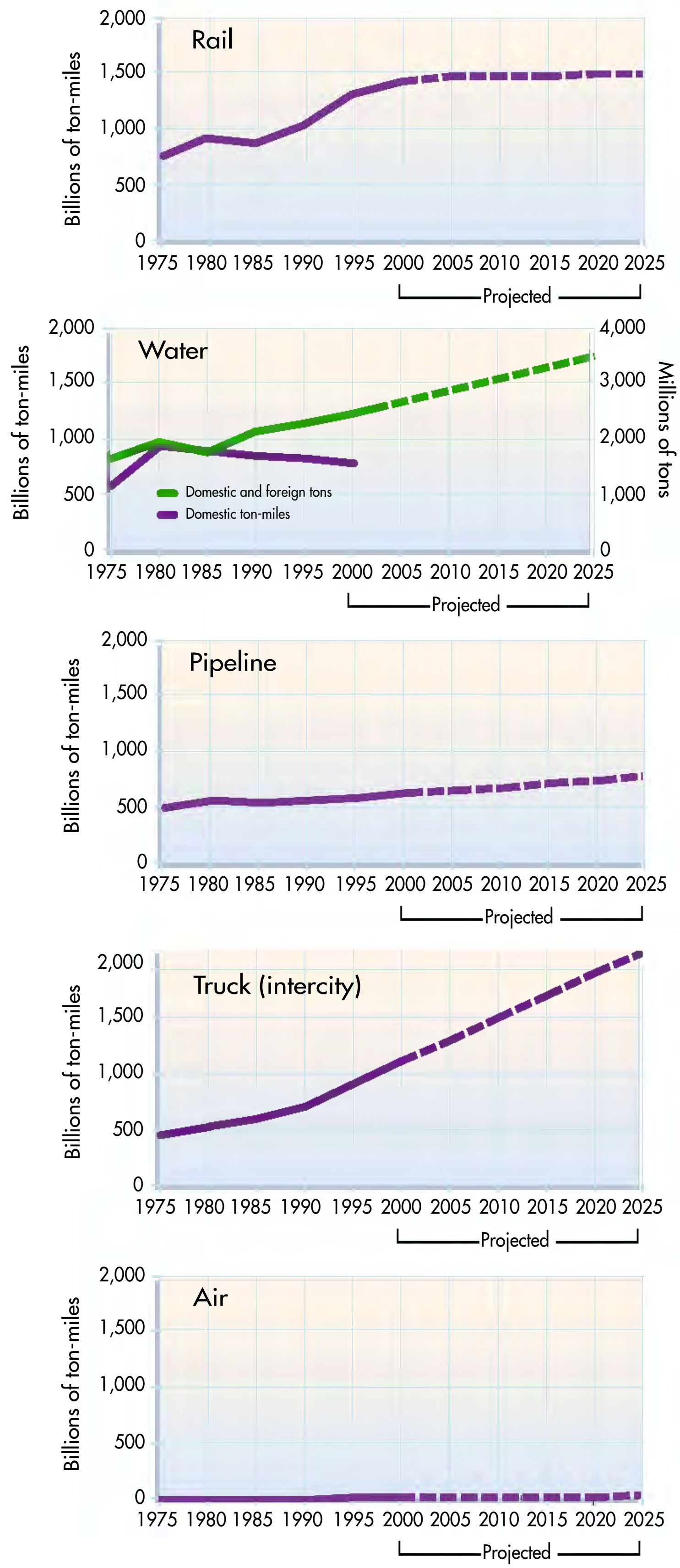
The next 25 years will be a challenging time for all sectors of the freight community. Congestion and capacity issues are already facing every mode. Intermodal connections need to be made more efficient.

Much of the transportation infrastructure requires modernization. Workforce shortages are projected. At the same time, e-commerce and increasing globalization of the economy could increase transportation demand. Just-in-time inventory systems are likely to move even more inventory out of warehouses and into the transportation system, requiring both system capacity and greater reliability. And economic production (GDP) is likely to grow by 84 percent, in 2000 dollars.

Given all these factors, we expect freight transportation to grow to just over 5 billion ton-miles by 2025—a 29 percent increase over our current estimates. But we also expect further shifts in how freight is moved and freight transportation is managed:

- A high volume of smaller shipments to satisfy low or noninventory

Ton-Miles of Freight by Mode: 1975-2025
(based on statistical forecast in table 1-1)



production and distribution requirements and express package delivery. Highly integrated freight transportation companies that provide full logistics/transportation services using multiple modes.

- The U.S. Coast Guard (USCG) sestimates that while domestic water freight movement is expected to increase moderately over the next quarter century, foreign waterborne commerce is expected to double during the same period. A significant increase in international freight movement will require much larger ships; deeper channels; and high-capacity, highly efficient intermodal cargo-handling ports. The innovative marine transportation system initiative started by Secretary Slater will be an important catalyst to address the changes necessary to meet the challenges this growth will present.

- A rapid growth in trucking due to the increase in point-of-sale and just-in-time inventory systems, express package delivery, and e-commerce. Trucks will continue to dominate the freight transportation market, although their share of the primary shipment tonnage transported in the United States is expected to remain relatively constant for the next 10 years.

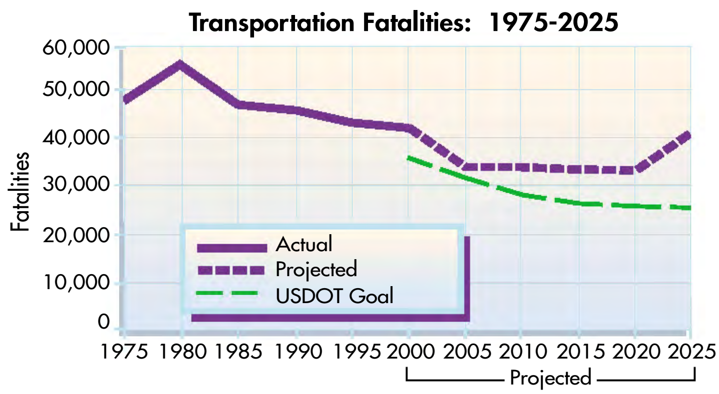
- Air cargo growth is expected at a pace even greater than today's because of e-commerce and globalization. Larger aircraft, both dedicated freighters and passenger aircraft with excess storage capacity, will carry cargo.

- FRA projections show that rail ton-miles will grow an average of 2 percent per year between 2000 and 2025.

The evolutionary changes of the past 25 years have created a highly efficient, market-driven freight system with increased responsiveness and lower costs to consumers and producers. But the success of our nation's freight movement system has generated a new set of issues—and future choices to be made—in areas of freight system development, utilization, and management. *The size and shape of the transportation system will be determined to a large extent by strategies for capital investment, financing, research and technology, and balancing mobility needs with safety and environmental considerations.*

Transportation Safety

Safety concerns have always been a critically important area of emphasis for the public sector. Safety is the Clinton-Gore Administration's top transportation priority and the Department's "North Star" by which we set our goals and policies to improve safety in all transportation modes. Under the Clinton-Gore Administration, the transportation system as a whole is the safest it has ever been. Advances in technology, our renewed focus on partnerships aimed at positively changing human factors, and effective legislation offer great hope for progress in reducing transportation crashes and fatalities.



In 1975, the nation saw nearly 50,000 fatalities associated with transportation. Highway crashes were the leading cause of death for individuals between 1 and 44 years of age, and accounted for 95 percent of all transportation fatalities [USDOT 1977].

At the time of the *Trends and Choices* report, the authors reasoned that if nothing were done, we would "lose the race with increased travel" and the total number of deaths would rise substantially. It was thought that by 1990 the highway death toll could exceed 60,000 per year [USDOT 1977]. This was clearly unacceptable.

Instead, Secretary Coleman established a planning goal to implement countermeasures that would cut the fatality rate (fatalities per 100 million vehicle miles of travel) in 1990. "The goal is not, of course, to have 40,000 fatalities in 1990 but to cut the fatality rate by more than 40 percent and to save more than 20,000 lives that year compared to what the situation would be without the countermeasures." [USDOT 1977]. The resulting forecast—adjusted for this ambitious plan—was 45,500 transportation fatalities in 1990.

That forecast was remarkably close to the actual number: 47,247 fatalities in 1990. Despite the rapid growth of transportation usage, the number of fatalities had actually declined, with safety gains in almost every category. Highway fatalities—still the dominant component of overall transportation safety—essentially held steady in the face of a 60 percent rise in vehicle-miles of travel [USDOT BTS 1999]. That accomplishment, alone, explains most of the difference between the original "no intervention" projections and the actual numbers by 1990. Meanwhile, maritime and aviation fatalities each dropped by more than 40 percent, and rail fatalities fell by 13 percent [USDOT BTS 1999]. And since then, transportation fatalities have dipped below 44,000.

Most advances in highway safety have come from improvements in road and motor vehicle design, increased seat belt use, decreased drunk driving, and improvements at rail grade crossings. Public awareness campaigns, launched by the USDOT in cooperation with non-profit organizations, have also helped improve safety. We expect additional improvements from advances in motor vehicle road designs, in-vehicle technologies, technology-enhanced traffic law enforcement, and improvements in pedestrian/cyclist safety. Advances in trauma response and medical treatment have significantly reduced the lethal consequences of many crashes, but further improvements are possible. *If the statistical trend of the past 25 years is applied to the next 25 years, fatalities could be expected to decrease to about 40,300 per year by 2025. However, we are not content with that scenario. So the USDOT has established a "stretch" goal of reducing highway fatalities by 20 percent—to 33,500—by 2008.* This will clearly require even more aggressive and innovative approaches to preventing crashes and reducing their lethal consequences. But if successful, this should put us on a path toward a major milestone: fewer than 25,000 highway fatalities by 2025.

"As we work together, let us aim for 'stretch goals' – goals that push us towards greater achievement than we can now imagine."

Secretary Rodney Slater
U.S. Department of Transportation

The goals and policies we set today will be pivotal for transportation safety over the next 25 years. The high marks we set today for the next quarter century will hopefully propel our progress beyond what we might otherwise achieve. Along with the goal for a 20 percent reduction in highway fatalities, the USDOT has set "stretch" goals for an 80 percent reduction in aviation fatalities by 2007, and a 50 percent reduction in motor carrier-related fatalities by 2010.

FAA's "Safer Skies" initiative is focusing on six key causal factors that contribute to the majority of incidents and crashes: controlled flight into terrain, loss of control, uncontrolled engine failure, runway incursions, approaches and landings, and weather. The FAA is working in partnership with the airline industry, pilots, technicians, and air traffic controllers to use improved forecasting and new communication technology to detect severe weather sooner.

In motor carrier safety, heightened public attention combined with new legislative mandates will be the basis for improvement—expanding safety regulatory and enforcement programs, coupled with technological innovations and proactive approaches by industry and government to raise safety program quality and effectiveness by all motor carrier operations.

"Secretary Rodney Slater has not only tried to get more money for the nation's roads, bridges, airports, rail, and mass transit – he has also tried to humanize the face of transportation and save lives."

William J. Clinton
President of United States
October 23, 2000

In October 2000, President Clinton signed into law the "Department of Transportation and Related Agencies Appropriations Act, 2000." This Act provides critical transportation safety funding and contains a provision that will help set a national impaired driving standard at 0.08 Blood Alcohol Content, thereby reducing drunk driving on the nation's roads and saving lives.

Railroad crossing crashes and fatalities declined dramatically since 1975, and today, the number of fatalities has been reduced by more than half. A significant factor contributing to this decline has been the forging of strong partnerships among rail labor, management, suppliers, state rail safety agencies, and other rail stakeholders. These partners impact rulemaking through the Rail Safety Advisory Committee and the only collaborative safety initiatives on every major railroad, called the Safety Assurance Compliance Program. These efforts have made 1993-1999 the safest seven years in railroad history. These partnerships, together with improved technology, education, and enforcement, can continue increasing safety in the future. Railroad worker and passenger fatalities and injuries are also expected to decline steadily in the next 25 years as a result of widespread use of Positive Train Control (PTC) and other Advanced Train Control Systems, improved locomotive and passenger car safety standards, and improvements in human factors. However, as train movements increase, and development and urbanization spreads along railroad tracks, the incidence of trespassing may increase, along with a corresponding rise in trespasser fatalities.

Fatalities associated with maritime operations have dropped nearly 50 percent since 1975, due in large part to improvements in recreational boating safety and the U.S. Coast Guard's marine safety programs. Improvements resulted from implementation of the Federal Boat Safety Act of 1971, which drove new regulations affecting both boat manufacturers and boat operators. The U.S. Coast Guard has partnered with States to conduct boater safety and education programs. The states have implemented their own boating safety programs with the help of federal grant funding, and commercial marine operations have been enhanced through Port State Control policies that focus on foreign vessels operating in U.S. ports—covering the design and maintenance of ships, as well as the capabilities and qualifications of their crews. An aggressive program to ensure that all foreign flag passenger vessels operating from U.S. ports comply with all applicable international and U.S. standards has resulted in no passenger deaths since 1984, and the death rate involving the U.S. domestic passenger vessel fleet continues to decline.

In the future, increased global trade will result in ships that are larger and faster, and which carry more cargo. Increased emphasis will be placed on changes in ship design and engineering standards to improve the structural safety, fire protection, and general safety of vessels. Additional improvements in human performance will follow the introduction of advanced technological, organizational management, and work environment products and practices.

Box 1-4

FAA and NASA: Working Together on Aviation Vision and Goals

On October 9, 1998, FAA Administrator Jane Garvey and NASA Administrator Daniel Goldin signed a formal agreement establishing a partnership between their agencies with the objectives of defining and achieving specific goals in aviation and future space transportation. This agreement, built on a long history of FAA-NASA joint efforts and cooperation, will provide the leadership needed to define, develop, and deploy the research and technology necessary for the nation's aviation system to meet the difficult challenges of the coming decades.

Looking into the future, NASA and FAA are working to achieve long-terms goals in these critical areas:

1. Reduce the aircraft accident rate by a factor of 5 by 2010, and by a factor of 10 by 2025.
2. Reduce CO_2 emissions of future aircraft by 25 percent by 2010, 50 percent by 2025, and possibly totally by 2030 to 2040; reduce NO_x emissions of future aircraft by a factor of 3 by 2010, 5 by 2025, and completely by 2030 to 2040.
3. Reduce the perceived noise levels of future aircraft by 50 percent (10 dB) from today's subsonic aircraft by 2010, and 75 percent (20 dB) by 2025.
4. While maintaining safety, triple the aviation system throughput, in all weather conditions, by 2010.
5. Reduce the cost of air travel by 25 percent by 2010 and by 50 percent by 2025.
6. Reduce travel time to the Far East and Europe by 50 percent by 2025 and do so at today's subsonic ticket prices.
7. Invigorate the general aviation industry, delivering 10,000 aircraft annually by 2010 and 20,000 aircraft annually by 2025.
8. Provide next generation design tools and experimental aircraft to increase design confidence, and cut the development cycle time for aircraft by 50 percent.
9. Reduce the payload cost to low-Earth orbit by an order of magnitude, from $10,000 to $1,000 per pound, by 2010, and by an additional order of magnitude from thousands to hundreds of dollars per pound by 2025.
10. Reduce the cost of interorbital transfer by an order of magnitude by 2015, and reduce travel time for planetary missions by a factor of two by 2015, and by an order of magnitude by 2025.

Source: National Aeronautics and Space Administration, *Roadmaps to the Future — Version 1.0*, available at http://www.nasa.gov/ as of Dec. 15, 2000.

Under Secretary Rodney Slater's leadership, the USDOT developed a bold and comprehensive plan to modernize our nation's Marine Transportation System (MTS). He led an MTS Task Force, which was a highly collaborative effort of federal, state, local, and private sector stakeholders, to develop a vision for the future, define the critical issues facing the industry, and implement a course of action. Safety remains MTS Task Force's most critical goal and will guide our action plans to improve vessel operations and better manage our marine infrastructure.

Technology, innovation, and leadership may well be the keys to major safety advances in the future. In particular, widespread deployment of collision-avoidance technologies and mitigation strategies will be necessary to achieve the dramatic reductions in deaths and injuries that we seek.

In March 1999, the USDOT held the first-ever National Transportation Safety Conference where we identified the top 10 issues that would lead to the creation of a National Safety Action Plan. These action plans were held together by the concept that "Safety is a promise we make and keep together."

1. Promote and require use of safety equipment in all transportation modes.
2. Promote a culture of safety for all transportation modes and the population.
3. Increase research of performance factors across all transportation modes.
4. Adopt a Federal uniform law of .08 percent blood alcohol concentration for drivers and a zero tolerance level for truckers.
5. Increase funding to support enforcement of existing transportation laws and regulations.
6. Maximize existing safety partnerships.
7. Do a better job of data collection and reporting across all jurisdictions.
8. Implement fatigue management practices.
9. Increase use of technology to improve safety in all transportation modes.
10. Improve international safety cooperation.

Moving forward from this conference, we have made progress. In October 2000, President Clinton signed into law a national impaired driving standard of 0.08 Blood Alcohol Concentration. This will reduce drunk driving on the nation's roads and save lives. We have taken steps to improve transportation safety data for strategic and operational decision, to develop and use advanced safety technologies, and to fund the enforcement of transportation-related laws and regulations.

"We have pursued a new strategy for prosperity–fiscal discipline to cut interest rates and spur growth; investments in education and skills, in science and technology and transportation, to prepare our people for the new economy; and new markets for American products and American workers."

William J. Clinton
President of the United States
January 27, 1998

The Environment

The future of the environment and the course of environmental protection are inextricably linked by a variety of factors and events. These include the rate of growth in the population and the economy, the use of and alternatives to fossil fuels, the nature of land use development patterns, and the application of technology and other factors that could help limit the negative impact of transportation on the environment.

Under the leadership of Vice President Gore, the Livable Communities Initiative was developed to ensure an improved quality of life and strong local economies by preserving open spaces, enhancing air and water quality, securing safe streets, and developing places where we work, but spend less time in traffic and more time with families, friends, and neighbors. In June 2000, First Lady Hillary Rodham Clinton and Secretary Rodney Slater designated 16 National Millennium Trails that connect our nation's landscape, heritage, and culture and demonstrate our national commitment to improving the quality of life for all Americans. Another initiative by President Clinton addresses findings that show the burdens of a polluted environment are borne disproportionately by members of minority and low-income communities. The initiative, known as Environmental Justice, advocates policies that will either cease, reduce, or evenly distribute such problems. Executive Order 12898 directs federal agencies to initiate procedures and actions that make environmental justice part of their basic mission. In 1997, the USDOT issued guidance to incorporate the principles of environmental justice throughout its programs, policies, and activities.

It will become increasingly challenging to balance the need for greater mobility with the needs of the environment. Growing tradeoffs among competing objectives make it more difficult, but not impossible, to develop new transportation facilities as costs of mitigation increase. Creative management of transportation systems to reduce congestion will become increasingly important.

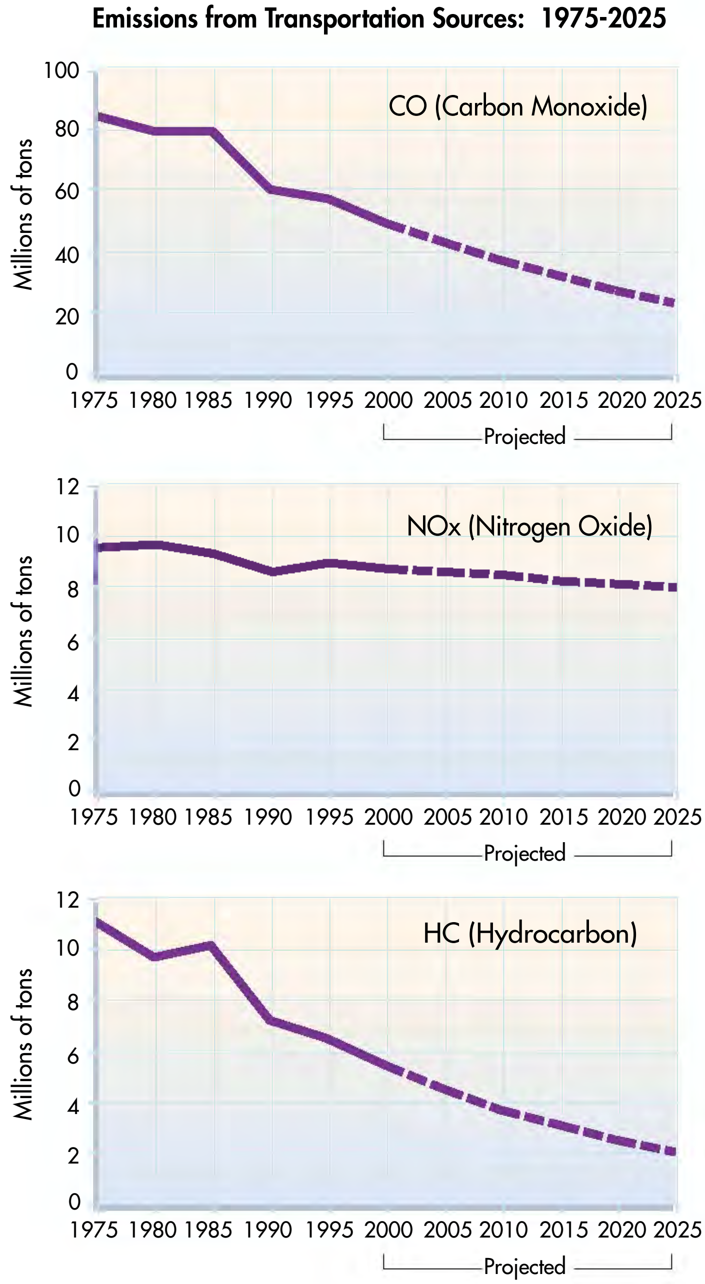
In the mid-1970s, transportation agencies were beginning to develop tools for assessing the environmental impacts of proposed transportation activities, following enactment of the National Environmental Policy Act in 1969. Other environmental statutes passed in the 1970s addressed particular resources. Over time, more sophisticated tools were developed to address environmental considerations, leading to a recent emphasis on improved processes and outcomes.

In 1975, air pollution posed a serious public health threat that was capturing the public's attention. In that year, unleaded gasoline was introduced for use in automobiles equipped with catalytic converters, and emissions standards for motor vehicles were becoming more stringent in general. Transportation sources produced 85 million tons of carbon monoxide (CO), 9 million tons of nitrogen oxide (NO_x), and 11 million tons of volatile organic compounds (VOC).

Since 1993, highway emissions declined by almost 15 percent – from 74.4 million tons to 63.7 million tons in 1999.

Trends and Choices forecast significant reductions in these pollutants by 1990 as mandated by the Clean Air Act (CAA) of 1970—CO declining from 85 to 27 million tons, NO_x declining from just over 9 million tons to just under 9 million tons, and VOC declining by more than half from 11 to just over 4 million tons. In fact, all three declined by 1990, but only NO_x declined by as much as Secretary Coleman's forecast. CO emissions dropped not by 68 percent but by a more modest 38 percent; VOC fell not by 61 percent but by 35 percent. Still, in view of the rapid growth in vehicle usage for both passengers and freight over this period, these changes reflect dramatic improvements in emissions and, therefore, air quality. The reduction in lead emissions, however, was most extraordinary—registering a decline of more than 99 percent by 1990. Major amendments to the CAA were enacted in 1977 and 1990. Emissions in all of these areas continued declining through 2000.

Clearly, this is not enough. Today, 39 percent of the U.S. population lives in a "nonattainment" area—not meeting National Ambient Air Quality Standards—for one or more of six criteria pollutants. Ground-level ozone, in particular, remains an important problem for about 90 percent of people in these areas. Further advances can be achieved through greater choices in transportation, reformulated fuels, or greater capture of pollutants. But projected growth in the population and the economy, along with the associated increases in travel and shipping, might easily offset these kinds of technological gains. And the use of fossil fuels or internal combustion engines present powerful constraints on the amount of improvement that can be made. The key will be in the development and widespread deployment of alternative energy storage systems, including fuel cells, batteries, hybrid vehicles, regenerative braking, or even flywheels. With break-throughs in one or more of these areas, we can expect a big decline or even the virtual elimination of vehicle emissions.



Emissions from airports and aircraft remain a concern, and in recent years, we have promoted strategies to reduce these emissions. International standards for cleaner aircraft engines have been developed, and today the current stage 3 standard, fully implemented in the United States by 2000, has resulted in the quitest aircraft fleet in U.S. history. New Stage 4 aircraft will result in even quiter and cleaner aircraft by 2025. Increased use of cleaner ground support equipment and other steps to reduce airport-related emissions are likely to be in place.

An emerging issue only beginning to be discussed by the public in 1975 was the potential for global climate change resulting from the buildup of greenhouse gases in the atmosphere. One of the most important of these greenhouse gases is carbon dioxide, and transportation is a major source of this. In 1975, transportation produced 350 million metric tons of carbon dioxide (CO_2) emissions, and the atmosphere carried 330 parts per million CO_2 by volume. Today, transportation produces nearly 500 million metric tons of CO_2 per year, and atmospheric loading is estimated to be about 370 parts per million—1.3 times pre-industrial levels. Scientists propose that changing global climate may result in further population shifts due to shoreline flooding, changes in agricultural patterns, increased intensity in weather-related disasters (e.g., hurricanes, tornadoes), and direct impacts on transportation infrastructure. The Clinton-Gore Administration has consistently supported strong environmental strategies to mitigate global warming. The USDOT is committed to mitigating the unwanted side effects of transportation-related emissions and established the Center for Climate Change and Environmental Forecasting to identify and promote transportation strategies to reduce greenhouse gas emissions.

Water pollution was not featured as a major problem in *Trends and Choices*, but the 1970s brought a series of high-profile oil spills that focused international attention. In response, regulations were developed in the 1970s and 1980s to address vessel design, construction, operations, maintenance, and manning, as well as many corresponding controls for the shoreside facilities that transferred oil to and from these ships and barges. Then, in 1989, the *Exxon Valdez* spilled a record 11 million gallons of oil in Valdez, Alaska. As a result, the Oil Pollution Act of 1990 brought about some of the most widespread changes in petroleum shipping to date, aimed especially at reducing the risk of catastrophic spills. This included an upgraded liability and compensation regime to encourage preventive measures by vessel owners and operators.

During the past eight years, the USDOT partnered with the shipping industry to develop prevention and response standards that reduced maritime oil spill from 5.3 gallons per million gallons shipped in 1993 to 2.7 in 1999.

Although the total number of spills has remained relatively constant, the total amount of oil spilled into U.S. waters has fluctuated significantly from year to year as a result of a small number of very large spills. But large spills clearly are becoming less common and smaller spills are being controlled as well. The future will depend very much on what happens to motor vehicles over the next 25 years, because transportation is the major user of oil, and U.S. production can supply only about half of all U.S. oil consumption. A continuing flow of oil imports will present continuing risks of spillage. A dramatic change in automobile design, on the other hand, could break the pattern of both U.S. reliance on foreign oil and the associated pollution risks of moving that oil.

The Clinton-Gore Administration's aggressive goals to speed innovations in environmental technologies will increase vehicle fuel economy, reduce fuel use, improve safety, and lead to greater U.S. energy independence. The Partnership for a New Generation of Vehicles program, a public-private endeavor, has made revolutionary technology breakthroughs for automobiles and light trucks that will make our economy more energy independent and help meet such environmental challenges as global warming.

The advent of increased environmental awareness and legislative action in the early 1970s paved the way for measures to prevent water contamination from other transportation-related sources, such as salt and other chemicals used to deice roads and runways. These actions included the Federal Water Pollution Control Act of 1972 and the Clean Water Act of 1977. With the expected increase in number of vehicles, the improper disposal of used motor oil may increase unless new vehicle technologies that do not require the use of motor oil are developed. There is a need for proper design of transportation infrastructure to reduce pollution from runoff from highways and airports. Use of new materials and sensor technologies can prevent leakage from oil storage tanks. The use of nanotechnology may provide materials for road surfacing that will prevent ice formation on the roads without the use of salts. Some of these options may be expensive to deploy, but if we are to achieve long-term sustainability, they may become our only options. Additionally, when we consider the societal and environmental costs of leaving these concerns unchecked, we may conclude that the mitigation costs are well within reason.

Striving to lessen noise pollution from aircraft, the USDOT worked with the airline industry and achieved remarkable results. In 1993, 2.1 million Americans were exposed to significant aircraft noise. By 1999, this number had fallen to 680,000.

Wetlands—an important component of our complex ecological systems—came under increasing pressure from agricultural activities, urbanization, and transportation infrastructure development during the 1960s and 1970s, but were only just emerging as a major issue in 1975. At that time, wetland loss was estimated at approximately 450,000 acres per year, primarily due to agricultural activities. As a result of increased emphasis on preserving our environment, wetland loss has been reduced to 50,000 acres per year, and less than 10 percent of this is estimated to be from highway construction activities. Today, wetlands are being restored as we work toward the national goal of a net gain in wetlands. In 1996, FHWA began nationwide monitoring of annual wetland loss and gain for the Federal-aid highway program. The data collected show that across the country the Federal-aid highway program has achieved a 150 percent gain in wetland acreage (i.e., 2.5 acres of wetlands gained for every acre of loss). The Federal-aid highway program has produced a total net gain of 11,628 acres of wetlands nationwide since 1996. It will be important to improve our conservation of finite resources such as wetlands and other habitats, cultural and natural resources, and green spaces as transportation systems are planned and implemented.

The recent emphasis on managing watersheds and conserving groups of species and ecosystems is likely to continue as we better understand the ecosystem processes that govern environmental quality. The challenge of reducing transportation pathways for the spread of invasive alien species is likely to continue into the next 25 years.

An unintended consequence of transportation is noise pollution. Today, highway and aircraft noise are considered major environmental problems, and with the projected growth in highwayand air travel by 2025, there is a need to further reduce vehicle noise. Although noise was considered in *Trends and Choices*, the only observation made about the future suggested that with the advent of quieter aircraft, the number of people exposed to aviation noise would be reduced. The impact of highway noise has been mitigated over the past 25 years through development of quieter engines, improved noise mufflers in vehicles, and construction of noise barriers along major highways. The Aircraft Noise and Capacity Act of 1990 made the quieter Stage 3 aircraft mandatory and older Stage 2 aircraft were fitted with "hush kits" to meet noise-reduction requirements. Stage 4 aircraft will further reduce the impact of aviation noise and quieter aircraft should make up much, if not all, of the fleet in place in 2025. International cooperation in development of noise standards will continue to be important as new noise standards are developed due to growth in passenger travel and freight movements.

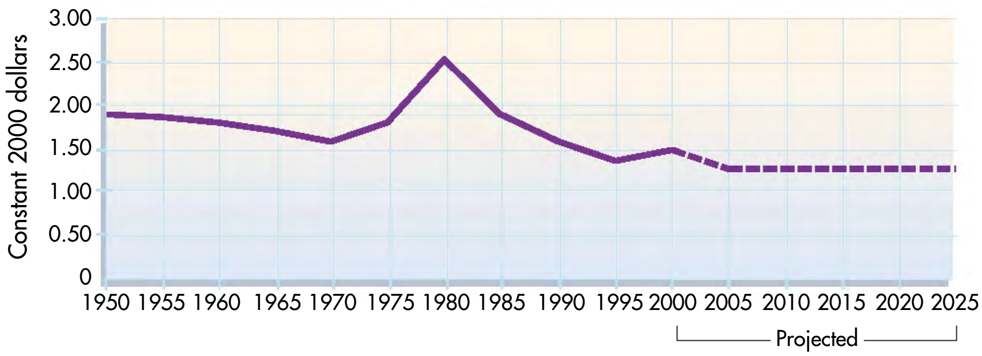
A major challenge for the future will be managing growth so that we retain our economic and environmental viability. Improved linkages between transportation and land-use planning will be needed to achieve a more sustainable environment. Dispersed, auto- and truck-dependent development patterns, often referred to as urban sprawl, can increase costs of providing community services and increase congestion, pollution, and consumption of natural resources. Land-use patterns that support a range of transportation choices—communities that encourage use of transit, walking, and bicycling—can begin to address these concerns, but will take many years to develop. Similarly, steps to increase efficiencies in and reduce environmental impacts of freight movement are also needed. By 2025, many of the environmental issues and problems are likely to be similar to those of today's world, largely because any changes or advances that have a substantial positive impact on the environment take a long time to produce results. We expect water quality and air and noise pollution to continue to improve due largely to enhanced technology (e.g., advances in vehicles, use of nanotechnology, and implementation of ITS), shifts in energy sources and modes of transportation, and reductions in pollutant runoff.

We will need to continue to minimize air, water, and noise pollution. This will require enhanced technology (e.g., advances in vehicles and fuels and implementation of ITS), shifts in modes of transportation, and better means of avoiding environmental impacts (e.g., advancing designs that minimize pollution from runoff). Identifying financing for our environmental efforts will also be a major challenge. There will be a greater emphasis on options that reduce the demand for transportation, such as telecommuting, electronic communications, and alternative work schedules coupled with efforts to further reduce pollution and energy consumption. Other options will include peak pricing and various user fees to positively impact congestion and environmental concerns.

Energy

In 1975, the United States consumed almost one-third (29 percent) of the world's petroleum production [USDOT BTS 1999]. Transportation represented a little over half (54.8 percent) of that consumption, but the United States was producing nearly two-thirds of its petroleum needs. *Trends and Choices*—written at a time of rising fuel prices—projected a slight (2 percent) decline in transportation energy usage by 1990, generally assuming that gains in fleet energy efficiency and changes in travel behavior would offset increases in travel and freight shipping.

Per Gallon Gasoline Pump Prices in Constant 2000 Dollars: 1975-2000



By 1990, while passenger travel was nearly as predicted (within 2 percent) and freight transportation was actually much lower than predicted, energy usage by the transportation sector had risen by 48 percent. While the Corporate Average Fuel Economy (CAFE) standards improved the fuel efficiency of highway vehicles—especially passenger vehicles—in the 1970s and early 1980s, these improvements began to level off by the late 1980s. Fuel prices had moderated, and consumers continued to use the automobile as the predominant choice for personal transportation. The average fuel economy of passenger cars hovered at 21.7 miles per gallon while the standard mandated by the Energy Policy and Conservation Act of 1975 was 27.5 miles per gallon by 1985. Since that time, new energy efficient technologies have been applied, for the most part, to enable owners to drive larger, more powerful vehicles, rather than reduce the amount of fuel used.

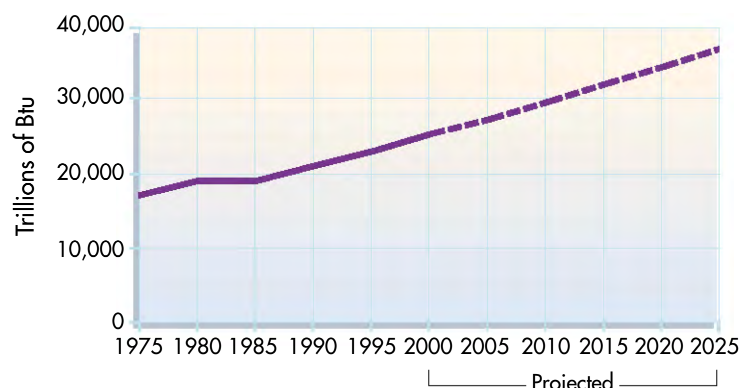
The trend of the 1990s is an extension of the trend of the late 1980s. With no changes being made to the CAFE regulations, and with a lower standard for passenger trucks than cars, ownership of light duty trucks, especially SUVs, began to soar. As a result, the energy efficiency of the U.S. highway vehicle fleet has begun to decline, while total vehicle-miles traveled continues to grow (around 2 percent per year).

Technology will probably be the single, most important factor in where we go from here. Regardless of the energy source, transportation will still require energy. If current trends are projected forward, energy use is likely to be 45 percent greater by 2025 than today, or depending on technologies that are deployed, increases may be offset by gains in technology. For example, electric motors are about twice as efficient as internal combustion engines in converting energy into work. They may be powered by batteries, fuel cells, solar panels, flywheels, or any of a variety of energy storage technologies. In addition, they will take advantage of lightweight materials and low-carbon fuel. Their widespread use could clearly reverse the long-term increases in energy use by transportation. Hybrid engines that use a combination of conventional internal combustion engines and battery-powered electric motors have already been introduced to the market. Honda's Insight gasoline-electric hybrid reportedly can achieve 70 mpg on the highway and 65 mpg in combined city/highway driving [Insight]. Perhaps just as importantly, most of these technologies would alter our dependence on oil—with all of the associated environmental and national security implications.

Two partnership programs initiated by the Clinton-Gore Administration, the Partnership for a New Generation of Vehicles program and the 21st Century Truck Initiative, are making significant progress in developing vehicles with low emissions and exceptional fuel efficiency. Today, as part of this federal government / U.S. auto industry partnership, DaimlerChrysler, Ford, and General Motors would be marketing hybrid vehicles that combine a gasoline or diesel-powered engine with an electric motors. Some models are capable of obtaining up to 80 miles per gallon on the highway. Environmental pressures from oil consumption and concerns about oil supply will continue to drive development of alternatives. Public acceptance of new technologies will be key. Public policy and public-private sector collaboration that facilitates the deployment of those technologies will be the major challenge for government agencies. With the right alignment of policies to stimulate the availability of highly efficient vehicles, with full utility and performance, and at reasonable costs (e.g. hybrid-electrics), transportation energy use would grow at a diminishing rate.

By the year 2025, transportation energy use is projected to rise from 25 trillion Btu per year to nearly 37 trillion Btu. Over the next quarter century, transportation energy growth will continue to be dominated by the burning of gasoline and diesel fuels. New powertrain designs, such as hybrid electric and fuel cells, will become more common. However, these new vehicle designs will be introduced slowly into the fleet over the next 10 years, and it will take several years before their sales volumes comprise a significant portion of new vehicle sales. Because it will take nearly a decade for such vehicles to make up a significant portion of the total U.S. vehicle fleet, their effect on transportation energy use may only begin to make an impact by 2025. By then, estimates are that vehicles powered by advanced technology powertrains will slightly exceed 50 percent of new car sales. Alternative policies such as tax incentives will encourage buyers to purchase these new vehicles.

Btu Used by Transportation Sources: 1975-2025



Globalization

The trend toward globalization was beginning to take shape when *Trends and Choices* was written. The leader in this phenomenon was the automobile industry. During that period, there was a high demand for fuel-efficient Japanese and European cars due to the energy crisis, and in 1975, 18 percent of the cars sold in the United States were imported. At that time, American automakers did not have any manufacturing facilities abroad. But soon, General Motors acquired an ownership stake in the Japanese manufacturing company Isuzu, and in 1978, the first foreign car was produced in the United States by Volkswagen. Since then, the increasing trend toward cross-border ownership and manufacturing facilities has led to intense consolidation and competition within the global auto manufacturing industry. Today, General Motors has manufacturing facilities in 50 countries, and Ford Motor Company has such facilities in 30 countries outside the United States. Similarly, there are numerous foreign manufacturers now operating in the United States.

Advances in communication and transportation technologies have been major forces allowing for the rapid growth in globalization and economic integration worldwide. Lower transportation costs and higher levels of service and speed have contributed to widely dispersed production and distribution facilities managed by firms that are truly international in scope.

The trend toward globalization is also highlighted by the increase in international air travel—both leisure- and business-related. This has heightened our sensitivity to the safety and security of passengers traveling across the globe and different aviation systems. Under the Clinton-Gore Administration, the United States signed 50 open skies agreements with countries around the world, extending the international reach of the nation's aviation system and making it truly global. These agreements remove all restrictions on airline service and increase competition and service. The FAA has initiated regional safety efforts, such as Safe Skies for Africa and the Partnership for Safer Skies with Latin America. The International Civil Aviation Organization has started the Universal Safety Oversight and Audit Program to ensure that countries provide adequate safety oversight in areas of personnel licensing, aircraft operations, and airworthiness. At the 1999 International Aviation Conference, held in Chicago, Secretary Rodney Slater announced safety audit requirements for U.S. carrier's code-sharing partners.

The integration of manufacturing facilities around the globe has been associated in many countries with the growing divestment of national firms from government ownership. This trend has important implications for international transportation as well, bringing efficiency and competitive marketing to the forefront as criteria of operating decisions. Supporting this development is the progressive deregulation of transportation, although there are still many restrictions on which carriers can operate and where they can pick up or discharge passengers and cargo. Privatization and deregulation have increased the pressure on airlines and ocean shippers either to merge or to conclude marketing alliances across national boundaries. Advances in computerized reservations, container shipping technology, and on-demand air freight have put a competitive premium on seamless integration of logistic services. Future transportation providers may have major operations in all modes and all regions of the world. We must continue to ensure that such consolidation does not reduce the competitiveness of the transportation industry.

During the next 25 years, the phenomenon of globalization will gain more momentum as more countries become linked by advanced information technologies and financial markets. If the necessary capital and infrastructure investments are not available to the less developed countries, they will not be able to share in the economic benefits of globalization, and they will fall further behind in the world economy. As globalization spreads, average per-capita income of countries around the world will become closer. These changes will also demand a rethinking of the remaining responsibilities of government toward private industries. International transportation will continue to require enforcement of safety codes, environmental standards, fair labor practices, precautions against criminal activity, and antitrust protections. In dealing with globalized firms, the present geographic division of sovereign authority will frequently prove inadequate, and the United States will have to collaborate with other countries to develop a common program.

Technology

Today, we have indeed reached a stage where we direct our resources toward finding solutions to our problems through technological improvements and enhanced efficiency. A prime example of a technology employed to solve problems and enhance efficiency is the computer chip, which makes automatic braking, fuel injection, pollution control, airbag deployment, and many other in-vehicle systems possible. Embedded computer chips are at the heart of many advancements that will one day become standard equipment on automobiles and trucks, such as driver alertness, perimeter (front, behind, to the side) monitoring, accident avoidance, automatic accident reporting, and automatic vehicle operation systems.

For example, the accuracy of GPS in real-time navigation and tracking is driving the development of several advanced systems across all modes of transportation. By 2025, GPS technologies will proliferate through all modes of transportation, functioning as both a transportation utility and a personal utility—an integral component of vehicles as well as such personal items as cellular phones. GPS will provide the basic infrastructure for a continuing and substantial improvement in the safety and efficiency of our national air space system.

Intelligent Transportation Systems (ITS) are being widely deployed to improve the mobility and safety of our surface transportation systems. Technologies such as ramp meters, electronic surveillance, and signal synchronization and pre-emption; advanced weather and road condition information; computer-aided dispatch systems; commercial vehicle technologies; and a host of infrastructure and vehicle innovations promise to reduce congestion, improve efficiency, and make travel safer. While all of these benefits are expected as we increase the deployment of GPS and ITS, some of the gains may be offset by the expected growth in highway travel by 2025.

The current trend of embedding new technologies into the operations and management of the transportation systems will continue and probably accelerate over the next 25 years. The management of transportation systems will become highly automated and increasingly real-time. Congestion will remain an issue, but advances in communication technologies will allow increased telecommuting options. New technologies will allow for the realtime pricing of transportation facilities to increase efficiency and reduce congestion delays. Information technology will play a prominent role both in shaping future transportation demands and in enabling advanced management and operations of transportation services in an era of constrained expansion of physical infrastructure.

National Security

In 1975, the United States and the Soviet Union were engaged in a protracted cold war, and the world was split into two major military alliances. In *Trends and Choices,* the authors tested the capacity of the intercity transportation impact for a conventional two-front war in 1990. They concluded that the 1990 national transportation system would have sufficient overall capacity. They reasoned that as the nation's transportation system continues to grow, the requirements of a military emergency become a smaller proportion of the total transportation demand.

In the early 1990s, the Gulf War proved that reasoning to be essentially valid. But the focus on national security has shifted considerably from the view in the 1970s. The Soviet Union collapsed along with the communist bloc, and today every country but one—Cuba— in the Western Hemisphere is a democracy. We now have increasing concerns over terrorism, and regional conflicts are a chronic problem. We also have continuing incidents of illegal immigration and drug smuggling by sea. Infrastructure security—both physical and technological—is another area of growing national concern, and access to oil—a factor in the Gulf War—continues to present a national security interest for the United States.

Continuing globalization of the world's economies will profoundly affect the national security picture. Globalization tightly couples the economies of different countries and tends to increase the power and influence of the private sector. It also tends to blur political boundaries and stimulate cross-boundary agreements, such as the European Union and the North American Free Trade Agreement (NAFTA). The forces of economic efficiency are likely to further stimulate the formation of such alliances. These forces will likely lead to an increase in the volume of trade and movement of people. In addition, our transportation system will be called on to meet the requirement to provide the just-in-time delivery of goods. This poses significant security challenges for the United States by a myriad of threats such as cyber-terrorism, smuggling of people and illegal drugs, protection of natural resources, and the introduction of weapons of mass destruction.

The maritime environment is particularly challenging with the heavy volume of containerized cargo inherent in the system. The key is in identifying the threats before they can manifest themselves in U.S. cities and waterways. To accomplish this, the USDOT, through the U.S. Coast Guard, will develop a new approach suited to the information age to allow us to conduct a risk assessment of every arriving, departing, transiting, and loitering vessel within a geographic coastal area of responsibility. This maritime goal dovetails with existing or envisioned security and transparency needs for other transportation modes, elevating border and economic security, as called for in President Clinton's National Security Strategy.

By 2025, transportation and computerization together will be the catalysts for continuing expansion of the global economy. International interests, in turn, should continue to grow in importance. Globalization challenges conventional thinking about national interests. As commerce grows in importance, so, too, will transportation; however, this will also increase our vulnerability to security threats. Policy direction will, therefore, be guided, by security considerations.

Policy

Today, a little over seven years after passage of the Government Performance and Results Act of 1993 (GPRA), the challenge to manage our programs with quantitative information that is reliable, accurate, timely, and relevant, is even greater. In keeping with this effort to streamline government, Vice President Gore's 1993 National Partnership on Reinvention moved the federal government to be more accountable to the public and not restrained by rules and regulations that can hamper federal agencies in carrying out their missions.

The USDOT was already poised for implementing GPRA, in part because of the visionary work of our predecessors who, like Secretary Coleman, laid out 10 principles encompassing the policy objectives of the time, addressing government's relationship with the private sector, international transportation concerns, how transportation can contribute to an enhanced quality of life, maintaining multimodal diversity and competition, and the role of the federal government. Many of the goals articulated then have since been met. But, again, we aren't stopping to merely recount our successes. We know we have much to do to improve the transportation system, to make it as safe as it can be; to finish the job of making it accessible to everyone; to increase its capacity to support a rapidly expanding economy; to protect and enhance communities and the natural environment; and to make our transportation system and the nation secure.

The Federal Highway Administration has been a leader in the application of concrete, asphalt, and steel. Administrator Slater made it a top priority to make the agency about more than concrete, asphalt, and steel—making it about people. Innovations included touring thousands of miles to meet with state and local community leaders to better respond to their highway transportation needs. This resulted in building bridges to carry new ideas and to help transform both federal and state DOTs. He also called for innovation in the way we paid for surface transportation. This resulted in the programs of innovative finance that have become a standard, adding billions to transportation infrastructure needs every year. He also recognized the need for expanded uses of research and technology. As a result, we have introduced many new technologies that have made our transportation system safer and more efficient.

As we take stock of the challenges we face, the USDOT has embraced a decisionmaking process that will ensure the public's interests are served, and that the public is involved in the process. This new process began with two plans that were subsequently named "best in government" by Congress—the Department's first Strategic Plan followed by the Department's first annual Performance Plan. In successive steps, we identified the outcomes that the public cares about, set goals to achieve those outcomes, developed our programs and budgets to deliver on our commitments, then measured our performance against our goals. Not all goals were met—to do so would indicate that we had made them too easy to achieve. Consequently, even when we fell short of the mark, we achieved many improvements in safety, mobility, economic growth, the human and natural environment, and national security.

The management of the vast transportation enterprise needs data: to monitor its performance and the performance of elements it affects to see if things are getting better, to monitor its environment, to plan for future transportation, and for command and control. But a particular effort needs to be made on behalf of decisionmakers so they can determine the state of the system, directions of change, and the costs involved in intervening to make things better.

A quickened pace that is driven by technology makes prediction a risky business. Yet, in some sense, we must do it. It is better to move with a direction in mind. This report also poses a challenge to its readers to debate what we have written and improve on the forecasts. Perhaps even in a few years we will have a brand new picture of the year 2025. But as Karl Pearson—considered the father of modern statistics—said, "*No scientific investigation is final; it merely represents the most probable conclusion that can be drawn from the data at the disposal of the writer. A wider range of facts, or more refined analysis, experiment, and observation will lead to new formulas and new theories. This is the essence of scientific progress*."

The Changing Face of Transportation is a part of our foundation. Its companion report— *Policy Architecture: A Framework for Transportation Decision Making in the 21st Century*—is our blueprint for the process of building a transportation system that gives the people of America the ability to live their lives to the fullest. Together, these documents are aimed at improving our ability to formulate good decisions, making the transportation system better serve the needs of the American people, and involving everyone in the process. They will help demonstrate a simple truth: that transportation truly is "the tie that binds."

Overview of This Report

The Changing Face of Transportation provides a historical, perspective, and futuristic look for policymaking. It reviews the major policy milestones of the past quarter century, and the social and economic context for those milestones and looks ahead to 2025. Secretary Slater has challenged us to develop data as a logical foundation for making future policy choices. Some of those choices are apparent already. Undoubtedly, others will emerge as the future unfolds.

This report is organized around six thematic areas:

- Growth, Deregulation, and Intermodalism;
- Safety;
- Globalization;
- People, Energy, and the Environment;
- Technology; and
- National Security.

Within each of these areas, we look at the world in the mid 1970s, the changes that have taken place since then, and the implications of those trends and others for the future of 2005.

A glossary at the end of the report clarifies terms used in the body of the report.

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chapter 2

Growth, Deregulation, and Intermodalism

"Looking into the future, we have to change our attitudes about transportation. This is the biggest challenge of transportation."

Congressman James Oberstar
2025 Visioning Session, San Jose, CA, June 24, 2000

"The transportation enterprise must get smarter, marrying new technologies with new innovative financing techniques."

Professor Joseph Giglio, Northeastern University
2025 Visioning Session, New York, May 18, 2000

"In the next 25 years, the challenge we will face is inertia or the unwillingness to try to do new things."

Roy Kienitz
Executive Director, Surface Transportation Policy Project
2025 Visioning Session, Saint Louis, Missouri, June 13, 2000

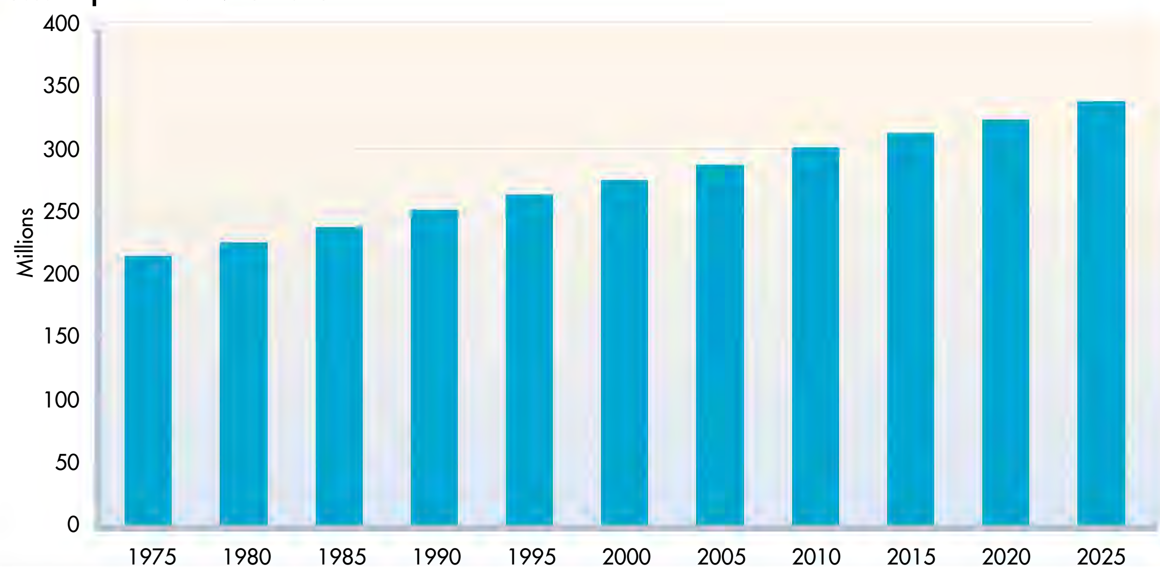
chapter 2

Growth, Deregulation, and Intermodalism

Over the past quarter century, the American transportation system changed dramatically in size and form as it carried ever-increasing numbers of passengers and volumes of freight, both domestically and internationally. A steady increase in population (figure 2-1) coupled with strong economic growth (figure 2-2) is largely responsible for tremendous demand for transportation services today.

Figure 2-1

U.S. Population: 1975-2025

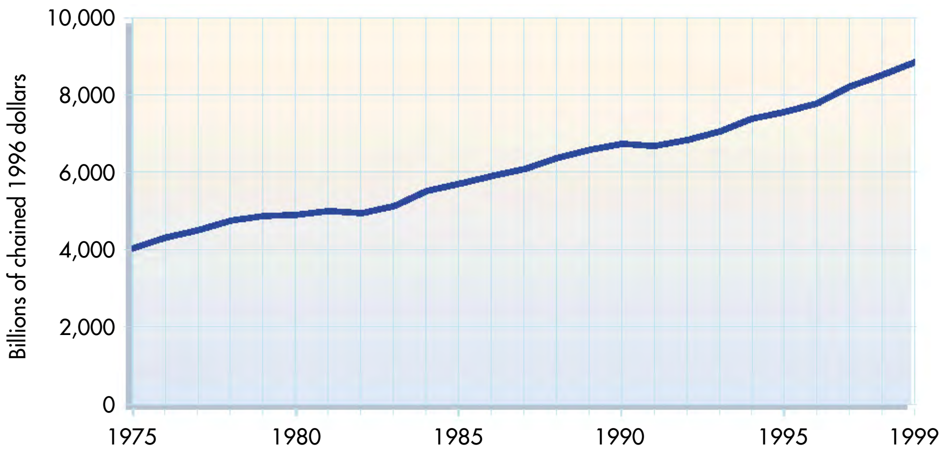


Note: Middle series projection.
Source: U.S. Department of Commerce, U.S. Census Bureau, *Statistical Abstract of the United States 1999* (Washington, DC: 1999). Projections: U.S. Department of Commerce, U.S. Census Bureau. *Annual Projections of the Total Resident Population as of July 1: Middle, Lowest, Highest, and Zero International Migration Series, 1999 to 2100*, available at http://www.census.gov/population/projections/nation/summary/np-t1.txt, as of Sept. 3, 2000.

Other forces also have had a significant impact on the way our transportation system has grown and the shape it has taken. Deregulation of the transportation industry is one such force. Deregulation of the aviation, rail, motor carrier, and maritime shipping industries over the past 25 years opened the door to thousands of new competitors, creating an environment that spawned innovative, efficient, and affordable transportation services, which supported a rapidly globalizing economy. Subsequently, globalization enabled growth of a transportation system that, today, spans every corner of the world.

Figure 2-2

Economic Growth in the United States: 1975-99 (Gross Domestic Product)



Source: U.S. Department of Commerce, Bureau of Economic Analysis, National Accounts data, available at http://www.bea.doc.gov/bea/dn/gdplev.htm, as of Aug. 24, 2000.

Intermodalism in the freight industry—the seamless movement of goods by several transportation modes on the same journey—is another significant change that has influenced the growth of the transportation system in the last 25 years. One of the most visible manifestations of intermodalism is the growth in container traffic, spurred by technological advances and the search for faster and cheaper ways to transport freight across the globe. Innovative ways of doing business—just-in-time manufacturing and delivery and supply chain logistics—demand intermodal movement within a guaranteed timeframe. While these changes are reverberating throughout the entire transportation enterprise, other factors are also influencing the growth of our transportation system:

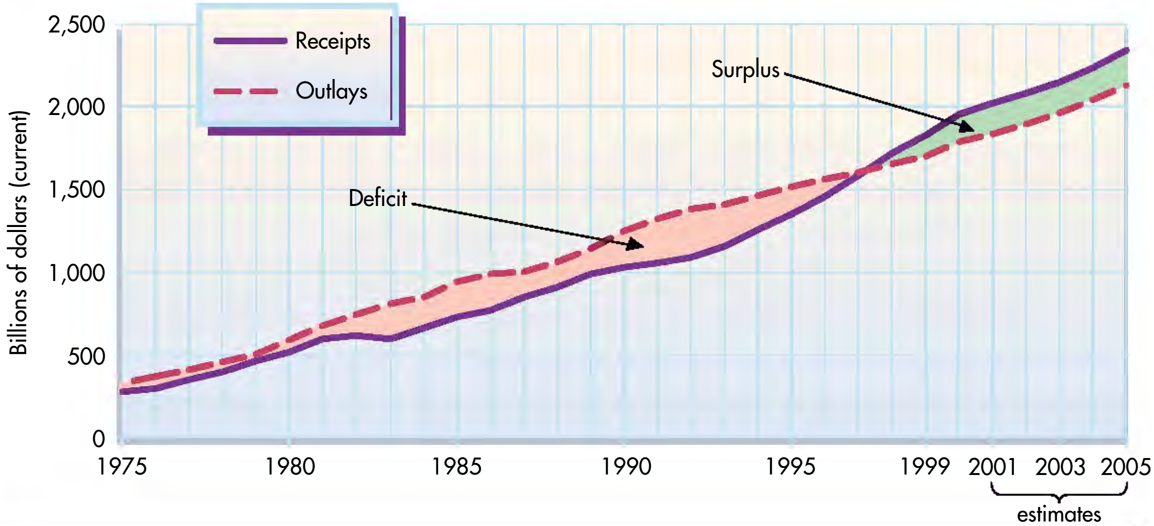
1. Federal budget deficits, which peaked during the 1980s and early 1990s (figure 2-3), reduced the available funding for building and maintaining transportation infrastructure. But by the late 1990s, the budget deficit was significantly reduced, and in recent years, unprecedented levels of public investment have been made in new transportation infrastructure. Projected federal budget surpluses over the next decade may result in even higher funding levels. The recently enacted U.S. Department of Transportation (USDOT) appropriations budget of $58.5 billion is the largest in the Department's history.

2. Communities concerned about transportation's impacts on their quality of life, particularly economic development, environment, land use, and congestion, have increased decisionmaking authority over how transportation funds will be spent in their areas. Little by little, these decisions have helped shape the national transportation system. Recently enacted surface and aviation transportation reauthorization measures increase the opportunity for public participation.

3. Technological innovations in the highway, rail, air, pipeline, and maritime transportation industries have made transportation cheaper, more productive, and, in many cases, faster. Transportation is also safer, with fatality rates dropping on our nation's highways,

Figure 2-3

Federal Budget Outlays and Receipts: 1975-2005



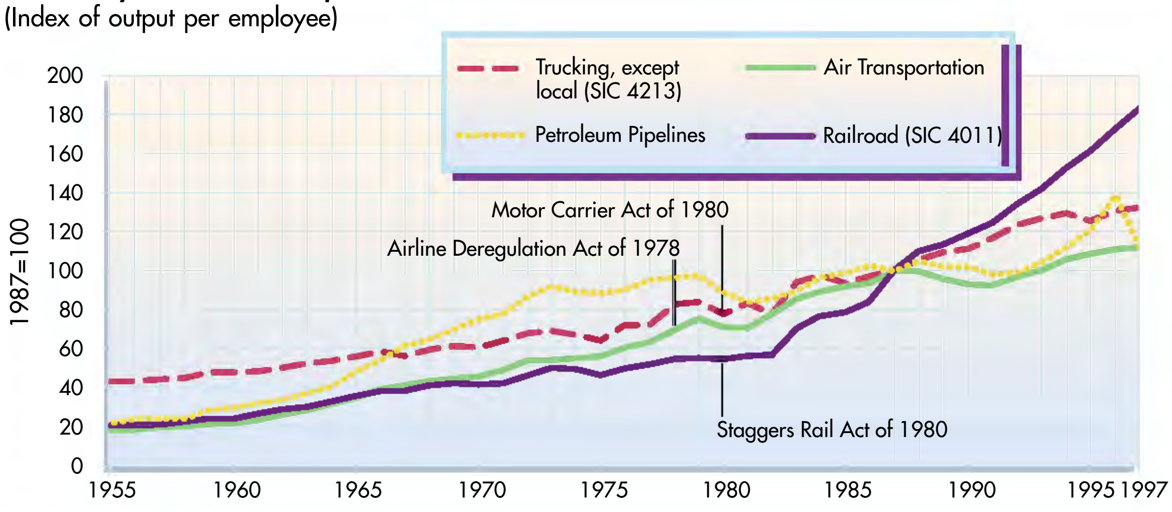
Source: U.S. Office of Management and Budget, Congressional Budget Office, *Historical Tables* (Washington, DC: Annual issues).

among recreational boaters and maritime workers, on the rails, in the skies, from pipeline mishaps, and from hazardous materials discharges. On the whole, our transportation system is the safest it has ever been.

The three interlinked trends—transportation system growth, deregulation, and intermodalism coupled with economic growth, increased funding for infrastructure, and technological innovations—reshaped the transportation enterprise in the last quarter century and produced enviable productivity gains across all modes of transportation (figure 2-4). The following sections, beginning with Growth of the Transportation System, trace each of these trends and their impacts in the last 25 years.

Figure 2-4

Productivity Trends for Transportation Industries: 1955-97
(Index of output per employee)



Source: U.S. Department of Labor, Bureau of Labor Statistics, Office of Productivity and Technology, December 1999.

Growth of the Transportation System

In the past two decades, the focus of transportation shifted from building transportation systems to adapting and modernizing transportation facilities and services. Growth during this period has largely been in *use* of the transportation system. People are traveling more frequently and more often for personal and business trips, and increasing numbers of people are vacationing and working in other countries. In business and industry, domestic and international companies have spurred an increase in the movement of freight around the world.

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

General Dwight D. Eisenhower

The interlocking elements of the U.S. transportation system support 4.5 trillion miles of passenger travel and about 3.7 trillion ton-miles of goods movement. The system includes more than 5.5 million miles of public roads, railroads, waterways, and oil and gas pipelines; over 19,000 public and private airports; and 230 million motor vehicles, railcars, aircraft, ships, and recreational boats. Growth and change have been experienced in several elements of the U.S. transportation system:

Highway travel is the predominant mode of transportation for both passengers and freight. The number of vehicle-miles traveled now exceeds 2.6 trillion miles, and continues to grow at a rate of about 2.5 percent per year. More freight is moving on the highways than ever before. [USDOT BTS 1997a; USDOC 1977].

Transit encompasses a wide range of vehicles, services, and settings. There were approximately 6,000 transit systems in the United States in the late 1990s [APTA 2000]. Ridership in 1999 reached 9 billion trips—the highest since the 1964 level of 10.4 billion.

Seven of the top 10 Public Works Projects of the 20th Century (in no particular order) were transportation related:

- **Bay Area Rapid Transit District (BART)**
- **Tennesse Valley Project**
- **Panama Canal**
- **Interstate Highway System**
- **Reversal of the Chicago River**
- **St. Lawrence Seaway/Power Project**
- **Golden Gate Bridge**

The other three projects are the Grand Coulee Dam & Columbia River Basin Project; Hoover Dam, Boulder Canyon; and Hyperion Treatment Plant.

American Public Works Association,
Top Ten Public Work Projects of the Century
www.pubworks.org

Once the country's leading provider of intercity freight and passenger transportation, the railroad system continues to be one of the nation's principal modes of transportation, although its share of both the freight and passenger market has declined considerably. In 1977, railroads accounted for 37 percent of the freight ton-miles. About 3 percent of all intercity passengers traveling on public carriers use rail service, compared with 5 percent in 1977.

Commercial airports operating in the mid-1970s serviced 4.5 million flights. By 1999, the number of flights handled at those same airports nearly doubled to 8.5 million. Passenger traffic has nearly tripled since 1975.

- The U.S. Marine Transportation System consists of waterways, ports, and their intermodal connections. Each component is a complex system within itself and is closely linked with the other components. Since 1975, domestic shipping has grown 16 percent by weight while waterborne foreign trade increased by 65 percent by weight. It is expected that these volumes will more than double over the next 20 years.

The following sections highlight the growth across all transportation modes in the last quarter century.

Highway System

The United States highway network consists of 4 million miles of roads and streets. Highway bridges also comprise a critical link in the nation's infrastructure. At present, there are about 600,000 bridges on the entire highway network [USDOT BTS 1999]. State and local governments control most roads and bridges in the United States, but all highways serve as part of an integrated national network.

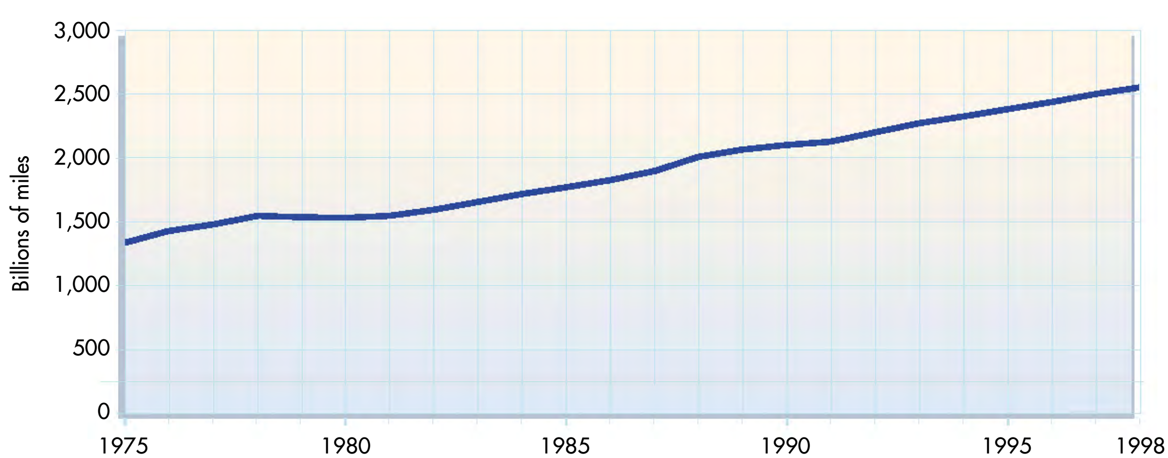
The Interstate Highway System (IHS) accounts for only one percent of all highway mileage, but carries 25 percent of the total vehicle miles of travel (VMT) [USDOT FHWA 1998]. With the completion of the Interstate System in the 1980s, the focus shifted toward maintaining and improving the system, improving traffic flow, and upgrading intermodal connections.

Growth in the number of drivers and cars, an increase in the number of trips per household, and increased freight movement are all contributing factors to growth in highway use over the last 25 years.

In the mid-1970s, the IHS had been under construction for nearly two decades, and 37,000 of its 42,500 miles were open to traffic. The advantages of the IHS were being felt across the entire country, and travel was increasing. Since 1975, VMT on the nation's roads has doubled (figure 2-5). Figure 2-6 shows the change in VMT per capita for various states between 1975 and 1998.

Figure 2-5

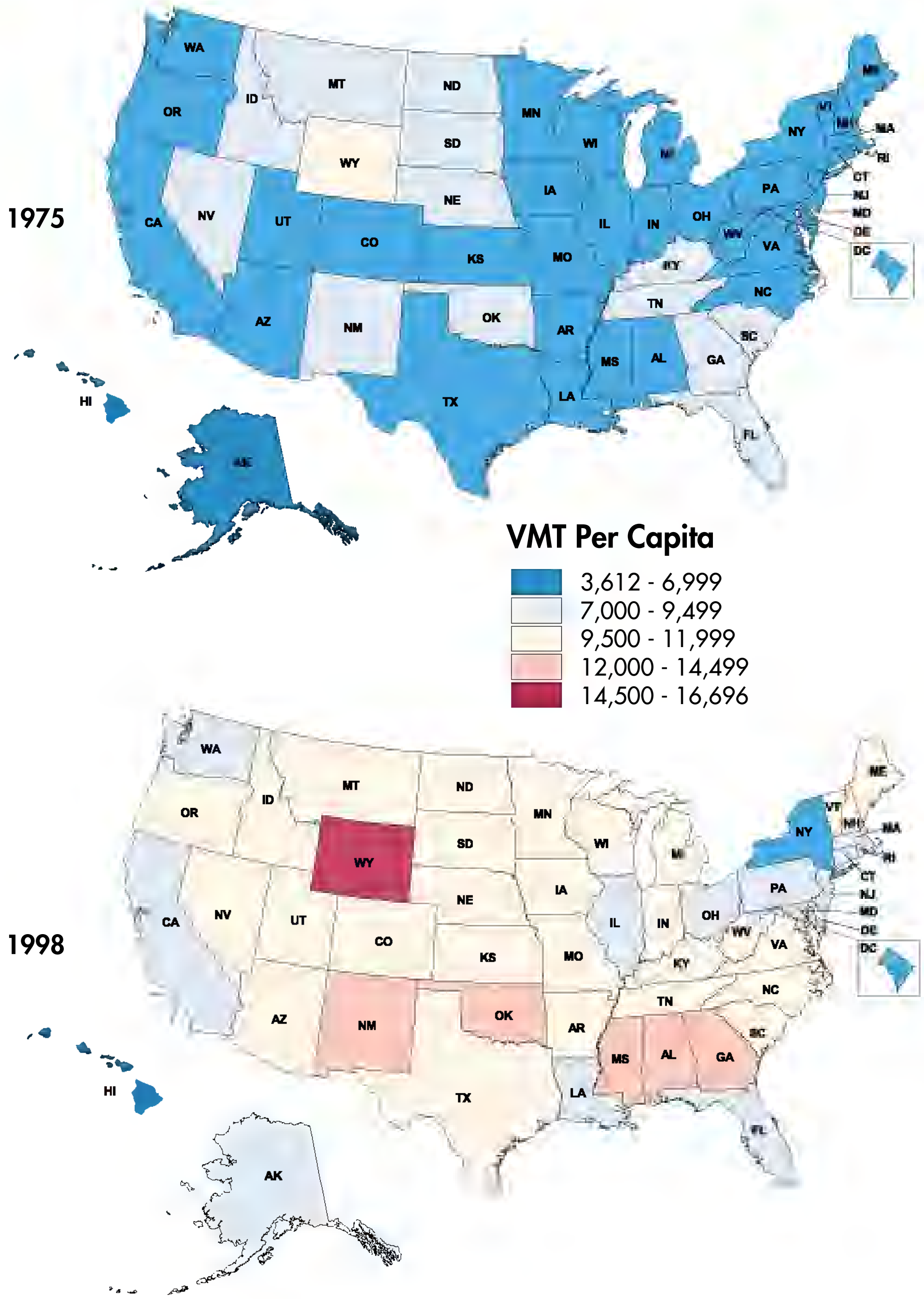
Vehicle-Miles Traveled (VMT): 1975-98 (Annual totals)



Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Annual issues).

Figure 2-6

Vehicle-Miles Traveled on Highways: 1975 and 1998

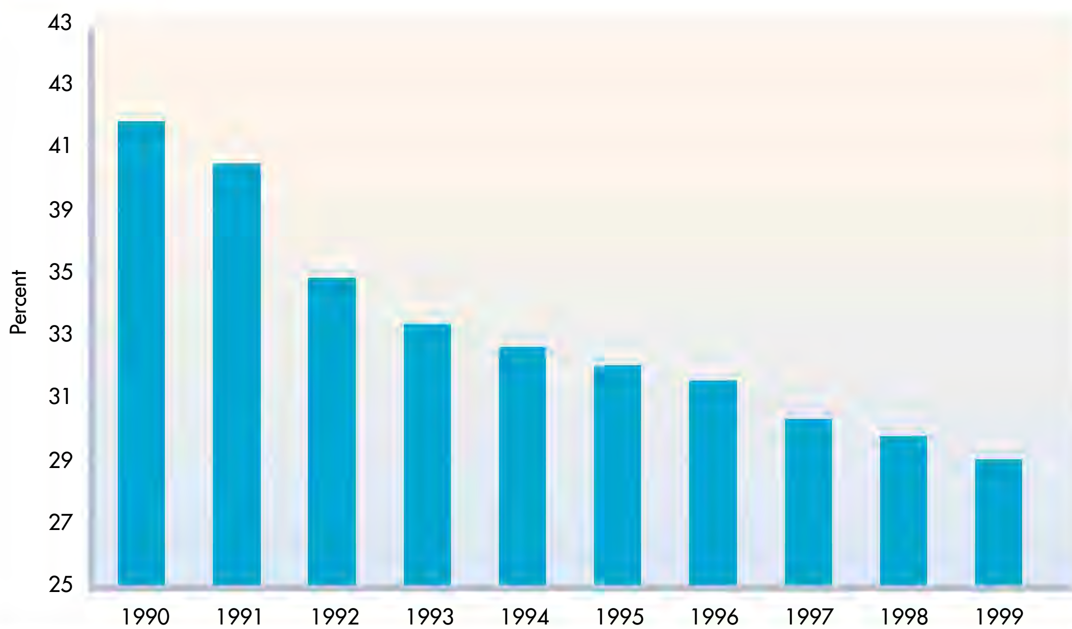


Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: 1975 and 1998).

Under the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, a National Highway System (NHS) was designated in 1995 comprising the completed IHS, urban and rural principal arterials, other strategic highways, and intermodal connectors. The NHS is 161,117 miles long—just 4 percent of the total highway miles—but carries 43 percent of the total VMT [USDOT 1999b]. Because of its network of intermodal connectors, which tie all transportation modes together as one, the NHS serves as the backbone of our nation's transportation system. ISTEA, and later the Transportation Equity Act for the 21st Century (TEA-21), enacted in 1998, provided a record level of funding for highway programs. According to a 1999 Federal Highway Administration (FHWA) study, increases in funding have improved Interstate pavement quality. In 1999, nearly 92 percent of the NHS pavement had acceptable ride quality [USDOT 1999b]. The NHS also includes 130,000 bridges, and only 23 percent of these were rated deficient—structurally deficient or functionally obsolete—in 1999. Of the nearly 600,000 bridges on all roads nationwide, about 29 percent were found to be structurally or functionally deficient in 1999, an improvement over the 42 percent that were deficient in 1990 (figure 2-7). FHWA data are confirmed by the American public. In a recent highway user survey, satisfaction with pavement condition increased from 48 to 60 percent of adult drivers "satisfied" between 1996 and 2000. Similarly, their satisfaction with bridge condition increased from 58 to 77 percent "satisfied" during that same period.

Figure 2-7

Percentage Deficient Bridges of Total Bridges: 1990-99



Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Annual issues).

Increased highway use led to growing congestion on our highway network, especially in and around urban areas. The FHWA's calculation of volume/capacity ratio, which compares peak-hour traffic to the theoretical capacity of the highway, found that more than half of peak-hour traffic in urban areas occurs under congested conditions, and the severity is increasing. Delay on the NHS costs billions annually in lost wages and wasted fuel [USDOT 1999b]. Congestion also affects air quality.

Studies at the Texas Transportation Institute (TTI) show that mobility in urban areas is getting worse. Recent analyses show that the average increase in delay per driver for 68 urban areas was 181 percent between 1982 and 1997 and 29 percent between 1992 and 1997 [USDOT 1999b]. Based on daily traffic volume per lane, travel in congested conditions has doubled since 1982 (figures 2-8 and 2-9).

Box 2-1

ISTEA/TEA-21

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) created a surface transportation program with flexible funding that created new opportunities to address statewide and urban transportation problems. ISTEA authorized $151 billion over six years for highways, mass transit, and safety programs.

The Transportation Equity Act for the 21st Century (TEA-21), signed into law on June 9, 1998, by President Clinton, built and expanded on ISTEA policies and programs. TEA-21 guaranteed a record $200 billion in surface transportation investment for highways, highway safety, transit, and other surface transportation programs from FY 1998 through FY 2003. Contrary to earlier predictions, TEA-21 continued all major ISTEA programs and added a number of new programs to meet specific safety, economic, environmental, and community challenges. Other special programs include:

- the Transportation and Community and System Preservation Program,
- the Transportation Infrastructure Finance and Innovation Act (TIFIA),
- the Access to Jobs and Reverse Commute, and
- the Rural Transportation Accessibility Program.

Although TEA-21 retains the basic structure established by ISTEA, it does include some important changes. Two of the most significant achievements of TEA-21 are: 1) guaranteed funding; and 2) the continuation and expansion of the landmark environmental programs created by ISTEA.

TEA-21 also strengthens the planning requirements, expands the flexible funding provisions, and places a stronger emphasis on safety. It includes some new programs, such as funding for border crossing and trade corridor activities, to improve freight movements. It continues special provisions for hiring women and minorities, the Disadvantaged Business Enterprise requirement, and labor protections such as the Davis-Bacon prevailing wage guarantee.

Box 2-2

Surface Transportation Financing

The Federal-Aid Highway Act of 1956, coupled with the Highway Revenue Act of the same year, established the Highway Trust Fund, into which a 3 cents per gallon fuel tax was deposited (in 1959, this was increased to 4 cents per gallon). Thus, the mechanism for financing expanded highway programs was created. The 1960s and 1970s saw no changes to this financing, but many changes were made in the 1980s and 1990s:

- The Surface Transportation Assistance Act of 1982 increased the motor fuels tax to 9 cents per gallon and allocated a portion of that fuel tax equal to about a penny per gallon to mass transit programs.

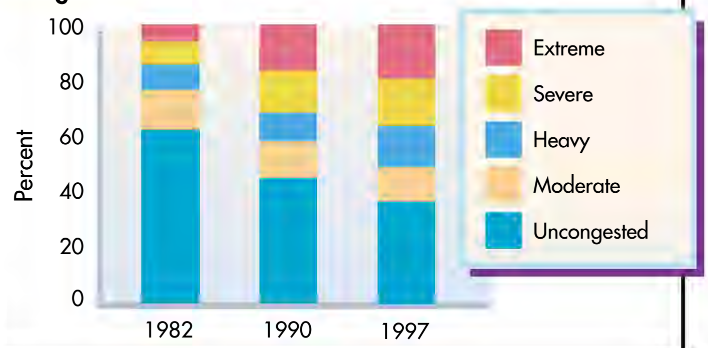
- Another increase of 5 cents per gallon -increasing the federal fuel tax to 14 cents per gallon -was enacted as part of the Omnibus Budget Reconciliation Act of 1990. For the first time in the history of the Highway Trust Fund, half of the revenues derived from this additional 5 cent fuel tax increase went to the general fund of the Treasury for deficit reduction. The general fund portion of the tax was imposed on a temporary basis through September 30, 1995.

- Another fuel tax increase of 4.3 cents per gallon was enacted effective October 1, 1993, with the entire increase directed to the general fund of the Treasury for deficit reduction. In addition, the 5 cents enacted in 1990 was extended and all directed to the Highway Trust Fund. So, fuel taxes deposited in the Trust Fund totaled 14 cents per gallon, with 2 cents dedicated to funding mass transit programs. Overall, taxes totaled 18.3 cents per gallon.

- The Taxpayer Relief Act of 1997 redirected the 4.3 cents general fund tax to the Highway Trust Fund, effective October 1, 1997. The Transportation Equity Act for the 21st Century (TEA-21) linked highway and transit spending directly to tax receipts. Of the 18.3 cents per gallon total, 2.86 cents is dedicated to funding mass transit programs.

Figure 2-8

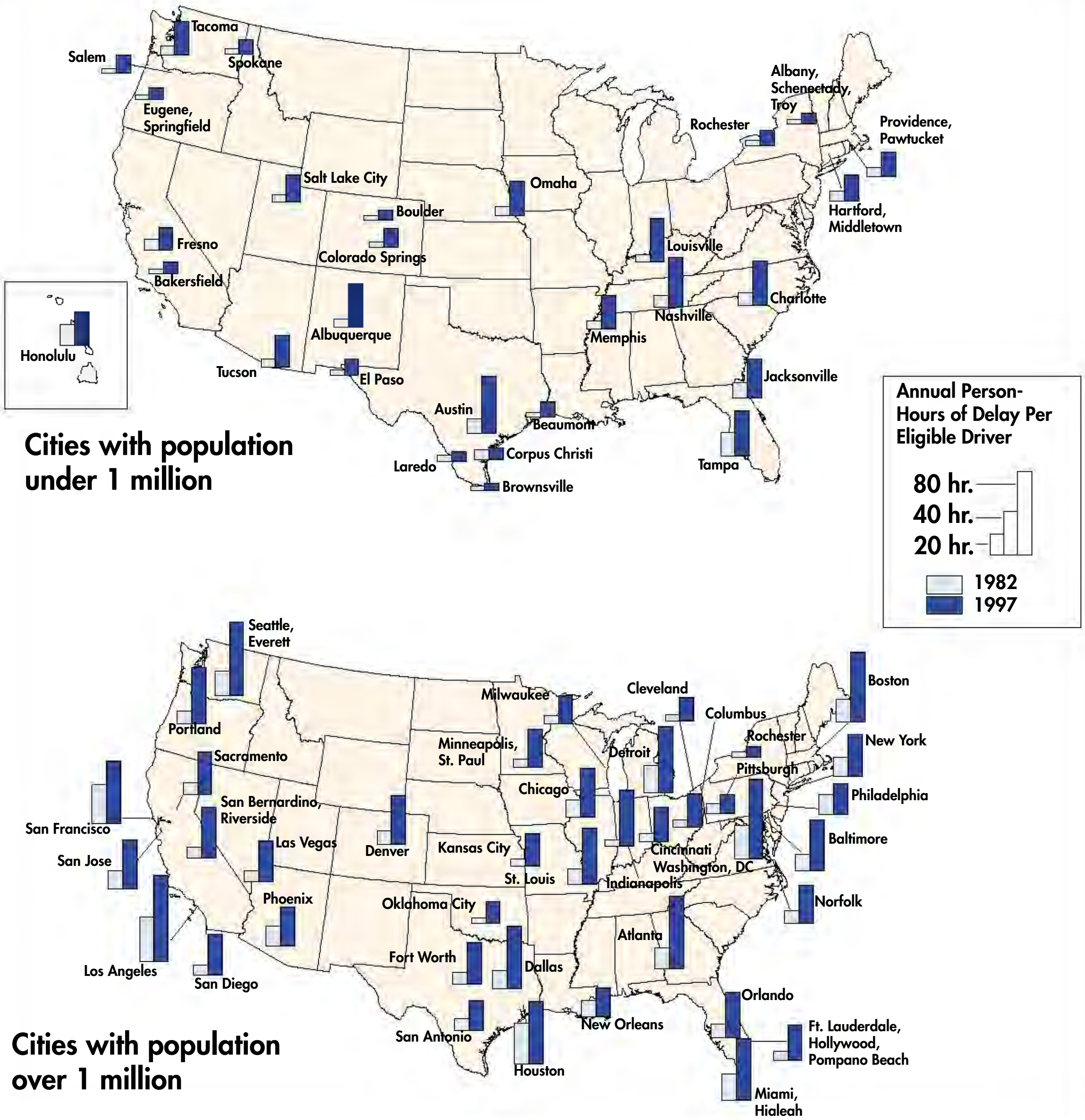
Congestion in 68 Urban Areas: 1982-97



Source: Texas Transportation Institute. *The 1999 Annual Mobility Report: Information for Urban America* (College Station, Texas: 1999).

Figure 2-9

Annual Person-Hours of Delay Per Eligible Driver: 1982 and 1997



Notes: An eligible driver is someone 16 years and older who is eligible for a driver's license. The cities shown represent the 50 largest metropolitan areas, as well as others chosen by the states sponsoring the study. For a detailed explanation of the formulas used, see the source document.
Source: Texas Transportation Institute, *Urban Roadway Congestion Annual Report* (College Station, TX: 1998).

Box 2-3

Telecommuting
Emerging technologies, including the computer, the Internet, and cellular telephones, are providing opportunities to work anywhere, anytime. Telecommuting, as this phenomena is known, is changing the way people live and work, including how, when, and where they travel. In fact, transportation issues have played a key role in spurring the growth of telecommuting. Gasoline shortages in the 1970s led to the recognition that working at home as a substitute for driving to work could save gasoline. Federal legislative acts such as the Clean Air Act Amendments of 1990 spurred the growth of telecommuting as a transportation demand strategy to reduce congestion and air pollution (see figure 2-10).

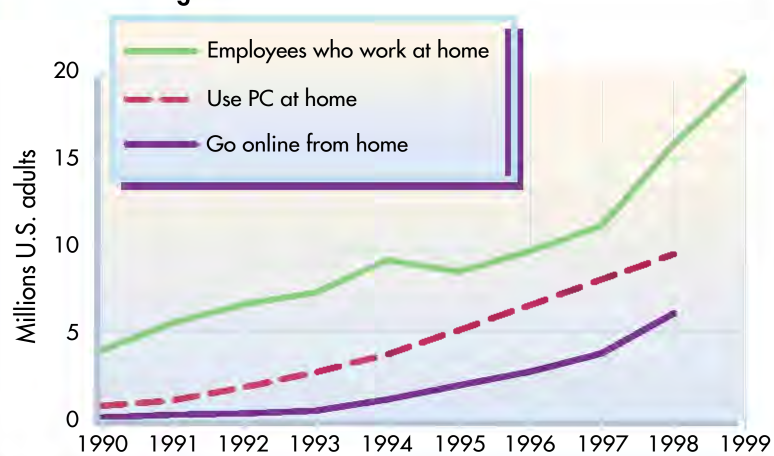
The Clinton-Gore Administration strongly promoted telecommuting. The National Telecommuting Initiative, endorsed by President Clinton's Management Council in January 1996, has resulted in a significant increase in the numbers of federal employees who telecommute.

Another Clinton-Gore initiative, the Commuter Choice Initiative, promotes a greater range of employer-provided commuting options designed to reduce traffic congestion, improve air quality, and allow employers to tailor transportation benefits to their individual employees' needs. This program has made it easier and more economical for people to get to work and has been shown to increase employee satisfaction, improve employee retention rates, and make employers more competitive.

Apart from increasing lane miles of highway (difficult to do in urban areas where congestion is most severe), approaches to mini–mizing congestion include telecommuting (box 2-3), work schedule changes, and the use of Intelligent Transpor–tation Systems (ITS).

Figure 2-10

New Technologies Drive Growth of Work at Home: 1990-99



Source: Joanne H. Pratt, *Cost/Benefits of Teleworking to Manage Work/Life Responsibilities*, report prepared for The International Telework Association & Council, Washington, DC 1999; Thomas E. Miller, *Recent Trends in Telework*, 1990-1998, data available at www.cyberdialog.com, as of July 2000.

ITS uses electronic information and communication technologies to augment the capacity of existing highway infrastructure. Examples of such systems include freeway management, arterial management, traffic signal control, electronic toll collection, transit management, and regional multimodal traveler information. These systems are explained in detail in Chapter 6, Technology.

Keys to the Future

Our highway system ranks as one of the top 20 engineering marvels of the 20^{th} century because of the freedom of mobility it provides to people [NAE 2000]. While significant improvements have been made in the last quarter century to improve pavement and bridge conditions and to improve the mobility of people and movement of goods, there is continued need for emphasis on developing better road construction, repair, and maintenance technologies.

There also is a need to take further steps to ease congestion in urban areas. A variety of strategies will be used to address capacity issues. If we remain visionary and vigilant and make prudent investments, congestion levels in 2025 will be much lower than they are today. Increasing the rate of deployment of ITS technologies will enhance capacity and help enable the effective, real-time intermodal operation of the surface transportation system. Vehicle-based technologies will facilitate high-density traffic flow. Continuous collection of real-time data on the performance of the transportation system and on projected demand will enable innovative strategies and services such as telecommuting, preferential treatment for high occupancy vehicles, and value pricing of transportation infrastructure.

By the year 2025, we will have moved substantially beyond today's modal perspective of transportation to one that views transportation as a seamless integration of transportation technologies, with the highway system as its backbone. A person-trip will be perceived as being from door to door and movement of goods as being from factory to point of retail or consumption, regardless of the number of modes used. Our highway system will be the backbone. The highway system's success in this role will result from a series of strategic research programs spurred by the Transportation Research Board's "Future Strategic Highway Research Program," which will yield more durable and efficient pavement and bridge technologies requiring less construction/reconstruction time, and fewer and shorter construction zone delays and traffic constrictions.

This holistic view of transportation and the implementation of ITS and construction technologies will yield a focus that centers on the efficient operation and management of a mature highway network.

There are ongoing efforts to collect remote sensing data for traffic management, infrastructure management, hazards and disaster assessment, and environmental impact assessment. By 2025, such data would be seamlessly integrated with data collected from ground-based sensors as part of ITS to enhance region-wide traffic management, safety, and efficiency of the entire transportation system.

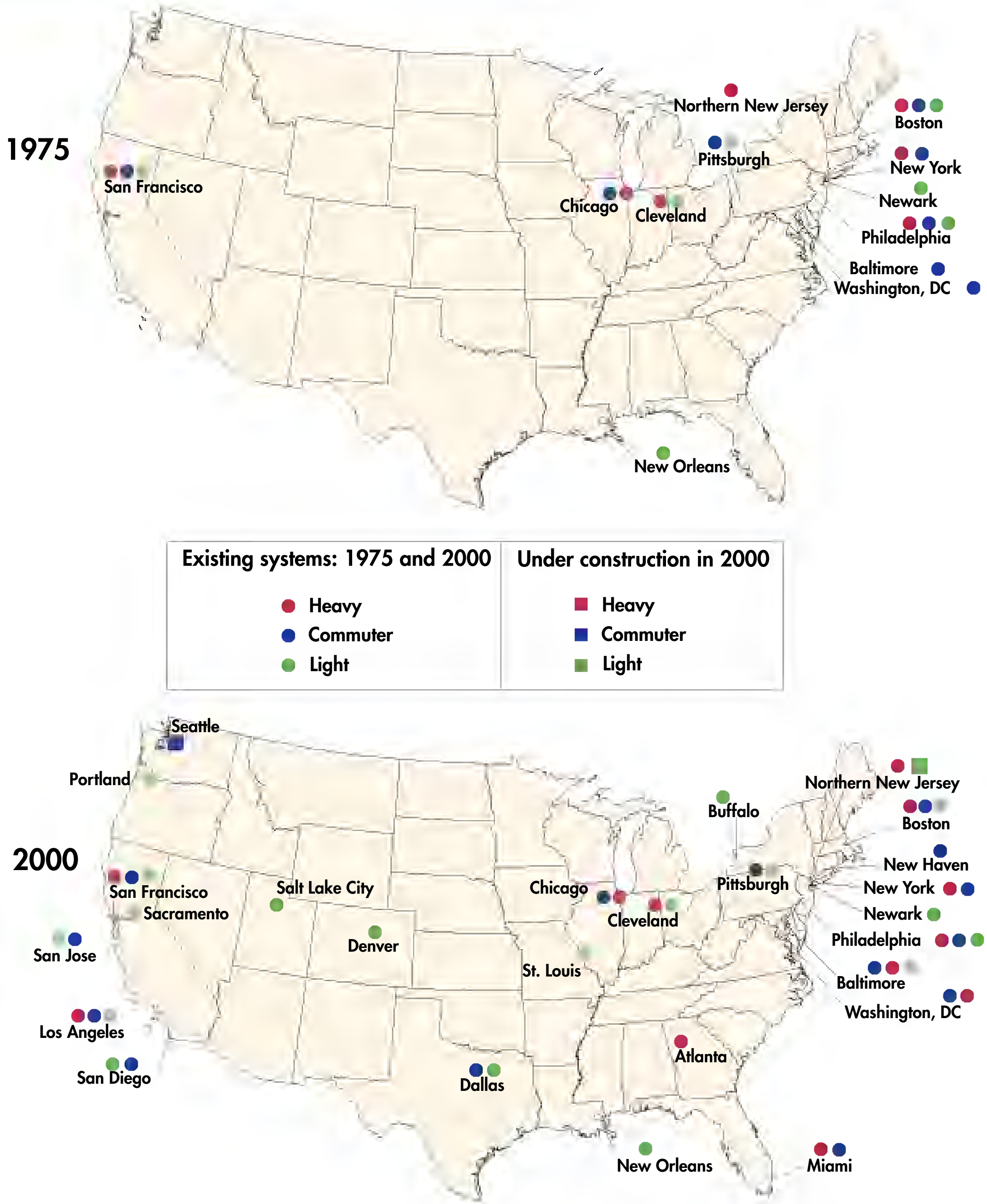
Transit

The U.S. transit system includes a variety of multiple-occupancy vehicle services designed to transport customers on local and regional routes. These services are operated by more than 5,000 public transportation systems throughout the United States and include rail, road, and water modes. Currently, the public transportation fleet comprises 129,000 vehicles in active service, of which 58 percent are buses, 26 percent are demand-responsive vehicles, 8 percent are heavy rail cars, 4 percent are commuter rail cars, 1 percent are light rail cars, and 3 percent are all other modes. In 1998, Americans made 8.7 billion passenger trips on transit with 61 percent of the trips on buses, 27 percent on heavy rail, and 8 percent on commuter and light rail.

Beginning in the 1960s, local public agencies were created to take over the transit operations of financially distressed private transit operations. Federal funds were made available for capital purchases in 1964. In the mid-1970s, the nation's transit systems were hoping to reverse years of ridership decline with a new program of operating assistance from the federal government (National Mass Transportation Act, 1974). Public involvement stemmed from the fact that transit systems provided mobility options for many people who were unable to travel by automobile due, for example, to income, disability, or age. In many areas, transit plays a role in strategies for mitigating congestion and air pollution. Some communities are also emphasizing transit as a means to reduce the negative effects of urban sprawl and enhance the quality of life, a core strategy of the Clinton-Gore Administration's Livable Communities Initiative (see box 5-11 in Chapter 5).

Figure 2-11

Urban Rail Systems in the United States: 1975 and 2000



Source: U.S. Department of Transportation, Federal Transit Administration, special tabulations, October 2000.

Between 1975 and today, two developments in U.S. urban transit service are notable. The first is the increase in the number of cities served by rail transit. Much of the growth in rail transit has been in new light rail systems (figure 2-11), including systems in Baltimore, Buffalo, Denver, Long Beach (California), Portland (Oregon), Sacramento, San Diego, San Jose, and St. Louis. In the late 1970s, Atlanta, San Francisco, and Washington, D.C., added to their heavy-rail systems, while Los Angeles began service on a new heavy-rail line in 1994. Miami and New Haven (Connecticut) added commuter rail service during this period, while Los Angeles and Washington, D.C., extended commuter rail services begun during the previous decade.

The second major development in the past quarter century is the expansion of bus transit service to lower density suburbs as a response to continued decentralization of population and employment within U.S. metropolitan areas. Suburban service extensions in many metropolitan areas were facilitated by the creation of regional transit authorities, which typically extended routes into previously unserved areas to secure a broader geographic base. Many smaller urban areas also established new services, often in response to concerns about automobile-related air pollution and energy consumption, or the mobility of transportation-disadvantaged groups. Today, there are more than 100 miles of transit lines under construction—the most since Woodrow Wilson was President. Additionally, 42 new projects are being designed and more than 100 being planned; demand for federal investment in transit facilities greatly exceeds available and anticipated funds. Ten communities are exploring the potential for bus rapid transit to achieve mobility, environmental, development, and community livability goals at a lower capital cost than light rail transit.

Over a 10-year period, from 1988 to 1998, federal, state, and local investments in transit have nearly doubled from $3.8 billion to $7.1 billion. State and local governments increased their annual transit investments from $1.36 billion to $3 billion, while federal participation increased from $2.5 billion to $4.1 billion. In addition to continuing record-level federal funds for transit investments, the ISTEA of 1991 and TEA-21 provide state and local governments with the flexibility to use specific highway funds to support transit investments. Over the past eight years, state and local governments have taken advantage of this flexible funding option, choosing to use a total of $4.9 billion of highway funds for transit.

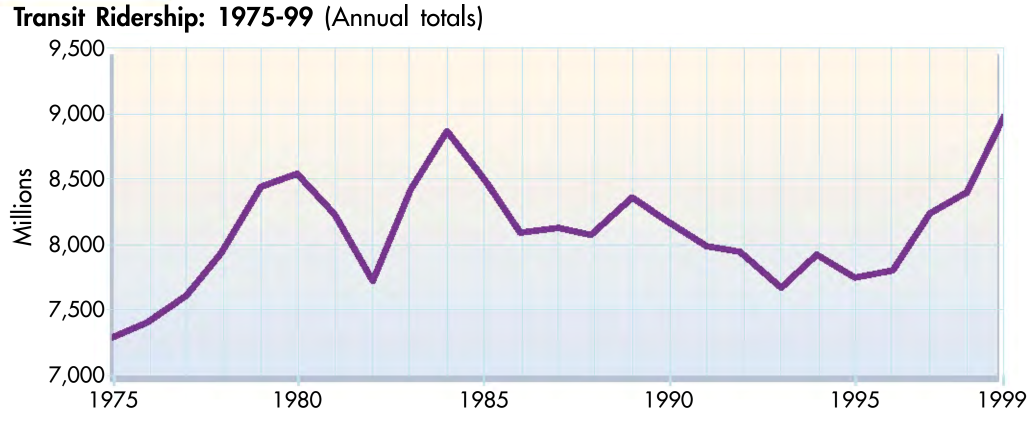
Besides providing increasing levels of financial support for transit, communities are acting to maximize the use of transit facilities by implementing a host of transit-oriented policies, such as zoning ordinances that encourage transit-oriented, mixed-use developments, joint developments that generate revenues and riders, policies that enable employers to support a variety commuter options, and fare policies that target specific travel markets for transit. Communities are also seeking to maximize the productivity of their transit operations through the use of ITS , such as automatic vehicle locator (AVL) systems and "smart" fare cards.

Partly as a result of these developments, the level of urban transit service provided nationwide has continued to grow into the 1990s. Ridership in 1999 reached about 9 billion trips (figure 2-12), the highest since the 1964 level of 10.4 billion.

Keys to the Future

Transit ridership has increased dramatically since the mid-1990s, and this trend is expected to continue over the next 25 years. The continuing trend toward lower densities and decentralization of economic activities presents difficulties for traditional transit services, which rely on ridership in densely populated areas. Equipment, services, and supporting policies must be designed to attract new ridership, and some are already in use. Newly developed technologies include signal pre-emption systems that in some settings have reduced onboard travel time by more than 30 percent. Advanced communications and use of global positioning systems (GPS) (see chapter 6) are reducing waiting times for transit users. These and similar technologies will make transit much more convenient in the future. Advances in bus design

Figure 2-12



Source: U.S. Department of Transportation, Federal Transit Administration, special tabulations, October 2000.

and construction, for example, will significantly improve bus safety, reduce operating noise, and increase efficiency. By 2025, the range of battery-powered electric vehicles, with back-up solar interchange systems, will exceed the 500-mile travel mark. Buses, charged overnight, will be ready to travel long distances.

Transit will remain a vital part of the total transportation picture by combining its best characteristics seamlessly with those of other modes. Indeed, transit ridership has been increasing and we expect that trend to continue. We must continue to invent innovative transportation routes, start new services, invent more responsive public and community transit, and create efficient, cost-effective programs.

That TEA-21 authorizes over 190 major transit projects is a recognition that communities throughout the United States view transit as a significant strategic element in their efforts to mitigate traffic congestion, improve air quality, reduce energy consumption, provide access to jobs, stimulate and sustain economic development, and strengthen community life. During the next 25 years, transit will become a competitive mode in regional multimodal transportation systems. Large urban areas will expand, and medium-sized urban areas will develop fixed guideway transit systems including commuter rail, light rail, and bus rapid transit. These systems will provide high-quality transit services that are designed to compete effectively with the automobile in a variety of travel markets. An extensive network of local and feeder bus services will support the fixed guideway transit services that, in turn, will provide "seamless" connections to the national transportation network at airports and intercity rail and bus depots. Transit providers will meet the growing need of an aging population for demand responsive transit with increasingly efficient and responsive paratransit services. ITS, such as AVL, will enable transit providers to respond in "real time" and to coordinate the extensive number of paratransit services provided in their communities.

Over the next 25 years, transit will continue to influence how urban planning and growth should occur. Coordinated transportation and land-use policies have impacted the shape of development. An interconnected network of high-speed intercity rail and magnetic levitation systems, and local commuter, rapid, and light-rail systems can form the backbone for a new pattern of development. These systems would serve to link livable rural, suburban, and urban communities. At each node, relatively dense clusters of housing and employments sites, connected with well laid out pedestrian linkages, would become the new standard of development. Such a pattern would provide increased choices and produce more efficient use of land and other resources.

By 2025, this approach to development will work because it will benefit the economy, the environment, social equity, and personal quality of life, all at the same time. Access to a broad mix of housing types, jobs, commercial areas, parks, and civic uses is within a short distance of transit stops. Services such as health care, education, and job training are readily available near transit. Street layout and building design maximize the ease of use and pleasure of movement for pedestrians, bicyclists, and persons with disabilities. Transit serves new communities in new centers, in-fill development, and redevelopment along transit corridors within existing neighborhoods. The new transit-oriented development expands transportation choices and broadens the range of housing types and costs for all Americans. Recent evidence suggests that areas that adopt policies designed to enhance transit access produce significant savings in automobile user costs.

By 2025, our nation's transit system will continue to meet and surpass communities' mobility needs as transit ridership doubles from its current level. As a nation, we would have fully embraced the fact that mobility options beyond the automobile enhance our collective quality of living and keep us competitive in the world economy.

Passenger Railroads

The Rail Passenger Service Act of 1970 established The National Railroad Passenger Corporation (popularly known as Amtrak) on May 1, 1971, following nearly a century and a half of intercity passenger operations by private freight railroads. At least since the end of World War II, the economic viability of rail passenger service had been declining. The advent of relatively inexpensive air travel in long-distance markets and the widespread availability of the private automobile for shorter trips generated new travel patterns and drew passengers away from the railroads. Other contributing factors included increasing costs and a declining share of mail traffic.

Since its founding, Amtrak rebuilt rail equipment and benefited from significant public investment in track and stations, particularly in the Northeast Corridor. Even more important has been a shift in prevailing attitudes, both in the nation and within Amtrak itself. The 1977 *Trends and Choices* report [USDOT] termed Amtrak as experimental, but after nearly 30 years, Amtrak is now a critical fixture in America's infrastructure. Figure 2-13 shows the frequency of service on various Amtrak routes in 1999; Amtrak ridership from 1975 to 1999 is shown in figure 2-14.

In 1997, President Clinton signed into law the Amtrak Reform and Accountability Act, which authorized a record $2.3 billion in payments for capital improvements to the rail system. This was the first Amtrak Reauthorization Act, made possible by timely intervention of the administration to prevent a systemwide Amtrak strike. The Act establishes the principle that Federal funds should go only toward capital subsidies to Amtrak, while operating costs should be paid from corporate revenues. Under this principle, operating subsidies will be phased out by 2003. The Act also expanded Amtrak management's flexibility, including the ability to contract out all types of work subject to labor-management negotiations; reorganized the Amtrak Board; and set up an independent commission (the Amtrak Reform Council) to monitor progress.

Following passage of the Act, the new Amtrak Board developed a strategy that emphasized high-speed rail corridor development (see Chapter 6 for a detailed discussion on high-speed rail systems), network expansion, customer service, and new profit centers. With the new strategy, Amtrak will:

- restructure service in the Northeast Corridor, with the new high-speed Acela Express trainsets and the recent completion of electrification from New Haven to Boston;
- proceed aggressively in conjunction with states outside the northeast on high-speed rail corridor development in the Pacific Northwest, California, the Midwestern Chicago Hub,

the Gulf Coast Corridor, New York's Empire Corridor, Pennsylvania's Keystone Corridor, and the Southeast Corridor linking the Northeast Corridor with the South Atlantic states;

- re-emphasize customer service by offering *service guarantees* (reimbursement coupons good for future travel) that are unprecedented in the American passenger transportation industry; and

- extend its franchise to other businesses, such as mail delivery, that traditionally formed part of its predecessor railroads' passenger operations.

Figure 2-13

Amtrak Passenger Rail System: 2000

Source: U.S. Department of Transportation, Federal Railroad Administration, Office of Railroad Development, special tabulations, October 2000.

Figure 2-14

Amtrak Ridership: 1975-99 (Annual totals)

Source: National Railroad Passenger Corporation (Amtrak), *Annual Report* (Washington, DC: Various years).

Keys to the Future

Amtrak will face the challenge of operating quality high-speed and conventional rail systems while generating a positive operating cash flow to help support its continuing investment requirements. Amtrak may extend service to regions now unserved by passenger trains and add additional daily trains to established long-distance routes. The most significant challenge for Amtrak is eliminating its dependence on federal operating subsidies while maintaining and increasing its ability to serve the nation's passenger transportation needs.

Corridors in many regions of the United States may provide high-speed rail (HSR) service by 2025 if state and Amtrak interest continues to grow and build on success of high-speed corridors (see Chapter 6 discussion on high-speed ground transportation). By 2025, next-generation high-speed rail technologies could mature to support reliable, cost-effective systems with superb quality, including nonelectrified corridors operating at top speeds ranging from125 to150 mph, positive train control in place nationwide to improve productivity and safety, elimination of virtually all grade crossings on routes with significant traffic, and infrastructure that delivers excellent ride quality at low cost.

The public would also benefit by reductions in airport and highway congestion and air pollution through increased use of passenger rail. HSR would provide expanded transportation options to a growing ridership by connecting to commuter rail and urban transportation systems. Analogous benefits could accrue on other, less heavily traveled Amtrak routes with upgraded conventional service quality, new equipment, and enhanced reliability.

In the Northeast Corridor, high-speed rail could generate 3.5 billion passenger-miles annually by 2025, more than double the 1.7 billion in 2000. Corridors designated thus far could bring high-speed rail service to almost 75 percent of the nation's metropolitan population — over 150 million people.

Aviation

Air travel is the fastest growing mode of transportation, becoming ever more popular and frequent. The growing pervasiveness of air travel can be seen by the increasing numbers of people that have flown on a commercial jet: less than 50 percent in 1975 compared with more than 80 percent today [ATA 1998]. After a lull in the 1980s, private sector aviation is also becoming more popular. And, on the freight side, air cargo is a rapidly growing segment of the air transportation market.

In the last quarter-century, the aviation industry has undergone dramatic growth (see figure 2-15 for enplanement growth in major markets). It has experienced consolidation, while at the same time, new-entrant, low-fare competitors have emerged. Older, established airlines, such as Eastern, National, and Pan American, have disappeared, while an expanding former intrastate carrier (Southwest) has become the model for many new airlines. Globalization of our economy, the development of hub-and-spoke systems, and the emergence of low-fare carriers have also contributed to an increasing number of flights.

Passenger traffic has nearly tripled since 1975 (figure 2-16) and is expected to reach one billion enplanements within the next decade [USDOT FAA 2000a]. Air cargo (freight, express, and mail) grew much faster than the passenger sector, increasing nearly fivefold from 5 billion revenue ton-miles (RTMs) in 1975 to 25 billion in 1999 (figure 2-17). During this period, airline employment more than doubled from 297,000 employees to 728,000 employees, and labor productivity increased. The ratio of enplaned passengers per employee rose by 25 percent, and the ratio of RTMs per employee rose by 89 percent over this period. This remarkable increase in output per employee arises, in part, from the use of larger and faster aircraft, changes in flight personnel requirements, changes in work rules and practices, and adoption of various marketing strategies.

Box 2-4

Air Traffic Performance-Based Organization

On December 7, 2000, President Clinton issued an executive order to establish an Air Traffic Organization (ATO) within the Federal Aviation Administration (FAA). The purpose of this order is to enhance the FAA's mission to ensure safety, security, and efficiency of the nation's air transportation system. Establishment of the ATO will further improve the delivery of air traffic services to the American public.

A Chief Operating Officer (COO) and a five member Board of Directors, drawn from business and labor leaders to help oversee the COO and the air traffic budget, will administer the new organization.

Specifically, the ATO will:

(a) optimize use of existing management flexibilities and authorities to improve the efficiency of air traffic services and increase the capacity of the system;

(b) develop methods to accelerate air traffic control modernization and to improve aviation safety related to air traffic control;

(c) develop agreements with the Administrator of the FAA and users of the products, services, and capabilities it will provide;

(d) operate in accordance with safety performance standards developed by the FAA and rapidly respond to FAA safety and security oversight findings;

(e) consult with its customers, the traveling public, including direct users such as airlines, cargo carriers, manufacturers, airports, general aviation, and commercial space transportation providers, and focus on producing results that satisfy the FAA's external customer needs;

(f) consult with appropriate federal, state, and local public agencies, including the Department of Defense and the National Aeronautics and Space Administration, to determine the best practices for meeting the diverse needs throughout the National Airspace System;

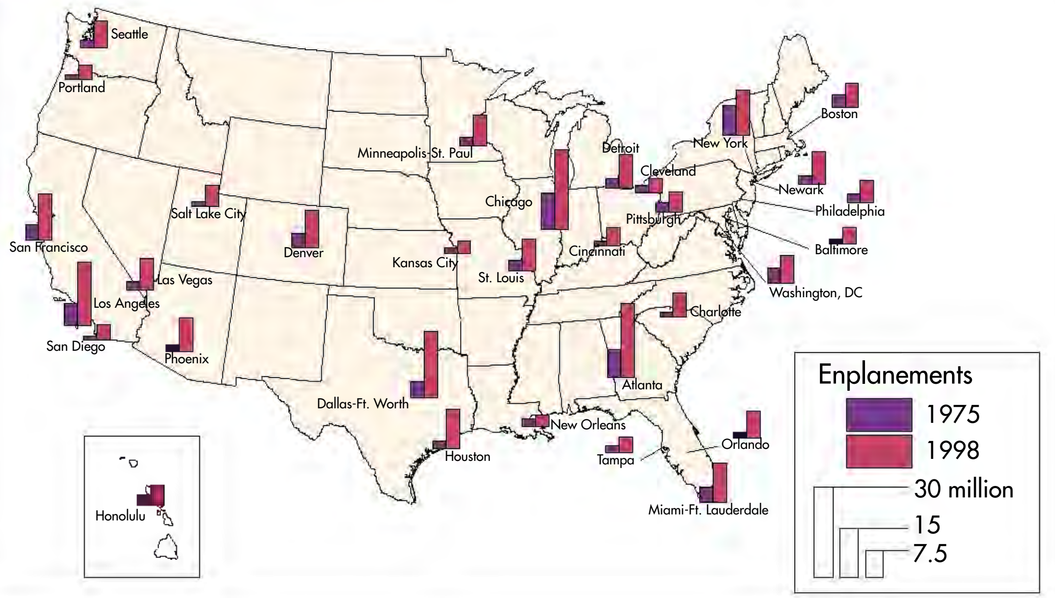
(g) establish strong incentives to managers for achieving results; and

(h) formulate and recommend to the Administrator any management, fiscal, or legislative changes necessary for the organization to achieve its performance goals.

The establishment of the semiautonomous ATO will go a long way toward improving our ability to cope with increasing congestion in the skies. It will allow more efficient management of the air traffic services and accelerate the reform of our air traffic system. Additionally, if we reform the way air traffic control service is financed, from a system financed by passenger taxes to one in which commercial users pay the costs of the services they use, we can ensure that air travel in the 21st century is the safest, most cost-effective, and most efficient in the world.

Figure 2-15

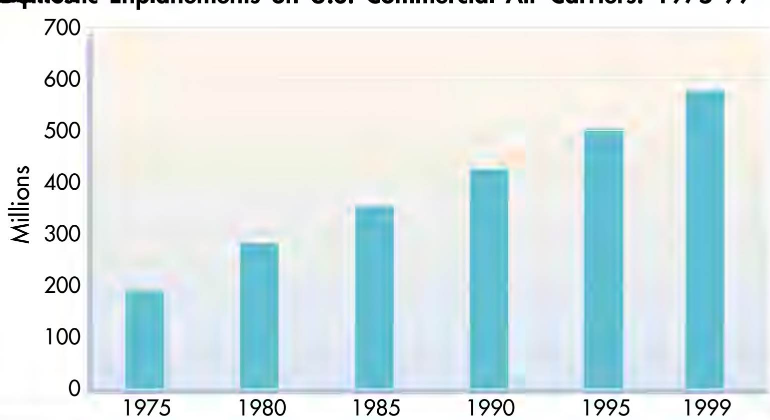
Enplanements in Major Markets: 1975 and 1998



Note: These data include those hubs that were classified as large hubs in either 1975 or 1998 or in both years. A large hub is a geographic area that enplanes 1 percent or more of national enplaned passengers. A hub may include more than one airport.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information, 1976; and *Airport Activity Statistics of Certificated Air Carriers, Summary Tables 1999* (Washington, DC: 1999).

Figure 2-16

Domestic Enplanements on U.S. Commercial Air Carriers: 1975-99

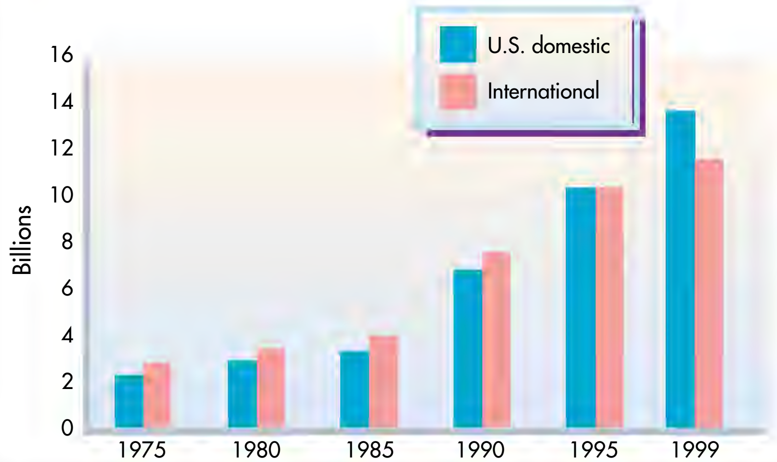


Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information (Washington, DC: Various years).

The increases in passenger and cargo traffic, however, have come with an associated price. More traffic has increased congestion in the aviation system, especially at the hubs. A study by the USDOT Inspector General's Office [USDOT OIG 2000] shows that delays are growing nationwide. The study tracked 2,036 domestic routes and found that gate-to-gate times had increased on 77 percent of them between 1988 and 1998.

Figure 2-17

U.S. Domestic and International Freight Revenue Ton-Miles: 1975-99



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information (Washington, DC: Various years).

Through collaborative leadership, the FAA is working with the aviation industry to address aviation congestion issues. In March 2000, USDOT initiated a collaborative spring/summer effort in cooperation with the airlines industry to reduce delays due to severe weather conditions. In August 2000, Secretary Slater convened, for the first time, airline industry stakeholders to discuss the current challenges facing the industry and promote innovative strategies to reduce congestion at the nation's airports. As a result of this meeting, three task forces were set up to: address airlines service quality performance, identify "best practices" in improving the accuracy and timeliness of flight information provided to air travelers, and expedite the investment in infrastructure. Similar collaborative efforts are continuing at the USDOT to reduce congestion and the resulting delays and to provide a better experience to the air travelers.

Box 2-5

AIR-21

The Aviation Investment and Reform Act for the 21st Century (AIR-21) was enacted by Congress and signed by the President in the spring of 2000. The act substantially increases funds for airport development both through the Airport Improvement Program and by enabling an increase in the Passenger Facility Charge. AIR-21 provides needed airport infrastructure grants that can result in competitive access for new entrant carriers across the nation. The Act also funds the continued redevelopment of the air traffic control infrastructure, providing the most significant changes in technology and procedures in 50 years.

Air-21 continues implementing the goal of modernizing and stabilizing FAA's critical air traffic services for the nation. It shifts FAA's air traffic management from a centralized command and control hierarchy to a more demand responsive and collaborative model managed by the expanded Aviation Management Advisory Council.

AIR-21 also contains increased authorizations to provide for USDOT enforcement of consumer protection, such as those prohibiting deceptive advertising and those providing denied-boarding protection.

Source: Public Law 106-181 (Apr. 5, 2000), Aviation Investment and Reform Act for the 21st Century (AIR-21), 2000. Information available at www.nw.faa.gov/airports/preservations/FieldAIR=21/index.htm/ as of Aug. 23, 2000.

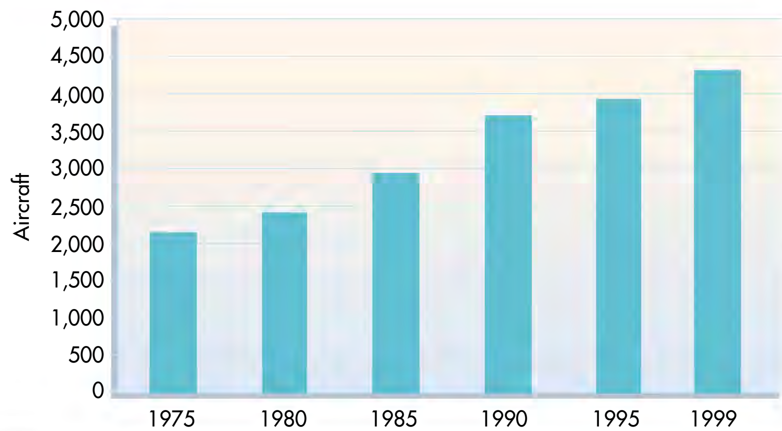
Large Commercial Air Carriers: To accommodate growth in domestic demand, commercial air carriers have expanded capacity. From 1975 through 1999, the number of large passenger jet aircraft in the U.S. fleet more than doubled, increasing from 2,135 in 1975 to 4,312 in 1999 (figure 2-18). Domestic available seat miles increased from 244 billion to 677 billion, up more than 177 percent.

As passenger miles increased during the last two decades, the average domestic load factor increased from 53 percent in 1975 to almost 70 percent in 1999 (figure 2-19). Air carriers also improved their operating profits by better managing full-fare and discounted seats. Due to increased load factors, airlines restructured and reduced unit costs, increasing efficiency and productivity.

U.S. domestic Revenue Passenger Miles (RPM) grew from 129 billion in 1975 to 473 billion in 1999—an average increase of 5.6 percent per year. From 1975 through 1999, commercial air carrier domestic fares, adjusted for inflation, declined 38.6 percent [USDOT BTS OAI n.d.(a)].

Figure 2-18

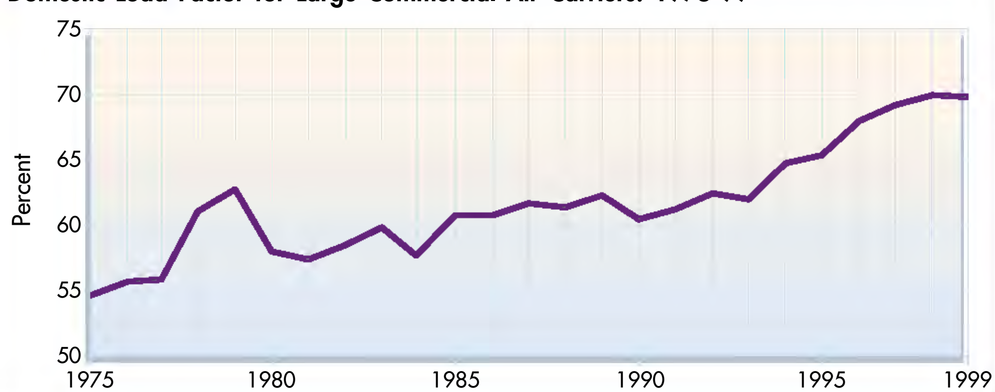
Large Passenger Jet Aircraft in the U.S. Fleet: 1975-99



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information (Washington, DC: Various years).

Figure 2-19

Domestic Load Factor for Large Commercial Air Carriers: 1975-99



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information (Washington, DC: Various years).

Box 2-6

Higher Profits for U.S. Airlines

During the 20 years since deregulation, U.S. air carriers have earned more than $38 billion in operating profits and more than $6.5 billion in net profit. The years 1994 to 1998 were the most prosperous, with more than $30.9 billion in operating profits and $14.6 billion in net profits.

From 1979 through 1983—the first five years of deregulation—the U.S. air carrier industry incurred operating losses of more than $1 billion. Losses resulted from operating in an increasingly unregulated market, petroleum price increases in 1979 and 1980, and the economic recessions of 1980 and 1982.

From 1984 through 1988, losses in the air-carrier industry began to reverse. During this time, operating profits were more than $10.3 billion, and net profits were more than $3.2 billion. Profits came from a stronger U.S. economy and slower growth in operating expenses. Slower growth in operating expense, in turn, resulted from increasing productivity, wage concessions from airline employees, and declining fuel costs.

The industry experienced difficult times again during the 1989 to 1993 period, when operating losses exceeded $2.1 billion, and net losses were almost $10.5 billion. In part, problems stemmed from uncertainties generated by the Gulf War and the threat of terrorism. Other reasons included a downturn in both U.S. and world economies, as well as rising jet fuel prices. In 1993, President Clinton signed legislation creating the National Commission to Ensure a Strong, Competitive Airline Industry to study problems facing the aviation industry. Former Virginia Governor Gerald L. Baliles chaired the commission, whose recommendations stimulated the return of the commercial aviation industry to profitability in 1994 and subsequent strong growth. The strong growth resulted from several factors, including a growing U.S. economy, an increase in worldwide traffic demand, declining fuel prices, and high load factors.

The historically high load factors being experienced by the industry today (70 percent domestic market and 74 percent international market) are attributed to the use of a wide variety of yield management strategies. Today's technology allows carriers to maintain large databases that include information on flights, bookings, and the impacts of seat-selling discounts. This information allows airlines to predict demand and manage capacity. Yield management systems are largely responsible for U.S. carriers increasing load factors by almost 17 percentage points system-wide since 1975 [USDOT BTS OAI n.d.(b)].

Airlines are changing their marketing strategies to take advantage of new opportunities offered by selling tickets via the Internet, because this allows them to cut costs and deal directly with travelers. The major air carriers encourage this method of distributing tickets by offering frequent flier mileage bonuses and discount fares for purchasing tickets over the Internet.

Box 2-7

Air System Financing

Airport and Airway Trust Fund dollars have accounted for approximately 64 percent of all FAA funding since the Trust Fund's creation in 1970. The Trust Fund percentage of the total has been increasing, from 40 percent in the 1970s to 54 percent in the 1980s and 71 percent in the 1990s. There were frequent statutory changes from the 1970s through the 1990s that redefined the eligible uses of aviation trust fund monies, particularly the mix of operations versus capital spending from the trust fund.

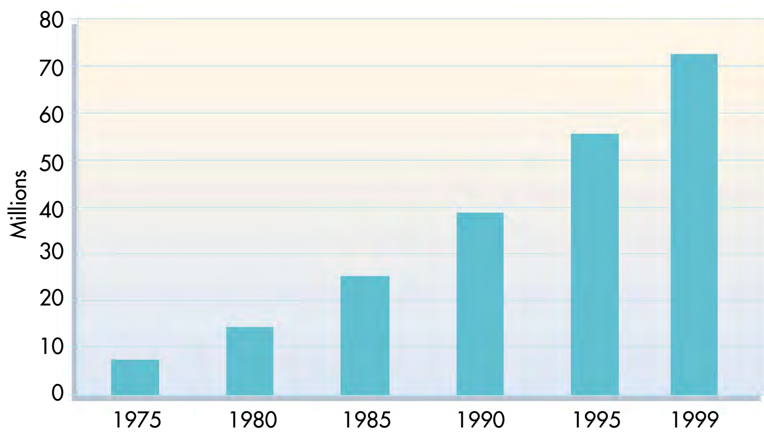
Regionals/Commuters: The Airline Deregulation Act of 1978 created major opportunities for the group of airlines originally called "commuter" airlines and now called "regional" airlines. In 1975, the industry was operating on the fringes of the service areas of the large commercial air carriers. The typical commuter airline was a fixed-base operator that provided scheduled air service to small communities using small aircraft that seated fewer than 30 passengers.

Between 1975 and 1985, regional/commuter enplanements more than tripled, increasing from 7 million to 25 million; revenue passenger miles increased almost five-fold, from 760 million to almost 3.8 billion [USDOT BTS OAI n.d.(c)]. The regional/commuter airlines became increasingly important sources for connecting traffic to major carriers. These connections led to the next significant trend to evolve from deregulation—the development of "code-sharing agreements" between the major and regional air carriers (see Chapter 4, box 4-3).

In 1986, large air carriers began purchasing their regional partners, and as of 1999, the major airlines owned 15 regionals, totally, or in part. The close relationship between the regionals and the large air carriers continues to shape the industry today. In 1999, the regional/commuter airline industry enplaned 72 million passengers, the result of a 10.1 percent average annual increase since 1975 (figure 2-20). Revenue passenger miles totaled 18.8 billion in 1999, representing an average annual increase of 14.3 percent [USDOT BTS OAI n.d.(c)].

Figure 2-20

Regional/Commuter Airline Revenue Enplanements: 1975-99



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information (Washington, DC: Various years).

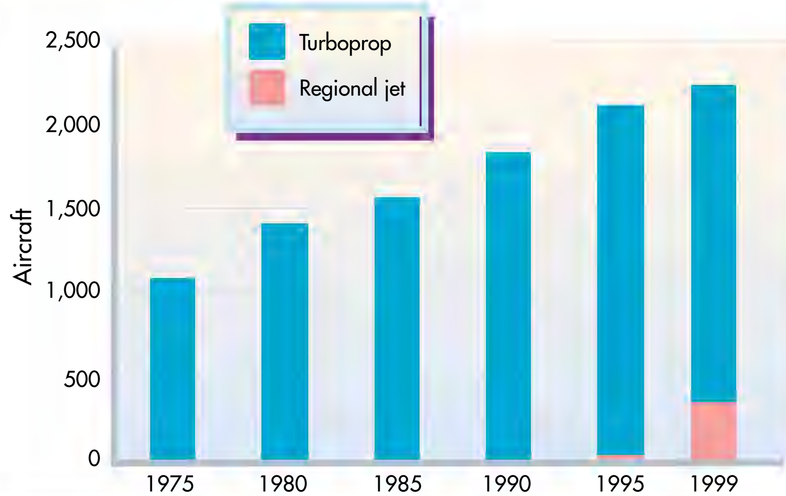
The evolution within the regional/commuter industry is also underscored by changes in the range of markets served and in the fleet composition. As passenger traffic continued to grow, larger regional aircraft with greater range were introduced into the regional fleets.

These new aircraft, designed to meet the mission and market demand of the regional industry, are probably the most visible sign of changes within the industry and reflect its growth and reach. During the 1980s and early 1990s, larger turboprop aircraft were prevalent. From the mid-1990s to today, new regional jets, first introduced in 1993, became common. Figure 2-21 shows the growth of the regional/commuter aircraft fleet. Between 1975 and 1999, the industry's average passenger trip length increased from 105 to 260 miles (figure 2-22). In the future, new regional jets will help shape and support regional/commuter airline growth.

The regional airline industry has become an integral part of today's national air transpor–tation system. However, this growth has led to increased consolidation. The number of airlines has declined significantly, while the average size of the carriers has increased dramatically. In 1975, there were 170 reporting carriers, which grew to a high of 245 in 1980. Since then, the number of regional/commuter airlines has declined steadily to only 93 carriers in 1999. In 1975, the 170 regional carriers averaged just over 42,300 enplanements per carrier, but in 1999, the 93 carriers averaged more than 778,000 passenger enplanements per carrier.

Figure 2-21

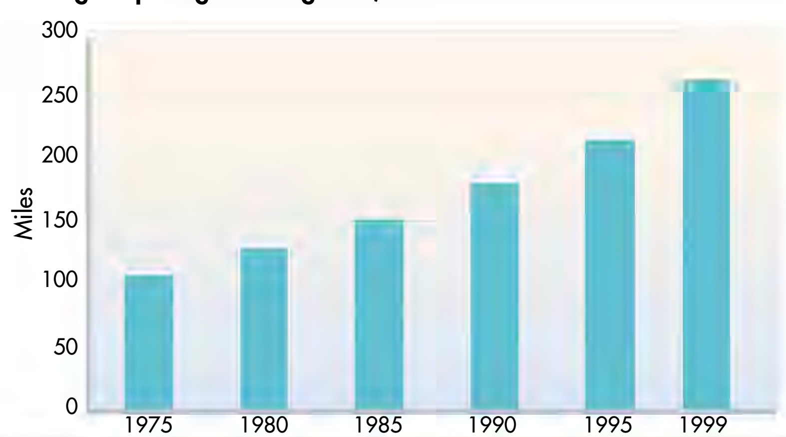
Regional/Commuter Passenger Aircraft Fleet: 1975-99



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Office of Airline Information (Washington, DC: Various years).

Figure 2-22

Average Trip Length on Regional/Commuter Carriers: 1975-99



Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

Today's regional airlines are more aptly characterized as large, professionally managed businesses, operating state-of-the-art aircraft and poised for continued growth [USDOT BTS OAI n.d.(c)].

Air Cargo: The demand for air cargo transportation has grown as economic activity has increased. Growth in air cargo activity has historically been strongly related to growth in the Gross Domestic Product (GDP). By providing faster ways for businesses to deliver high-value goods to customers, air cargo transportation has become a major factor in economic growth.

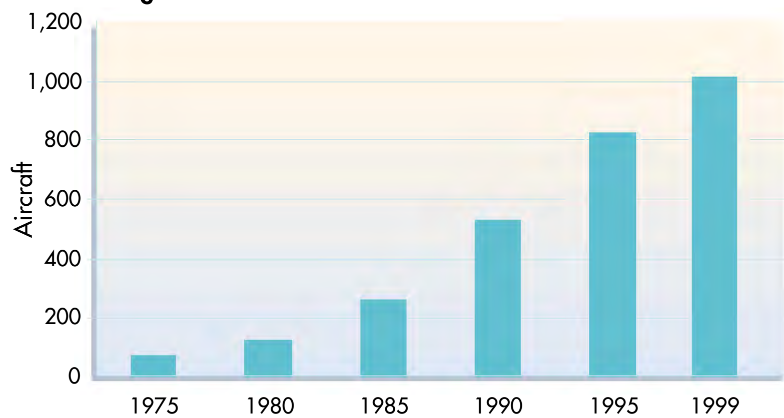
Air cargo has grown even faster than airline passenger traffic. The 6.1 percent annual growth in domestic freight RTMs from 1975 to 1999 was greater than the percent growth in RPMs (figure 2-17). Industry growth was primarily attributable to the growth of all-cargo carriers, which accounted for more than two-thirds of domestic freight RTMs in 1999 [USDOT BTS OAI n.d.(b)]. Federal Express and United Parcel Service are the two largest domestic all-cargo carriers. Both of these carriers are integrated carriers providing door-to-door service using intermodal systems.

Freight also is moved in the cargo-holds of passenger aircraft and in dedicated all-cargo aircraft. To meet the increased demand for air-freight traffic, the fleet of dedicated all-cargo jet aircraft increased from 70 aircraft in 1975 to 1,013 aircraft in 1999 (figure 2-23). The most significant change in the fleet during the 1980s was the extensive use of Boeing 727 freighters due to the rapid growth of integrated express carriers.

General Aviation: General aviation—the use of business and corporate aircraft, personal aircraft, and air taxis—is in a period of strong growth, with more planes flying, more new aircraft being delivered, and more pilots earning their licenses. Even greater increases are projected for the next quarter century [USDOT FAA OAPP 2000].

Figure 2-23

U.S. All-Cargo Fleet: 1975-99



Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

After a decline in the early 1990s, general aviation activity increased 4.3 percent per year between 1996 and 1999 [USDOT FAA 2000b]. The turnaround in general aviation is attributed to the U.S. economic expansion during the Clinton-Gore administration, in 1993, President Clinton's first trip to Everett, Washington, focused on bringing the aviation leaders together to foster growth in the industry after a serious downturn in prior year profits. The General Aviation Manufacturers Association (GAMA) estimates that more than 7,000 U.S. companies operate business aircraft. Favorable economic conditions have improved the market demand for business jets, especially for larger aircraft with ranges of more than 6,000 miles. In addition, fractional ownership, aircraft shared among several individuals or businesses, has contributed to the demand for business jets [GAMA 2000].

Fixed-wing piston aircraft continue to dominate general aviation, currently accounting for more than 79 percent of the active fleet. Currently, the size of the fixed-wing piston fleet is similar to that of 1975, but the industry is rebounding from a decline in the early 1990s (figure 2-24). The size of the fixed-wing turbine fleet has more than tripled since 1975, totaling 12,700 in 1999 (figure 2-25).

GAMA has estimated that more than 25,000 manufacturing jobs have been created in the general aviation industry as a result of GARA. GARA limits the number of years for which manufacturers are liable for general aviation aircraft. The general aviation industry had been in a dramatic decline in the 1980s—U.S. companies sold more than 17,000 piston aircraft in 1979 and had dropped to less than 700 in 1999—citing the costs of liability insurance for older aircraft as a major cause in this decline. GAMA also reports increases in general aviation exports, new general aviation products due to increases in research and development by its members, and an increase in the number of student pilots [GAMA 1999].

Commercial Space Transportation: Commercial space transportation did not exist in 1975. However, since the mid-1990s, commercial space-launch activities have grown as U.S. com–mercial companies responded to the increased global demand for commercial satellite-launch

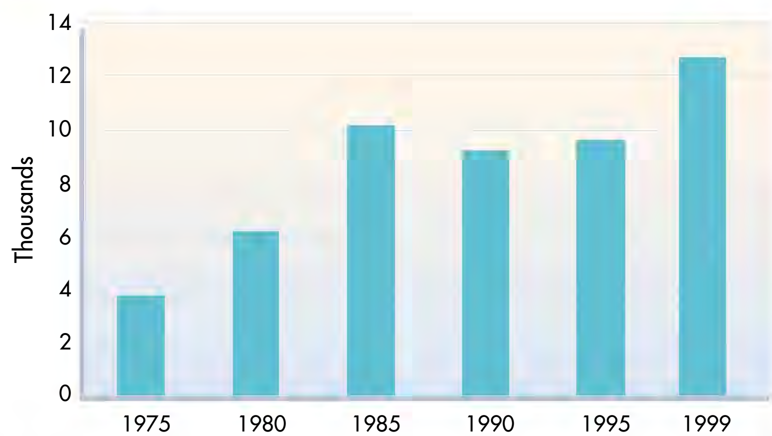
Figure 2-24

Fixed-Wing Piston Aircraft: 1975-99

Source: U.S. Department of Transportation, Bureau of Transportation Statisticas, Office of Airline Information (Washington, DC: Various years).

Figure 2-25

Fixed-Wing Turbine Aircraft: 1975-99



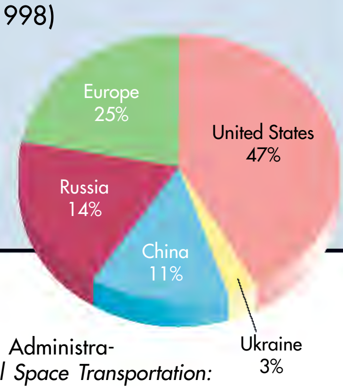
Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

services. The first U.S. commercial launch took place in 1989. In 1999, there were 17 FAA-licensed commercial space launches, for a total of 130 launches through July 2000; of these, 115 have been successful [Smith 2000].

The growth in the commercial satellite-launch industry was prompted by the destruction of the space shuttle *Challenger* and the subsequent decision to prohibit commercial payloads on the shuttles. This left the United States with severely limited launch capability. Other nations entered this business, setting the stage for the highly competitive and growing world market in space launch. The United States went from zero commercial launch capability in 1988 to $1 billion in launch revenues in 1998. In 1998, U.S.-based launch providers achieved a 47 percent share of the international commercial launch market (figure 2-26).

Figure 2-26

Commercial Satellite Launches by Country: 1998 (Percent of market share in 1998)



Source: U.S. Department of Transportation, Federal Aviation Administration, *Commerical Space Transportation: 1998 Year in Review* (Washington, DC: 1999).

Before 1990, most responsibilities for the U.S. space-launch bases and ranges belonged to the government, particularly the Air Force. Today, commercial launch operators and spaceports are responsible for operating and maintaining the satellite and launch vehicle facilities and launch complexes that they lease or license from the Air Force. The FAA has issued a space-launch site operator's license for commercial spaceports at Vandenberg Air Force Base, California; Spaceport Florida at Cape Canaveral Air Station, Florida; the Virginia Space Flight Center at Wallops Island, Virginia; and Spaceport Alaska at Kodiak Island, Alaska. The FAA has also licensed launches from the Sea Launch venture, which had its first successful launch in 1999 from a sea-based platform near the equator in the Pacific Ocean.

These spaceports focus on small to medium rockets used primarily to launch low Earth orbit (LEO) communications satellites. LEO satellites orbit at altitudes ranging from 100 to 22,300 miles—the distance required for geostationary orbit. Demand for this type of launch is increasing, and a number of firms are competing to establish constellations of LEO satellites providing global mobile communications systems. All of the numerous proposed LEO systems use varying numbers of evenly spaced satellites circling the globe, so that one is always within reach of Earth-bound communications devices. They essentially allow anyone, anywhere on Earth, to communicate with anyone anywhere else, using a special handheld telephone (Big LEO) or other, nonvoice communications device, such as a pager or alphanumeric messaging receiver (Little LEO).

Keys to the Future

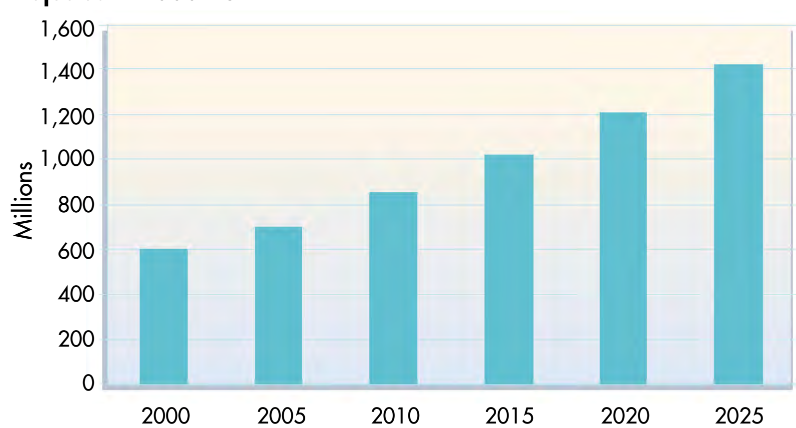
FAA estimates show that commercial airlines will continue to benefit from moderate to strong economic growth. The forecasts also expect a combination of technological improvements and continued cost containment efforts to benefit the overall financial performance of both U.S. and foreign flag carriers.

In addition, the operation of a fleet consisting entirely of Stage 3 aircraft (aircraft with reduced noise level), which are more fuel-efficient, will result in further cost savings and increased industry productivity. These productivity improvements should strengthen overall industry financial performance, reduce air-carrier marginal costs, and benefit the traveling public with lower airline fares. Further, we are working with our international partners to develop a Stage 4 aircraft and schedule it for future deployment.

Domestic enplanements are predicted to increase 3.4 percent per year from 2000 to 2025 (figure 2-27). To accommodate the growth in traffic over this period, the large air carrier jet passenger fleet is expected to increase 3.6 percent per year, expanding from 4,355 aircraft in 2000 to an estimated 9,941 aircraft in 2025 (figure 2-28). With congestion already apparent at airports and in the skies, capacity issues must be addressed to accommodate future growth.

Figure 2-27

Domestic Enplanements on U.S. Commercial Air Carriers: Projected – 2000-25

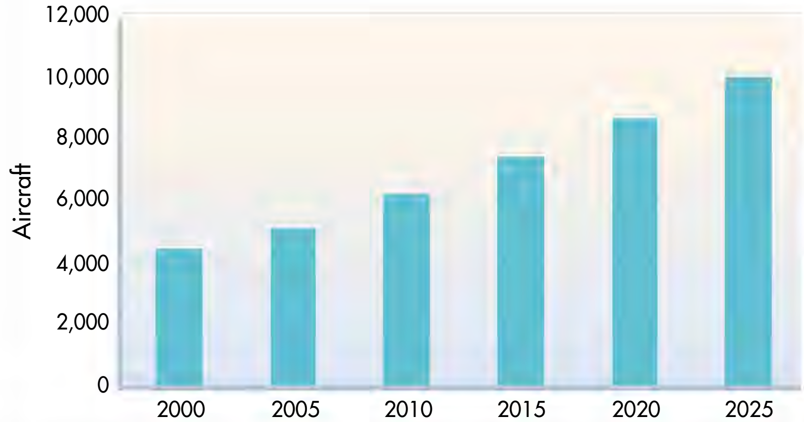


Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

The FAA, in cooperation with NASA, is carrying out research and development to modernize the National Air Space (NAS) system and improve its safety, security, efficiency, and environmental compatibility. Together, they have set a vision and identified goals to be achieved by 2025 (see box 1-4). Daniel S. Goldin, NASA administrator, foresees a future in which new technological developments will allow our aviation system to meet growth in air travel by 2025 (see box 6-13).

Figure 2-28

U.S. Commercial Air Carriers' Passenger Jet Aircraft: Projected – 2000-25

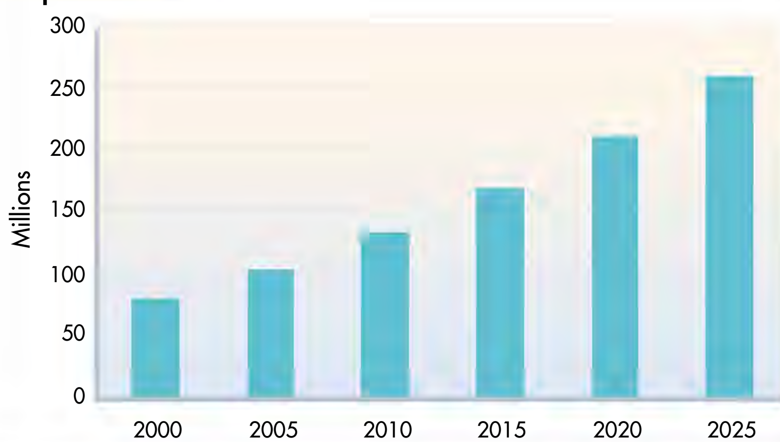


Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

Over the next 25 years, the regional/commuter airline industry is expected to continue outpacing the growth of large commercial air carriers. By 2025, the regional airline industry is estimated to enplane more than 244 million passengers annually, at a 4.7 percent average annual growth rate (figure 2-29). By 2025, the regional/commuter industry's share of total domestic enplanements is predicted to be well over 15 percent, compared to 11.2 percent in 1999.

Figure 2-29

Regional/Commuter Air Carrier Enplanements: Projected – 2000-25



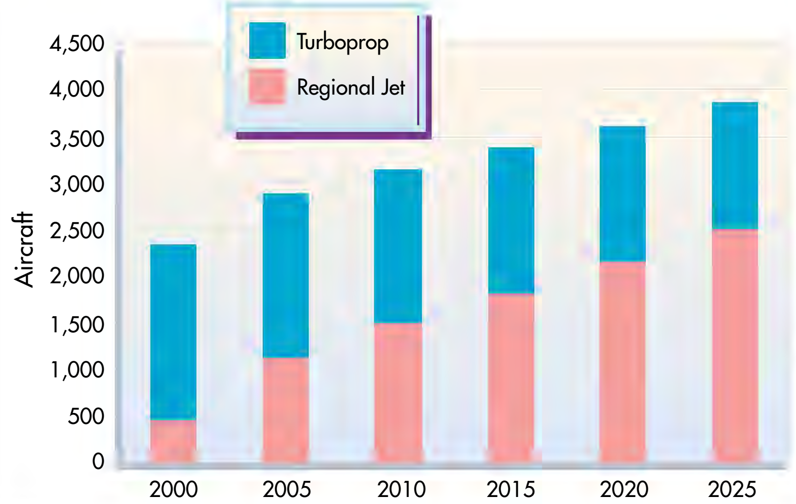
Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

More than any other factor, the change in the regional aircraft fleet will define the industry's future. While deregulation was the driving force behind the industry's growth from 1978 through the mid-1990s, the popularity and recent rapid introduction of regional jets and the market applications they dictate will shape the industry's future trends.

During the next 25 years, the regional/commuter fleet is expected to increase from 2,237 aircraft in 1999 to 3,870 in 2025, an increase of 73 percent (figure 2-30). More significantly, regional jets are expected to become the mainstays of the fleet midway through this 25-year period. By 2025, regional jets may account for nearly 65 percent of the fleet, compared to only

Figure 2-30

Regional/Commuter Commercial Passenger Aircraft Fleet: Projected – 2000-25



Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

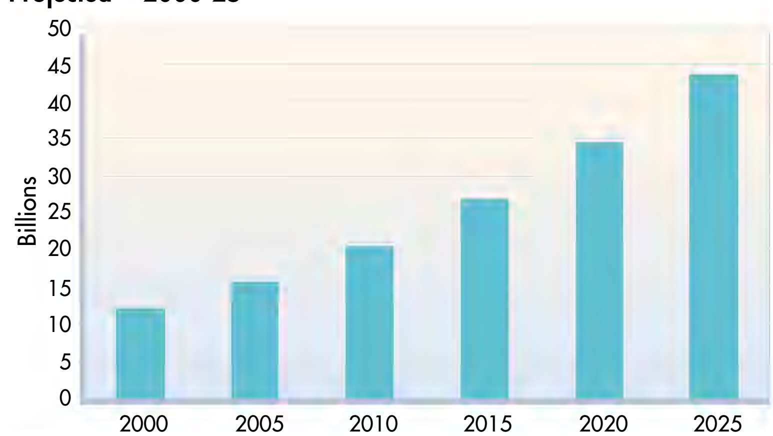
15 percent in 1999. The number of turboprops may actually decline by an estimated 28 percent. The projected large growth in the number of regional jets raises questions about the ability of the air traffic system to handle the demand placed on it. The expected decline in the number of small turboprops may also mean that some small communities will lose all scheduled air service.

Air cargo growth is expected to mirror trends in economic growth. The ever-increasing trend toward globalization could stimulate demand for both domestic and international markets.

Domestic air cargo RTMs are forecasted to increase nearly four times between 1999 and 2025, with an annual increase of more than 5 percent to reach 43.7 billion RTMs in 2025 (figure 2-31). The all-cargo carriers are expected to accommodate nearly all of the additional growth. To accommodate the demand for air cargo growth, the fleet of all-cargo jet aircraft is forecasted to more than double between 1999 and 2025. The fleet is projected to increase from 1,046 aircraft in 2000 to 2,646 aircraft in 2025, an annual increase of 3.8 percent. An increasing percentage of the future cargo fleet will be composed of passenger aircraft conversions.

Figure 2-31

U.S. Domestic Air Freight Revenue Ton Miles: Projected – 2000-25



Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

In 1999, narrow-body aircraft and wide-body aircraft accounted for 67.7 and 32.3 percent of the all-cargo jet fleet, respectively. The number of wide-body aircraft is forecasted to grow much faster than that of narrow-body aircraft and account for more than half the fleet by 2011. A key issue will be the capacity of existing infrastructure to handle the increasing air cargo movement efficiently.

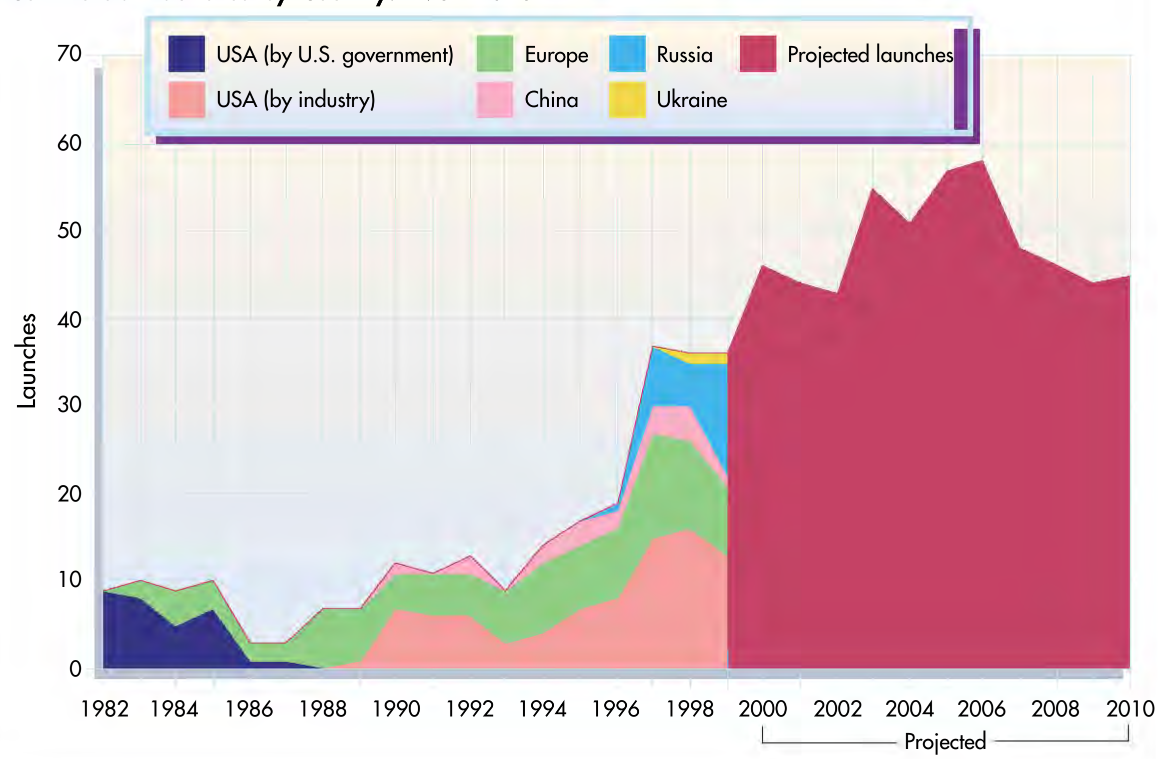
The general aviation fleet is expected to continue its growth over the next 25 years. The largest absolute increase is projected to be in the number of active fixed-wing piston aircraft—increasing from 165.2 thousand to 190.7 thousand.

The fixed-wing turbine aircraft fleet is expected to almost double over the next 25 years, reaching 24,900 in 2025. Rotocraft are forecast to increase by more than 36 percent over the same period, from about 7,700 in the year 2000 to approximately 10,500 in 2025. Increases in the numbers of experimental aircraft and other aircraft (gliders, lighter-than-air, balloons) are also expected.

The FAA and the Commercial Space Transportation Advisory Committee (COMSTAC) project an annual average of 51 commercial space launches worldwide through 2010, a 40 percent increase from the 36 commercial launches conducted worldwide in 1999 (figure 2-32). It is forecasted that, on average, the following type and number of launches will occur each year through 2010: 40 launches of medium-to-heavy launch vehicles (25 to geosynchronous orbit and 15 to LEO) and 11 launches of small launch vehicles to LEO.

Figure 2-32

Commercial Launches by Country: 1982-2010



Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

Government and industry representatives have worked together to consider alternatives for the several possible paths along which U.S. space-launch capability may develop over the coming decades, as well as the appropriate near-term steps. It is likely that the FAA and the Air Force will develop a shared relationship for determining commercial-launch safety requirements.

Maritime Shipping

The U.S. maritime transportation system consists of waterways, ports and their intermodal connections, vessels, vehicles, and system users. During the past 25 years, pressure to lower prices and improve service, as well as the growing application of new technologies have transformed the maritime shipping industry. Maritime shipping has generally been intermodal; other forms of transportation are needed to haul cargo to and from ports. The container revolution has made the connections to rail and truck significantly more efficient. The increased use of containers during the past 25 years has far outpaced that of other forms of maritime trade (dry bulk, tanker, and general cargo).

In 1975, the U.S. domestic shipping industry was growing rapidly due to an increase in crude oil trade and was projected to grow even faster. But by 1998, it had grown by only 16 percent in tonnage (figure 2-33) due to increased dependence on pipelines to transport crude oil. On the other hand, waterborne foreign trade has grown 65 percent by weight (short-tons) since 1975 (figure 2-34). The projected growth in domestic shipping led to improvement of the nation's inland waterway system, including the Tennessee-Tombigbee Waterway, new locks and dams on the Mississippi River, and the St. Lawrence Seaway (figure 2-35), and other improvements. Figure 2-36 shows the overall U.S. inland waterway system.

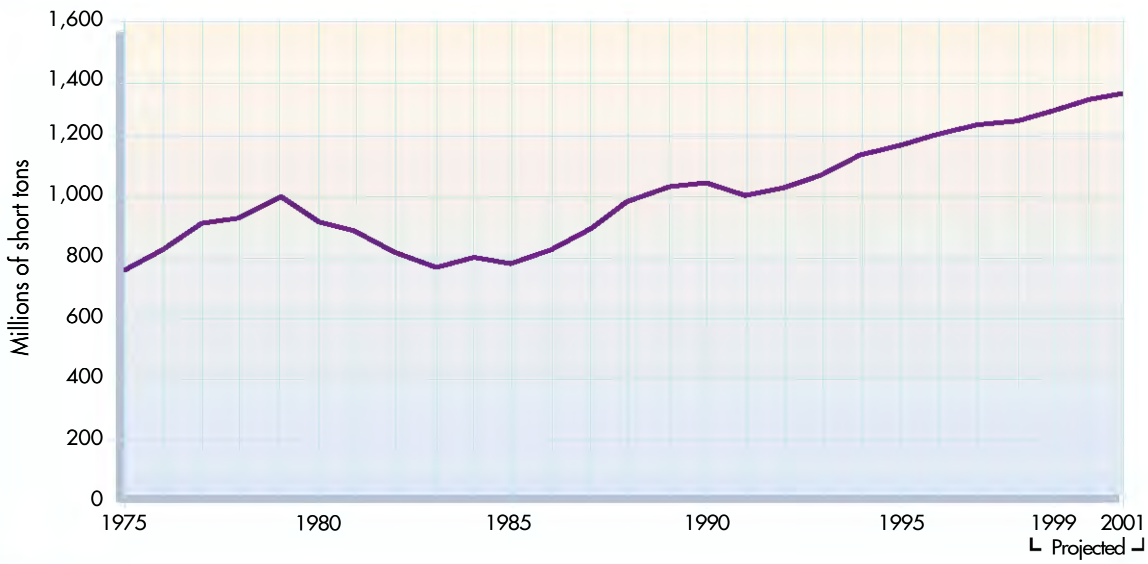
Figure 2-33

U.S. Waterborne Domestic Trade: 1970-98 (Annual totals)

Source: U.S. Army Corps of Engineers, Water Resources Support Center, *Waterborne Commerce of the United States 1998, Part 5, National Summaries* (Fort Belvoir, VA: 2000).

Figure 2-34

U.S. Waterborne Foreign Trade: 1975-2001 (Annual totals)



Source: U.S. Army Corps of Engineers, Water Resources Support Center, *Waterborne Commerce of the United States 1998, Part 5, National Summaries* (Fort Belvoir, VA: 2000); DRI/McGraw-Hill, *World Seatrade Service* (New York, NY: McGraw-Hill Companies: 1999).

Figure 2-35

The St. Lawrence Seaway

Source: Environmental Systems Research Institute, Inc., *ESRI Data & Maps* (CDROM) (Redlands, CA: 1999).

Figure 2-36

U.S. Inland Waterway System: 1999

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Atlas Database (Washington, DC: 2000).

Based on the Maritime Administration's analysis of a survey conducted by the American Association of Port Authorities, the U.S. port industry has invested approximately $15 billion since 1973 on improvements in its port facilities and infrastructure. Between 1979 and 1989, new construction was 72.6 percent of total U.S. public port industry capital expenditures. In the 1970s and 1980s, the North Atlantic ports ranked highest in the level of total industry investments [USDOT MARAD 1997]. Port industry investments between 1994 and 1998 account for about 42 percent of total U.S. port industry investments since 1973. Types of investment include new construction and modernization/rehabilitation. For 1998, new construction accounted for 73.3 percent of total expenditures. Also for 1998, the Pacific Coast ports accounted for nearly 50 percent of total industry investment.

The world's general-cargo trades were revolutionized by U.S. shipbuilding innovations in advanced containerships and roll-on/roll-off vessels. At the end of 1975, the United States held 25 percent of the world's fleet of general cargo ships, which carried 30 percent of the tonnage. Tables 2-1 and 2-2 show the status of the U.S. oceangoing merchant fleet in 1975 and 1999, respectively. Growth in the number of full containerships began to change the shipping world, as shipping lines and ports developed container facilities to compete with noncontainer general-cargo vessels.

In 1975, New York led all U.S. ports in tonnage. The Port of Long Beach was the tenth-ranked port by tonnage (table 2-3); primary trade for California ports was tanker imports of petroleum and petroleum products. The tanker trade, hurt by the worldwide oil crisis of previous years, was beginning to recover in 1976 due to increased petroleum imports. Overall, the liner trade was strongest at that time and was expected to continue to increase, while the cruise industry carried only a limited number of passengers.

Table 2-1

U.S. Oceangoing Merchant Marine: as of June 30, 1975
(Self-propelled vessel ≧ 1,000 gross tons)

	Privately owned		Government-owned		Total	
	Ships	Deadweight tons (000)	Ships	Deadweight Tons (000)	Ships	Deadweight tons (000)
Combination passenger/cargo	7	59	57	354	64	413
Freighters	162	2,190	215	2,176	377	4,366
Bulk carriers	19	543	0	0	19	543
Intermodal	148	2,807	4	47	152	2,854
Total U.S. flag	583	14,610	308	2,999	891	17,609

Source: U.S. Department of Commerce, Maritime Administration, June 1976.

Table 2-2

U.S.-Flag Oceangoing Self-Propelled Merchant Vessels of 1,000 Gross Tons and Over as of Apr. 1, 1999

Active fleet	Ships	Deadweight tons (000)
Tanker	123	7,914
Dry bulk	14	579
Containership	82	2,905
Roll-on/roll-off	27	552
Cruise/passenger	4	37
Other	28	689
Total	**278**	**12,676**

Source: U.S. Department of Transportation, Maritime Administration, U.S. Merchant Marine Data Sheet, as of Apr. 1, 1999.

Table 2-3

U.S. Oceanborne Foreign Trade Top 10 Ports (1975)
(Thousands of tons)

U.S. Port	Imports	Exports	Total
New York	50,153	5,524	55,677
Baton Rouge	39,861	8,563	48,424
Houston	23,520	13,360	36,880
Norfolk	5,818	27,694	33,512
Philadelphia	29,055	4,370	33,425
New Orleans	13,814	19,170	32,984
Baltimore	17,546	13,309	30,855
Corpus Christi	17,125	3,844	24,969
Beaumont	15,441	3,476	18,917
Long Beach	13,348	4,975	18,323

Source: U.S. Department of Commerce, Maritime Administration, *United States Oceanborne Foreign Trade Routes* (Washington, DC: 1978).

The maritime industry has changed more dramatically in the past 30 years than in any other period in history. Where shipping could once be divided into tankers, bulk carriers, and dry-cargo ships, there are now many more specialized ship designs. Container ships, which first appeared in the 1960s, are now commonplace, although their proportion of the world shipping fleet is still relatively small. Between 1994 and 1998, the number of container vessels grew by 57 percent (figure 2-37). Roll-on/roll-off ships dominate short sea routes in many parts of the world.

World containerized trade moves almost doubled between 1991 and 1999 (figure 2-38), and U.S. ports on both coasts have responded to their increased activity. By 1987, New York was the top U.S. port in the container trade, followed by Long Beach, and the top 15 U.S. container ports accounted for 89 percent of the total activity in the United States. Figure 2-39 shows the location of the top 25 container ports and the volume of containers handled in 1987 and 1999 (see also tables 2-4 and 2-5).

Figure 2-37

World Container Vessel Fleet: 1994-98

Source: Lloyd's Maritime Information Service, vessel inventory datafile, various years, available at www.lmis.com/f-sdat.htm, as of October 2000.

Figure 2-38

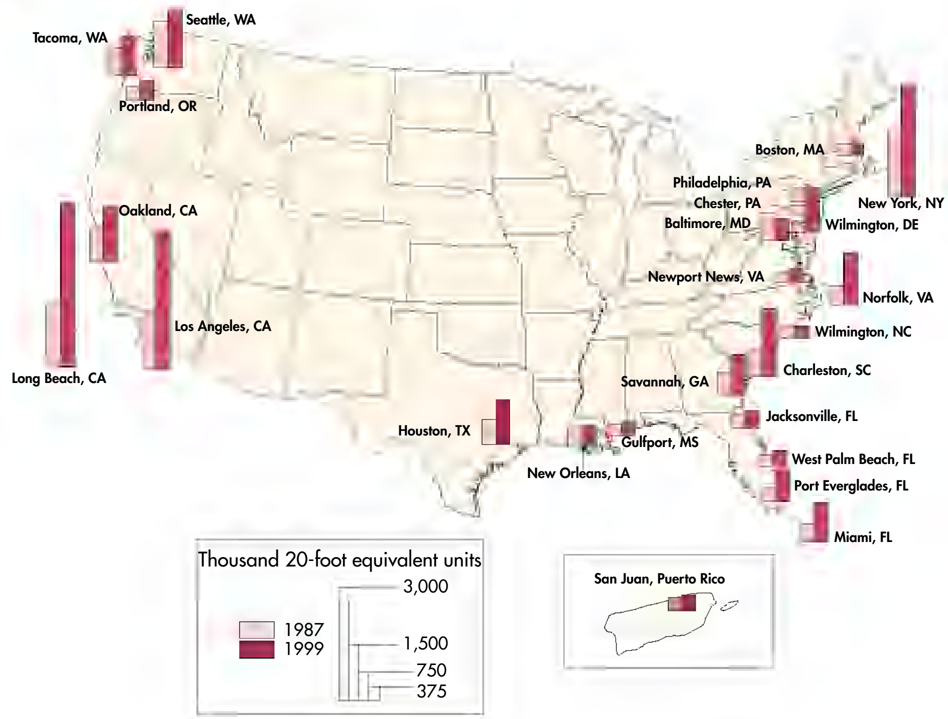
World Containerized Trade Moves: 1991-2001

*TEU = Twenty-foot Equivalent Unit.

Source: K.C. Sjetnan, 1999, *Cargo Systems, The Future of the Container Shipping Industry* (London: IIR Publications, Ltd.).

Figure 2-39

Top 25 U.S. Container Ports: 1987 and 1999



Source: *Journal of Commerce*, data from Port Import/Export Reporting Service (PIERS), 2000.

Table 2-4

U.S. Waterborne Container Trade – Top 10 Ports
(Thousands of metric tons)

U.S. Port	1997
Long Beach, CA	20,142
Los Angeles, CA	15,231
New York, NY	15,003
Charleston, SC	8,996
Seattle, WA	7,980
Oakland, CA	7,289
Norfolk, VA	7,433
Houston, TX	6,207
Miami, FL	4,982
Savannah, GA	4,895

Source: *Journal of Commerce*, data from PIERS, 1998.

Table 2-5

Top 20 Container Ports: Throughput 1998

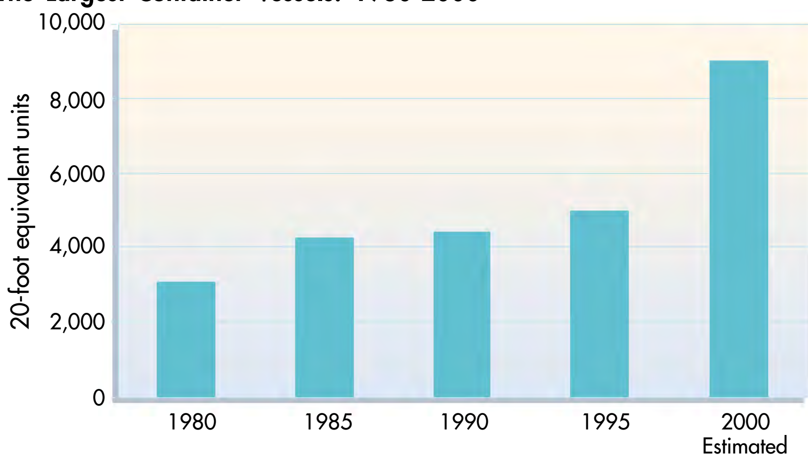
	Port	Container throughput
1	Singapore	15,100,000
2	Hong Kong	14,582,000
3	Kaohsiung	6,271,053
4	Rotterdam	6,010,000
5	Pusan	5,752,955
6	Long Beach	4,100,000
7	Hamburg	3,546,940
8	Los Angeles	3,378,218
9	Antwerp	3,265,000
10	Shanghai	3,000,000
11	Dubai	2,804,104
12	Tokyo	2,495,000
13	New York/New Jersey	2,465,993
14	Felixstowe	2,461,823
(Tie) 15	Gioia Tauro	2,100,000
	Kobe	2,100,000
17	Yokohoma	2,091,240
18	San Juan	1,990,272
19	Manila	1,856,372
20	Algreciras	1,825,614

Source: K.C. Sjetnan, 1999, *Cargo Systems, The Future of the Container Shipping Industry* (London: IIR Publications, Ltd.).

Ships, on average, are getting bigger. Today's container vessels have 50 percent or more cargo capacity than those of 1975. Figure 2-40 shows the increasing size of container vessels between 1980 and 2000. The first mega-container ship, with a capacity of 8,000 20-foot equivalent units (TEUs) (e.g., a TEU is the length of a container divided by 20), was developed by a German consortium in 1997.

Figure 2-40

The Largest Container Vessels: 1980-2000



Source: K.C. Sjetnan, 1999, *Cargo Systems, The Future of the Container Shipping Industry* (London: IIR Publications, Ltd.).

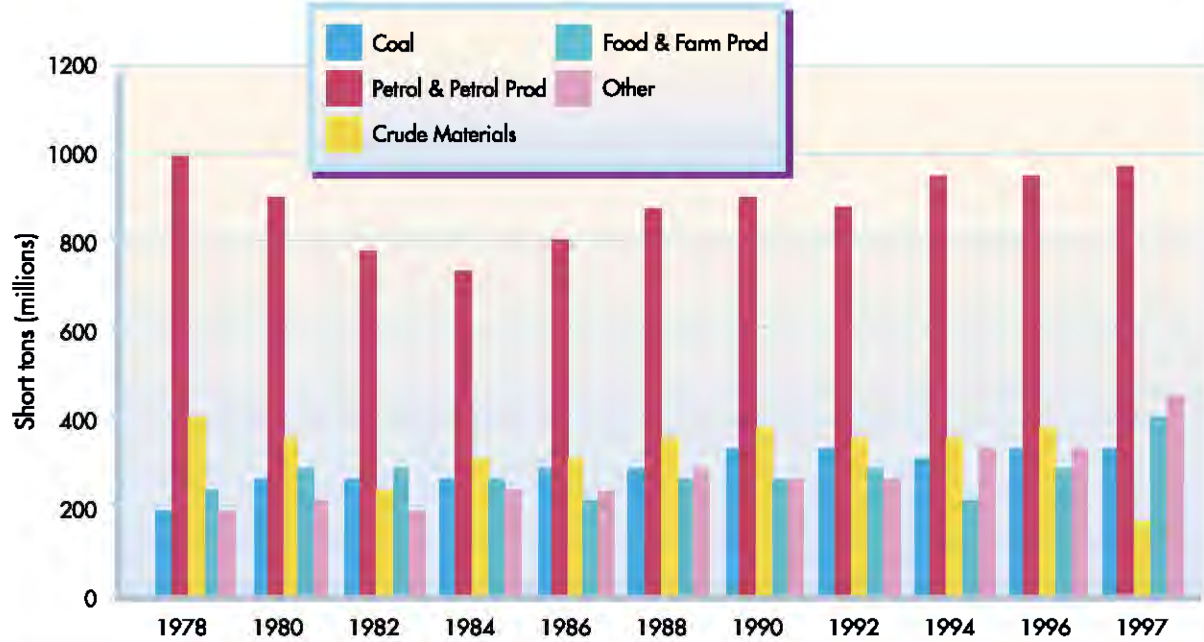
The container revolution has emphasized the serious infrastructure problems facing the U.S. ports and waterways. The newer, larger ships of the 1970s required deepening of waterways and ports, but a political stalemate over funding in the early 1980s stopped these improvements. The Water Resources Development Act (WRDA) of 1986 provided the impetus for many U.S. ports to deepen channels to enable them to handle large bulkships. The WRDA fundamentally altered the financial basis of the maintenance of American harbors by creating a new Harbor Maintenance Trust Fund. Rather than relying on general appropriations to pay for port deepening and maintenance dredging, funds were collected by a tax—the Harbor Maintenance Tax—on cargo value. The WRDA also, for the first time, required local project sponsors (state and local agencies) to pay a share of costs. Since then, the U.S. Supreme Court has ruled that the Harbor Maintenance Tax is an unconstitutional tax when applied to exports. In 1999, the Clinton Administration proposed a fee based on registered tonnage of a ship, adjusted for the ship's cargo and passenger capacity.

U.S. domestic waterborne trade, consisting primarily of bulk commodities moving on U.S. inland, Great Lakes, and coastal waters, suffered during the oil shortages of the mid-1970s, the inflation and financial crises of the early 1980s, and the Mississippi River flood in 1993. In the 1990s, however, it has shown moderate increases. The top three commodity groups in the U.S. domestic waterborne trade over the past 10 years have been petroleum and petroleum products, crude materials, and coal. In the mid-1980s, food and farm products fell to number four, behind coal. Figure 2-41 shows the top commodities shipped by waterborne commerce in the United States.

The North American cruise passenger trade has shown steady growth for almost two decades, increasing an average of 7.6 percent per year from 1980 to 1997. The cruise industry, which is primarily foreign-owned, is using new ships and amenities to attract the vacation dollars of American tourists [DRI/McGraw-Hill 2000].

Figure 2-41

U.S. Total Waterborne Commerce: 1978-97



Source: U.S. Army Corps of Engineers, *Waterborne Commerce of the United States 1998, Part 5, National Summaries* (Fort Belvoir, VA: 2000).

Keys to the Future

As foreign trade continues to grow, U.S. ports and their intermodal connections face four significant problems:

- changing business practices;
- ports must seek new financial resources for expansion and deepening projects to accommodate the new generation of bigger, faster cargo ships;
- environmental concerns that have impacted port expansion must be addressed; and
- maintenance projects and landside connections must be improved.

The U.S. Supreme Court's ruling, in March 1998, that the Harbor Maintenance Tax is an unconstitutional tax on exports has placed funding for port expansion, deepening, and maintenance in jeopardy. Proposals have been made to adopt other tax structures or return to the use of general appropriations for port projects. In any case, a strategic investment in the marine transportation system is required to meet future global demands.

The U.S. Coast Guard will continue to seek innovative means of managing our nation's waterways to ensure the safe and efficient movement of people and goods. These efforts must proactively manage the multiple competing uses of the nation's waterways and ensure that increased usage of the waterways for both commerce and recreation does not degrade the safety, efficiency, and environmental integrity of the waterways. The outcome of these efforts will ensure the continued reliability and efficiency of waterway transportation needed to accommodate the increased demands the marine transportation system will face in light of projected increases in maritime trade.

Spurred by an expected three-fold increase in container traffic by 2025, the maritime sector will likely follow the lead of the aviation industry and establish a “hub and spoke” system of marine transportation. One or two megaports (hubs) on each coast will receive and send line-haul traffic, which would be lightered up or down the coasts on container barges. Establishment of hub and spoke systems will likely be further prompted by the inability of most U.S. ports to handle future generations of container megaships while the likelihood of constructing new, large ports is very low.

Many areas of the country, such as New York, Boston, and Oakland, have experienced lengthy permit application processes for dredging ports because of environmental concerns related to disposal of dredged material in the ocean.

Ports, in cooperation with other modes of transportation, must also look to innovative means of moving cargo to and from landside destinations. The total volume of domestic and inter–national marine trade is expected to triple over the next 25 years. Major U.S. ports face prob–lems of landside congestion and scarcity of land to accommodate these increasing cargo flows.

In southern California, the Alameda Corridor is under construction to move huge volumes of cargo to and from the Ports of Los Angeles and Long Beach. The 20-mile, $2.4 billion corridor, expected to be open in 2002, connects the ports by rail to an intermodal transfer site. Accompanying truck lanes are also part of the project. In northern New Jersey, officials are considering construction of a new portway for trucks to move cargo to and from Port Newark and Port Elizabeth. Other ports are also considering projects to provide better on-dock or near-dock rail access and to improve the flow of truck traffic into and out of ports. Over some medium-distance destinations, it may be possible to promote barge operations to ease landslide congestion.

The use of new information technologies is likely to increase the global nature of shipping as buyers and sellers use the Internet to execute transactions worldwide as they solicit product bids, obtain freight rates, and charter ships online.

By 2025, port operations will be fully automated and information technologies, beyond today’s tracking and tagging, will specify where and when a container should be loaded and what time it should arrive at the port, eliminating storage needs while promoting seamless transfer of containers across transportation modes. However, these technological improvements will not obviate the need for people. Low-cost global positioning system (GPS) receivers can also improve operations. For example, very accurate positioning readings can help ship pilots find navigable channels, greatly reducing the need to dredge.

All of these technologies will help meet the higher expectations businesses will demand of transportation services: reliability, timeliness, efficiency, low cost, and damage minimization.

Deregulation

Since the late 1970s, both the nature and importance of regulation have changed as the federal government has undertaken some major deregulation initiatives. In the mid-1970s, nearly all interstate transportation was subject to government economic regulation. By 1999, the decisionmaking process covering entry, exit, pricing, and quality of service has been relinquished by the federal government and turned over to the carriers and to market forces. Regulatory emphasis has shifted from economic controls, such as rate and entry controls, industry concentration, labor relations, and antitrust immunity to safety, environmental, and capability concerns.

Significant deregulation legislation includes the Motor Carrier Act of 1980 for Interstate trucking; deregulation of intrastate trucking in 1994; the Revitalization and Regulatory Reform Act of 1976 and the Staggers Rail Act of 1980 for railroads; the Bus Regulatory Reform Act of 1982 for buses; the Airline Deregulation Act of 1978 for airlines; and the 1984 Shipping Act for ocean carriers.

Generally, the goal of deregulation has been to remove or reduce government-imposed constraints on the power of the market forces to determine industry economics. The desire to relax these constraints often grew out of recognition by the transportation enterprise that the conditions that stimulated the original regulatory actions no longer applied. In most cases, deregulation has been successful in creating conditions more conducive to industry success, but in some circumstances has led to decreased service options in rural areas.

This section on deregulation focuses on the far-reaching changes that resulted from the economic deregulation of the motor carrier (trucking and bus), freight railroad, aviation, and maritime industries, and looks at the impacts on transportation activity.

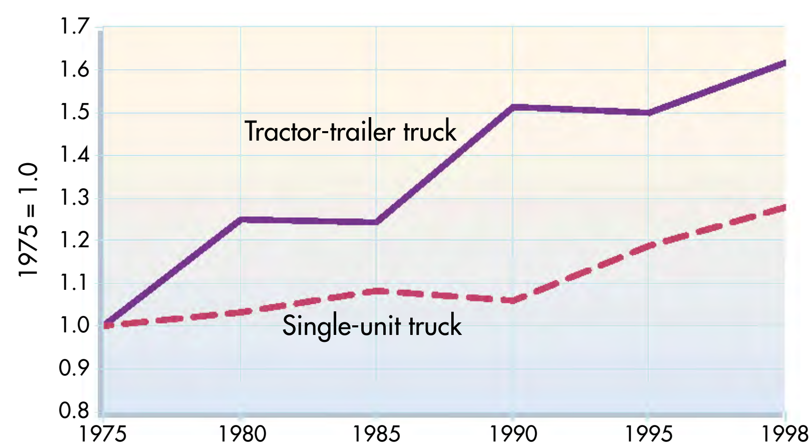
Motor Carriers

The motor carrier industry comprises truck and bus companies. In 1975, the motor carrier industry was regulated by the Interstate Commerce Commission (ICC). The ICC controlled routes of service and rates through its rate bureaus. Start-up companies were required to prove that their plan to provide new service was in the public's best interest. Only a limited number of truck and bus companies were authorized to provide service—18,000 truck companies in 1975 compared with nearly 500,000 today [USDOT FMCSA 2000]. Responding to concerns about the economic inefficiency of the trucking industry, the ICC loosened the entry standards in the late 1970s. The Motor Carrier Act of 1980 further eased barriers to entry.

Trucking companies were given authority to set rates independently, and most antitrust immunity for collective rate-making was eliminated. As a result, existing carriers expanded into new services with new routes and new, smaller carriers entered the business operations. In the years immediately following 1980, the use of private carriers ("in-house" trucking fleets) declined as companies chose to take advantage of lower rates and improved service by the for-hire carriers. During the 1980s, the number of motor carriers and commercial trucks increased (see figure 2-42 for growth in the number of commercial trucks). Today, there are nearly 500,000 trucking companies providing service, most of them with six or fewer trucks (table 2-6).

Figure 2-42

Index of Number of Commercial Trucks: 1975-98



Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: various years).

Deregulation also led to fragmentation of industry services and concentration of market power. Under the regulatory regime,

Table 2-6

Active Interstate Carriers by Fleet Size: 2000

Fleet size (number of power units)	Number of Carriers			
	Hazardous material	Passenger carriers	All others	Total
One	9,083	5,927	204,269	219,279
2 to 6	17,249	4,535	139,021	160,805
7 to 20	9,028	1,470	32,058	42,556
21 to 100	5,194	832	9,799	15,825
101 to 5,000	1,644	147	1,417	3,208
Over 5,000	17	1	8	26
Unspecified	1,410	2,360	80,587	84,357
Total	**43,625**	**15,272**	**467,159**	**526,056**

Note: Data include intrastate hazardous materials carriers.
Source: U.S. Department of Transportation, Federal Motor Carrier Safety Administration, *Motor Carrier Management Information System Report LS50B901* (Washington, DC: March 2000).

many carriers offered both truckload (TL) and less than truckload (LTL) services. But, under deregulation, carriers began to specialize in either LTL or TL with the vast majority of carriers entering the TL segment. Very few carriers entered the LTL sector, and the largest LTL carriers have increased their control of that segment even more significantly. Deregulation also increased the use of owner operators, drivers who own their vehicle and typically rent themselves out to larger carriers.

Increased competition has improved industry efficiency as carriers face constant pressure to reduce operating costs or risk losing market share to competitors. Since labor represents a relatively significant portion of total operating costs in the industry, drivers' wages have not been immune to this pressure. Since 1975, drivers' real earnings, adjusted for inflation, have declined. Coinciding with, and partially responsible for, this wage stagnation has been a decrease in the number of for-hire drivers represented by labor unions, with representation falling from a high of 60 percent in 1973 to below 25 percent by 1995.

Less than half of total trucking activity on the nation's highway network, measured by both ton-miles and value of shipments, occurs within state boundaries [USDOT BTS 1997b]. In 1994, 41 states still maintained some form of economic regulation over intrastate trucking. With interstate trucking deregulated, intrastate rates were 40 percent higher than rates for interstate moves of the same distance. The federal government removed intrastate regulations in 1994.

Bus companies, too, were given freedom to set rates and determine routes as a result of deregulation in 1982. Economic deregulation spurred strategic reorganization of the bus industry, created conditions for improved services, and, in certain cases, resulted in diminished services. Greyhound and Trailways joined forces in 1987 to provide a larger network of intercity bus service. In addition, new, smaller regional carriers have started providing service to specialized niche markets. These carriers not only serve geographic markets, but also sectors of the population, such as senior citizens, metropolitan commuters, vacation travelers, or luxury travelers. About 4,000 private motorcoach companies operate in the United States, offering charters, tours, regular route service, and other bus services [ABA n.d.].

Following deregulation and with increasing competition from airlines and automobiles, bus companies eliminated many unprofitable routes and stops, particularly in rural areas. In 1982, more than 11,000 locations were served nationwide, down from more than 16,000 in the early 1970s. Today, the number of locations served has fallen to just about 5,000, with much of the curtailed service in rural areas. The Federal Transit Act provides support for the intercity bus needs of rural residents.

Keys to the Future

Today, regulatory concerns focus on safety in both the truck and bus industry. The new USDOT Federal Motor Carrier Safety Administration (FMCSA) was created in 1999 by the Motor Carrier Safety Improvement Act to step up enforcement efforts and target more resources to ensure safety compliance. New efforts using information technology are underway to improve safety data collection, its timeliness, and dissemination to enforcement officials. The FMCSA was the first regulatory agency to move many of its regulatory process to the Internet in order to fully maximize public participation in its processes. This could have a major impact and help USDOT ensure safer movement of goods and passengers on our highways as we look to the future. For a discussion of safety trends, see Chapter 3.

Today, the motor carrier industry remains an integral part of the increasingly intermodal supply chains. By 2025, large logistics providers who today manage these supply chains will have their own truck fleets largely through acquisitions and mergers of existing motor carriers. These companies will also own air- and sea-based fleets to provide door-to-door service across the world. The increase in LTL shipments for just-in-time deliveries will provide opportunities for using smaller containers, compared to the 20- to 40-foot containers used today.

By 2025, the United States, Canada, and Mexico will have seamless cross-border movements truly creating a seamless North America. This will provide tremendous economic benefits to the entire region.

Freight Railroads

In 1975, the nation's railroads—once the cornerstone of the transportation system—were foundering under ICC regulations that dated back to the 19th century. They did not have enough capital to invest in new track and equipment and operated with unsafe and deteriorating equipment. In 1976, more than 47,000 route-miles—about 25 percent of the nation's total—were operated at reduced speeds because of dangerous conditions [AAR 2000a].

The Railroad Revitalization and Regulatory Reform Act of 1976 partially deregulated rail rates and expedited merger processing. That year, government-sponsored Conrail replaced seven bankrupt northeastern rail lines. In 1980, the Staggers Act gave railroads the freedom to set rates, subject to maximum rate regulation, and were allowed to abandon service on unprofitable rail lines.

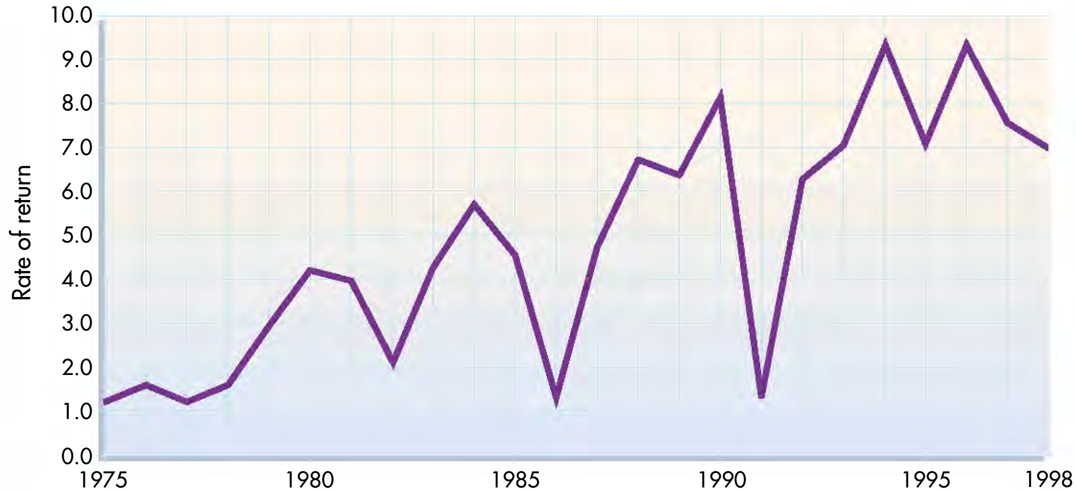
The Staggers Act was the springboard for the U.S. railroad industry. From 1980 to 1998, rail freight rates per ton adjusted for inflation declined an average of 38 percent and Class I (major) freight railroads averaged a 7.5 percent return on their net investment, up from 2 percent in the 1970s (figure 2-43). Figure 2-44 shows the Class I railroad performance indices for labor productivity, revenue ton-miles, revenues, and workforce from 1975 to 1998.

Over the past 20 years, the railroad industry experienced many changes:

1. The industry consolidated, and today, there are eight Class I (major) railroads in the United States. Class I railroads now own approximately 100,000 miles of road (route-miles), down from 192,000 in 1975. Figure 2-45 shows the 1998 volume of freight moved along various route lengths of the rail network, including Class I railroads, regionals, and short-lines.

Figure 2-43

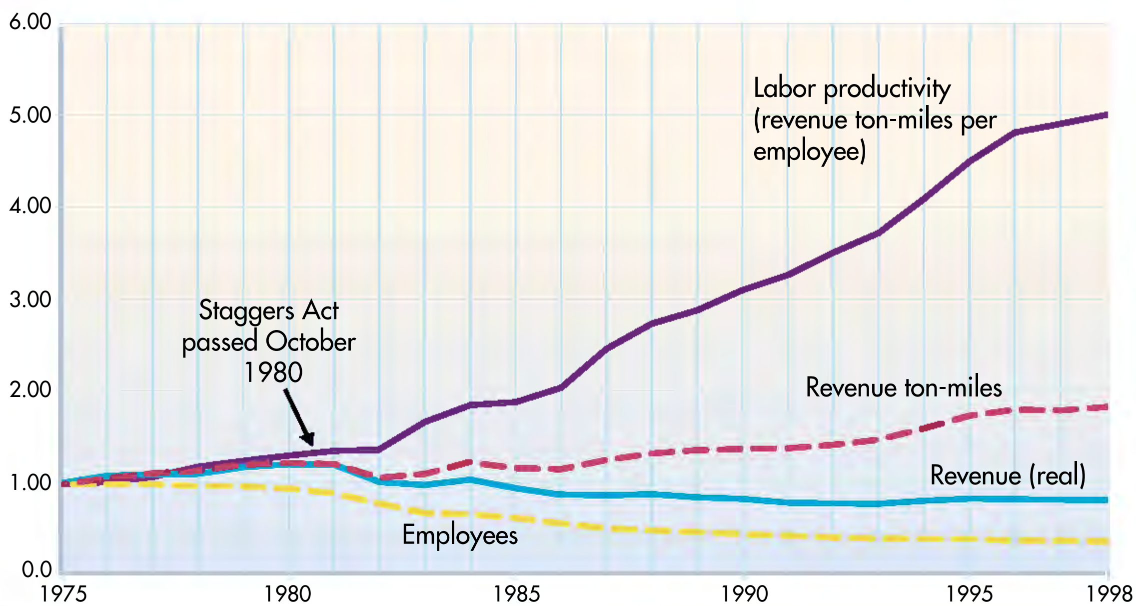
Class I Railroad Rate of Return on Net Investment: 1975-98



Source: Association of American Railroads, *Railroad Facts* (Washington, DC: various years).

Figure 2-44

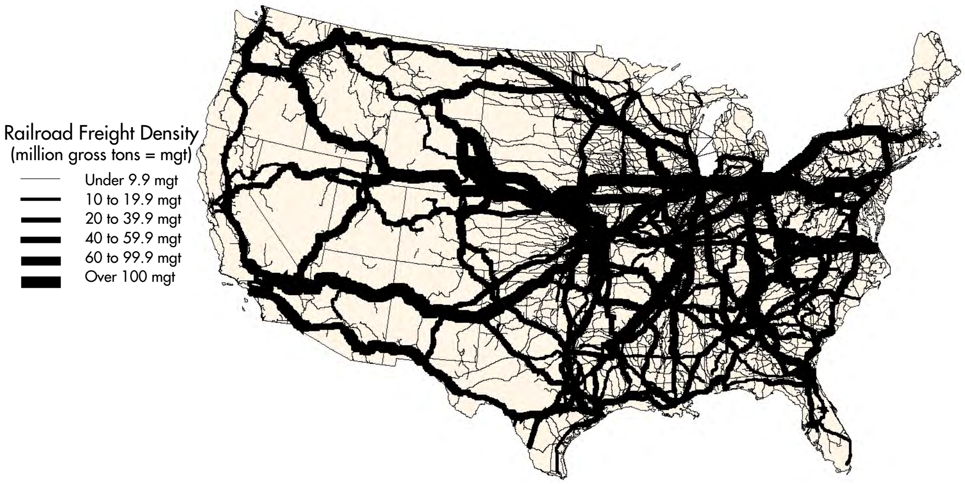
Class I Railroad Performance Indices: 1975-98 (1975 = 1.0)



Source: Association of American Railroads, *Railroad Facts* (Washington, DC: various years).

Figure 2-45

Railroad Network Showing Volume of Freight: 1998



Note: Data for Hawaii are not shown here as they have no freight railroads; data were not available for Alaska.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Atlas Database 2000 (Washington, DC: 2000).

2. Ninety-one thousand miles of rail line were abandoned or sold by major railroads. Many of the lines were sold to new, aggressive regional and short-line railroads. Regional and short-line railroads operated 50,000 miles of road in 1998 [AAR 2000a].
3. The railroads have undergone productivity growth that far outpaces the American economy as a whole [AAR 2000b].
4. Railroads established connections with trucking and ocean-shipping companies so that today, intermodal traffic has grown from 3.1 million trailers and containers in 1980 to 8.8 million in 1998 [AAR 2000b].

Between 1981 and 1995, the federal government increased funding to the states for rail freight planning and acquisition, rail facility construction, and rehabilitation. The Railroad Rehabilitation and Improvement Financing (RRIF) Program an innovative program of TEA-21, provides loans and loan guarantees for railroad capital improvements to state and local governments, corporations, railroads, and joint ventures that include at least one railroad for the first time ever in the rail industry.

The resurgence of the freight railroads proved so successful that Conrail was privatized in 1987. At that time, this was the largest initial public offering ever made in the nation's history. In 1999, Conrail was absorbed by CSX and Norfolk Southern in a historic consolidation tying East Coast and Midwest freight traffic to the South through two different systems.

Today, the overall challenges facing the railroad industry is to address issues of safety, congestion, productivity, and cost in an environment of ongoing mergers and consolidation. As the industry moves increasingly to consolidation, it is critical to maintain the competitiveness of the rail industry.

Keys to the Future

The Federal Railroad Administration expects rail ton-miles to increase from an estimated 1.46 trillion in 2000 to 2.40 trillion in 2025 and the rail freight industry to grow an average of 2 percent per year between now and 2025. This growth reflects the adoption of technological advances in communications, command, and control; more fuel-efficient locomotives; high-capacity, lightweight freight cars; and moderate traffic growth, led by intermodal traffic.

In this decade, the industry's movement toward mergers is expected to continue, and the number of major railroad systems may be reduced from today's seven to as few as two transcontinental railroads. There is uncertainty over the structure the railroad industry will take, however, in large part due to uncertainty over what rules will ultimately be applied to future railroad merger applications. Currently, there is a proceeding underway, initiated by the Surface Transportation Board (STB) proposing a rewrite of the merger rules. These proposed changes would require applicants to explore the consequences of possible merger activities of other railroads, provide service assurances to shippers, and enhance competition for the first time ever. The final rule, due in June 2001, will influence the speed and extent of future railroad mergers.

In the future, there is the possibility that non-railroads could acquire railroad systems and operate them very differently than they are operated today. Innovative transportation companies, such as the United Parcel Service, could acquire railroads to strengthen their multimodal operations and control the railroad's operation rather than be a customer of that railroad as we have historically seen.

The issue of access to rail lines of competing railroads will continue to be contentious. If, to increase competition, access is mandated by either the STB or Congress, the owning railroads could be faced with reduced financial ability due to more complex operations, and worsened service. Alternatively, such access could provide improved service if the additional carrier can provide innovative, low-cost service. The pricing of access is critical in order not to discourage the owning railroad from investing in roadway.

With increased financial pressures on the major railroads to provide improved service and reduce cost, one solution is to expand capacity. This is possible through adoption of technological improvements, such as Positive Train Control. In addition, out of financial necessity, these railroads may be more amenable to an increased federal government role in funding projects that provide both public and private benefits.

Aviation System

In 1975, the Civil Aeronautics Board (CAB) controlled market entry by new airlines, regulated cargo rates and passenger fares, provided government subsidy to airlines, and controlled interairline relations, such as mergers and agreements.

In 1978, the U.S. Congress passed the Airline Deregulation Act, ending four decades of economic regulatory policy that governed the development of domestic air transportation. Prior to 1978, air regulation came under intense criticism from academic economists, and later by lawmakers, who wanted open competition in the air industry to replace government control of entry, exit, pricing, and other industry structures. The 1978 Deregulation Act created conditions for competition, removed restrictions on domestic service entry, allowed market-based fares and pricing, made changes to antitrust laws to conform to general antitrust principles, recognized the need to continue service to small communities, and abolished the CAB [Brenner et al. 1985].

Deregulation changed the air industry structure, both in terms of the airlines offering services and the nature of the services offered. One major change in airlines' operations is the change in route structure from a linear point-to-point network, in which airplanes flew through a series of points collecting passengers along the route, to a hub-and-spoke network. The primary advantage of the hub-and-spoke network is that it allows airlines to connect several origins with multiple destinations without having all points directly connected. "Hubbing" allowed carriers to serve more markets without having to increase fleet size and seat capacity on flights to and from smaller cities, although total miles traveled could be higher. The hub-and-spoke system cut airline operating costs and allowed airlines to create more comprehensive networks to efficiently serve many different city-pair markets. It also resulted in fewer direct flights to destinations and allowed airlines to establish dominance at their hubs. Before deregulation, there were only a few airports with limited hub-and-spoke operations for the major carriers, including Atlanta, Chicago O'Hare, Denver, Dallas/Fort Worth, Minneapolis, New York, and St. Louis. At present, there are more than 20 airports designated as hubs by the major carriers (table 2-7).

Major airlines also withdrew from small markets to focus on their hub-and-spoke systems. At the end of 1978, large U.S.-certified airlines served 473 airports in 49 states and the District of Columbia (there was no service in Delaware) [USDOT FAA 2000a]. By the end of 1998, only 260 airports were served by large commercial air carriers [USDOT FAA 2000c]. This gap has been filled by regional airlines.

There has been a growing concentration of market share among the largest airlines. In 1999, the four most dominant airlines measured by enplanements were Delta Air Lines, United Airlines, American Airlines, and Southwest Airlines. The four largest carriers increased their percentage of total system enplanements from 40.7 percent in 1978 to 53.1 percent in 1998 (figure 2-46). The four largest carriers also significantly increased their share of total RPMs, expanding from 43.5 percent in 1978 to 65.3 percent in 1998 [USDOT BTS OAI n.d.(b)].

Small communities that lost airline service due to deregulation received subsidized services through the federal Essential Air Service program. When the program was started in 1978, 383 communities received subsidies. As of July 2000, 106 communities still receive subsidies, with 30 of those communities located in Alaska [USDOT Office of Aviation Analysis 1998].

While the major airlines implemented their hub-and-spoke systems, other parts of the commercial air carrier industry also changed:

1. The advent of Southwest Airlines extended the system it used in the unregulated intrastate Texas market, creating a model for new low-fare entrants. Cities across the country sought service from Southwest.

Table 2-7

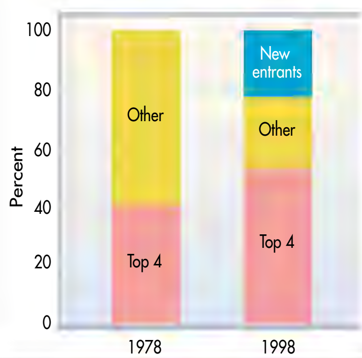
Airline Domestic Hubs

United	Chicago (O'Hare) Los Angeles San Francisco Washington, DC Denver
Northwest	Minneapolis/St. Paul Detroit Memphis
Continental	Houston New York/Newark Cleveland
U.S. Air	Philadelphia Pittsburgh Charlotte
TWA	New York (JFK) St. Louis
America West	Phoenix Las Vegas Columbus, Ohio
Alaska	Seattle Los Angeles Portland Anchorage

Source: Airline websites, as of August 2000.

Figure 2-46

Top Four Largest Carriers' Enplanements: 1978 and 1998



Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

2. Following Southwest's marketing strategy of focusing on short-haul routes and low-fare pricing, new entrants frequently served smaller and less used airports in metropolitan areas, cutting their operating costs and reducing the threat of congestion that would cause delays. In 1999, at least eight new airlines filed applications with the USDOT to begin scheduled domestic passenger jet operations [USDOT BTS OAI n.d.(b)].
3. New regional carriers, designated as commuter carriers prior to 1978, linked smaller markets to the major airlines' hub-and-spoke systems. These markets had frequently faced a loss of service as the major airlines consolidated to their hubs. The regional jets can carry up to 70 passengers, cruise at speeds of more than 500 mph, and have a range of about 800 miles, all significant improvements over earlier turboprop aircraft.
4. To provide small and medium communities with connecting service to and from large hub airports, to create traffic to feed their hub airports, and to maintain their market share, established airlines entered into code-sharing relationships with regional carriers.
5. Major airlines also created new, low-fare subsidiaries such as Delta Air Lines, Delta Express, U.S. Airways' Metro Jet, and the United Airlines Shuttle to compete with the new entrants.
6. Applying information technology, airlines implemented "yield management systems," which allowed them to sell different seats on the same flights for widely varying prices. Although purchase conditions were frequently complex, business travelers who purchased tickets closer to flight times generally paid significantly more than travelers who bought their tickets well in advance.

Deregulation also had a positive impact on fares. Between 1978 and 1998, real airfares have declined by more than 30 percent in domestic markets and by 43 percent in international markets, helping to create a mass market for air travel [USDOT BTS OAI n.d.(b)]. As a result of declining fares, the industry yield (revenues per RPM) has declined (figure 2-47), but the airlines remain profitable.

A 1999 USDOT study found that from 1979 to 1997, inflation-adjusted average fares increased 26 percent in short-haul markets without low-fare competition, but declined 36 percent in markets with competition [USDOT FAA 2000a]. The study also found differences in traffic growth. In short-haul markets with low-fare competition, passenger traffic has nearly quadrupled since 1979—an increase of 60 million passengers [USDOT 1999a]. Traffic in other short-haul markets grew by only 48 percent, or 26 million passengers, over the same period [USDOT FAA 2000a].

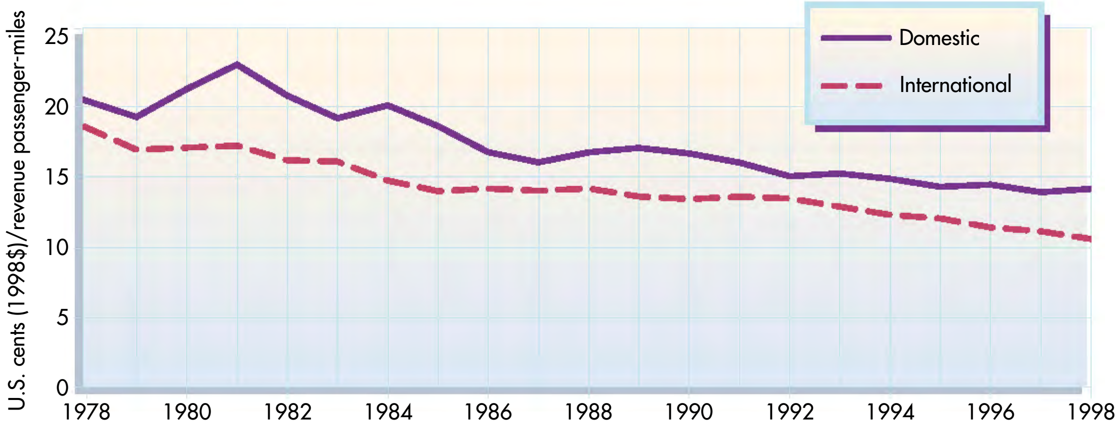
An analysis of 50 city-pairs representing a geographic sample of short- and long-haul markets, as well as travel in and between large, medium, and small hub airports, found variations in fare trends. Between 1979 and 1998, real fares increased in 16 of the 25 markets that were less than 700 miles apart. However, during the same time period, real fares declined in 21 of the 25 markets more than 800 miles apart and in 14 of the 15 city-pairs more than 1,100 miles apart [USDOT BTS OAI n.d.(b)]. Under regulation, short-haul fares were kept artificially low and were cross-subsidized by higher long-haul fares.

Keys to the Future

The issue of competition remains a major issue in the aviation industry. We must address growing concern by new-entrant airlines that major airlines have used anticompetitive practices to drive them out of markets. The USDOT and the Department of Justice (DOJ) have both taken steps against anticompetitive actions, including a USDOJ antitrust suit against American Airlines for anticompetitive actions on four routes from its Dallas-Ft. Worth Airport

Figure 2-47

International and Domestic Yield: 1978-98



Source: U.S. Department of Transportation, Federal Aviation Administration, *Working Paper on Aerospace Capacity and Demand* (Washington, DC: 2000).

hub. The USDOT identified best business practices, which airports could undertake to assure access to new entrants and carriers seeking to expand their service. A new law requires USDOT to analyze airports' competition plans in response to the AIR-21 [Public Law 106-181].

While deregulation has provided higher levels of service and lower fares to much of the country, certain areas have received fewer benefits. Travelers in some mid-sized cities on the East Coast and in the Midwest have experienced limited service and pay relatively high fares on certain routes. Since low-cost, convenient airline service is now a major factor in economic growth and our quality of life, provision of adequate air service to these communities remains an issue to be addressed.

Our efforts will continue to improve the efficiency of our air transportation system and enhance domestic competition so that the American public in all communities will reap the benefits of deregulation. We have to be visionary and vigilant to ensure that industry restructuring and alliances bring greater benefit to all air travelers. At the same time, we have to ensure that the regulatory environment does not curtail the profitabiliy of the industry.

Maritime

In 1975, the shipping liner industry operated on a regulated system of conferences established in the 19th century. These conferences were voluntary associations of ocean carriers that served as rate-setting mechanisms globally or on particular trade routes. Conferences also attempted to ensure strong support for national flag carriers.

The Shipping Act of 1916 endorsed antitrust immunity for conferences and adopted the concept of "common carriage" (all shippers, small or large, must be treated equally by carriers) as its guiding principle. This law regulated the ocean-shipping industry for the next 68 years. Meanwhile, technological advances in the industry, especially containerization, dramatically improved the industry's productivity in the 1960s.

The advent of containerization and the growing uncertainty about the future of the conference system led to calls for reform, culminating in the Shipping Act of 1984. This Act allowed the conferences to engage in collective ratemaking activities, but provided Federal Maritime Commission (FMC) oversight. The FMC's primary responsibility is to "protect the nation's oceanborne trade from unfair treatment by foreign governments and to ensure that carrier agreements do not unduly impair competition or adversely affect service or rates." The Commission also is charged with monitoring the rates and practices of carriers owned or controlled by their respective governments.

Box 2-8

The Jones Act

After World War I, Congress enacted the Merchant Marine Act of 1920, Section 27 of which is known as the Jones Act. The purpose of the Jones Act was to maintain reliable, domestic shipping services and to ensure the availability of the domestic merchant marine industry to U.S. armed forces in times of national emergency. The Jones Act fleet is a central component of American military sealift. More than 75 percent of the self-propelled ocean-going vessels over 1,000 gross tons in the Jones Act fleet are militarily useful. Approximately 124,000 U.S. citizens are employed under the Jones Act maritime industry's vessel crews or on shore-side jobs.

During the past 25 years, opponents frequently targeted the Jones Act for repeal. However, supporters focusing on national security impacts and economic implications have succeeded in preserving the Act.

The Jones Act requires U.S.-built, -owned, and -registered vessels to be used in waterborne commerce along the inland waterways, across the Great Lakes, along the U.S. seaboard, and between the U.S. mainland and noncontiguous U.S. states and territories. This practice is known as cabotage and has been part of U.S. policy since 1789. Cabotage also is common in most maritime nations; more than 40 industrial nations have cabotage laws similar to those of the United States.

During the 1990s, the shipping industry underwent major consolidation in an effort to improve the efficiency and productivity of the industry. Some of the important mergers were P&O Container and Nedlloyd, Neptune Orient and APL Ltd., and Sealand and Maersk. Liner carriers are currently using vessel-sharing arrangements with other carriers to improve productivity. As a result, individual companies have less need to provide direct services to multiple ports. Carriers can move cargo through a limited number of hub ports and use other intermodal transportation, such as train, air, truck, or vessel feeder services, to connect the hub with the cargo's ultimate destination or origin. In the United States, the ports of Long Beach and Los Angeles in California are the largest container hub ports in North America. Table 2-8 shows the hub ports in various world regions.

Table 2-8

World Container Port Ranking: 1998

Container traffic, TEUs* (000s)			
Rank	Port	Country	TEUs
1	Singapore	Singapore	15,136
2	Hong Kong	China	14,582
3	Kaohsiung	Taiwan	6,271
4	Rotterdam	Netherlands	6,004
5	Busan	South Korea	4,539
6	**Long Beach**	**USA**	**4,098**
7	Hamburg	Germany	3,588
8	**Los Angeles**	**USA**	**3,378**
9	Antwerp	Belgium	3,266
10	Shanghai	China	3,066
11	Dubai	UAE	2,804
12	Tokyo	Japan	2,495
13	**New York/New Jersey**	**USA**	**2,466**
14	Giola Tauro	Italy	2,126
15	Yokohama	Japan	2,091

*TEUs = 20-foot equivalent units.

Source: Mark Lambert et al., *Containerization International Yearbook 1999* (London: Emap Business Communications, Ltd: 1999).

Under pressure for deregulation from the shipping industry, the U.S. Congress passed the Ocean Shipping Reform Act (OSRA) in 1998. OSRA allows shippers and ocean carriers to enter, for the first time, into confidential service contracts that must be filed only with the Federal Maritime Commission. Under previous Acts, the carriers had to share this infor-mation with all other shippers, small or large, who could then demand similar rates from ocean carriers. Now rates may be negotiated on a case-by-case, one-to-one basis between shippers and carriers. This deregulation may eventually lead to disbanding of the confer-ences because they would effectively be unable to set rates. OSRA strengthens provisions that prohibit unfair foreign shipping practices and provides greater protection against discrim-inatory actions. It could also lead to another round of consolidation in the industry.

In 1999, the USDOT collaborated with other federal agencies to develop a bold and comprehensive plan to modernize our nation's Marine Transportation System (MTS), as required in the U.S. Coast Guard Authorization Act of 1998. The MTS vision is to be the world's most technologically advanced, safe, secure, efficient, globally competitive, and environmentally responsive system for moving people and goods by 2020.

Keys to the Future

The consolidation of ocean liner-shipping companies and vessel-sharing activity has raised questions about the importance of nationality among carriers, as well as concern that national and economic security could be weakened by the blurring of carrier nationalities. We are likely to face questions about the extent of the liner-carrier industry's globalization through the consolidation process.

The full effect of the 1998 changes is not yet clear, but the liner industry's trend is toward hub ports. Major carriers, many of them newly consolidated, are using only a limited number of ports and employing intermodal transfers to connect with other locations. This trend emphasizes the importance of intermodal connections at ports and also raises questions about future investment in nonhub ports.

Intermodal Freight Transportation

The U.S. transportation system, responding to domestic economic growth, global competition, and advances in information and production technologies, has undergone major changes in the freight transportation industry—what is being transported, how it is transported, and the origins and destinations of the transported goods. This section looks at how these changes have evolved over the last quarter century, particularly intermodalism. Intermodalism is a term used to describe the movement of freight through the transportation system using two or more modes that interconnect and interchange, allowing timely and cost-efficient delivery.

This section also discusses the growth in container use; the rise in global markets; shifts from a manufacturing to a service economy; a general shift from a supplier-driven, high-inventory freight logistics ("push") system to a consumer-driven, low-inventory, just-in-time freight logistics ("pull") system; and e-commerce. See Chapter 5 for a similar discussion of the changes in the passenger transportation industry.

Advances in technology and efforts to improve productivity led the move to intermodal freight shipments. During the past 25 years, motor carriers, railroads, and ports have invested in container facilities as they recognized the efficiency of containerized transport. Growth in container transportation worldwide and associated developments by railroads and ports have resulted in growth in intermodal transportation. The growing demand for intermodal transport has also spurred demand for larger, specialized container ships and enough inter-modal capacity to handle increased landside traffic. Today, an increasing proportion of cargo from the Pacific Rim moves through West Coast container ports, particularly Los Angeles and Long Beach, for destinations not only on the west coast, but throughout the nation.

Freight movement is increasingly becoming "mode invisible" with performance (time, cost, and reliability) determining the choice of mode or modes. The ability to interchange goods between modes in a timely, cost-effective manner (primarily through containerization) has become crucial to measuring system performance. Today, freight transportation logistics goals are performance-based, rather than modally based, and the ability to interconnect and interchange among modes to optimize the end-to-end movement of freight is vital. At the same time, the individual modes continue to fill market niches (e.g., high-speed, or low-cost), within an intermodal framework.

In 1975, waterborne commerce dominated international trade tonnage and value. Trucking was the leading mode of domestic freight transportation from the standpoint of value, while rail was the leader in terms of ton-mileage. Domestic waterborne commerce via barges along the inland waterways, Great Lakes, and coastwise routes was important, but handled less tonnage and value than either truck or rail. The intermodal container, first introduced in 1956 for domestic ocean/truck services, began a period of accelerated growth. However international container shipping had not begun its period of explosive growth, and domestic intermodal and doublestack rail services had not been initiated.

Today, water continues to handle more international cargo by value, and substantially more international cargo by weight, than any other mode. But, growth in high-value trade with Canada and Mexico (principally by truck, but also by rail and pipeline) has led to a substantial share of U.S. international trade by value for trucks. Growth in the global market for high-value, time-sensitive goods also has led to a substantial international trade value for air cargo. Domestically, trucks still carry more freight by value, and rails carry more ton-miles. Trucks increased their share of intercity tonnage, while river barges and Great Lakes and coastwise shipping had a slightly reduced share (although actual tonnage increased). In terms of ton-miles, both rail and truck increased their share of total movement, while the waterways remained relatively constant. Figure 2-48 shows domestic ton-miles of freight from 1975 to 1997. Figure 2-49 shows the domestic ton-miles of freight moved by different modes during the same period.

To assemble the most efficient intermodal freight system, carriers have diversified and, in many cases, consolidated. Companies, such as FedEx, UPS Worldwide Logistics, Hub Group Logistics, Schneider Logistics, and Ryder Dedicated Logistics, have created air-truck, rail-truck, ocean-truck, and ocean-rail combinations to become the leading players in domestic and worldwide freight movements.

Box 2-9

Intermodal Transportation and Supply Chains

Intermodal transportation, with options for integrating multiple modes, provides a flexible response to the changing supply chain management requirements in global markets and distribution systems. Integrating modes requires a process or systems approach for execution and a higher degree of skill and broader knowledge of the transportation/supply chain processes—information, equipment, and infrastructure. Intermodal transport, as it moves from a focus on infrastructure components to a holistic focus on process or systems, will have more viability and applicability in the world of global supply chain management.

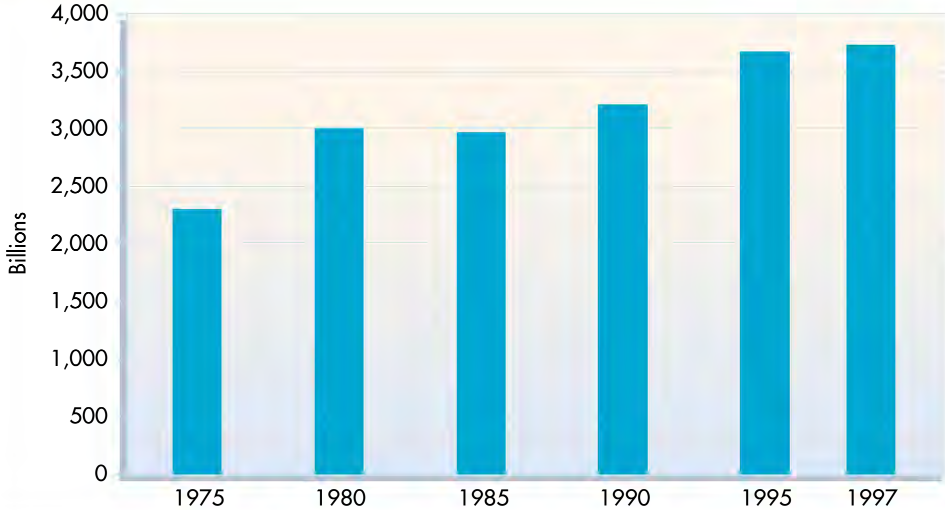
A supply chain is defined as a set of three or more organizations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer. Supply chain management is defined as the systematic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.

It is in this time of information and communications technology and capability that the supply chain processes, and the modes supporting those processes, are gaining the capability of being integrated.

Source: W. DeWitt and J. Clinger, *Intermodal Freight Transportation*, Transportation Research Board, Transportation in the New Millennium (Washington, DC: 2000).

Figure 2-48

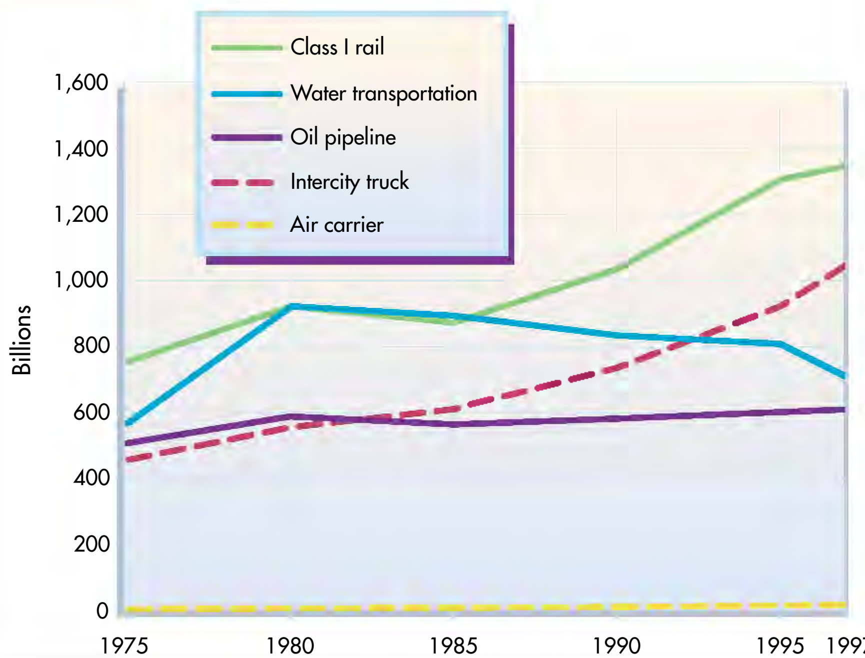
Total Ton-Miles of Freight: 1975-97



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics* (Washington, DC: 1999).

Figure 2-49

Domestic Ton-Miles of Freight: 1975-97



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics* (Washington, DC: 1999).

National to Global Markets

The U.S. freight system has been driven by the rapid growth of international trade, which has influenced the development of marine cargo facilities, air cargo facilities, land border crossings, and domestic access infrastructure to connect these international ports of call with domestic U.S. origins and destinations.

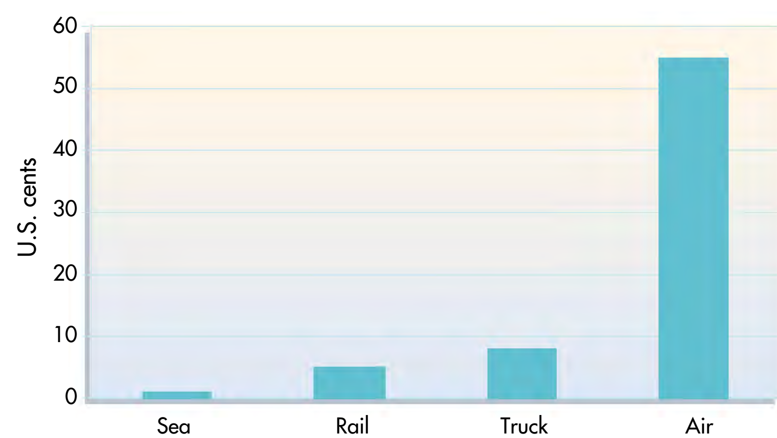
In 1975, U.S. freight transport was organized to serve regional and national markets. With much of the Interstate highway system (IHS) in place by 1975, businesses had built a truck freight system organized around regional and national supply chain and distribution networks. Trucking had displaced the railroads as the dominant mode of domestic freight transportation, just as the railroads had displaced the riverboats and barges a century earlier. In most cases, trucking was more flexible and more time-sensitive than rail service, and could provide customized service to manufacturers and distributors. Domestic truck transportation accounted for a growing portion of the nation's total freight shipments by value, although railroads carried more by tonnage.

In 1975, international trade accounted for a modest portion of total U.S. freight movements with the majority of this trade moving between Europe and east coast ports. Cross-border trade with Canada was growing, especially among automobile manufacturers, but trade with Mexico and Latin America was limited. A wave of growth in expanding global markets was being felt on the west coast, where the surge in trade with Japan and Korea was reshaping the west coast ports and transcontinental rail service.

Today, the continuing growth in international trade has sparked a push for upgraded seaports, airports, rail terminals, border crossings, air cargo facilities, and navigation channels, as well as the highway and rail access corridors needed to support them. Water transport carries the most international cargo by weight and also by value, because it is the most inexpensive mode of transportation (figure 2-50). Air cargo also hauls a growing share of international trade by value, stemming from the growth in the global market for high-value, time-sensitive goods. Trucks, taking advantage of the growth in trade with Canada and Mexico, also move a substantial share of international trade by value.

Figure 2-50

Average Cost of Transporting One Ton One Mile: 1998



Source: K.C. Sjetnan, 1999, *Cargo Systems, The Future of the Container Shipping Industry* (London: IIR Publications, Ltd.).

Japan and Korea are still our major western Pacific trading partners, but the Asian market has expanded to encompass China and some Southeast Asian nations as our top trading partners. Despite the recession in East and Southeast Asia in 1997, the volume of freight in the Pacific trade continues to grow and is triggering additional port expansions around the Pacific Rim.

The North American Free Trade Agreement (NAFTA) has increased trade between the United States and Canada, and between the United States and Mexico. The European Union (EU) and NAFTA experience has spurred the formation of the MERCOSUR (Southern Common Market) free-trade agreement among the major South American economies, as well as a series of ongoing negotiations to integrate the Caribbean and Latin American economies into a broad trade zone of the Americas.

Manufacturing to Service-Based Economy

The types of commodities moved on the freight system are directly related to the structure of our economy, which determines production and consumption patterns. Over the past 25 years, the U.S. economy has expanded its industrial output while evolving to an information and service-based structure.

The U.S. economy in 1975 was transitioning from a manufacturing economy to a service economy. It was recovering from the economic and social impacts of the Vietnam War, but growth alternated with periods of sharp recessions. Unstable fuel supplies and prices sent shock waves through the economy, dampening domestic and international trade.

The U.S. economy was losing manufacturing jobs to the booming, low-wage Asian economies. Traditional manufacturing jobs were being replaced by jobs in the growing service industries (i.e., business services, health services, and finance), and in the technology sector. The resultant economic pressures resulted in a massive restructuring of the U.S. business enterprise. By 1975, businesses were lobbying for lower freight transportation costs and better freight services to facilitate establishment of manufacturing facilities abroad.

Today, the economy's service sector is larger than all other sectors in output and growth potential. It also has fueled the longest period of economic expansion in U.S. history. The service-producing sectors of the economy now account for about two-thirds of the nation's economic output and three-quarters of its jobs. This economy is slowly shifting from mass manufacturing and distribution toward custom manufacturing and retailing—a world of mail-order houses and overnight delivery.

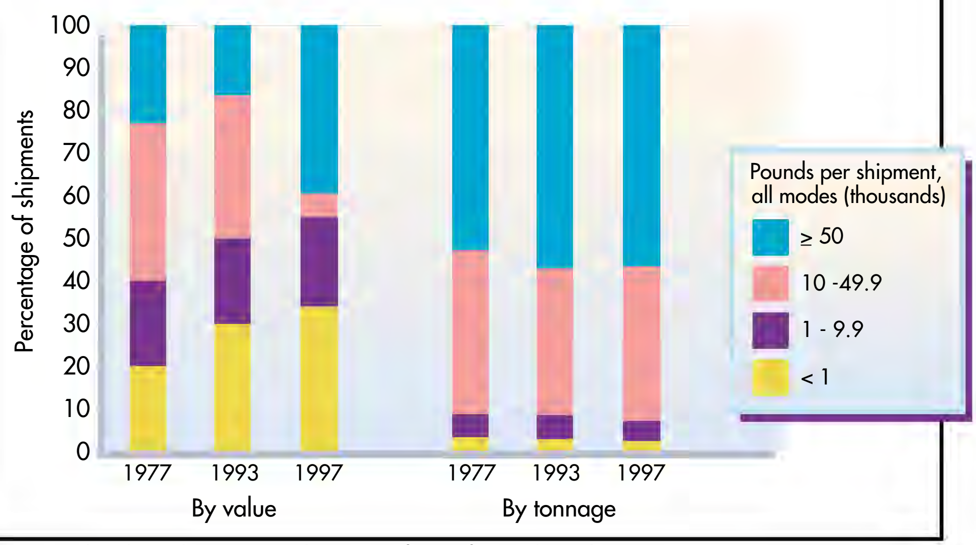
These changes in the U.S. economy have transformed the nature of the freight moved in both domestic and international markets. More freight is being moved over longer distances. This freight is lighter (with more frequent shipments) and higher in value, on average, than it was 25 years ago (figure 2-51).

The cost per unit of moving freight has dropped significantly from 25 years ago. Total logistics costs (e.g., transportation, warehousing, administration, and insurance) account for a significantly smaller proportion of the GDP than in 1975. Inefficient freight operations have been reorganized and new logistics practices adopted.

The relative shares of U.S. domestic versus U.S. international freight movement have also changed. Domestic freight still accounts for the dominant share by volume and value, but the share of international freight by value is growing.

Figure 2-51

Freight Shipments by Value and Tonnage: 1977, 1993, and 1997



Note: 1977 data limited to primary shipments of manufactured goods.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Commodity Flow Survey data (Washington, DC: Various years); and U.S. Department of Commerce, Census Bureau, Commodity Flow Survey data (Washington, DC: Various years).

Just-In-Time Systems

Another critical element of freight transportation is the relationship between consumer and producer, which encompasses the logistics decisions a producer makes to optimize performance, customer service, and profitability. Today's businesses often require higher priced, higher quality transportation to assure timely product deliveries with little product loss or damage. As business manufacturing and delivery practices have changed, so too have transportation modes to fit a dynamic economy moving toward lower overall production and distribution costs.

The logistics system of 1975 was a "push" system. Manufacturing, distribution, and retailing were organized to support mass production, warehousing, and retailing.

In the push system, large hierarchical corporations used centralized design, production, and marketing to achieve economies of scale. These integrated manufacturers purchased materials and components from suppliers in large batches. Long production runs by the manufacturer generated large inventories of finished products, which were warehoused by distributors until shipped to retailers and customers. Throughout the process, large inventories were maintained to buffer against changes in supply and demand cycles. Transportation was organized to move goods through the logistics chain from supplier to manufacturer, to distributor, and to the retailer. Each link was operated independently and managed and priced within strict guidelines.

Today, the logistics system is increasingly a "pull" system. Retailers, distributors, manufacturers, and suppliers track customer demand daily and hourly through point-of-sale cash registers and electronic purchase order data interchange. Orders and purchase patterns pull goods through the supply chain. Increasingly, industries do not produce parts and final products until an order is placed, giving rise to just-in-time manufacturing and retailing systems.

This shift from a "push" to a "pull" system is a result of the information revolution brought about by computer and communication technologies. The "pull" system tailors products and delivery to consumers' needs and business cycles. The risk of over- or under-production is reduced, as is the need to maintain large, costly inventories.

The information revolution and the "pull" logistics system have reshaped freight transportation. With improved communications and control, manufacturers and retailers have substituted more frequent and longer distance transportation services to obtain lower cost labor and supplies. This pressures carriers to provide integrated and intermodal transportation services that are cost-effective, timely, reliable, and can be tracked from door-to-door. Third-party logistics companies (3PLs) have emerged as the dominant brokers of transportation services, often handling the whole freight trip from manufacturer to customer. Fourth-party logistics companies (4PLs) are an emerging trend.

Keys to the Future

The rate of public investment in domestic freight infrastructure is lagging behind changes in freight movement patterns. Growth in government investment in intermodal connectors providing access to ports, airports, marine terminals, rail terminals, and truck terminals has not kept pace with growth in international and domestic freight and changing logistics strategies of business and industry, creating even greater needs for public - private partnerships and investments.

The nation's highway and rail freight systems, which were developed for the east-west trade, are being strained by the north-south NAFTA trade, especially at border crossings. Trade flowing from South Asia via the Suez Canal is forcing reinvestment in older east coast ports, and the growth of Latin American trade may soon overwhelm Florida and Gulf ports. The demand for international air cargo service, much of it carried as belly cargo in wide-body passenger planes, could outstrip the supply of planes and ground facilities handling capacity.

Passengers and freight are competing for space on crowded transportation facilities, such as highways, freight railroads, and airports. Freight service will face questions of incompatibility with new high-speed passenger rail. At seaports, containerships compete for space with cruise ships; and on congested highway freight corridors, truck-only lanes, or truckways, may be an option.

Improving intermodal connectors became a focus of federal policy in the 1990s, but new policies and programs may be needed, especially where connectors span many jurisdictions. It may be necessary to examine the financing of local freight-related improvements that provide regional and national benefits.

The public or private sector, or some form of partnership between the two may need to finance building truck staging and rest areas to improve carrier productivity and reduce truck travel in urban settings. There also may be a need to improve staffing, skills, data, and planning tools needed to support freight planning and investment at the federal, state, and local levels.

As U.S. carriers and 3PLs expand globally and foreign operators move into the U.S. transportation market, competition will intensify. Governments will be faced with balancing the needs of domestic companies against the free and open international movement of freight. There will be questions of providing support and coordination for efficient operations such as free and fast passage of freight and personnel, standardization of policies affecting equipment and lading, fair access to foreign ports and airports, and protection from subsidized competition.

Box 2-10

Third- and Fourth-Party Logistics

The growth in U.S. freight transportation and the deregulation of transportation services created opportunities for new transportation services, increased competition among transportation service providers, and changed the relationships between shippers, consignees, carriers, and intermediaries. These changes, in part, led to the emergence of third-party logistics (3PL) service providers in the early 1980s and, more recently, to fourth-party logistics (4PL) providers.

As production, distribution, and customer expectations changed, so did firms that provide logistics services. In 1980, a third-party logistics service described a for-hire provider that performed outsourced functions, such as carrier selection, warehousing, rate negotiations, and freight payments. Today, these companies provide more services, including logistics information systems, inventory management, customer order management, and real-time information feedback to customers.

Fourth-party logistics service describes a for-hire provider that manages an entire supply chain by integrating the resources, capabilities, and technology of its own firm with those of complementary service providers to deliver a comprehensive supply chain solution to customers. These firms provide value-added services beyond the traditional logistics functions, such as business strategy consulting, business redesign, technology integration, management of multiple service providers, and migration to e-systems.

Today, the average number of outsourcing relationships with logistics providers has risen to more than 6 per company in certain industries, with more than 50 percent of Fortune 500 companies having at least one contract with a 3PL provider. Industry estimates indicate that, by 1999, gross revenues for outsourced logistics totaled nearly $46 billion and are expected to increase rapidly in coming years.

Industry consolidation and e-commerce are two key factors that will change the future of 3PLs and 4PLs. For the immediate future, industry experts speculate that major acquisitions and mergers of 3PLs in Europe in 1999 may spark a similar trend in the domestic U.S. logistics market. Providing superior solutions to manage the logistics needs of Dot-Com retailers and the business-to-consumer market will determine how competitive 3PLs and 4PLs will become in the ever-expanding global marketplace.

Sources: Logistics Management and Distribution Report, 2000 Annual Report Online; S. Boyson, T. Corsi, M. Dresner, and E. Rabinovich, Managing Effective Third Party Logistics Relationships: What Does It Take?, *Journal of Business Logistics*, vol. 20, no. 1, pp. 73-100 (1999); T. Prince, Onward in the Brave New World of Logistics, *Journal of Commerce*, available at http://www.joc.com/, as of Aug. 20, 2000.

Concerns exist about the effect of the concentration of market power in a small number of private 3PLs and retail distribution companies. Competition resulting from economic deregulation could be undone by the market dominance of a limited number of carriers or 3PLs or both.

With 3PLs emerging as the new business model for transportation and logistics, questions exist concerning their impact on competition and safety and whether there is a need for additional or redesigned regulation. Further changes in regulation may be needed to respond to the industry’s shift to shared containers and truck chassis, vessel-space chartering agreements, and expanded use of independent owner-operators.

After two decades of consolidation, the rail industry may face questions about open access in order to produce competition at a time when there are pressures for transcontinental rail freight systems. There also are questions of whether regulatory streamlining of customs clearance operations and truck size, weight, and safety enforcement will keep pace with market growth and freight movement.

We may have to consider workforce-related issues, such as shortages of trained truck drivers (each driver turnover costs about $8,000 in replacement and training costs) and railroad engineers, worker training, and modifications of work rules.

Despite significant gains, some challenges remain because of global trends. Our nation has become an increasing part of a global economy and has expanded its manufacturing capability, while transforming itself to a largely service-based economy. The relationship between consumer and manufacturer has become much more direct, with shorter production cycles and delivery times, increased customization, and sharply reduced inventory. Advanced information technologies and e-commerce have enabled better control over material and information and facilitated business-to-business and business-to-consumer communications.

The dynamic changes of the past 25 years have created an efficient, market-driven freight system, providing a variety of time-sensitive and lower cost services to consumers and producers. This freight system stimulated the economic expansion of the 1990s and itself was positively changed by the economic growth it helped spur.

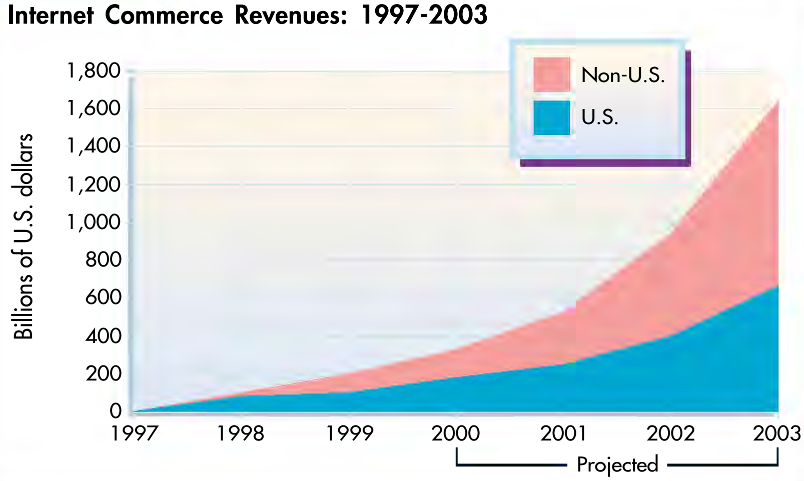
Box 2-11

E-commerce

By expanding marketplaces, the Internet is having a major, if not yet fully realized and understood, affect on business. According to one estimate, e-commerce revenue is expected to top $1,600 billion by 2003 (figure 2-52). The U.S. share of users and revenues is expected to decline somewhat in the future (figure 2-53). E-commerce results in fewer personal shopping trips, but requires more delivery trips. However, the practical impact of e-commerce on transportation is uncertain. As much as 90 percent of e-commerce, appears to be business-to-business (B2B) transactions, rather than business-to-consumer (B2C) sales known as "e-tailing." E-commerce may result in a shift in how goods are purchased, as well as how they are delivered.

Figure 2-52

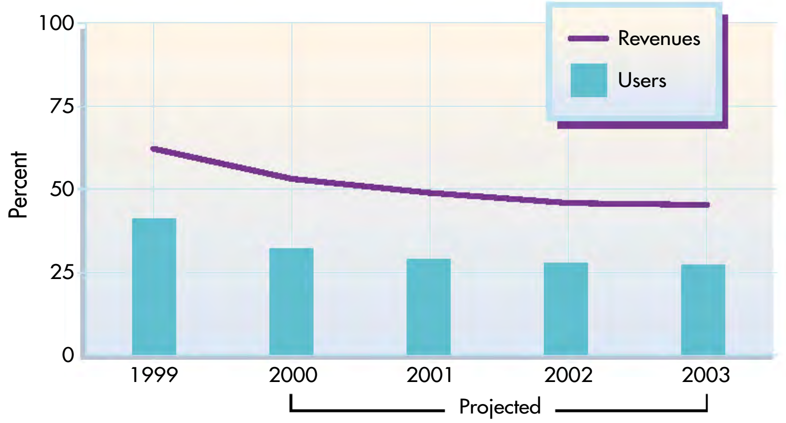
Internet Commerce Revenues: 1997-2003



Source: International Data Corp., EBusiness Trends, *Internet Commerce Market Model,* Vol. 6, no. 1, 2000, available at http://www.idc.com, as of May 15, 2000.

Figure 2-53

U.S. Percentage of Web Users and Internet Commerce Revenues as a Proportion of World Share: 1999-2003



Source: International Data Corp., EBusiness Trends, *Internet Commerce Market Model,* Vol. 6, no. 1, 2000, available at http://www.idc.com, as of May 15, 2000.

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chapter 3

Safety

" There is need for a real emphasis on safety in all highway program funding. Safety should be a 'North Star' for every one. It cannot be just the direction for the USDOT."

Dr. Robert Scopatz
Kissimmee, Florida
2025 Visioning Session, Atlanta, GA, Mar. 13, 2000

"Seat belt use is just as important to transportation safety as vaccinations are to disease. We must look at seat belt use as a public health issue."

Dr. Marvin Liebovich
2025 Visioning Session, Apr. 20, 2000

chapter 3

Safety

The public embraced the need for higher levels of transportation safety in the late 1960s and early 1970s, creating a climate for new safety initiatives. Since then, the focus on safety within the U.S. Department of Transportation (USDOT) has progressively increased. Today, safety is the Department's "North Star." Working closely with other levels of government and the private sector, the USDOT is aggressively pursuing safety initiatives in all modes of transportation: highways, motor carriers (trucks and buses), transit, railroads, aviation, the maritime industry, and pipelines.

Over the last 25 years, many new transportation safety measures have been successfully implemented. Death and injury rates have been reduced on the roads, rails, and waters, as well as in the skies. In 1975, transportation-related incidents were the sixth leading cause of death in the United States, accounting for nearly 50,000 fatalities. By 1998, transportation-related incidents had become the eighth leading cause of death, accounting for nearly 44,000 fatalities (figure 3-1) in which 41,501 people died on the nation's roads, 667 in air crashes (none of these involved U.S. air carriers), and more than 1,500 were from other transportation-related incidents [USDOT BTS 1999]. Table 3-1 shows the detailed distribution of transportation-related fatalities for all modes in 1998, the latest year for which these numbers are available.

"Safety is President Clinton and Vice President Gore's highest transportation priority, and reaching this goal will benefit all. I call on you, the safety leadership of America, in partnership with the Department, to join us in a renewed effort to increase seat belt use and reduce catastrophic loss of lives on our highways."

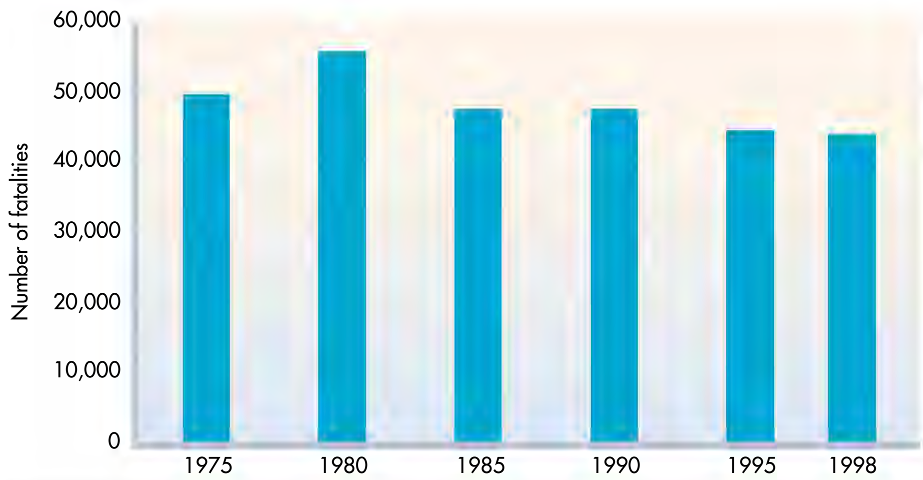
Rodney E. Slater,
Secretary, U.S. Department of Transportation
Mar. 13, 2000

This improvement in safety took place while travel across all modes of transportation increased substantially. The success of safety programs is especially visible on our highways. The fatality rate per 100 million vehicle miles traveled (VMT) for highway traffic crashes (which constitute more than 90 percent of all transportation-related fatalities annually) has been reduced by more than half. The fatality rate went from 3.4 in 1975 to 1.5 in 1999 (figure 3-2), while the VMT nearly doubled during the same period [USDOT NHTSA 2000].

USDOT has set specific targets for the next few years to improve transportation safety. These include President Clinton's goal to reduce child fatalities in highway traffic crashes by 25 percent by 2005, Vice President Gore's initiative to reduce the U.S. commercial air carrier fatal crash rate by 80 percent by 2007, and the USDOT's goals to reduce highway fatalities by 20 percent by 2008 and commercial truck-related fatalities by 50 percent by 2010. Specific rail safety [USDOT OST and FRA 1996], transit safety [USDOT FTA 2000], maritime safety [USDOT 1999], and pipeline safety [USDOT RSPA 2000a] initiatives also are in place.

Figure 3-1

Total Fatalities in All Modes of Transportation: 1975-98



Note: For 1975, 1980, and 1985, there may be some overlap in fatality numbers between various modes. The overlaps may affect 1 percent of data and would not impact the shape of the graphic. 1998 numbers are based on preliminary BTS estimates.

Sources: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: April 1999), Table 3-1, page 203.

Table 3-1

Transportation Fatalities by Mode: 1998 and 1999

Fatalities by mode	1998	1999
Highway	41,501	41,345
Percent change from previous year	-1.29	-0.30
Recreational Boating	813	773
Percent change from previous year	-0.97	-4.92
General Aviation	621	622
Percent change from previous year	-5.91	0.16
Railroad	577	530
Percent change from previous year	-4.15	-8.15
Highway-Rail Grade Crossing	431	402
Percent change from previous year	-6.51	-6.73
Transit (1997-1998)*	275	286
Percent change from previous year	4.17	4.00
Commercial Maritime Transportation**	107	154
Percent change from previous year	-30.52	43.93
Pipeline	18	26
Percent change from previous year	80.00	44.44

*1999 transit data are unavailable.

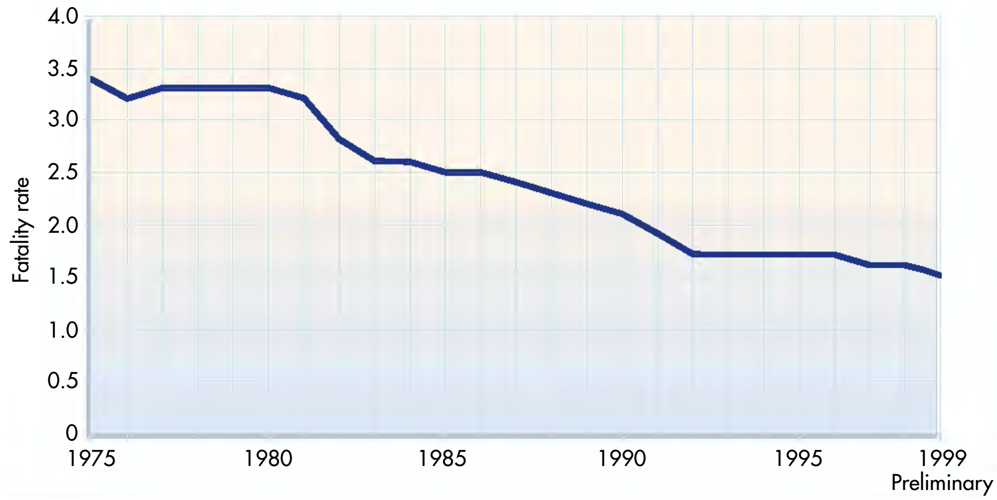
**1999 data are preliminary and subject to change as state and local jurisdictions close fatal accident cases.

Note: Summing the numbers in the table will not result in a correct count for all fatalities because some are double counted.

Sources: Data compiled from various government agencies as cited in the U.S. Department of Transporation, Bureau of Transportation Statistics, *National Transportation Statistics 1999*, table 3-1, available at http://www.bts.gov/ntda/nts/nts.html, and the U.S. Department of Transportation, *1999 Performance Report/2001 Performance Plan,* available at http://www.dot.gov/ost/ost_temp/. Preliminary highway data for 1999 are from the U.S. Department of Transportation, National Highway Traffic Safety Administration, personal communication, October 2000.

Figure 3-2

Motor Vehicle Crash Fatality Rate Per 100 Million Vehicle-Miles Traveled: 1975-99
(Annual rates)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

As we start this new century, the United States has one of the safest transportation systems in the world. New strategies are being developed to continue the success of the last quarter century as the returns from past programs near saturation. In the decades to come, we will strive to make our transportation system even safer by being visionary and vigilant and by using new technology that complements laws, regulations, and enforcement measures.

Human error is a leading contributor to transportation-related safety problems, and research in understanding the human factors appears to be one of the key areas for future emphasis. The National Science and Technology Council's National Transportation Science and Technology Strategy highlights human performance and behavior as one of the research areas that could dramatically transform transportation in the coming years. The USDOT, through its multimodal Human Performance Coordination Committee, has set specific goals and is leading the effort to make the transportation system safer by promoting research and development in this field (box 3-1).

In March 1999, the USDOT hosted the first-ever National Transportation Safety Conference and brought together the entire transportation safety community across all transportation modes. At this conference, the safety community adopted the motto "safety is a promise we make and keep together" and identified 10 top goals and objectives that led to the creation of a National Safety Action Plan. These action goals are held together by a collaborative leadership effort to mobilize the public and private sectors to:

1. promote and require use of safety equipment in all transportation modes,
2. promote a culture of safety for all transportation modes and the population,
3. increase research of performance factors across all transportation modes,
4. adopt a federal uniform law of 0.08 percent blood alcohol concentration for drivers and a zero tolerance level for truckers,
5. increase funding to support enforcement of existing transportation laws and regulations,
6. maximize existing safety partnerships,

7. do a better job of data collection and reporting across all jurisdictions,
8. implement fatigue management practices,
9. increase use of technology to improve safety in all transportation modes, and
10. improve international safety cooperation.

Since the conference, this collaborative effort has yielded key improvements in addressing safety. In October 2000, President Clinton signed into law a national impaired driving standard of 0.08 blood alcohol concentration. This will reduce drunk driving on the nation's roads and save lives. Together we have taken steps to improve transportation safety data for strategic and operational decision, to develop and use advanced safety technologies, and to fund the enforcement of transportation-related laws and regulations. In addition to the top 10 goals, the USDOT has major programs to address human-performance related safety issues.

Box 3-1

Human Performance Factors

Human performance-related problems play a significant role in the safety of U.S. transportation systems. Because 70 to 90 percent of transportation crashes involve human error, reducing or mitigating these human errors can have a significant impact on associated human, environmental, and financial costs.

The USDOT has established a multimodal Human Factors Coordinating Committee (HFCC) as the focal point for human factors issues within the Department. The HFCC's responsibilities include developing and implementing a national strategic agenda for human factors research in transportation and serving as a human factors information resource to the transportation community. The HFCC facilitates the implementation of human factors elements of the USDOT Strategic Plan and supports the activities of the USDOT Research and Technology Coordinating Council as well as the National Science and Technology Council's Committee on Technology and its Subcommittee on Transportation R&D.

"We need to employ human factors expertise in the design, development, evaluation and use of transportation technologies and systems to ensure that we do not exceed the limits of human performance, and that we use the full capabilities of the human. We compromise the capabilities of technologies when we fail to consider human performance issues associated with their use. We need transportation systems that adapt to humans instead of humans adapting to them."

Rodney E. Slater
Secretary, U.S. Department of Transportation
Human-Centered Systems: The Next Challenge in Transportation, June 1999.

A heightened awareness of the role of human performance and behavior issues in transportation safety is occurring at a time when a variety of new technologies are being developed and introduced into transportation systems to enhance their capabilities. The major areas of human factors-related concerns associated with transportation systems include:

- fatigue and workload,
- hours of service,
- training and certification,
- automation,
- passenger security,
- aging and mobility,
- information overload,
- substance abuse, and
- adequate staffing.

continued on next page

Box 3-1 continued

The USDOT human factors coordinated program is integrated and synergistic and incorporates the following elements:

- **modal specific** –each mode will continue to conduct focused, applied programs designed to support their unique needs.

- **cross-modal** –new initiatives will sponsor broadly applicable projects that complement the modal programs and can be tailored for use by the modes.

- **interagency** –all of the USDOT's human factors research programs will leverage the resources of other federal agencies.

The human factors research program supports long-term national transportation goals to:

- ensure safer, more efficient, and more productive transportation products and services;

- provide reliable, safe, dependable transportation systems that will enable efficient U.S. industries to achieve or maintain world-class competitiveness;

- improve the integration of national transportation resources to provide "seamless" transportation to customers using multiple modes; and

- provide mobility for diverse populations and ensure the accessibility of transportation technologies and services.

Within the broad framework of human-factors research, each of the modal agencies have their own programs. The Federal Aviation Administration human factors program conducts research to support the development and implementation of equipment, training, and procedures that enhance the safety and efficiency of National Airspace System operations. The U.S. Coast Guard plan focuses on safety issues and organizational design. At the Maritime Administration, the focus is on productivity and competitiveness through safe, pollution-free construction and operations. The Federal Highway Administration, Federal Motor Carrier Safety Administration, and the National Highway Traffic Safety Administration focus on regulation, achievement of crash and injury reduction, and improved mobility for all citizens. The Federal Transit Administration is focusing on education for both transit agency managers and employees on the dangers and long-term expense and consequences of fatigue. The Federal Railway Administration program conducts research on railroad operating practices, railroad system design, and grade crossings to improve the overall safety of railroad operations, with a particular emphasis on reducing railroad employee fatigue.

Some representative systems being developed as a part of this research effort are collision avoidance systems, development and application of technology to measure driver fitness, fatigue research, an intelligent vehicle initiative, flight deck human factors, designs to accommodate aging drivers, and implementation of piloting navigation aids.

Projects under the various human factors initiatives are conducted in partnership with other federal agencies such as the Department of Defense and the National Aeronautics and Space Administration, as well as, where appropriate, with academia and industry. The key is to conduct research that will lead to a transportation system that adapts to the human, as opposed to the current system that requires the human to adapt to it. By working together, federal agencies and nongovernmental organizations can enjoy the synergy and economies of scale that make the most effective use of research and development efforts in the pursuit of answers to the nation's most pressing transportation safety and efficiency problems.

continued on next page

Box 3-1 *continued*

The USDOT human factors research initiative is developing advanced technologies to mitigate human error and upgrade skills specifically for new operators and older individuals through the application of advanced instructional technology. The overall goal of this initiative is to reduce transportation incidents by as much as one-third by the year 2020 by focusing on two critical areas:

- managing operator fatigue to sustain alertness; and
- upgrading operator abilities and skills, especially those related to recognizing and responding to imminent crash threats.

Specifically, the key elements of the coordinated program are two new multiagency human performance and behavior initiatives relating to fatigue detection and alertness enhancement the Operator Fatigue Management (OFM) Initiative and Advanced Instructional Technology (AIT) Initiative. The strategic goal of the OFM is to reduce the economic impact from fatigue-related transportation injuries, fatalities, and property and environmental damage or loss by one-third within 20 years of the implementation and application of OFM findings, products, practices, and systems. The desired outcome of the AIT is to reduce the rate of motor vehicle crashes, deaths, and injuries among operators who participate by 33 percent within 20 years. This will be accomplished by using AIT techniques to enhance vehicle operator skills, decisionmaking, and safety-related attitudes.

Attention to human-centered technologies in transportation will contribute to U.S. leadership in transportation products and services. Currently, the United States is a leader in systems integration technologies, which will be key to achieving a competitive edge in the future. By linking our strength in systems integration to human performance, the "human-centered systems" concept will contribute to the commercial success of U.S. transportation systems.

Highway Safety

"One of the most successful governmental efforts to protect the public is in the area of auto safety. Hundreds of thousands of lives have been saved, thanks to laws requiring safety features such as bumpers, seatbelts, and airbags."

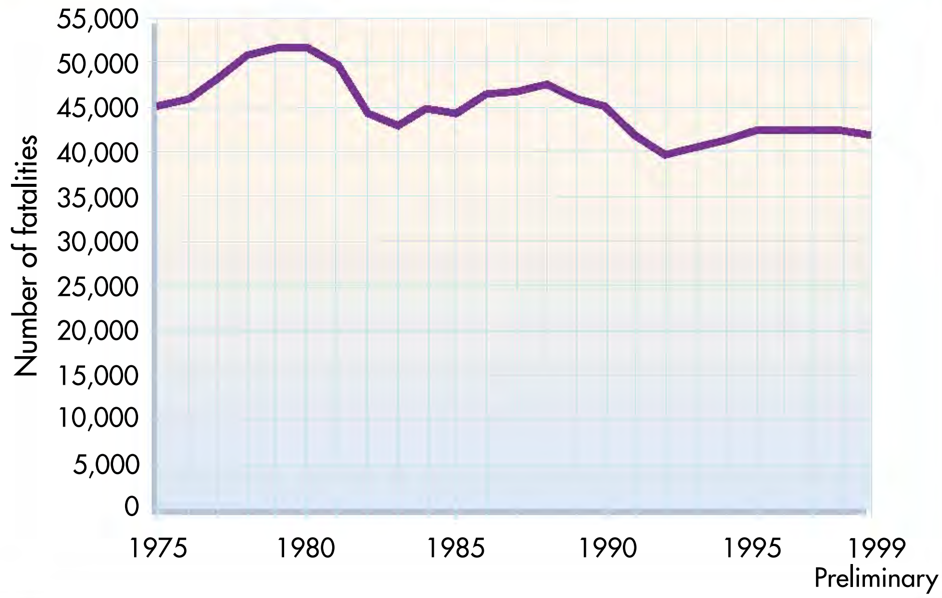
President William J. Clinton
Radio Address to the Nation
Feb. 27, 1999

When National Transportation Trends and Choices was issued in 1977, the legislative framework and funding for highway safety improvement programs had already been initiated by passage of the Highway Safety Acts of 1966, 1970, and 1973. The 1970 Act also established a new agency: the National Highway Traffic Safety Administration (NHTSA) under the USDOT, which along with other USDOT administrations (Federal Highway Administration, the new Federal Motor Carrier Safety Administration, Federal Transit Administration, and Federal Railroad Administration) provides leadership in promoting highway safety. In the last 25 years, new programs have been developed and safety on our nation's highways has improved owing to a combination of efforts by government regulatory agencies, the transportation research community, vehicle manufacturers, law enforcement agencies, and the public.

NHTSA's preliminary estimates show that 41,345 people were killed in highway crashes in 1999—3,180 fewer than in 1975 (figure 3-3). Figure 3-4 provides a comparison of fatalities by state for 1975 and 1998. The reduction in fatality rate per 100 million VMT (as shown in figure 3-2) since 1975 saved an estimated 46,000 lives in 1998 alone, and an estimated 479,000 lives since 1975 (figure 3-5).

Figure 3-3

Motor Vehicle Crash Fatalities: 1975-98 (Annual totals)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Although highway crash fatality rates have declined, new strategies are being developed to provide even further reductions. In this context, some of the major issues that need to be addressed within the broad framework of improving highway safety include:

1. crash characteristics (single-vehicle run-off-the-road crashes, vehicle rollover and size compatibility in multivehicle collisions, and pedestrian and bicyclist fatalities);

2. behavioral characteristics (impaired driving; speeding; aggressive driving; driver fatigue; and use of safety belts, child restraints, and motorcycle helmets);

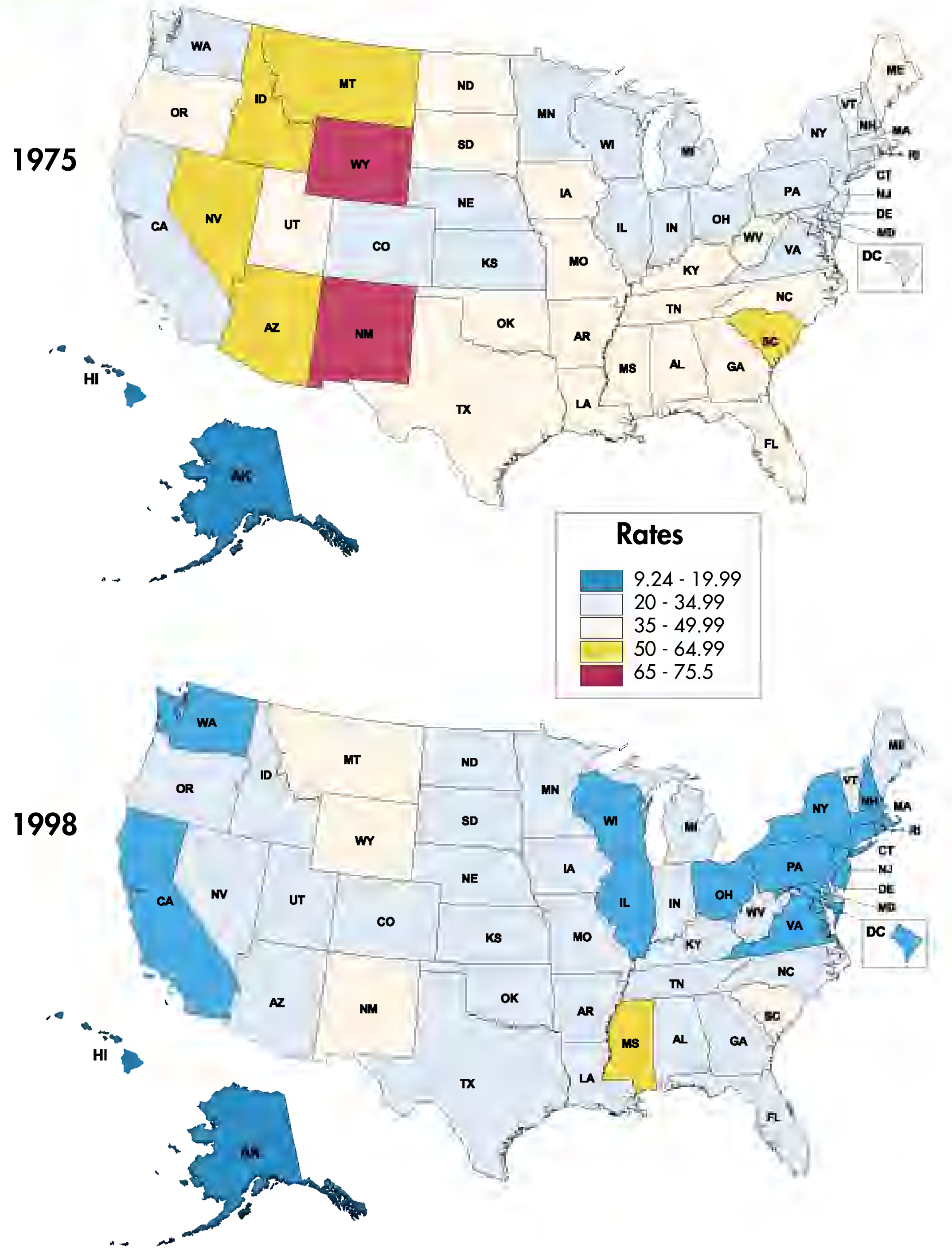
3. demographic characteristics (younger and older drivers);

4. vehicle safety characteristics (vehicle crashworthiness, crash avoidance standards, and air bags); and

5. road characteristics (highway speed limits and safer roads).

Figure 3-4

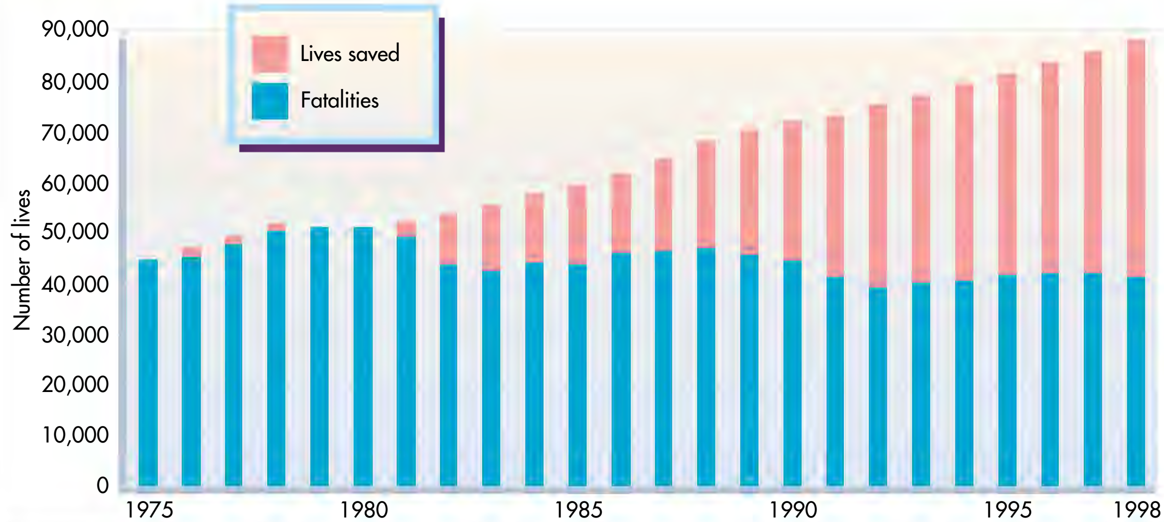
Total Traffic Fatalities: 1975 and 1998



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-5

Highway Fatalities and Estimated Lives Saved (based on 1975 fatality rate per 100 million VMT): 1975-98



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999); U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Various years).

Crash Characteristics

Single-Vehicle Run-Off-the-Road Crashes: In 1998, 40 percent of traffic crash fatalities were vehicle occupants (including drivers) killed in single-vehicle crashes (table 3-2). This includes approximately 15,000 people who are killed each year as a result of run-off-the-road collisions with fixed objects, such as trees, embankments, guardrails, and utility poles. According to NHTSA, between 1974 and 1994, as many as 28 percent of all highway traffic fatalities can be attributed to crashes with fixed objects [USDOT NHTSA 1998d]. In rural areas, these crashes accounted for 66 percent of all traffic fatalities [USDOT FHWA 2000a]. Key factors in these collisions included driving errors associated with inattention, excessive speeding, and evasive maneuvers.

Table 3-2

Total Fatalities in Motor Vehicle Crashes by Type of Crash: 1998

Drivers/occupants killed in single-vehicle crashes	16,671
Drivers/occupants killed in two-vehicle crashes	15,724
Drivers/occupants killed in more than two-vehicle crashes	2,964
Pedestrians killed in single-vehicle crashes	4,795
Bicyclists killed in single-vehicle crashes	737
Pedestrians/bicyclists killed in multiple-vehicle crashes	449
Others/unknown	131
Total	**41,471**

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Improvements in freeway ramp and curve designs, use of "rumble strips," state-of-the-art road features, (i.e., breakaway devices, barriers, and crash cushions), highly visible reflective signs and markings, and variable message signs are being used to reduce the numbers of these crashes and their severity. Several advanced technologies (discussed later in box 3-6), such as night vision enhancement and driver drowsiness detection systems might also be valuable in reducing single-vehicle crashes and fatalities.

Vehicle Rollover and Size Compatibility Issues: Since the early 1980s, the category of vehicles referred to as light trucks and vans (LTVs) has grown dramatically. The vehicles in this category include pickup trucks, vans, minivans, truck-based station wagons, and sport utility vehicles (SUVs). New LTV sales are growing at a compound annual growth rate of 8 percent, while the overall vehicle fleet is growing at a rate of 2 percent. These popular vehicles now represent 34 percent of the total fleet on U.S. highways [USDOT NHTSA 1998c].

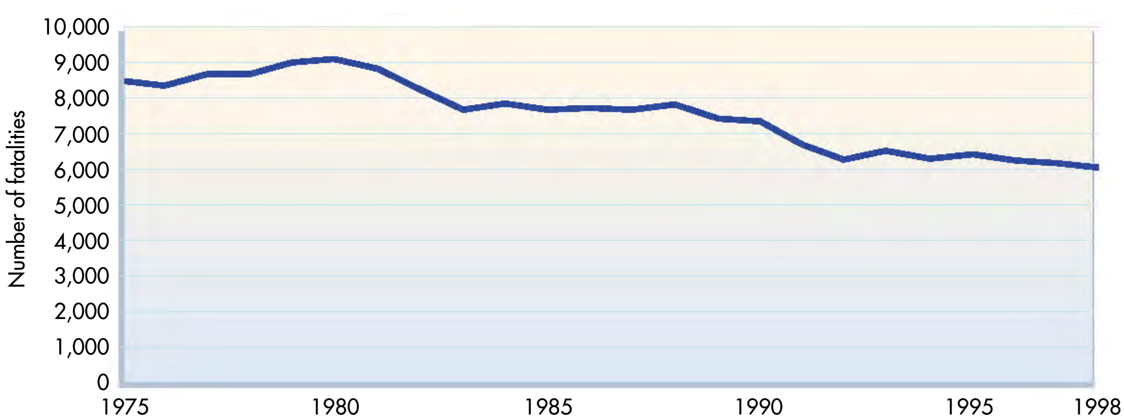
There are two characteristics of LTVs that can cause fatalities in traffic crashes: propensity to roll over and size compatibility. For example, SUVs are twice as likely to roll over as passenger cars, increasing the likelihood of occupant ejection and fatal injury. This contributes to the average rate of 98 rollover fatalities per million registered vehicles for SUVs compared to 47 such fatalities per million registered vehicles for all vehicle types.

Compatibility issues involve differences in vehicle size, weight, and geometry in multivehicle crashes, which can put occupants of cars at greater risk in an LTV-car crash than in a crash involving two or more cars. For example, research at the University of Michigan Transportation Research Institute shows that when an SUV strikes a passenger car in a frontal crash, occupants of the car are five times as likely to have fatal injuries as the occupants of the SUV; in cars that suffer side impacts, fatalities are 30 times higher for car occupants [USDOT NHTSA 1998c].

Pedestrian and Bicyclist Safety: Pedestrian and bicyclist fatalities in motor vehicle-related crashes declined between 1975 and 1998 from a combined total of more than 8,500 to about 6,000 each year (figure 3-6 and box 3-1). Ninety percent of these fatalities were pedestrians. In fact, more pedestrians are killed each year than the combined fatalities from air, sea, and train incidents. In 1998, approximately 5,220 pedestrians were killed and 77,000 injured in traffic crashes [USDOT NHTSA 1999b]. In the same year, there were 761 bicyclist fatalities. Table 3-3 lists some of the major factors involved in pedestrian fatalities in 1998, and table 3-4 lists major factors involved in bicyclist fatalities.

Figure 3-6

Pedestrian and Bicyclist Fatalities in Motor Vehicle Crashes: 1975-98



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Table 3-3

Factors in Pedestrian Fatalities: 1998

Factors	Number	Percent
Walking, playing, working, etc., in roadway	1,589	30.4
Improper crossing of roadway or intersection	1,517	29.1
Failure to yield right-of-way	709	13.6
Darting or running into road	649	12.4
Not visible	414	7.9
Inattentive (talking, eating, etc.)	131	2.5
Physical impairment	70	1.3
Failure to obey traffic signs, signals, or officer	67	1.3
Emotional (e.g., depressed, angry, disturbed)	25	0.5
Getting on/off/in/out of transport vehicle	22	0.4
Blackout	12	0.2
Nonmotorist pushing vehicle	8	0.2
Other causes	106	2.0
None reported	1,271	24.3
Unknown	105	2.0
Total	**5,220**	**100**

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Table 3-4

Factors in Bicyclist Fatalities: 1998

Factors	Number	Percent
Riding, playing, etc., in roadway	167	21.9
Failure to yield right of way	163	21.4
Improper crossing of roadway or intersection	89	11.7
Failure to obey (e.g., signs, control devices, officers)	47	6.2
Operating without required equipment	38	5.0
Erratic, reckless, careless, or negligent operation	36	4.7
Not visible	32	4.2
Failure to keep in proper lane or running off road	29	3.8
Making improper turn	27	3.5
Inattentive (talking, eating, etc.)	25	3.3
Driving on wrong side of road	16	2.1
Failing to have lights on when required	15	2.0
Improper entry/exit from trafficway	11	1.4
Improper lane change	10	1.3
Other factors	74	9.7
None reported	216	28.4
Unknown	12	1.6
Total	**761**	**100**

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Box 3-2

Pedestrian and Bicycle Trips

According to the Nationwide Personal Transportation Survey (NPTS), walking trips declined from 9.3 percent to 5.5 percent of all personal trips between 1977 and 1995, while bicycle trips increased from 0.6 percent to 0.9 percent during the same period [Pickrell & Schimek 1997]. Assuming the average trip length for pedestrians has remained the same, risk to pedestrians may not have actually decreased.

Pedestrians aged 25 to 44 suffered the highest number of fatalities, while for bicyclists, those 10 to 15 years old were the most vulnerable [USDOT NHTSA 1999b]. One significant factor in pedestrian and bicyclist fatalities is time of day—most pedestrian and bicyclist fatalities occur between 6:00 PM and 9:00 PM when visibility is low [USDOT NHTSA 1999b].

The Transportation Equity Act for the 21st Century (TEA-21) enhances integration and project funding for pedestrian and bicycle safety. It also requires states and metropolitan planning organizations to include bicyclists and pedestrians in their long-range transportation plans.

Behavioral Characteristics

Impaired Driving: Alcohol-related death rates were not compiled prior to 1982. That year, alcohol (Blood Alcohol Concentration (BAC) $\geq$ 0.01) was involved in 57 percent of all highway-related fatalities (figure 3-7). By 1999, this number dropped to 38 percent. In actual numbers, 15,794 people died in alcohol-related crashes in 1999 [USDOT 2000], compared to 25,165 such deaths in 1982 [USDOT NHTSA 1999a].

Improved state and local education programs; stiffer enforcement, including adoption of the .08 blood alcohol content law by 18 states (figure 3-8); higher minimum drinking age; and reduced tolerance for drinking and driving all have been major factors in reducing alcohol-related deaths[1]. However, alcohol is still the single largest factor in highway-related traffic fatalities. See figure 3-9 for alcohol-related crash fatalities by state in 1992 and 1998.

Also, in 1998, 18 percent of passenger car drivers, 20 percent of LTV operators, 1 percent of large truck operators, and 31 percent of motorcycle operators involved in fatal crashes were legally intoxicated (BAC equal to or greater than 0.10) [USDOT NHTSA 1999a]. Alcohol intoxication also poses a safety risk to pedestrians (see box 3-2).

Box 3-3

Alcohol Intoxication and Pedestrian Fatalities

In 1998, of the total number of pedestrians (14 years of age or older) killed in crashes, 33 percent were intoxicated. Also, of the total number of pedestrians killed in traffic crashes, 46 percent died in alcohol-related crashes where either the driver of the vehicle or the pedestrian, or both, were under the influence of alcohol.

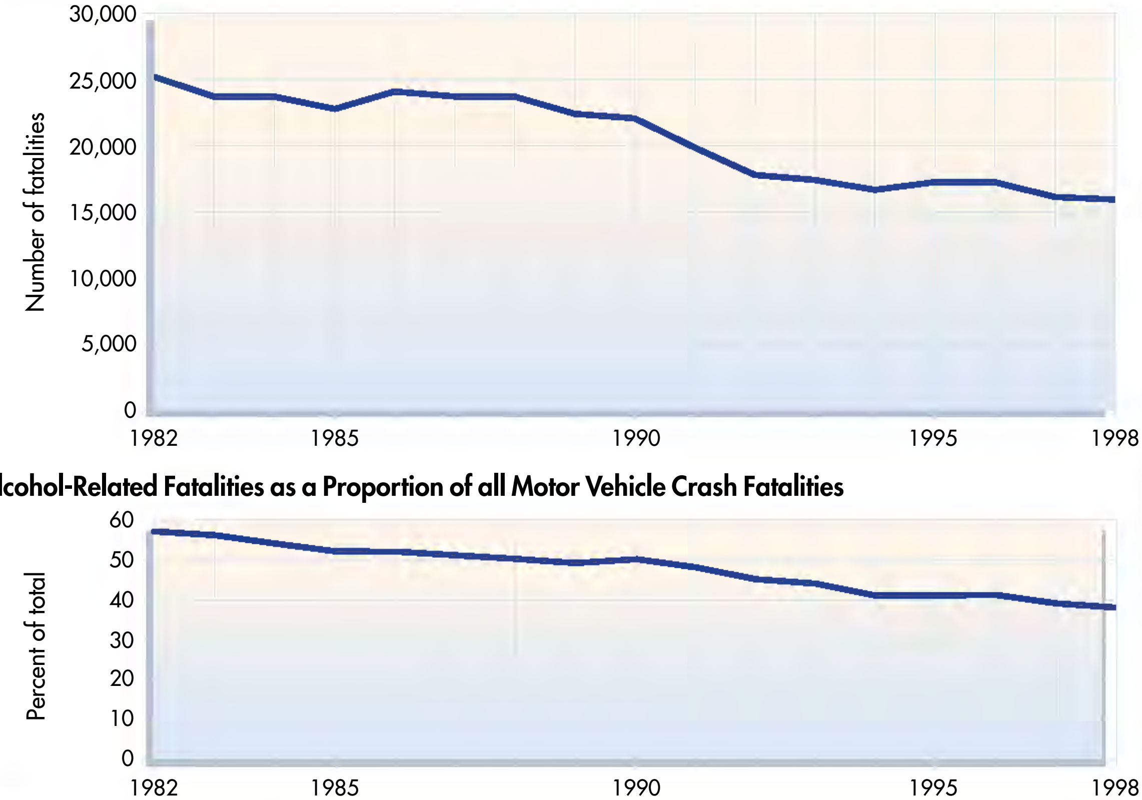
Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998*, DOT HS 808 956, available at http://www.nhtsa.dot.gov/people/ncsa/pdf/Overview98.pdf, as of July 7, 2000.

By age group, 21- to 34-year-olds comprised the highest percentage of intoxicated drivers involved in fatal crashes (figure 3-10). In 1975, the minimum drinking age for all alcoholic beverages was less than 21 years of age in 26 states (figure 3-11), and in 11 others, beer and wine could be bought at age 18. Such variations created "blood borders" as teenagers drove to neighboring states to drink and then attempted to drive home intoxicated.

[1] Any state that does not adopt a BAC of 0.08 by year 2004 will lose a portion of federal highway funds—2 percent in 2004, 4 percent in 2005, 6 percent in 2006, and 8 percent in 2007.

Figure 3-7

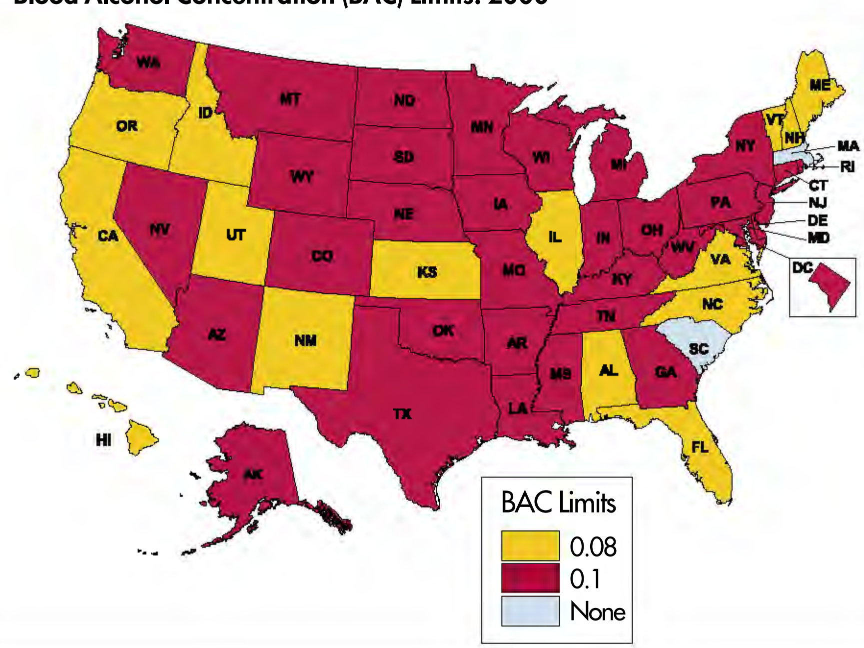
Alcohol-Related Fatalities in Motor Vehicle Crashes: 1982-98 (Annual totals)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-8

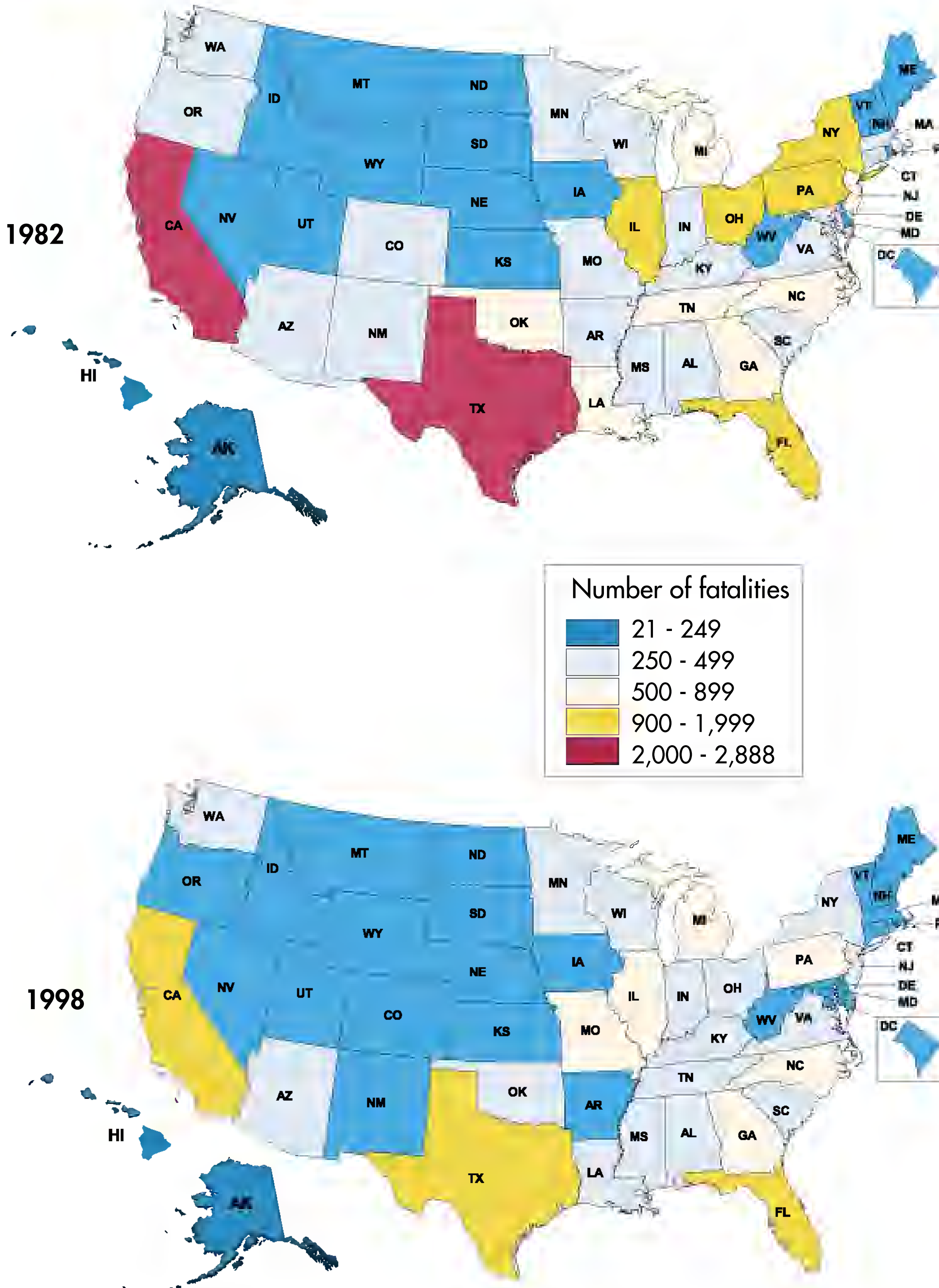
Blood Alcohol Concentration (BAC) Limits: 2000



Source: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA), *Digest of State Alcohol-Related Safety Legislation* (Washington, DC); and USDOT, NHTSA, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-9

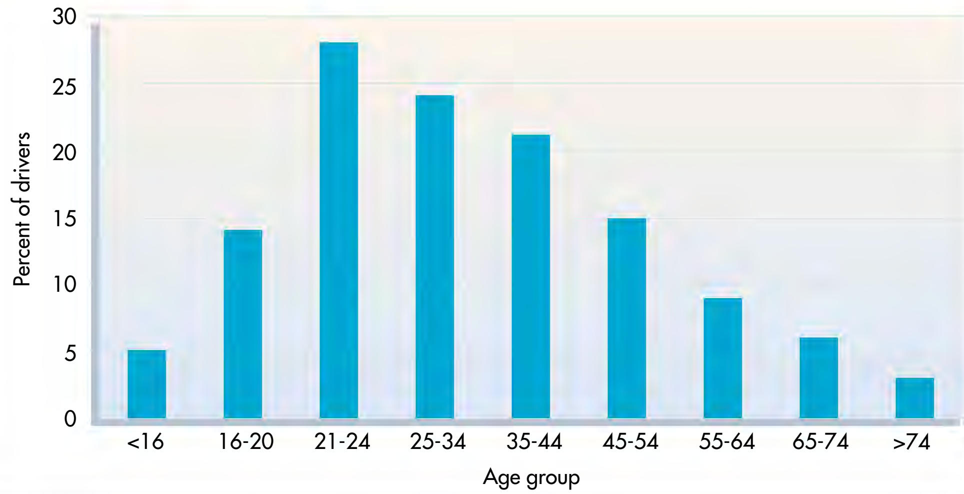
Alcohol-Related Traffic Fatalities: 1982 and 1998



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts* (Washington, DC: 1982 and 1999).

Figure 3-10

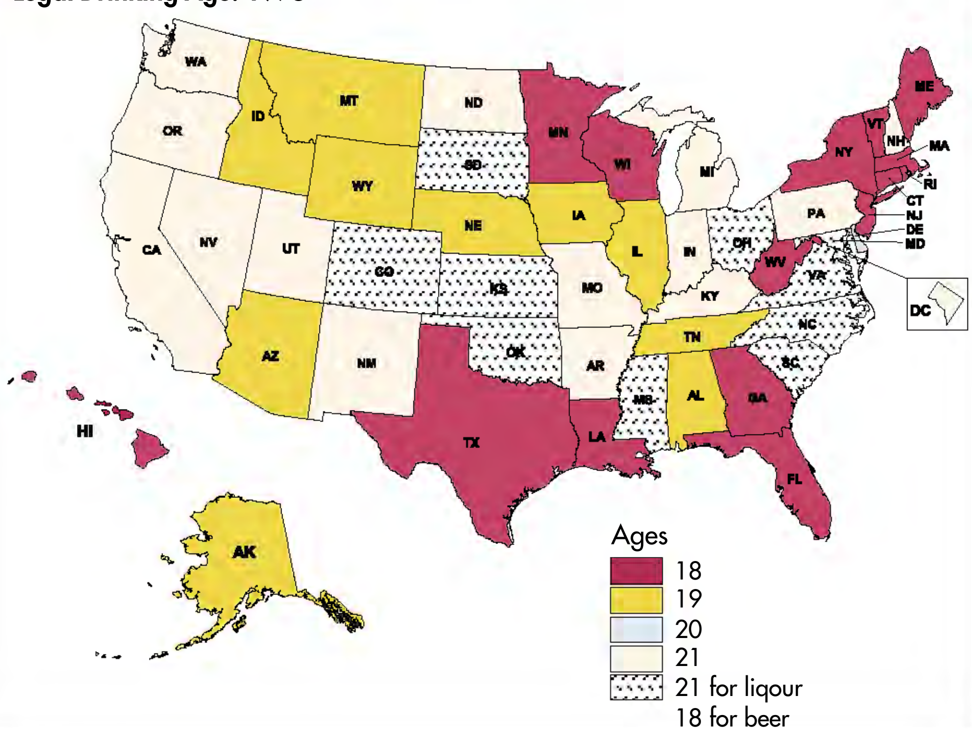
Drivers in Fatal Crashes with a Blood Alcohol Concentration of ≥0.10, by Age: 1998



Note: National Highway Traffic Safety Administration (NHTSA) estimates alcohol involvement when alcohol test results are unknown.
Source: U.S. Department of Transportation, NHTSA, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-11

Legal Drinking Age: 1975



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Alcohol and Highway Safety Laws: A National Overview* (Washington, DC: 1979).

Under TEA-21, some portion of federal highway funding was restricted until states adopted a statute that not only prevented drivers under the age of 21 from obtaining alcoholic beverages, but also prevented persons of any age from making alcoholic beverages available to those under 21 [23 CFR Part 1313]. As a result, today, all 50 states and the District of Columbia have set the minimum drinking age at 21. NHTSA estimates that laws raising the minimum age for drinking have altogether saved 18,220 lives since 1975 [USDOT NHTSA 1998a].

Speeding and Aggressive Driving: Speeding—exceeding the posted speed limit or driving too fast for conditions—is one of the most pervasive factors contributing to traffic crashes. Speeding is a factor in 33 percent of all fatal crashes, and this percentage has remained consistent from 1993 to 1998 [USDOT NHTSA 1999c].

In 1998, 12,477 lives were lost in crashes where speeding was cited as a factor; the economic cost to society of these crashes was estimated by NHTSA to be $27.7 billion [USDOT NHTSA 1999c]. Collector and local roads have the highest speed-related fatality rates, both in urban and rural areas, while Interstate highways have the lowest speeding fatality rates. There also is a strong link between alcohol intoxication and speeding; 47 percent of speeding drivers between 21 and 24 years of age involved in fatal crashes were alcohol impaired [USDOT NHTSA 1999c].

Aggressive driving—when individuals commit a combination of moving traffic offenses that endanger other persons or property—became a safety issue in the 1990s, and it threatens to become a major public safety concern for the motoring public and law enforcement agencies in the 21st century. Some behaviors typically associated with aggressive driving include exceeding the posted speed limit, following too closely, making erratic or unsafe lane changes, improperly signaling lane changes, and failing to obey traffic control devices (e.g., stop signs, yield signs, traffic signals, and railroad grade cross signals). NHTSA calls the act of running a red light one of the most dangerous forms of aggressive driving. Increasing travel times due to congestion on our roads, especially in large cities, is considered to be one of the major triggers of this type of behavior. Exact numbers on fatalities and injuries caused by aggressive driving are not available at this time, but NHTSA is working toward collecting this information [USDOT NHTSA 1998b].

Driver Fatigue: In recent years, driver fatigue and drowsiness may have been a factor in 56,000 crashes annually, resulting in 1,550 fatalities and 40,000 injuries a year [USDOT NHTSA 1998e]. The causes of driver fatigue have been attributed to certain sleep disorders (sleep apnea, insomnia, narcolepsy) or just lack of sufficient rest. NHTSA is undertaking public education campaigns targeted at high-risk groups to reduce these types of crashes. FHWA and NHTSA also are cooperating in laboratory and field research to study driver drowsiness detection devices in vehicles, which can alert drivers to impending crash situations (see box 3-7, Advanced Vehicle Safety and Control Systems).

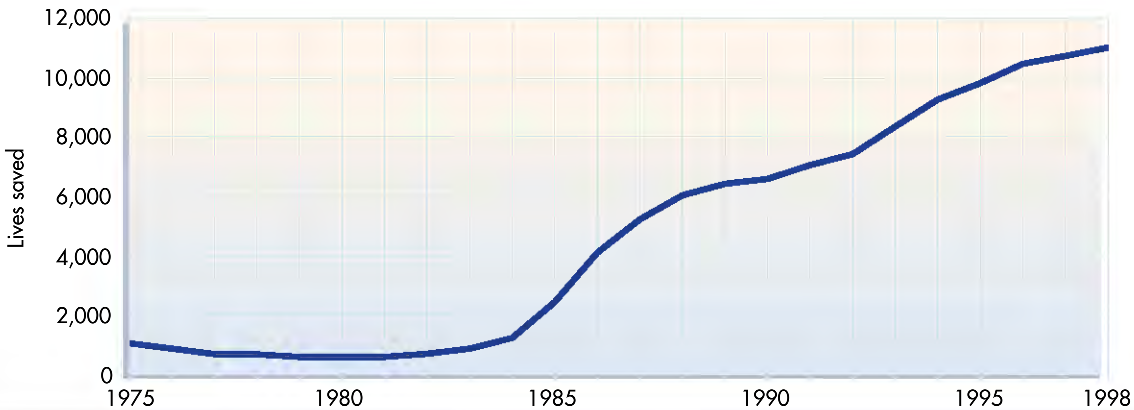
USDOT, NHTSA

Safety Belt Use: Safety belt use is the most important measure vehicle occupants can take to protect themselves in the event of a crash. When used, safety belts reduce the risk of fatal injury to front-seat passenger car occupants by 45 percent. For light truck occupants, safety belts reduce the risk of fatal injury by 60 percent [USDOT NHTSA 1998e]. From 1975 to 1998, as many as 112,000 lives may have been saved through the use of safety belts, including 11,000 in 1998 alone [USDOT NHTSA 1999b] (figure 3-12).

Use rates are not available for 1975, but 1982 surveys found that only 11 percent of vehicle occupants used safety belts [USDOT NHTSA 1983]. Today, the reported safety belt use rate is 79 percent in the 14 states and the District of Columbia with primary enforcement laws and 62 percent in the 36 states with secondary enforcement laws [NSC 1999]. Primary enforcement laws permit law enforcement officers to stop a vehicle and write a citation whenever they observe a violation of the safety belt law; secondary enforcement allows a citation to be given only after a vehicle is stopped for another traffic violation [NSC 1999]. The USDOT has been carrying out mobilization efforts in collaboration with nongovernmental organizations to encourage the use of seat belts. As a part of this effort, in November 2000, Mothers Against Drunk Driving became involved in the Operation ABC Mobilization: America Buckles Up Children. Figure 3-13 shows current seat belt use laws in each state.

Figure 3-12

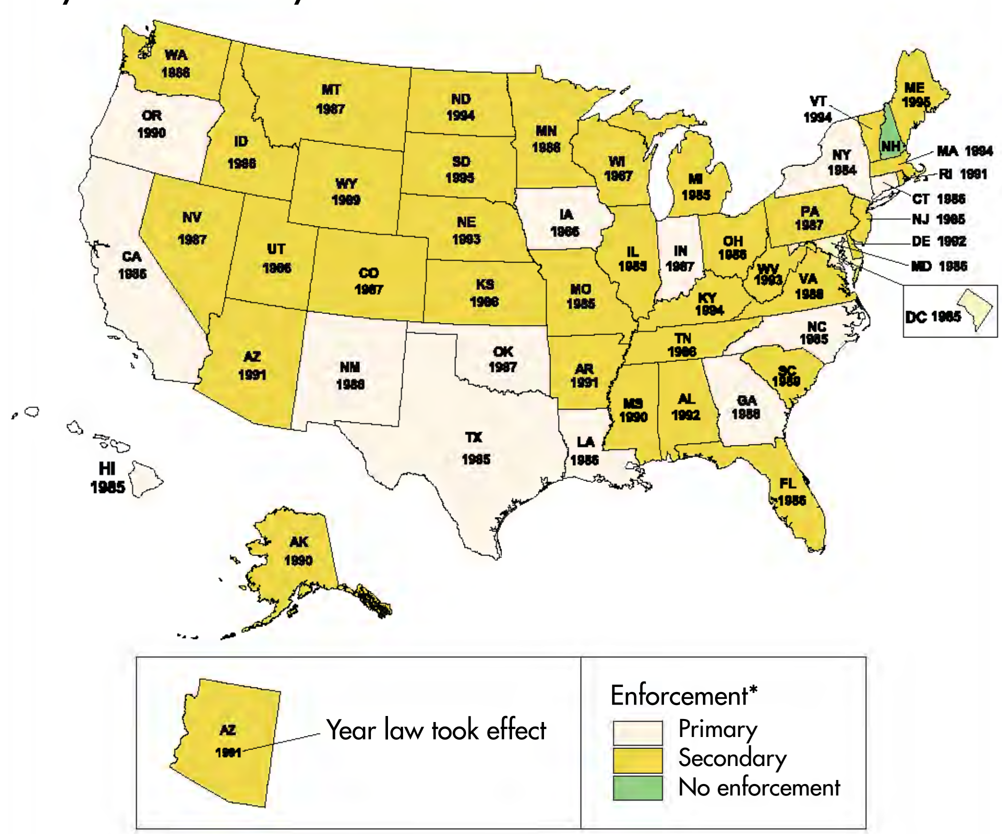
Estimated Number of Lives Saved Each Year by Use of Safety Belts: 1975-98
(Annual totals)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-13

Key Provisions of Safety Belt Use Laws: 1998



* With secondary enforcement, police officers are permitted to write a citation only after a vehicle is stopped for some other traffic violation. With primary enforcement, police officers can stop vehicles and write citations whenever they observe violations of safety belt laws.

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

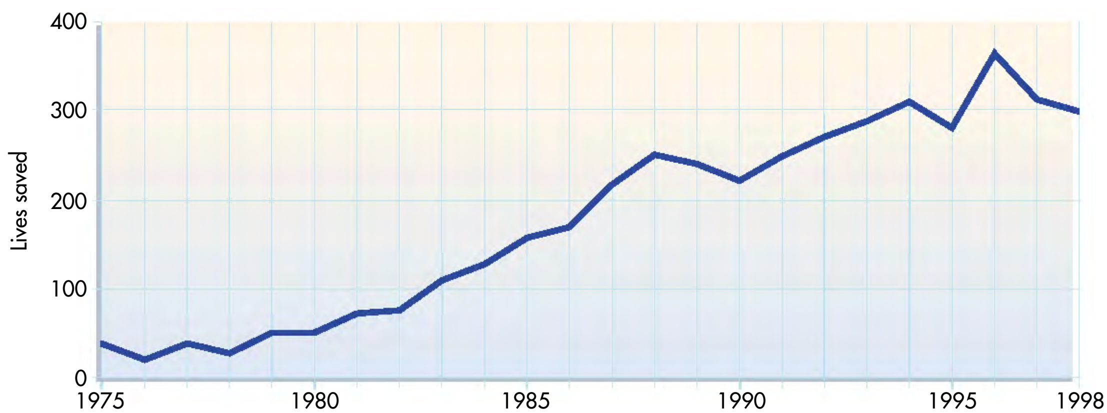
Child Restraints: Standards for child restraint systems in motor vehicles were set in 1971, but major changes were made in 1981. Child restraint systems have been shown to reduce fatal injuries by 69 percent for infants less than 1 year old and by 47 percent for children up to 4 years old [NSC 1999]. All states have had child restraint use laws in effect since 1985, but these laws vary.

The use of child restraint systems has saved an estimated total of 4,193 lives since 1975 (figure 3-14). According to NHTSA, 173 additional lives could have been saved in 1998 if all children less than five years of age were properly restrained in appropriate safety seats [USDOT NHTSA n.d. (a)].

Motorcycle Helmet Standards and State Helmet Use Laws: Motorcyclists have the highest fatality rate of all motorists on the roads. This rank has remained unchanged since 1975, although their fatality rate has decreased from 56.7 to 20 per 100 million VMT. The fatal crash involvement rate for motorcycles also is the highest—22.7 per 100 million VMT in 1998, compared to a rate of 1.9 for passenger cars, 2.2 for light trucks, and 2.5 for large trucks [USDOT NHTSA n.d. (b)].

Figure 3-14

Estimated Number of Lives Saved Each Year by Use of Child Restraints: 1975-98 (Annual totals)



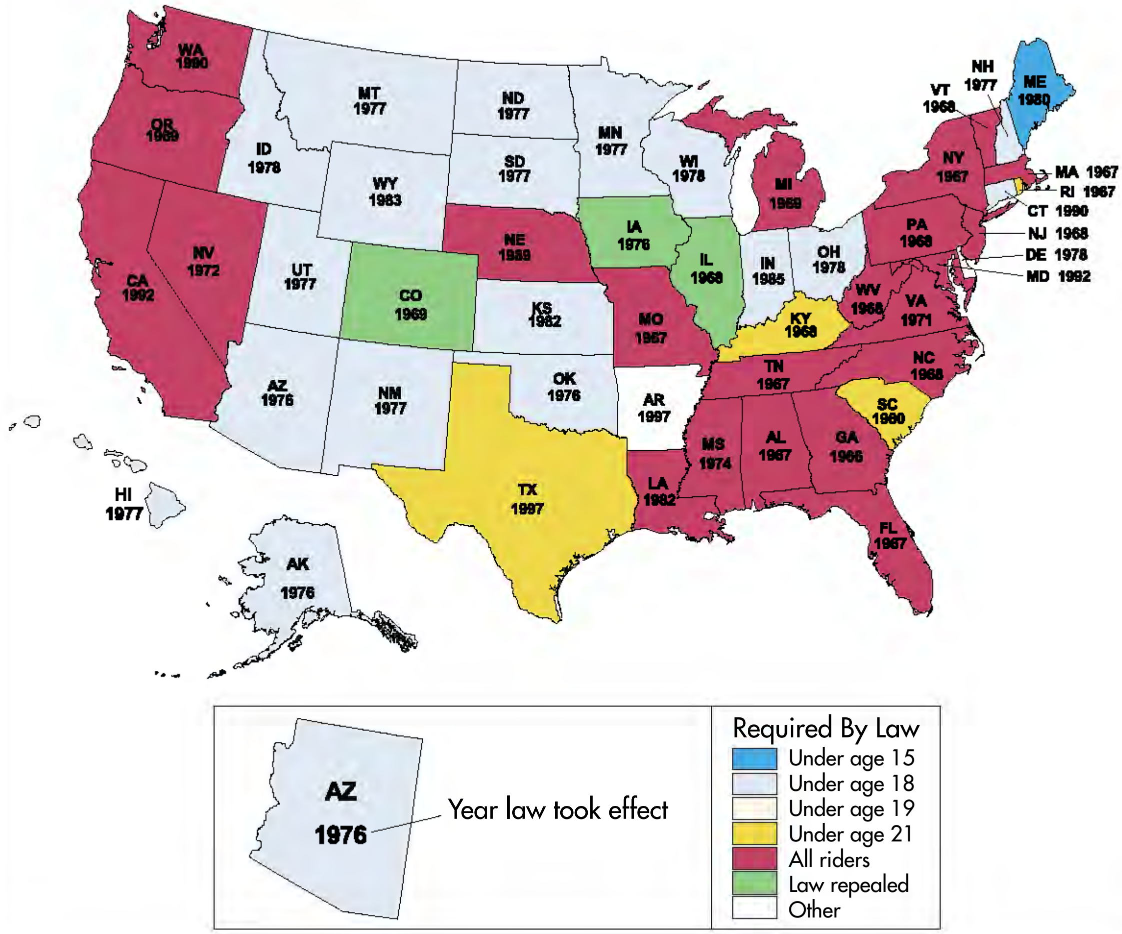
Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

NHTSA performance standards for motorcycle helmets went into effect in 1974. In 1998, 22 states, the District of Columbia, and Puerto Rico required all motorcycle riders to use helmets. In another 24 states, only riders under 18 years of age are required to wear helmets, while 3 states have no laws regarding helmet use (figure 3-15).

A 1998 NHTSA survey estimated the use of helmets at 67 percent nationwide [USDOT NHTSA n.d. (b)]. Previous NHTSA surveys have shown helmet use at nearly 100 percent in states with universal helmet use laws and as low as 34 percent in states with limited or no helmet use laws. The use of helmets saved the lives of an estimated 500 motorcyclists in 1998 (figure 3-16). An estimated 307 additional lives might have been saved that year if all motorcyclists used helmets. The use of motorcycle helmets reduced the risk of fatal injuries to motorcyclists by an estimated 29 percent [USDOT NHTSA n.d. (b)].

Figure 3-15

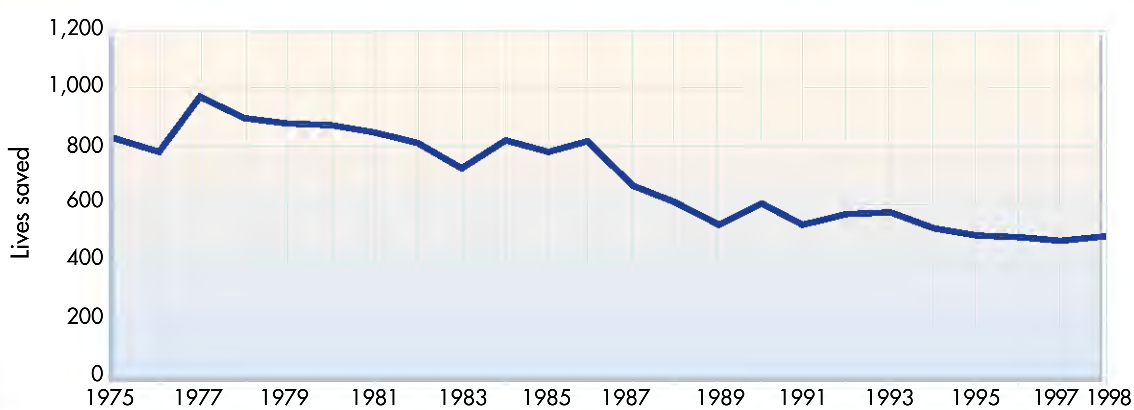
Motorcycle Helmet Use Laws: 1998



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-16

Estimated Number of Lives Saved Each Year by Use of Motorcycle Helmets: 1975-98
(Annual totals)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Demographic Characteristics (age)

Increasing numbers of younger and older drivers—the highest risk segments of the population—will create a new highway safety challenge in the 21st century. In 1998, 40 percent of the drivers who died in crashes were in one of these two age groups—23 percent in the 16-to-24-year age group and 17 percent were in the 65-and-older age group [USDOT NHTSA 1999a]. The traffic crash fatality rate per 100,000 population is the highest in the 16-to-24-year age group, followed by those over age 74 (figure 3-17).

The expanding U.S. population—a 23 percent increase is expected by 2025 [Hollmann et al. 2000]—will lead to an increase in the number of drivers on the road, and changing demographics in the United States will result in a shift of drivers from younger to older age groups. The 17 million licensed drivers 70 years old and older in 1999 [USDOT NHTSA 1999a] could increase to as many as 25 million by 2025 [Slater 2000]. Therefore, we must take steps to address the needs of this growing sector of our population.

Box 3-4

Older Drivers and Technologies

As the "baby boom" generation ages, the safety of older drivers will become an even greater concern. Although older people use automobiles less than younger ones, they are nonetheless highly auto-dependent. Among urban people 75 to 84 years of age, 90 percent of all trips are by automobile, and for urban people 85 years and older, 86 percent of all trips are by automobile. In rural areas, the comparable dependency figures are 94 and 83 percent, respectively. The automobile is the dominant mode of travel among older people, and it likely will remain so.

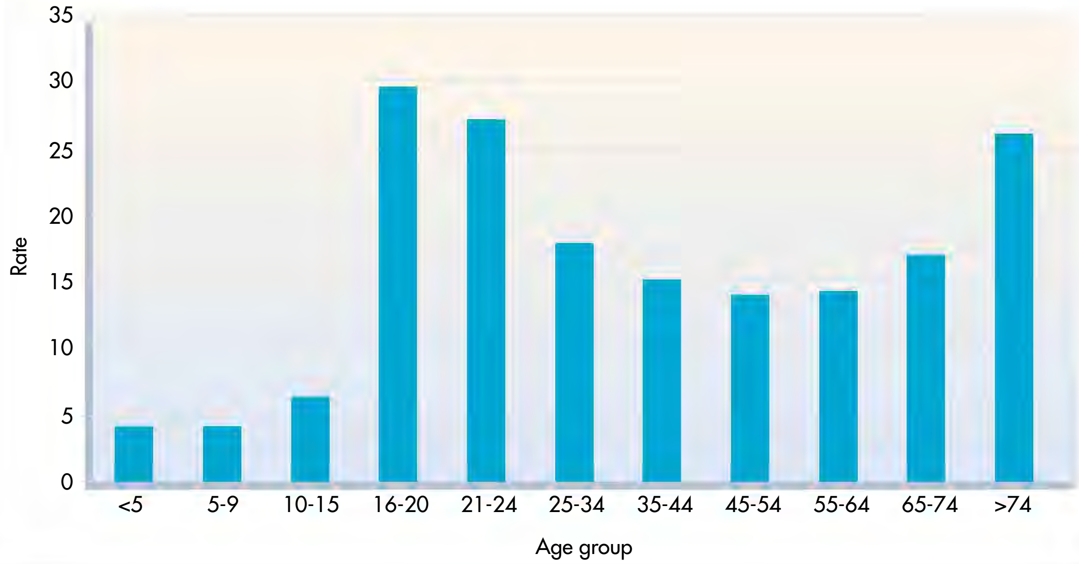
In the future, we may expect that seniors will tend to *age in place* as they do today. Many will stay in their existing residences in suburban, exurban, or rural neighborhoods rather than relocate to retirement communities. They will, therefore, be highly dependent on the private automobile; and as they get older, driving will likely become more difficult. Many older people are aware of their limitations and reduce their driving in difficult circumstances or voluntarily discontinue it. As a result, their incidence of automobile crashes per licensed driver is less than for other groups (see figure 3-18).

Older people are less able to survive the trauma of crashes (see figure 3-19). When they are victims of automobile crashes, people over 80 are four times more likely to die than 20-year-olds. With many more older adults driving in the future, the fatalities for this population segment will probably climb faster than for the overall population. This scenario presents a formidable challenge for future transportation managers, but opportunities abound to counter this trend by making highways and automobiles safer and providing better options for other transportation services, such as public transportation and paratransit.

Highway engineers have begun updating standards for signs, control devices, and highway and intersection designs to provide increased consideration for the needs of an aging population. In future vehicles, a number of new technologies should become operational that will protect and aid older drivers, particularly vehicle collision and crash avoidance warning systems, speech navigation, and information and warning systems. But designs also must be found to make future vehicles more crashworthy for older, more fragile drivers and passengers.

Figure 3-17

Persons Killed per 100,000 Population in Highway Crashes by Age Group: 1998



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Vehicle Characteristics

NHTSA sets safety standards for all motor vehicles. These standards are designed to improve vehicle safety in the event of a crash (crashworthiness standards) and to improve the vehicle so drivers can better avoid collisions (crash avoidance standards). Over the last three decades, NHTSA has set crashworthiness standards covering a wide range of issues, including:

- side impact protection,
- vehicle rollover stability,
- roof crush resistance,
- air bags,
- safety belts,
- fuel system integrity,
- head restraints,
- upper interior protection,
- advanced windshield glazing,
- school bus safety,
- child safety seats,
- flammability of interior materials,
- heavy truck underride, and
- advanced air bags.

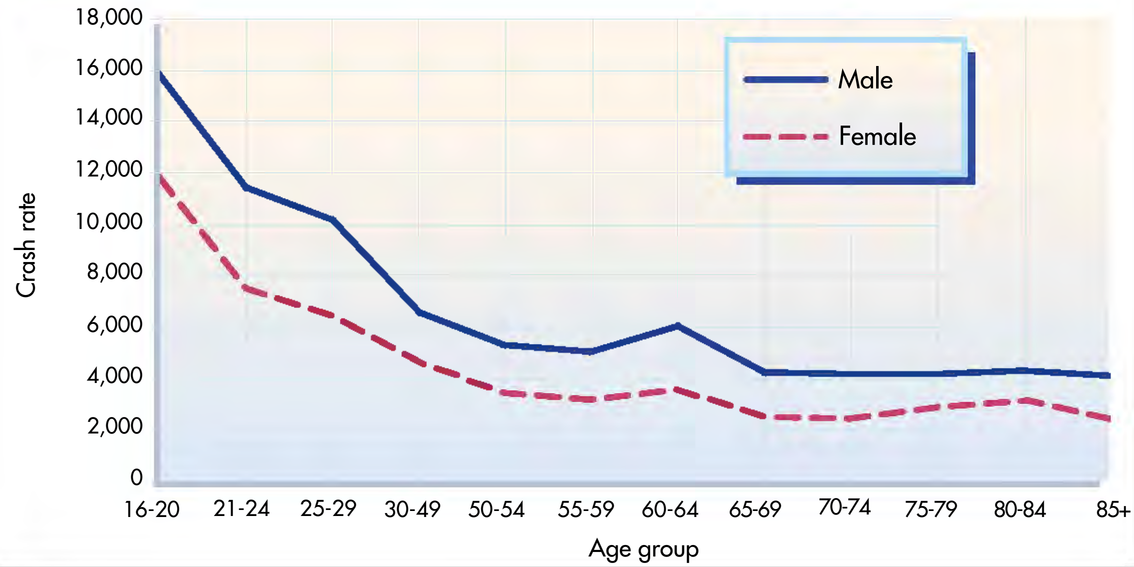
Crash avoidance standards have included:

- antilock brakes,
- center high-mounted stop lamps,
- heavy truck conspicuity,
- electronic brake controls,
- heavy truck splash and spray, and
- school bus visibility issues (i.e., mirrors and signal arms).

This is just a partial list of the changes implemented to protect vehicle occupants and others who use the roadways. NHTSA also conducts crash tests on vehicles under the New Car Assessment Program. This program was initiated in 1979 and provides consumers with crashworthiness ratings for new model vehicles. Together these regulations and programs have helped contribute to the dramatic decline in fatality rates since 1975, preventing thousands of fatalities and injuries every year.

Figure 3-18

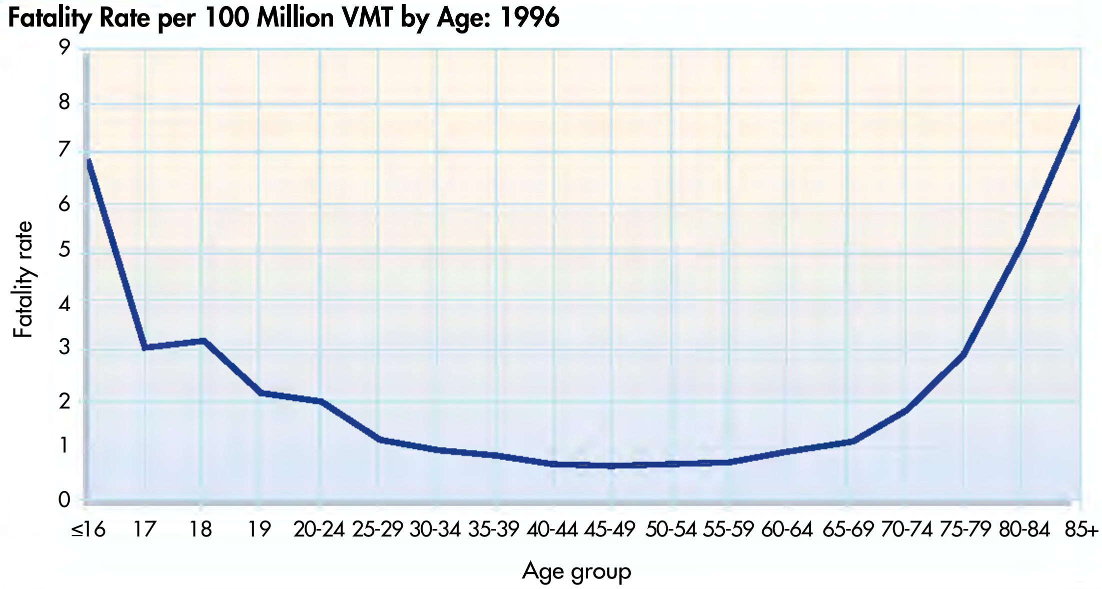
Crash Rate per 100,000 Licensed Drivers by Age and Gender: 1998



Note: Data not included for the District of Columbia.
Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Figure 3-19

Fatality Rate per 100 Million VMT by Age: 1996



Note: Data not included for the District of Columbia.
Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

USDOT, NHTSA

As part of its new car assessment program, the National Highway Traffic Safety Administration uses a 35-mph frontal impact test to measure the crashworthiness of the 1999 Volkswagen Beetle.

Aside from safety belts, perhaps the most well-known vehicle safety feature is air bags. Automobile manufacturers sold air bags as optional equipment for many years before they became required equipment for cars in 1997 and for multipurpose passenger vehicles, trucks, and buses in 1998. NHTSA estimates that air bags saved 3,706 lives from 1975 through 1998, including 1,043 in 1998 (figure 3-20).

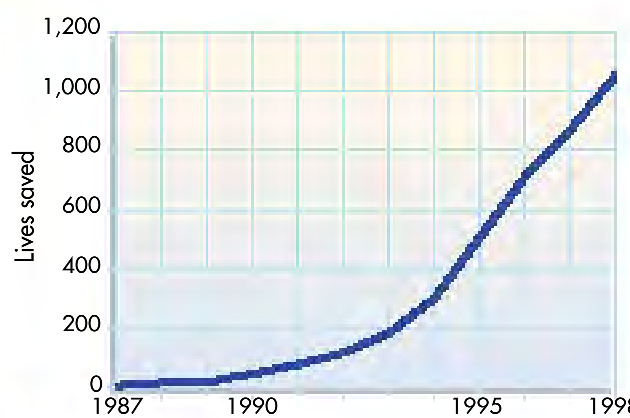
Air bags have been at the center of controversy due to the deaths of vehicle drivers and passengers from air bags that deployed in a small number of low-speed crashes. Through April 1, 1999, 78 children and 60 adults have been killed by air bags in such crashes [Insurance Institute 2000]. Children under 12 have been most vulnerable. In most of these cases, the children were in rear-facing child restraints, improperly placed in front seats, or were unrestrained; most of the adults were unrestrained.

NHTSA has adopted new requirements, to be phased in over the next few years, to minimize the risk of injury from air bags. Vehicle manufacturers are developing smart air bags using microsensor technologies (crash severity sensors, occupant weight and proximity sensors, and safety belt and seat-position sensors) to adjust the air bag deployment rate during a crash to reduce injuries.

Additionally, some popular models of vehicles are now fitted with side air bags to reduce the risk of injury from side impact crashes.

Figure 3-20

Estimated Number of Lives Saved Each Year by Use of Air Bags: 1987-98 (Annual totals)



Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

Road Characteristics

Safer Roads: Since 1975, FHWA leadership, advocacy, and other programs have provided progressively higher safety standards and guidance for road design, construction, and maintenance practices, which have been adopted by highway authorities nationwide. All federal-aid projects are required to improve or maintain safety. Examples of road infrastructure safety improvements to reduce crash impacts include installing or upgrading breakaway poles, safety barriers, and crash attenuators. Examples of road infrastructure safety improvements to reduce crashes include rumble strips, travel lanes, shoulders, roadside clear zones, and traffic control devices.

Evaluations of the two special programs, the Federal-aid Hazard Elimination Program and Rail-Highway Crossing Program, suggest that these two safety programs contributed to preventing 58,000 deaths and 1.1 million nonfatal injuries between 1974 and 1995 [USDOT FHWA 1996].

New technologies being incorporated into the road infrastructure for safety include improved safety monitoring and driver advisory systems, such as changeable message signs and radio, high visability signs and markings, new and improved materials and designs for crashworthy devices and traffic control devices.

Speed Limits: In 1973, Congress set a National Maximum Speed Limit (NMSL) of 55 miles per hour (mph) as a temporary energy conservation measure. States that failed to enforce the speed limit faced highway-funding sanctions [USDOT FHWA 2000b]. Safety advocates, citing a decrease of 9,000 highway fatalities during the first year, backed the speed limit as a safety measure. It became permanent in 1974.

As the memories of the gas crisis of the 1970s faded, pressure began to build, especially in western states, for the repeal of the 55-mph speed limit. In 1987, the federal government gave states the option of an NMSL of 65 mph on rural Interstate highways and certain rural freeways without risking the loss of federal highway funds. In December 1995, the NMSL was repealed completely, and full authority to set speed limits on public roads was returned to states and local communities.

Since 1995, all states except the District of Columbia and Hawaii have raised the speed limit on some or all of their Interstate highways. Figure 3-21 shows current maximum rural Interstate speed limit by state. NHTSA is collecting travel speed and crash data to determine if there is conclusive evidence of an association between speed limits and crashes.

Box 3-5

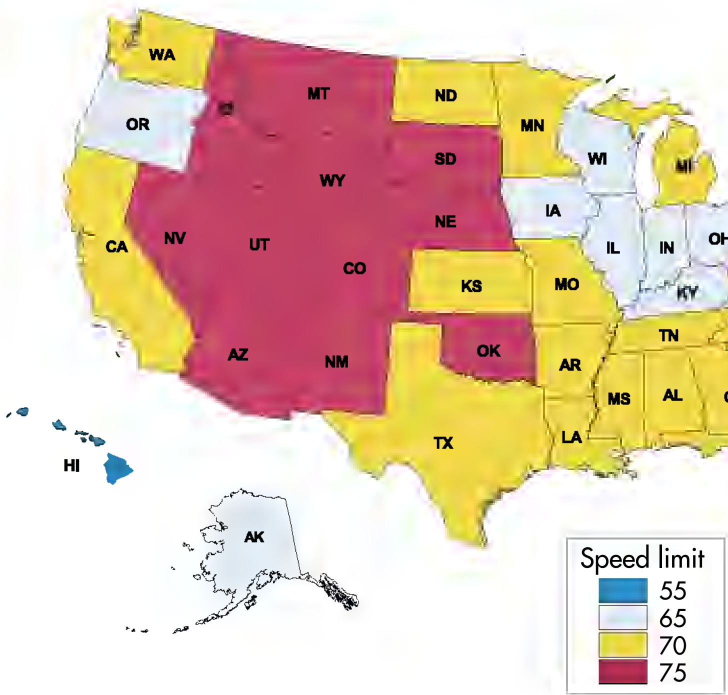
Speed Management and Variable Speed Limit Technology

Speed management involves matching speed with roadway design and area characteristics. Many factors must be taken into consideration, including type and amount of roadside development, road design, accident experience, pedestrian presence, and weather conditions. Speed management practices include setting realistic speed limits, traffic calming techniques, and public education.

One technology-based speed management approach is the variable speed limit (VSL), which sets speed limits appropriate to weather and traffic conditions. VSL has been used successfully in Europe to adjust speed limits to improve safety and traffic flow. VSL is a part of the Intelligent Transportation System (ITS) group of technologies.

Figure 3-21

Maximum Rural Interstate Speed Limits: 2000



Note: Data not included for the District of Columbia.

Source: U.S. Department of Transportation (USDOT), National Highway Traffic Safety Administration (NHTSA), *Traffic Safety Facts 1998* (Washington, DC: 1999); and USDOT, NHTSA, personal communication, October 2000.

Safety Data

Better Data and Safety Management Systems: Availability of better data has improved our understanding of the causes of highway crashes and has allowed us to measure the success of safety efforts. Safety management systems and better safety data now are used by many states to identify safety concerns and to determine which initiatives are most beneficial in reducing crashes.

Before 1975, it was difficult to study the causes of motor vehicle crashes because there was no national-level database. In 1975, the Fatal Accident Reporting System (FARS) was established by NHTSA to create a national-level database of the most severe motor vehicle crashes, those involving a fatality. Since then, these data have been updated and analyzed each year, factors contributing to crashes have been studied, and improved measures have been developed. FARS was later renamed the Fatality Analysis Reporting System.

FARS data are supplemented by another database developed by NHTSA in 1988, the National Automotive Sampling System. This database has two components: the General Estimates System (GES) and the Crashworthiness Data System (CDS). The GES contains data from a nationally representative sample of law enforcement-reported crashes of all severities, including those resulting in death, injury, or property damage. The CDS database includes additional detailed information on an annual sample of approximately 5,000 law enforcement-reported traffic crashes across the country, which are studied in great by crash investigators.

The FHWA established the Highway Safety Information System (HSIS), which provides a sample database of highway safety and road inventory data from each state. It is used to study highway safety issues, direct research efforts, and evaluate effects of safety measures.

Together, these systems provide an overall measure of highway traffic safety and are used to identify traffic safety problems, suggest solutions, and provide a basis on which to evaluate the effectiveness of motor vehicle safety standards and highway traffic safety initiatives.

Box 3-6

Safety In Numbers

The *Safety In Numbers* project was developed in response to Secretary Slater's 1999 National Transportation Safety Conference, where stakeholders identified better data collection and reporting across all jurisdictions as one of the top priorities for safety improvement.

Under this initiative, four Safety Data Workshops were organized by the Bureau of Transportation Statistics (BTS) in September and October 1999, with a concluding national conference held in April 2000, in Washington, D.C., to gather input and develop an action plan for improving the quality of safety data. Organized along "modal" lines, these workshops (two surface transportation and one each for aviation and maritime transportation) brought together more than 200 stakeholders representing the diverse interests of the transportation community, such as nonprofit organizations, associations, businesses, government (state, local, and federal), advocacy organizations, and academia.

These workshops laid the foundation for a "Safety Data Action Plan" with BTS as the lead USDOT agency for improving data quality and ensuring intermodal collaboration. Key issues addressed in this plan include improving data quality, timeliness, and relevance; developing methods for examining safety intermodally; developing data standards; increasing data accessibility and sharing; and using technology to automate data collection and dissemination.

Keys to the Future

Over the last 25 years, the highway fatality rate has dropped steadily, reaching an all time low of 1.5 per 100 million VMT in 1999. However, the rate of decrease has slowed in recent years, and we are seeing "diminishing returns" on current safety improvement efforts. If the current fatality rate is not reduced and VMT grows at the current rate of 1.96 percent annually, about 60,000 people will be killed on the highways in 2015.

In order to continue the trend of significant yearly reductions in the VMT fatality rate over the next 25 years, greater application of safety management to our nation's roads will be required. It will be necessary to adapt new safety strategies and vehicle technologies to match changing demographics and ever-increasing highway traffic. Vehicle safety also must be enhanced, and occupants must be encouraged to take advantage of the protection provided by safety belts, child safety seats, and motorcycle helmets.

The USDOT has targeted a 20 percent reduction in highway-related fatalities and injuries by 2008. To achieve this goal, safety strategies and advanced technologies will need to address issues such as:

high levels of alcohol-impaired driving,
alcohol-impaired pedestrians,
failure of nearly one-third of the driving population to wear safety belts,
growing size of vehicles and safety problems due to incompatibility between large and small vehicles,
high numbers of pedestrian and bicyclist fatalities,
highway-rail grade crossing fatalities,
special needs of the rising numbers of aged drivers,
issues relating to growing population of young drivers,
rising incidence of aggressive driving and speed-related crashes,
run-off-road crashes, and
intersection crashes.

Most of these issues were highlighted during the first-ever National Transportation Safety conference hosted by the USDOT in March 1999 and subsequently during the 2025 Visioning Session on safety. We must remain visionary and vigilant and aggressively pursue actions that promote these strategies.

New, advanced crash-avoidance and vehicle control systems are on the verge of being introduced into the general market for all vehicle types. In the next few years, extensive deployment of these technologies is likely as they become less expensive. Some of these technologies are presented in box 3-6.

Box 3-7

Advanced Vehicle Safety and Control Systems

Night vision enhancement: This technology, which uses an infrared sensor behind the center of the vehicle's grill, detects people, animals, and moving vehicles on the road well before the vehicle's headlights, even high beams, can illuminate them. The image of the person, animal, or vehicle is projected onto a black-and-white head-up display on the windshield in front of the driver.

Drowsy driver detection systems: These systems track driver alertness through observation of eye movements and lanekeeping variation (which is a key predictor variable for detecting driver drowsiness). Drowsy driving can be caused by a combination of sleep loss, driving when circadian rhythms are low (early morning hours and mid-afternoon), or driving for long periods of time. The vehicle devices alert the driver when such behavior is detected.

Adaptive cruise control: Automotive Adaptive Cruise Control (ACC) is a "smart" device that maintains a driver-selected headway interval between vehicles. ACC monitors the headway interval, provides an audible warning, and slows the vehicle when the interval becomes dangerously narrow. Next generation or "Intelligent" systems, once set, will automatically maintain a safe distance, governed by throttle and brake control.

Rear-end collision avoidance: A rear-end collision occurs when safe distance is not maintained due to a driver's unawareness and a lack of safe distance information. Rear-end collision-avoidance systems will typically sense critical information about an impending collision, process the information into a usable form, and present this information to the driver (or directly to the vehicle) in a way that elicits appropriate collision avoidance action. Rear-end collision-avoidance systems may include Driver Warning, Intelligent Cruise Control, and Automatic Control systems.

Collision notification: This is a "Mayday" system for passenger vehicles that automatically and reliably detects the occurrence of a crash and alerts emergency medical services (EMS), police, and fire agencies. The primary objective of the system is to significantly reduce emergency response times for personal injury crashes by automatically assembling and transmitting a cellular telephone message from the vehicle to local emergency agencies. The message would include the vehicle location and crash severity data.

Intersection collision avoidance: This system consists of traffic-actuated warning signs linked to pavement loops and a traffic signal controller to enhance driver awareness of the traffic situation at intersections, particularly unsignalized intersections where signalizing would be prohibitively expensive.

Vehicle stability enhancement: Two countermeasures have been identified by NHTSA to help reduce the incidence of heavy-vehicle rollovers. The first is a Roll Stability Advisory System, which measures the rollover stability properties of a typical tractor-semitrailer as it is operated on the roadway and provides the driver with a graphical depiction of the vehicle's loading condition relative to its rollover propensity. The second countermeasure is a Rearward Amplification Suppression System that selectively applies brakes to wheels to stabilize the vehicle and thereby reduce the incidence of rear-trailer rollover in double- and triple-trailer combination vehicles during crash-avoidance steering maneuvers.

Source: Hagler Bailly, Inc., *The Market for Emerging Technology Applications in Transportation: Market Analysis and Forecast* (Washington, DC: 1999).

Automation of enforcement efforts—monitoring red-light running or speed-limit violations—can help improve crash avoidance by making drivers more aware and increasing compliance and respect for traffic control devices and traffic laws intended to prevent crashes. Further improvements in data collection systems can provide timely information necessary to maximize the effectiveness of safety measures. Strategies relying on more accurate data about trends can be developed to improve public services, such as emergency services, enforcement, and hazardous materials teams.

By the year 2025, we will have made a quantum leap forward in reducing highway fatalities and injuries by dramatically decreasing the number of crashes that occur on America's roadways. Automated cruise control and collision avoidance systems, including interactive systems to prevent collisions at intersections, will be widely available. Detection systems that alert drowsy drivers or prevent the operation of a vehicle by impaired drivers will be more widely accepted and commonly used. Automated observation technologies will permit more effective enforcement of highway safety laws, particularly speeding and red-light running violations, thereby substantially reduce crashes.

Improved safety data and information systems, as well as a better understanding of highway crash causation, will ensure that infrastructure investments are targeted toward the highest hazard locations using the most effective countermeasures available. To make the driving task safer for an older driving population and other users, improved computer-aided highway design—for example, next-generation high-visibility pavement designs, enhanced pavement markings and signs, and other roadside safety hardware—will ensure that we have in place a highway system that actively works to prevent crashes and minimizes the severity of crashes when they may occur.

Motor Carrier Safety

A quarter century ago, the Interstate Commerce Commission (ICC) regulated the economic aspects of the motor carrier industry. The FHWA had responsibility for safety regulation, performing several thousand on-site reviews annually for carrier compliance with both federal safety and hazardous materials regulations.

In 1975, about 15,000 carriers had authority to provide interstate transportation for hire [Hill 2000]. Economic deregulation of for-hire interstate truck and bus transportation, signed into law in 1980 and followed by intrastate deregulation, meant that nearly anyone could begin service anywhere. There was a flood of new entrants—mostly small carriers, creating a safety oversight challenge for the FHWA and the states.

Between 1975 and 1998, annual VMT for large trucks more than doubled—from 81 billion miles to 196 billion miles [USDOT FHWA 1975–1998]. Despite this increase in large-truck VMT, both the fatality rate and total crash incident rate per 100 million VMT have decreased for large trucks. The number of fatalities, however, has risen over the same period. In 1999, 5,203 people were killed in crashes involving large trucks compared to 4,500 in 1975. Figure 3-22 shows the fatalities in large truck crashes from 1975 to 1998. On average, 80 percent of those killed in large-truck crashes were nonmotorists or occupants of other vehicles involved in the crash [USDOT FMCSA 2000a].

In the mid-1970s, about 18,000 roadside driver-vehicle safety inspections were conducted each year by a small federal field staff [Hill 2000]. In 1982, Congress enacted the Motor Carrier Safety Assistance Program, a multimillion-dollar grant program under which states perform roadside driver/vehicle inspections and carrier on-site compliance reviews. By 1999, more than 2 million inspections per year were being conducted (figure 3-23) mostly by states. Figure 3-24 shows the percent of vehicles and drivers removed from service ("out of service") as a result of these roadside inspections.

Figure 3-22

Fatalities in Large Truck Crashes: 1975-98 (Annual totals)

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1998* (Washington, DC: 1999).

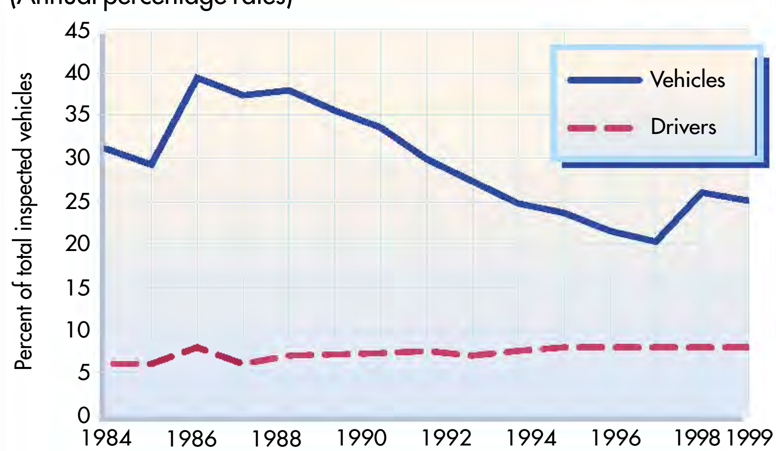
Figure 3-23

Number of Vehicle Inspections: 1984-99 (Annual totals)

Source: U.S. Department of Transportation, Federal Motor Carrier Safety Administration, Motor Carrier Inspection Database (Washington, DC: Various years).

Figure 3-24

Out-of-Service Inspections*: 1984-99
(Annual percentage rates)



* Roadside inspections that result in the vehicle and/or driver being removed from service for violating Federal Motor Carrier Safety Regulations or Federal Hazardous Materials Regulations.

Source: U.S. Department of Transportation, Federal Motor Carrier Safety Administration, Motor Carrier Inspection Database (Washington, DC: Various years).

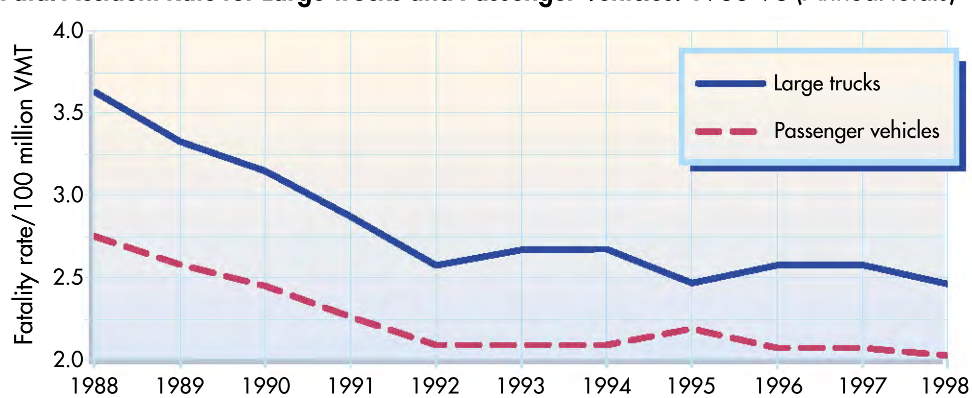
By the mid-1980s, with deregulation, ease of entry, and limited safety oversight, the FHWA requested and received authority from Congress to hire 300 additional inspectors to enforce safety regulations [Hill 2000]. The FHWA also expanded its information systems to gather additional safety information on all interstate motor carriers whose number had expanded to more than 190,000 [USDOT FMCSA 2000b].

Other major safety actions quickly followed. Under a 1987 law, commercial truck and bus drivers are prohibited from having more than one commercial driver's license (CDL), thereby preventing operators from circumventing driving suspensions by spreading citations among licenses from various states. Another change was that drivers were required to pass comprehensive road tests in the vehicles they were to operate. Subsequent changes included mandatory drug and alcohol testing of commercial drivers, which began in 1990; improved medical screening; and a 1994 ban on radar detectors in commercial vehicles.

By the late 1990s, the FHWA was able to use its data system to target high-risk carriers for on-site compliance reviews to bring them into regulatory compliance or, in the worst cases, levy fines or even suspend operations. Most states also have adopted the Federal Motor Carrier Safety and Hazardous Material Safety Regulation standards or have state laws comparable to these federal standards for trucks that operate only within the state and, therefore, are not subject to federal regulations. States also have increased enforcement efforts to improve compliance with these safety standards. As a result of these safety initiatives, NHTSA estimates show that the involvement rate of large trucks in fatal crashes per 100 million large truck VMT decreased from 4.9 in 1975 to 2.5 in 1998. Figure 3-25 shows the decline in fatal crash involvement rate (per 100 million VMT) for large trucks between 1988 and 1998.

Figure 3-25

Fatal Accident Rate for Large Trucks and Passenger Vehicles: 1988-98 (Annual totals)



Source: U.S. Department of Transportation, Federal Motor Carrier Safety Administration, *Large Truck Crash Profile: The 1998 National Picture* (Washington, DC: 2000).

To further improve the enforcement of motor carrier safety programs and reduce fatalities from crashes involving large trucks, the Federal Motor Carrier Safety Administration (FMCSA) was created by the Motor Carrier Safety Improvement Act of 1999. This legislation provided increased resources to target:

- increased roadside inspections,
- compliance reviews and enforcement actions,
- improved safety data,
- additional research into the causes of crashes,
- increased education for highway drivers,
- review of the CDL program, and
- close monitoring of new truck and bus drivers.

Keys to the Future

On January 1, 2000, the FMCSA began its life with the ambitious goal of reducing fatalities in crashes involving trucks and buses by 50 percent over the next 10 years. This target, the centerpiece of the Commercial Motor Vehicle Safety Action Plan, was announced by the Secretary of Transportation in May 1999.

Current trends suggest that over the next 25 years, the number of large trucks and their VMT may continue to grow significantly. The North American Free Trade Agreement (NAFTA) and the expanding international freight trade also may create more truck traffic. If truck travel continues to grow at its current rate, the miles traveled will increase by approximately 55 percent by 2025 to more than 300 million truck-miles per year. Given this growth rate, large truck fatalities would be expected to increase to over 8,300 in 2025 if the current fatality rate of 2.7 fatalities per 100 million miles traveled does not change. However, we can do better. Our stretch goal of reducing motor carrier-related fatalities by 50 percent by 2010 will propel further reductions by 2025. The FMCSA and the trucking industry will be challenged to reduce deaths while the motor carrier industry grows rapidly. The major challenges likely to be faced include:

- collecting accurate information to allow field staff to focus on motor carriers and drivers identified as the highest safety risks and to remove problem carriers and drivers from the road;
- increasing safety awareness among the driving public on how they can better cope with trucks and buses on the highways;
- increasing safety awareness among commercial drivers and safety personnel in the area of fatigue recognition and management;
- developing standards for the many new motor carriers expected to enter the industry; and,
- using technology advances—crash avoidance systems, early hazard detection, countermeasures for driver fatigue, and roadside brake examination on moving vehicles—to increase safety in the truck and bus industries.

Possible long-range solutions include:

- imposing crashworthiness requirements to reduce fatalities in truck/car collisions,
- requiring new carriers to demonstrate knowledge of existing safety regulations,
- setting aggressive and accountable goals for states to reduce fatalities,
- imposing stiffer requirements on CDL applicants for traffic and drug- and alcohol-related violations, and
- establishing a National Commission to study how economic considerations may affect drivers' decisions to drive for longer periods without rest.

The momentum developed to meet the 2010 goals could propel us to even higher levels of safety. While crashes involving large trucks are frequently deemed not to be the fault of the operator of the truck, advanced technological systems installed in trucks together with carefully targeted investments will continue to reduce large truck-related fatalities. By 2025, a target of reducing fatalities far beyond the 50 percent goal by 2010 is entirely feasible.

Transit Safety

In 1975, transit, like the intercity rail system, was beset by serious financial difficulties. As transit ridership steadily declined from the late 1940s through the early 1970s, public agencies were forced to bail-out the financially beleaguered private transit operators. The public agencies kept transit systems operating, but limited funds remained for system upgrades and safety improvements.

In the past quarter century, fare increases, public funding, and, recently, increased ridership to more than 9 billion have improved the financial stability of transit agencies. New equipment and tracks, better safety training, and tougher federal and state oversight have produced transit systems that are safer and more efficient.

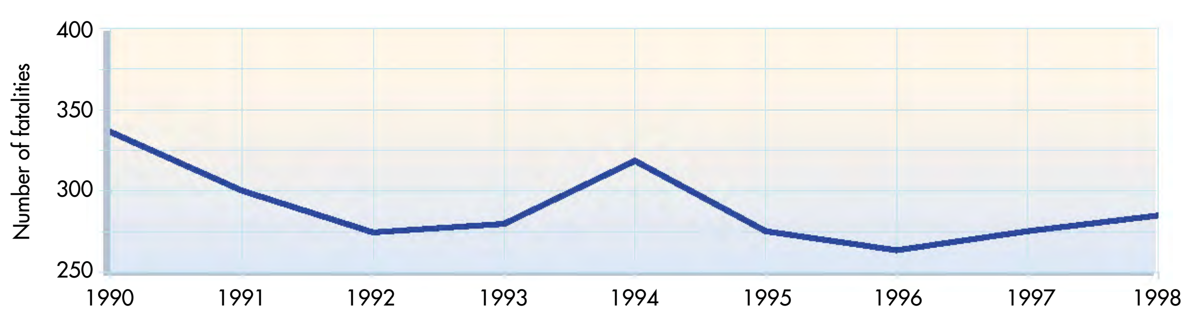
Twenty-five years ago, the major focus of most transit agencies was to generate enough funds to continue operating. Many transit systems considered operating funds to be top priority, while maintenance for aging tracks and vehicles was a lesser concern. These systems could not afford new equipment.

Beginning in 1975, transit systems received some relief from the pressures of generating operating expenses with the first federal operating assistance and an increase in federal funds for capital assistance. When the Federal Mass Transit Account was established in 1983, funded by a penny-per-gallon gas tax, transit systems began receiving even more federal capital funds, freeing more of their own money for operating expenses. Many state and local governments also recognized the financial crisis facing transit agencies and came to their aid; some provided direct aid, and others provided dedicated local tax revenues. As these funds were combined with revenues from the farebox, transit agencies gradually began to invest in system improvements and new equipment. Greater attention also was focused on preventing operator errors through better training and stricter enforcement of drug and alcohol standards.

Between 250 and 300 people die annually in transit incidents (figure 3-26), and about 55,000 people are injured, according to the Federal Transit Administration (FTA). Figure 3-27 shows the declining trend in transit incidents between 1990 and 1998 (fatality and injury data are unavailable before 1990). There are more deaths and injuries on bus systems than on other transit modes, more incidents per million vehicle-miles on light rail than on other modes, and more deaths per 100 million unlinked passenger trips on commuter rail systems.

Figure 3-26

Fatalities in All Transit Incidents: 1990-98
(Annual totals)



Source: U.S. Department of Transportation, Federal Transit Administration, Safety Management Information System (Washington, DC: 1998).

Figure 3-27

Transit Incidents: 1990-98
(Annual totals)

Source: U.S. Department of Transportation, Federal Transit Administration, Safety Management Information System (Washington, DC: 1998).

In 1995, Congress mandated the FTA to create the State Safety Oversight program, requiring states to manage the safety of rail transit systems and to develop system safety program standards. This requirement applies to 34 transit agencies in 22 states. Commuter rail safety is covered by Federal Railroad Administration (FRA) safety standards.

Keys to the Future

If current trends continue, transit systems will be carrying more riders early in the new century—particularly the aging U.S. population, which may create more transit demand for ridership.

Increased investment in new and better equipment by transit agencies is one solution for providing the safety needed for increasing ridership. Recently, transit agencies have joined in testing railcars and railcar windows. New technologies (e.g., rear collision avoidance, lane change and merge collision avoidance, road departure warning, and pedestrian/passenger sensing) also promise to increase the margin of safety.

Transit agencies also can provide improved safety education and training for the workforce. In 1999, the Transportation Safety Institute provided more than 53,000 hours of training for transit workers.

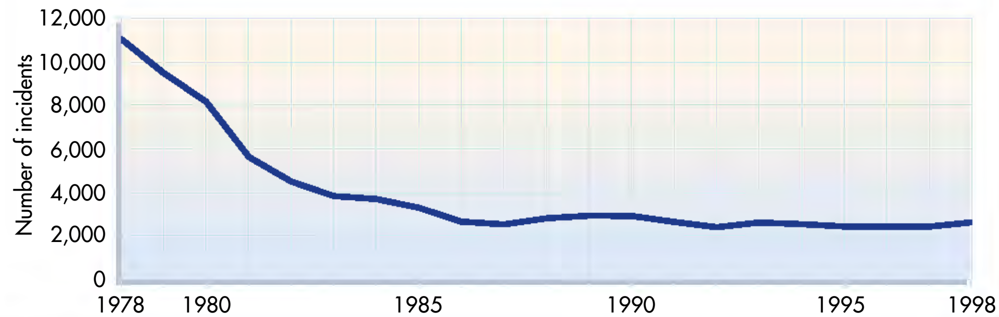
Railroad Safety

In 1975, much of the U.S. railroad industry was hobbled by major financial problems. Railroads, struggling to survive, lacked the funds to maintain existing infrastructure or buy new equipment. Deteriorating track and aging railcars and other equipment posed significant safety threats.

Following economic deregulation in 1980, the railroads gradually regained financial strength and the resources to reach higher safety levels. Today, with increasing rail traffic, safety has improved and the number of railroad-related crashes and fatalities have decreased (figures 3-28 and 3-29). But, we can do more—the FRA has set a 5-year goal to reduce the rate of fatalities fatalities in rail-related incidents by 25 percent [USDOT FRA 1999].

Figure 3-28

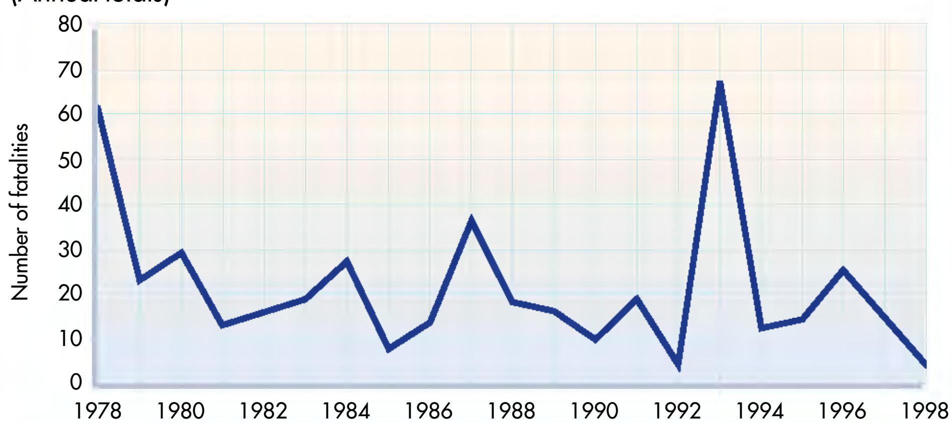
Total Train Incidents: 1978-98
(Annual totals)



Source: U.S. Department of Transportation, Federal Railroad Administration, *Accident/Incident Overview* (Washington, DC: Various years).

Figure 3-29

Fatalities in Train Incidents: 1978-98
(Annual totals)



Source: U.S. Department of Transportation, Federal Railroad Administration, *Accident/Incident Overview* (Washington, DC: Various years).

Significant challenges in the railroad industry have confronted the USDOT from the time of its creation in 1966. The FRA was granted broad safety rulemaking authority under the Federal Railroad Safety Act of 1970 [Public Law 91-458] and set the first federal track safety standards in 1971 [36 *Federal Register* 20336] and, in 1973, set freight car safety standards [38 *Federal Register* 32230]. The new regulations did not immediately improve the railroads' safety performance. In 1978, total train crashes, excluding highway-rail grade crossing and trespass incidents, reached 10,991 with 61 fatalities, including 24 deaths resulting from the release of hazardous materials from 232 railcars involved in train crashes [USDOT FRA 2000].

Part of the problem in the mid-1970s was that economic regulation curtailed the railroad industry's ability to generate sufficient revenues to maintain its infrastructure. The Staggers Rail Act of 1980—legislation that liberalized the regulatory environment for railroads—initiated the industry's return to financial recovery. Safety improved with increased investment in railroad infrastructure, including technologically advanced physical plant and equipment. At the same time, the industry was faced with new, higher safety standards set by the FRA, ranging from crashworthiness standards for tank cars to alcohol and drug testing regulations for operators and other workers.

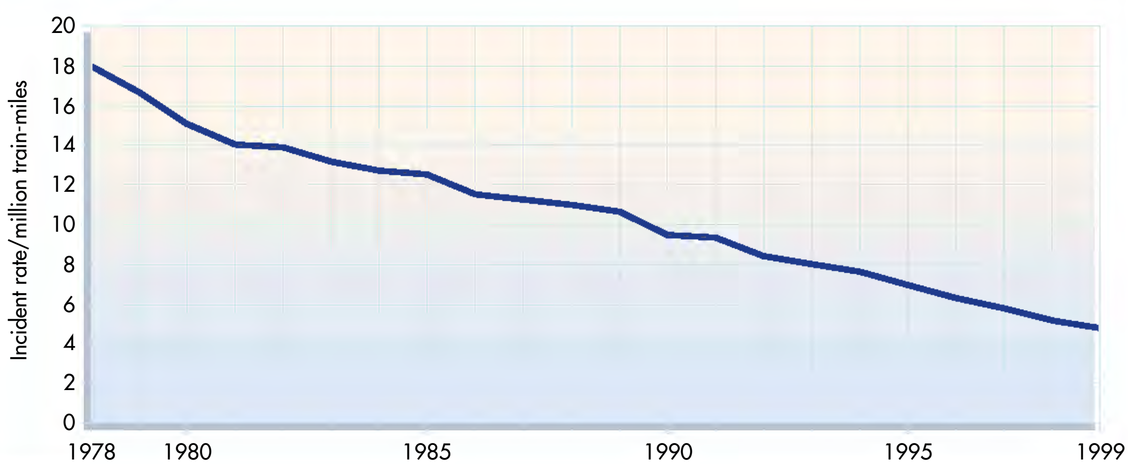
As a result of these measures, rail-related injuries dropped by 75 percent between 1978 and 1993 [USDOT FRA 2000]. During the same period, incidents declined by more than 75 percent while the incident rate per million train-miles dropped by more than 65 percent. The highway-rail grade crossing incident rate was reduced by more than 75 percent, from 18 per million train-miles to 4.8 per million train-miles (figure 3-30). Since 1980, only three people have died as the result of hazardous materials release in train crashes [USDOT FRA 2000].

These substantial safety improvements took place while freight railroad traffic increased to a record 1.1 trillion ton-miles by 1993. The fatality rate per million train-miles stayed nearly constant from 1978 to 1993, but with FRA's new safety inspection program and continuing investment, the rate then decreased by 38 percent from 1993 to 1999 (figure 3-31). From 1993 to 1999, despite increases in highway and train traffic, incidents at highway-rail crossings decreased by 29 percent, and crossing deaths decreased by 36 percent. Figure 3-32 shows the location of grade crossing fatalities in 1998. Overall railroad fatalities fell by 27 percent, and total railroad injuries fell by 39 percent [USDOT FRA 2000]. In 1999, only 39 hazardous materials releases were due to train crashes—an 83 percent drop since 1978 [USDOT FRA Annual issues].

FRA promotes strategic partnerships with rail labor, management, suppliers, state rail safety agencies, and other rail stakeholders. through the advent of this partnership concept, begun in 1993, a new safety culture has emerged within the railroad industry to implement safer operating practices and procedures. This new safety culture, along with technological advances, permits new and innovative practices to be adapted and thereby improve the overall safety of the industry as well as the quality of life of the employee.

Figure 3-30

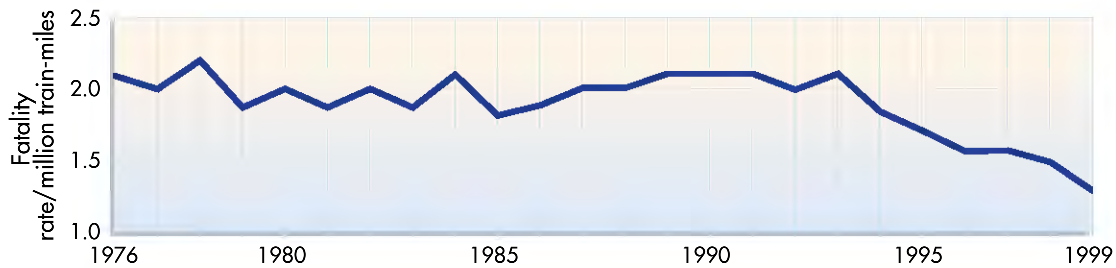
Highway-Rail Grade Crossing Incident Rate: 1978-99



Source: U.S. Department of Transportation, Federal Railroad Administration, Annual Safety Statistics, (Washington, DC: Various years).

Figure 3-31

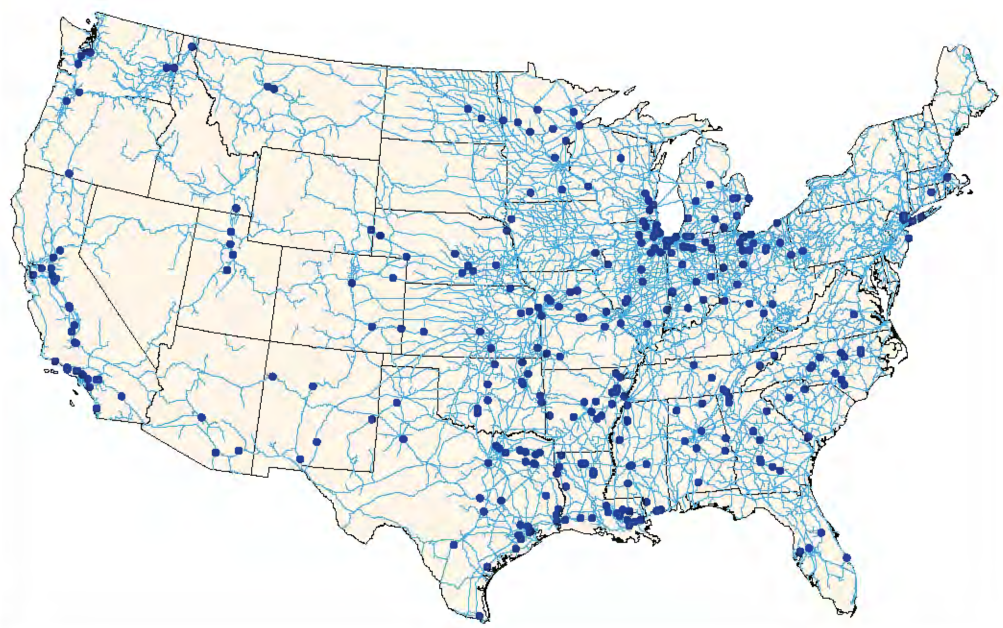
Rail-Related Fatality Rate, Including Highway-Rail Grade Crossings: 1976-99



Source: U.S. Department ot Transportation, Federal Railroad Administration, Annual Safety Statistics (Washington, DC: Various years).

Figure 3-32

Grade-Crossing Fatality Locations: 1998



Source: U.S. Department of Transportation (USDOT), Federal Railroad Administration, Offices of Policy and Safety, special tabulations (Washington, DC: 2000); and USDOT, Bureau of Transportation Statistics, National Transportation Atlas Database 2000.

Box 3-8

Highway-Rail Grade Crossings

Combined public and private action has been successful in eliminating thousands of crossings and reducing fatalities and grade crossing crashes. Figure 3-33 shows the decline in highway-rail grade crossing fatalities. Between 1974 and 1993, 49,000 public grade crossings were eliminated. In 1994, the USDOT developed the Rail-Highway Grade Crossing Safety Action Plan, whose implementation eliminated another 9,000 public grade crossings. The 1996 Federal Railroad Administration (FRA) requirement for all locomotives to have warning lights also helped produce significant reductions in the rate of grade crossing incidents. To add another safety precaution, Congress required FRA to issue rules preempting state and local laws banning the sounding of locomotive horns at public grade crossings. FRA also has expanded and strengthened its partnerships with groups such as Operation Lifesaver. As a result of these measures, deaths at highway-rail grade crossings have declined by more than half since the late 1970s [USDOT FRA 2000].

(continued on next page)

Box 3-8 *continued*

Highway-Rail Grade Crossings

Still, many rail-related fatalities—402 in 1999—result from collisions between trains and motor vehicles at railroad crossings. About 159,000 public grade crossings remain, with about 20 percent having automatic gates and another 20 percent having flashing lights [USDOT OIG 1999]. Figure 3-34 shows the highway-rail grade crossings by active and passive controls. Almost one-third of the more than 3,000 grade crossing collisions in 1999 (and 42 percent of the fatalities) occurred in five states: California, Illinois, Indiana, Louisiana, and Texas [USDOT FRA 2000]. FRA focuses a broad-based approach in these states including education and enforcement under Operation Lifesaver and through public announcements. Under proposed FRA rules, communities wishing to prohibit the sounding of locomotive horns at public grade crossings may be required to implement other grade crossing improvements, such as four-quadrant gates, photo enforcement, and roadway medians.

Today, trespassing has become the leading cause of railroad fatalities [USDOT FRA Annual issues]. Each year, approximately 500 people are killed as a result of trespassing on railroad rights-of-way. Railroads face the challenge of identifying sites vulnerable to trespassing, improving awareness, and installing fencing.

In 1997, after the merger of Union Pacific and Southern Pacific, concerns about merger-related safety problems—blending different corporate cultures and reconciling different operating rules and practices—arose. To address these concerns, the FRA, the Surface Transportation Board, and the two railroads worked jointly to develop Safety Integration Plans (SIPs)—blueprints to ensure critical safety needs were addressed. CSX and Norfolk Southern (NS) implemented SIPs as part of their acquisition of Conrail. Despite well-publicized service problems, reported crashes and injuries decreased in the realigned CSX and NS territories.

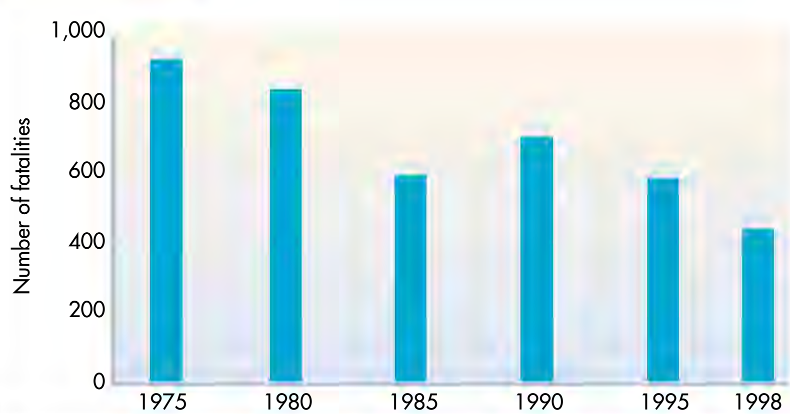
"Our challenge is about saving lives. It is about ensuring that more people arrive home safely each and every day — people who work on railroads, travel on railroads, and live near railroads. Our results speak for themselves. The years 1993-1999 were the safest seven years in rail history."

Jolene Molitoris
Administrator,
Federal Railroad Administration

In the past seven years, the safety focus has moved from site-specific inspections and enforcement to a cooperative industry-government partnership to identify and solve systemwide safety problems. This paradigm shift is the same as the work between NHTSA and its partners that focuses on prevention and not just response. As a result, safety regulations rules have been issued on bridge protection, maintenance of way, trackside workers, passenger train emergency preparedness, passenger equipment, two-way end-of-train devices, and track safety standards. Partnerships also were formed to address highway-rail crossings and to develop recommendations on other safety issues. In the first 6 years of this new cooperative safety approach, the fatality rate per million train-miles declined by 27 percent [USDOT FRA 2000]. Inspections, violation reports, and fines also were reduced. Today, approximately 400 FRA safety inspectors, joined by 150 state inspectors, monitor compliance with FRA safety regulations.

Figure 3-33

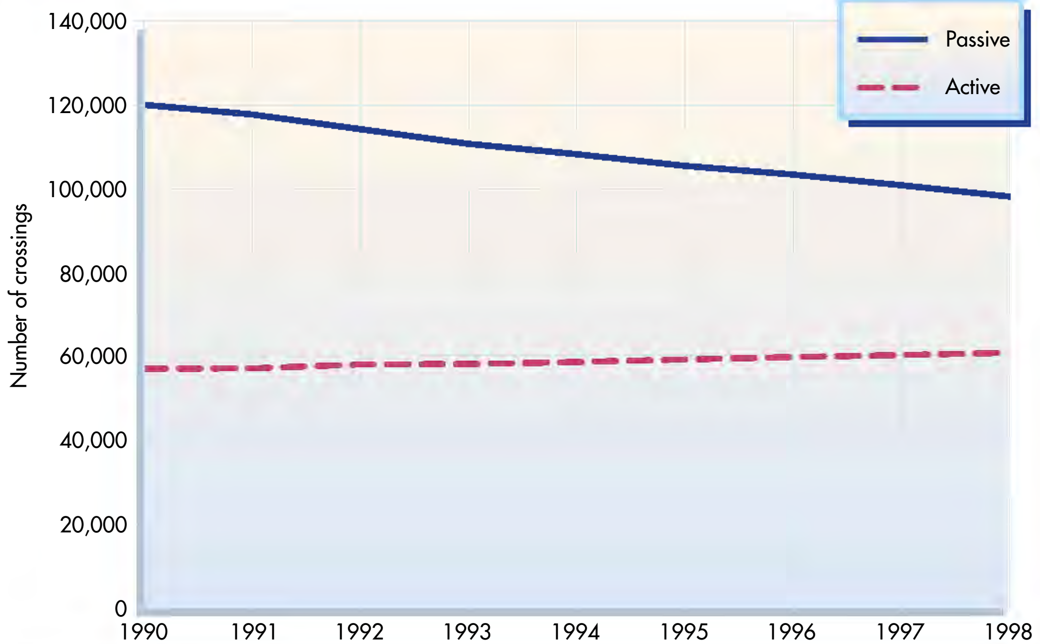
Highway-Rail Grade-Crossing Fatalities: 1975-98



Source: U.S. Department of Transportation, Federal Railroad Administration, *Railroad Safety Statistics Annual Report* (Washington, DC: 1998).

Figure 3-34

Number of Highway-Rail Grade Crossings by Active and Passive Controls: 1990-98
(Annual totals)



Source: U.S. Department of Transportation, Federal Railroad Administration, *Railroad Safety Statistics Annual Report* (Washington, DC: Annual issues).

Keys to the Future

Based on FRA's current safety programs and strategies, its goal is to achieve an entire year with *zero* employee-on-duty fatalities before the year 2025. FRA has also set the goal of reducing highway-rail grade-crossing fatalities 75 percent by the year 2025 to fewer than 100 per year. Working with its rail industry partners, FRA hopes to cut the train accident rate by nearly 50 percent by 2025 [USDOT FRA 1999]. Further progress in rail safety requires continued partnership between FRA and the rail industry to actively address the following key issues, as called for during the 1999 National Transportation Safety Conference:

- researching, testing, evaluating, and implementing alternative grade crossing technologies to prevent highway grade crossing accidents;
- researching human factors, including fatigue, which hamper operator alertness, resulting in crashes;
- promoting safety in high-speed train operations, including those reaching 90 to 150 mph on existing railroad rights of way; future trains reaching 200 mph using advanced steel-wheel-on-rail systems on largely new rights of way; and trains reaching 300 mph with magnetic levitation (maglev), where magnetic forces lift, propel, and guide a vehicle over a specially designed guideway;
- safe sharing of mainline freight track with light rail, commuter rail, and intercity passenger operations; and
- deploying positive train control systems (box 3-8).

To improve safety, the FRA and the railroad industry are examining ways to develop Intelligent Railroad Systems that would incorporate new digital communications technologies into positive train control, electronically controlled braking systems, grade crossings, and defect detection in tracks.

The FRA recognizes that there are many contributing aspects to human factor-caused train incidents, such as fatigue and train operator experience. The FRA is exploring more sophisticated ways of developing and analyzing data associated with these incidents. The FRA also is working with the railroads to strengthen job training and compliance with safety regulations.

Box 3-9

Technology for Rail Safety

Intelligent Railroad Systems use digital communications technologies for train control, braking systems, grade crossings, and defect detection to make the railroad system safer. New electronic sensors, computers, and transmission systems will help railroads detect hazardous equipment and track conditions and prevent collisions and derailments.

- Positive Train Control (PTC) systems will use digital data link communications networks, positioning systems, and on-train and control center computers to maintain assured separation between trains.
- Electronically controlled pneumatic brakes will substantially shorten braking distance by using an electronic signal to simultaneously apply all brakes on a train.
- Intelligent grade crossings with sensors will send information about trains to highway traffic control centers and to motorists through roadside traffic information signs. Sensors will send information to both trains and railroad control centers if a stalled vehicle blocks a grade crossing.
- Electronic sensors, on or alongside tracks and on locomotives and freight cars, will identify track and equipment problems and transmit the information to train and maintenance crews, and to control centers, in order to stop or slow a train, if necessary, to initiate repairs.
- New high-speed trainsets will have complex, computerized safety systems that are integrated with the safety system for the entire railroad.

Aviation Safety

A quarter century of focus on aviation safety has made air travel an extremely safe mode of transportation. The rate at which major U.S. aviation crashes (hull losses with fatalities) occur has decreased by more than two-thirds in the past two decades [USDOT FAA 2000b].

"Already, there is less than one fatal crash for every one million commercial flights. But we know we can do better still. Any accident, any death in the air is still one too many."

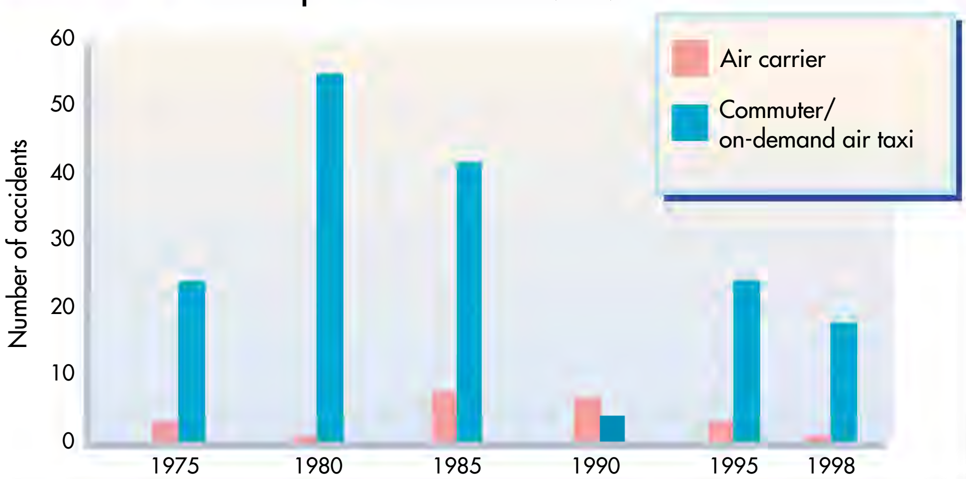
President William J. Clinton
in announcement on airline safety
Jan. 14, 2000

Stricter enforcement, higher standards, evolving technology, and information sharing have combined for continuous long-term safety improvements in air travel for both commercial and general aviation (figures 3-35 through 3-37). Figure 3-38 shows the decline in fatal U.S. air carrier accidents per 100,000 departures since 1978. For example, today, commercial aircraft are equipped to "know" when they are not configured properly and to employ corrective actions. They "know" when they are too close to terrain or too close to each other. In the past 25 years, there have been major breakthroughs in:

- air traffic control system technologies,
- understanding human factors that cause crashes,
- development of simulators used for training pilots,
- airframe and engine reliability,
- onboard automation,
- cabin safety and survivability, and
- crash investigation data.

Figure 3-35

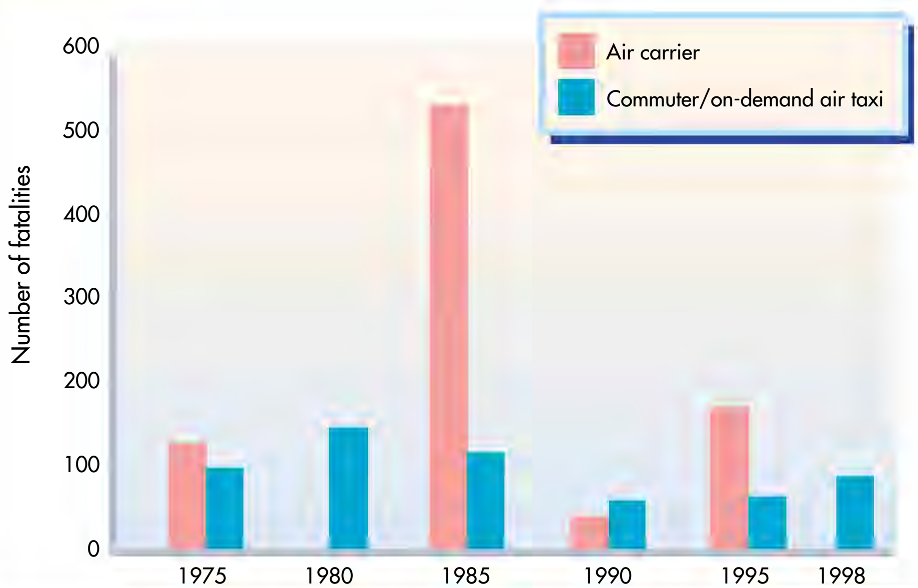
Fatal Commercial Air Transportation Accidents: 1975-98



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: 1999), Tables 3-9 through 3-13, pages 221-225.

Figure 3-36

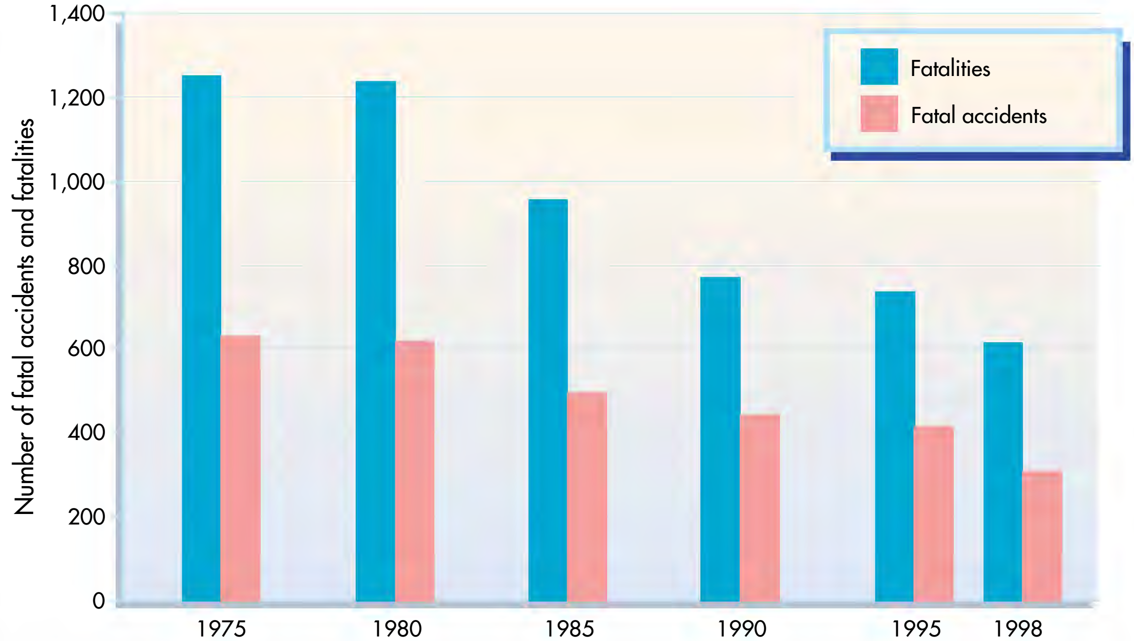
Commercial Air Transportation Fatalities: 1975-98



Note: There was one fatality involving air carriers in 1998.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: 1999), Tables 3-9 through 3-13, pages 221-225.

Figure 3-37

Fatal Accidents and Fatalities in General Aviation: 1975-98



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999* (Washington, DC: 1999), Table 3-14, p. 226.

Figure 3-38

Fatal U.S. Air Carrier Accidents Per 100,000 Departures: 1978-98

Source: U.S. Department of Transportation, Federal Aviation Administration, personal communication, 2000.

In the early 1970s, the aviation industry did not have a good safety record, prompting criticism of Federal Aviation Administration (FAA) policies. In January 1975, Claude S. Brinegar, the Secretary of Transportation (1973–1975), appointed a special 10-person *Task Force on the FAA Safety Mission* to examine FAA's organizational structure, management, and performance on safety issues. In April 1975, during Secretary William T. Coleman's administration, the task force made recommendations to the FAA that enabled the FAA to improve its organizational efficiency and expedite rulemaking procedures [USDOT FAA OPA 2000]. These improvements allowed the FAA to address some of the most challenging aspects of aviation safety—issues that would remain at the forefront of FAA programs during the next 25 years. Some of the issues addressed by FAA since 1975 are described in the following paragraphs.

Altitude Safety: The FAA examined landing approach procedures following the December 1974 crash of a Boeing 727 into a mountain near Berryville, Virginia, while on approach into Dulles International Airport. Soon after the crash, the FAA implemented higher standards by specifying pilot responsibilities for maintaining safe altitude and specifying the role of air traffic controllers in maintaining pilots' awareness of altitude restrictions.

The agency also expedited work on a technological solution by requiring installation of a Ground Proximity Warning System (GPWS) on large airliners. The system provided both visual and audible warning signals if an aircraft descended too close to the ground. All major airlines were in compliance with the GPWS rule by the end of 1976. In March 1992, the rule was extended to turbine-powered aircraft with 10 or more passenger seats flown by air taxi and commercial operators. More recently, the FAA and industry have taken steps to equip airliners with more advanced terrain awareness warning systems.

Rapid Decompression Standards: In July 1975, the FAA raised standards requiring wide-body jets to withstand the effects of rapid decompression. Concern about aircraft airworthiness was prompted by the March 1974 crash in France of a Turkish Airlines McDonnell Douglas DC-10 wide-body airliner, killing all 346 people on board in the worst air disaster up to that time. In this incident, a cargo door of the jet opened in flight, producing explosive decompression that disabled vital flight-control cables. This series of events led to a broader use of FAA airworthiness directives to ensure in-flight safety of aircraft systems.

Separation Standards: Also in 1975, the FAA increased the standard of distance separation for small aircraft landing behind larger aircraft that are capable of generating wake turbulence. Depending on the size of the lead aircraft, the new procedures required a separation of either four or six miles for the trailing plane. In the 1990s, the FAA modified these standards to give added protection from wake turbulence to small aircraft traveling behind the Boeing 757.

Structural Safety: As the service lives of commercial aircraft are extended, greater focus has been placed on the safety of aging aircraft. This problem was highlighted by a 1988 incident in which structural fatigue caused the opening, in mid-flight, of an 18-foot gap in the fuselage of an Aloha Airlines plane. One cabin attendant was ejected from the aircraft by the force of decompression. The FAA responded with a new approach to aging aircraft—replacement of mandatory inspections with preventive modifications for high-service airliners and the replacement of certain parts after a specified number of flight hours or takeoff-and-landing cycles.

Fire Safety: In March 1977, the full destructive potential of post-crash fire—and the need for higher standards and new technology—was revealed when a fiery runway collision involving a Dutch and a U.S. airliner produced history's worst airline incident at Tenerife, Canary Islands. That incident claimed the lives of 583 passengers and crew. The FAA's

Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee made a series of recommendations for research and rulemaking.

In 1984, the FAA published two SAFER-based rules on fire-resistant seat cushions and escape-path marking. During the next several years, the agency issued important fire protection rules that included stricter flammability standards for interior materials and improved protection for cargo compartments.

Fire concerns continued into the 1990s. The 1996 crash of a ValuJet DC-9 in the Florida Everglades was traced to a fire in the cargo compartment. The subsequent investigation resulted in new rules banning oxygen generators from the cargo holds of passenger planes, new focus on labeling and handling hazardous materials, and new rules for fire detection and suppression systems in cargo compartments by March 2001 (see the Hazardous Materials Safety section found later in this chapter).

The investigation following the crash of a SwissAir MD-11, in 1998, focused on wiring and insulation and the tests used to determine flammability. Aircraft insulation blankets covered with metalized Mylar were ordered replaced within four years in five types of transport aircraft, and the standard used to determine material flammability was tightened.

Wires and Fuel Tanks: The July 1996 crash of Trans World Airlines (TWA) Flight 800 into the Atlantic Ocean killed 230 passengers and crew. The investigation of that crash heightened attention to the dangers of corroded wires that could ignite fuel tank vapors. Inspections by the FAA and the National Transportation Safety Board (NTSB) determined that the wires near fuel tanks in Boeing 747s and other planes required maintenance. The follow-up included new certification standards and mandatory maintenance instructions on fuel systems for newly designed aircraft, a design review of the fuel tank system of larger existing transports, and a requirement for manufacturers to design specific programs for fuel tank maintenance and protection.

Commuter Airline Safety: As economic regulation of airlines was phased out by legislation enacted in 1978, the FAA adjusted its oversight program. The rules governing air taxis and commuter airlines (Federal Aviation Regulations, Part 135)—the fastest growing segment of the air transportation business—were revised in December 1978 to include mandates for better pilot qualifications and training, more stringent aircraft maintenance programs, and more sophisticated safety equipment. In 1980, the FAA added additional experience requirements for commuter airline crews.

These revisions were designed to bring the safety level of the commuter airlines closer to those of major airlines. In December 1995, the Commuter Safety Initiative set a single level of safety for all travelers by applying the stricter standards of major airlines (Federal Aviation Regulations, Part 121) to commuter airlines that had scheduled passenger operations and/or used aircraft seating 10 to 30 passengers or propelled by turbojets. The rules contained provisions on standards for airplane performance and for flight crew training and qualifications. In addition, the regulations also extended to commuter airline pilots the age-60 rule on mandatory retirement, which had formerly applied to airline pilots flying larger aircraft.

Aviation Safety Reporting: In 1975, the FAA established the Aviation Safety Reporting System (ASRS), designed to collect information on potentially unsafe conditions from airspace users. To encourage reporting of safety problems, the program generally granted immunity from disciplinary action to pilots or controllers filing timely reports. Although immunity programs had been instituted before, the ASRS was the first that did not limit immunity to reports of near midair collisions.

The program was enhanced by an agreement between the FAA and the National Aeronautics and Space Administration (NASA) under which NASA would operate a third-party reporting system, guaranteeing anonymity to individuals providing the data. To help collect safety-related information, the FAA opened a confidential Aviation Safety Hotline in July 1985 for reports of specific regulatory violations.

Collision Avoidance Equipment: The use of airborne collision avoidance equipment was a major technology development of the past quarter century. By 1975, the FAA had already been studying this technology for several years; and by 1981, the agency had pursued a design, which was designated the Traffic Alert Collision Avoidance System (TCAS). In 1989, the FAA directed airlines and commuter operators to install TCAS.

Keys to the Future

Although today's air-incident rate is low, an even lower rate is necessary for the future to improve safety in a rapidly growing aviation industry. Based on projected 15-year growth rates in the industry, current worldwide incident rates will produce an aircraft loss somewhere in the world every eight days [Boeing 2000a, 2000b]. In the United States, the present incident rate would produce an aircraft loss about every three months by 2015. The FAA's 2007 goal is an 80 percent reduction in the air carrier fatal incident rate [Flynn 2000] from the 1994 through 1996 levels.

"The ultimate aim of our efforts is to assure a safe and secure system that enhances the unprecedented levels of mobility we have achieved and which fuels our economic growth while improving the quality of the environment."

Ashish Sen
Director, Bureau of
Transportation Statistics

To achieve this ambitious reduction, major breakthroughs and innovations—new ways of acquiring and sharing knowledge about safety, new ways of setting safety standards, and a new way of working with the aviation community—will be needed. This will require creative strategies that go beyond the government's traditional regulatory role, as well as timely implementation. To further improve aviation's safety record, public and private researchers must work cooperatively to achieve new and innovative breakthroughs from technology, advances in automation, and new human factors knowledge.

The FAA's future safety strategies will focus on a collaborative process that involves working with the aviation community to prevent crashes by finding potential causes. An important element will be new data systems to provide necessary information. These new systems depend on the day-to-day exchange and analysis of operational data by government, industry, and academia. The FAA is working with the aviation community to identify and address potential causes of crashes using data from flight recorders, maintenance reports, and other sources.

"Both Safer Skies and GAIN mark what I think is a historically important shift in direction for aviation safety. Both rely on partnership—on the FAA and the aviation industry working together. Both take a preventive approach. And, both rely on information technology."

Jane F. Garvey
Administrator
Federal Aviation Administration
Third GAIN World Conference
Nov. 4, 1998

Based on detailed analysis of recurrent crash causes, the FAA works with the aviation community to prevent crashes through targeted, systematic interventions. *Safer Skies*, the Administrator Garvey's Safety Agenda [USDOT FAA 2000c], highlights three broad initiatives that will change over time. Commercial Aviation Safety addresses accident causes such as controlled flight into terrain (CFIT), uncontained engine failures, approach and landing, loss of control, and runway incursion. General Aviation Safety addresses causes such as CFIT, weather, loss of control, survivability, aeronautical decisionmaking, and runway incursion. Cabin Safety, the third initiative, addresses passenger interference, passenger seat belt use, carry-on baggage, and child restraints.

The FAA also is working with the worldwide aviation community to develop a privately owned and operated Global Aviation Information Network (GAIN) to collect, analyze, and disseminate aviation safety information. GAIN will dig deeper into the worldwide unreported occurrences of aviation incidents to gather information for their prevention.

To measure success, the agency has specific targets for improvement by specified dates [USDOT FAA 2000a].

1. *Fatal Air Carrier Accident Rate*: By 2007, reduce the U.S. commercial air carrier fatal accident rate per 100,000 hours flown by 80 percent of the 3-year average from 1994 to 1996. This performance goal was the chief safety recommendation of the 1997 White House Commission on Aviation Safety and Security.

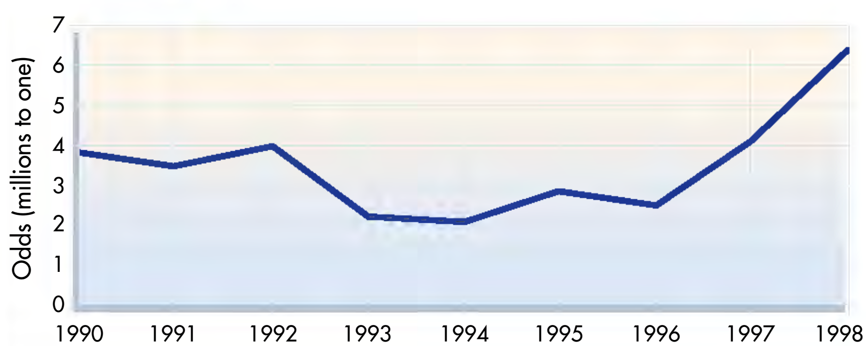
2. *General Aviation Fatal Accidents*: Reduce general aviation fatal accidents to produce a 20 percent improvement over the projected 2007 estimate of 437. This goal was agreed upon by a coalition representing the general aviation community and the FAA.

3. *Occupant Risk*: Increase the probability that passengers and crew will survive an air carrier flight (figure 3-39).

Looking into the future, NASA and the FAA are working together to achieve the long-term goal of reducing the aircraft accident rate by a factor of 5 by 2010, and by a factor of 10 by 2025.

Figure 3-39

Probability that Passengers Will Survive an Air Carrier Flight



Source: U.S. Department of Transportation, Federal Aviation Administration, Working paper on Aviation Safety, draft, March 2000.

Box 3-10

Flight Data Recorders

The first permanent requirement for flight data recorders aboard specific commercial aircraft became effective in 1958. A requirement for Cockpit Voice Recorders followed in 1967. Since then, the requirements have continually expanded—to business-type jets in February 1975, to some existing and newly manufactured large commuter aircraft in 1988, and to new jet and turboprop commuter aircraft in 1989. Voice recorders were mandated in 1988 for all multiengine, turbine-powered commuter and air taxi aircraft able to seat six or more persons with a two-pilot crew. In 1989, the FAA ordered the installation of more sophisticated digital flight data recorders on about

(continued on next page)

Box 3-10 *continued*

2,000 older, large commercial jets. Requirements for voice recorders and flight data recorders also were extended to general aviation aircraft with multiple turbine engines. In recent years, the National Transportation Safety Board (NTSB) and the Federal Aviation Administration (FAA) have been seeking to use advanced recording technology to better identify the causes of aviation crashes and predict trends to prevent future crashes.

Flight Data Recorders

The flight data recorder onboard aircraft records many different operating conditions of the flight that can aid in an investigation in case of a crash. The items monitored can include anything from altitude, airspeed, and heading to flap position, autopilot mode, or even smoke alarms. When used in conjunction with other information gained in the investigation, the flight data recorder and the cockpit voice recorder are playing an ever-increasing role in determining the causes of aircraft crashes.

In 1995, in response to an NTSB recommendation, the FAA called on the aviation industry to begin voluntarily retrofitting Boeing 737 aircraft with upgraded digital flight data recorders (DFDRs). In 1997, the FAA ordered the installation of such DFDRs by August 2001.

The number of specific areas of flight information—data parameters—will be set at 88 for newly manufactured aircraft and will be increased from 11 to 17 or 18 for older aircraft. These parameters deal primarily with information such as the position of flight controls and pilot input.

In response to an NTSB recommendation based on the finding that a rudder malfunction resulted in the deaths of 132 passengers and crew aboard USAir (now USAirways) Flight 427 in 1994, the FAA has proposed additional flight data recorder parameters for the rudder systems of Boeing 737s. Newer Boeing 737s would have upgraded rudder parameters installed by August 4, 2000, while older 737s would have to be in compliance by August 2001.

In response to NTSB recommendations, the FAA also is proposing to increase the 30-minute recording now required on cockpit voice recorders to two hours and to require a 10-minute backup power supply by January 1, 2005. Additionally, the agency is proposing that aircraft built after January 1, 2003, have combination voice and data recording systems. One unit would be close to the cockpit; the other would be in the back of the aircraft.

Maritime Safety

New safety regulations, technological change, education and training programs, and enhanced law enforcement have made our waters much safer than they were 25 years ago. Most fatalities, injuries, and incidents on the water involve recreational boating (which has become an increasingly popular pastime), but fatalities have declined 50 percent since 1975 [USDOT USCG 1999]. Fatalities from commercial vessel operations have decreased by 87 percent from 1975 levels, even though traffic has increased [USDOT USCG 2000c]. Maritime workers still have a fatality rate that is four to five times greater than the average for all other U.S. occupations [USDOT BTS, MARAD, and USCG 1999]. Fishermen are more likely than other maritime workers to die on the job, even though commercial fishing fatalities are down 20 percent since passage of the Commercial Fishing Industry Vessel Safety Act of 1988 [USDOT USCG 1999].

From 1995 to 1999, 60 people died on commercial passenger vessels from all causes (excluding natural causes and diving accidents), and the number of passenger injuries averaged 183 over that same time period [USDOT USCG 2000e]. The NTSB in 1989, and again in 1993, identified serious shortcomings in passenger ship safety and issued recommendations to improve standards for fire protection, crew qualifications, emergency drills, and crew language requirements.

Safety on our waters has improved over the last 25 years as a result of efforts by the U.S. Coast Guard (USCG), in collaboration with industry, the public, and the states. Concerted efforts are being made to improve safety even further. The strides made in the last 25 years and the future direction of safety programs are discussed in detail below for each aspect of the maritime system.

Recreational Boating: Recreational boating fatalities peaked at 1,466 in 1975. In response to the high number of fatalities that year, the USCG implemented an aggressive enforcement campaign to crack down on boaters operating under the influence of alcohol, along with efforts to increase the use of life jackets. As a result of these efforts, recreational boating fatalities declined to 734 by 1999 (figure 3-40). Figure 3-41 shows recreational boating accidents by state in 1975 and 1998.

Of the 815 reported recreational boating fatalities in 1998, 217 were alcohol-related [USDOT USCG 1999], and alcohol was involved in 15 percent of all fatal boating accidents (Figure 3-43). Operating a watercraft while intoxicated became a federal offense in 1998, but the USCG is seeking to tighten enforcement even further by lowering the blood-alcohol content level from 0.10 percent to 0.08 percent in all states (20 states already have a 0.08 percent blood-alcohol concentration limit). This is the same standard used today for motor vehicle drivers [USDOT USCG 2000b].

While jet skis and other personal watercraft are involved in as many accidents as open motorboats, more than five times as many people die in open motorboat accidents [USDOT USCG 1999]. Use of life jackets by jet ski users and the reluctance of many boaters to wear life jackets may be the difference. Although jet skiers are less likely to drown than motorboat passengers, they are much more likely to die from blunt force trauma—the primary cause of death in personal watercraft mishaps [USDOT BTS, MARAD, and USCG 1999].

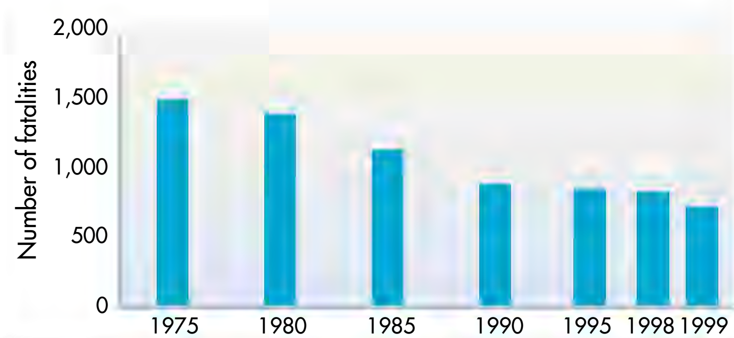
Box 3-11

Growth of Recreational Boats

Today, more people than ever are spending their recreational time on the water, and the number of state-registered recreational boats grows annually (figure 3-42). Adding to the mix of boats and recreational vessels are thousands of personal watercraft, more commonly known as jet skis. According to the National Marine Manufacturers Association, an estimated 106,000 personal watercraft were sold in 1999, up from 29,000 in 1987.

Figure 3-40

Fatalities Involving Recreational Boating: 1975-99



Source: U.S. Department of Transportation, U.S. Coast Guard, Office of Investigation and Analysis, Compliance Analysis Division (Washington, DC: Various years).

Box 3-12

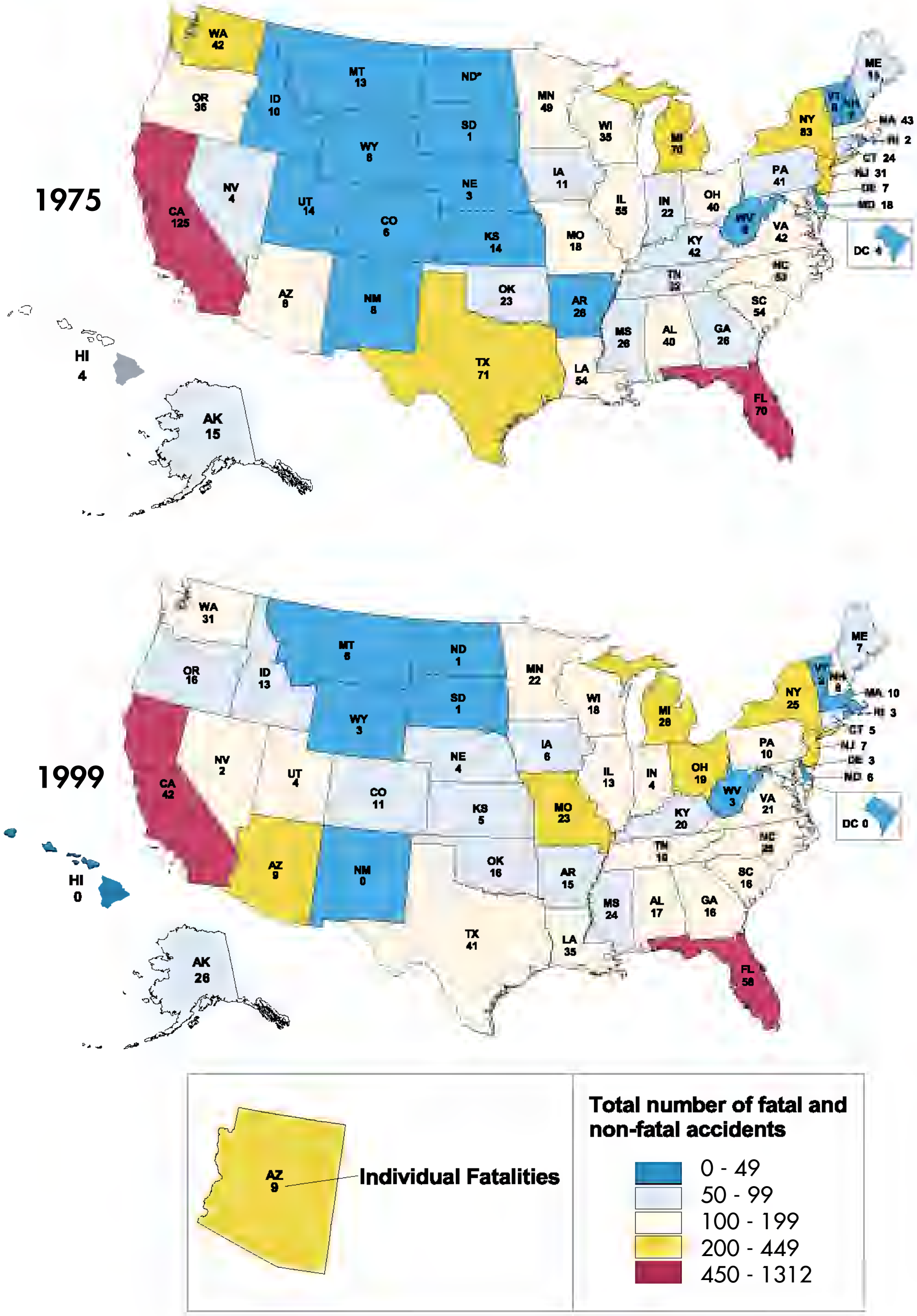
Life Jackets

The vast majority of boating fatalities result from factors that can be controlled or eliminated by individual boaters. Simply wearing a life jacket can vastly improve the chances of surviving a boating accident. About 7 out of 10 boating fatalities are caused by drowning. About 90 percent of these victims were not wearing life jackets.

Source: U.S. Department of Transportation, U.S. Coast Guard, "Campaign Targets Boating Fatalities for Elimination," (news release), available at http://www.safeboatingcampaign.com/2000announce.htm, as of June 19, 2000.

Figure 3-41

Recreational Boating Accidents: 1975 and 1998



Note: Data on individual fatalities in North Dakota are not available for 1975.

Source: U.S. Department of Transportation, U.S. Coast Guard, *Boating Statistics* (Washington, DC: Annual issues).

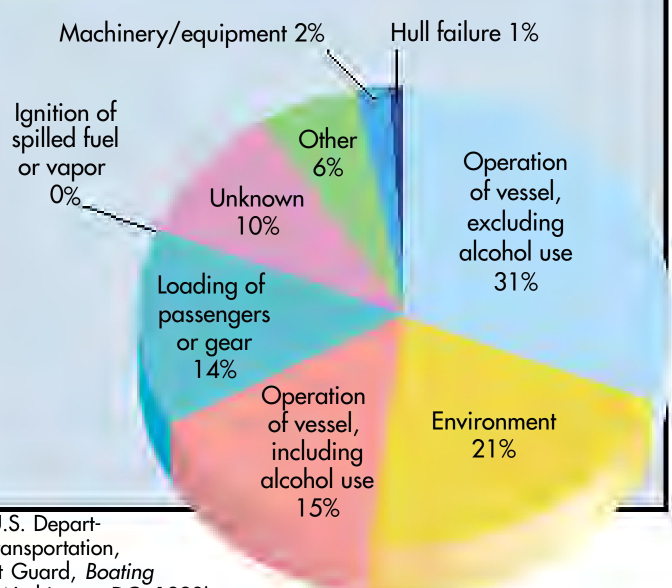
Figure 3-42

Number of Recreational Boats: 1975-98

Source: U.S. Department of Transportation, U.S. Coast Guard, *Boating Statistics* (Washington, DC: Annual issues).

Figure 3-43

Recreational Boating Fatalities, by Cause: 1998



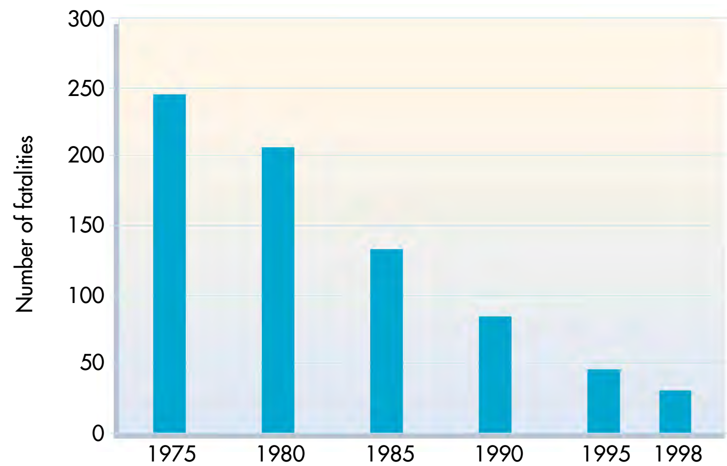
Source: U.S. Department of Transportation, U.S. Coast Guard, *Boating Statistics* (Washington DC: 1998).

Commercial Vessel Operations: In 1975, safety was a growing concern as 243 commercial maritime industry fatalities were recorded (figure 3-44). In the 1970s, new navigation safety regulations became effective, and the USCG began to focus on ensuring compliance by thousands of foreign vessels entering U.S. waters. Federal research and development centered on ship control, navigation, and communication as a means of improving vessel operations and enhancing safety.

Since then, much of the maritime transportation industry has implemented electronic shipboard controls for better navigation, communications, and maneuvering. Computer-based systems for steering and machinery monitoring, along with antistranding sonar systems to prevent vessel groundings also have improved ship safety. Through the Internet, mariners receive notices about potentially hazardous situations on a real-time basis.

Figure 3-44

Fatalities Involving Commercial Waterborne Transportation: 1975-98



Source: U.S. Department of Transportation, U.S. Coast Guard, Office of Investigation and Analysis, Compliance Analysis Division (Washington, DC: Various years).

Continued emphasis on vessel inspections as well as on improvement of design and equipment requirements combined with new vessel-tracking technology, worldwide digital communications, and integrated navigation systems using electronic charting have allowed the commercial maritime transportation system to attain high levels of safety. As the number of marine casualties has dropped, so has the number of fatalities. The principle focus of marine safety efforts is now on human error, a primary causal factor in four out of five marine accidents.

Prevention Through People (PTP), a USCG initiative, attempts to reduce the human factors problem through education and training programs, as well as by publishing and broadcasting information for mariners on weather, waterway depth, changes to navigation markers, and hazards to navigation. In 1995, to further reduce the human factors problem in maritime incidents, the world's maritime community reached an agreement on new standards and certifications for training and educating mariners, which is now being implemented.

Passenger Vessels: The U.S. domestic passenger vessel fleet consists of approximately 6,200 vessels, of which approximately 98 percent are small passenger vessels (e.g., charter fishing, harbor tour, or dinner cruise boats) or ferries. Passenger vessels in the domestic fleet carry approximately 200 million passengers annually. Ferry vessels carry 134 million of these passengers. There are approximately 130 foreign-flag passenger vessels that operate from U.S. ports. These vessels carried almost 5.5 million passengers on cruises in 1998 [USDOT 1999]. The USCG enforces applicable domestic and international safety standards on the U.S. domestic passenger vessel fleet and international safety standards on foreign-flag passenger vessels operating out of U.S. ports. The aggressive USCG examination program of these vessels has resulted in no passenger deaths on a foreign-flag vessels operating from U.S. ports since 1984, and the death rate involving the U.S. domestic passenger vessel fleet continues to decline.

"Based on careful analysis, the Coast Guard has focused its safety efforts toward the source of most accidents: human error. The Prevention Through People program has created partnerships throughout industry that have significantly reduced the number of maritime accidents—without additional regulations."

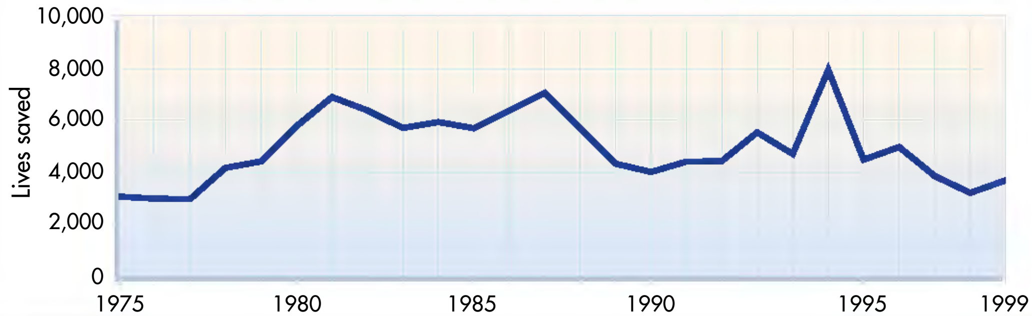
Adm. James M. Loy
Commandant,
U.S. Coast Guard

Today, technological advances have made passenger vessels safer, but they also have increased the complexity of vessel operation and maintenance. Newer vessels, which often have much higher passenger capacities than previous vessels, have increased the number of possible casualties in the unlikely case of a catastrophic event. Passenger-vessel traffic is increasing rapidly due to the growing markets for cruise ships, gambling ships, and passenger ferries; and the number of high-speed, high-capacity passenger vessels is also growing. Such increases can offset technological safety advances as the opportunity for human error, resulting in collisions and/or vessels running aground, increases.

Search and Rescue: Over the past quarter century, the USCG has rescued more than 3,000 boaters, fishermen, divers, and swimmers each year—or more than eight a day—from the nation's oceans, rivers, lakes, and bays (figure 3-45). Figure 3-46 shows the number of lives saved and lost in search and rescue missions in various USCG districts.

Figure 3-45

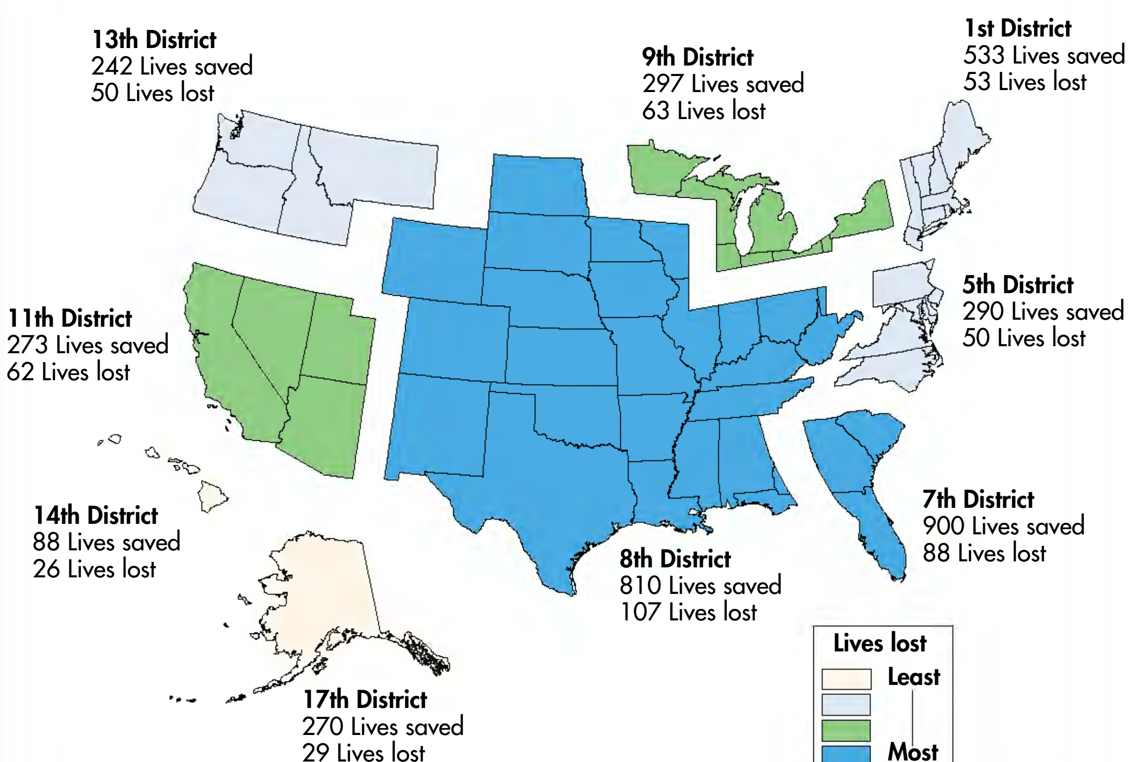
Lives Saved in Search and Rescue Missions: 1975-99 (Annual totals)



Source: U.S. Department of Transportation, U.S. Coast Guard, *Search and Rescue Summary Statistics* (Washington, DC: Annual issues).

Figure 3-46

U.S. Coast Guard Districts and the Number of Lives Lost and Saved: 1999



Source: U.S. Department of Transportation, U.S. Coast

In addition to search and rescue activities in U.S. waters, the USCG, under international agreement, is responsible for search and rescue activities in about 50 percent of the North Atlantic Ocean and more than 75 percent of the North Pacific Ocean, an area covering more than 28 million square nautical miles [USDOT USCG 2000d]. The USCG's search and rescue system—a high-impact, highly computerized structure—consists of multimission shore stations, 23 cutters, 1,400 small boats, and more than 200 aircraft, all linked by communications networks [USDOT USCG 2000a]. More than 10 percent of the USCG's operational hours for aircraft, cutters, and boats are devoted to search and rescue.

Distress calls: Over the last 25 years, the world's maritime system emerged from dependence on 19^{th} century telegraph code to send distress signals, to modern communications technology—the Global Maritime Distress and Safety System (GMDSS).

Distress calls using Morse code (the familiar S-O-S) have saved thousands of lives, but its use required skilled radio operators spending many hours monitoring the radio distress frequency, and its range was limited. In 1988, the International Maritime Organization set a February 1, 1999, deadline for ships to complete installation of GMDSS technology. U.S. ships were compelled to comply by the Telecommunications Act of 1996, which set GMDSS as the new standard.

This new system is based on a combination of satellite and terrestrial radio services and has changed international distress communications from being primarily ship-to-ship based to ship-to-shore Rescue Coordination Center based. Now used almost universally, GMDSS can reliably determine a vessel's position, home in on its exact location, broadcast maritime safety information, and provide general and ship-to-ship communications.

Keys to the Future

Recreational Boating: In the next quarter century, the number of recreational boaters is expected to increase by more than 65 percent to more than 130 million annually [Loy 1999]. The success of safety efforts will depend on the effectiveness of many education and enforcement programs that focus on seamanship and the use of life jackets. The Coast Guard estimates that the use of life jackets might have saved more than 500 drowning victims in 1998 alone [USDOT BTS, MARAD, and USCG 1999].

Increases in recreational and commercial traffic (particularly barge traffic) on shared waters pose a growing threat to recreational boaters, mariners, and the environment. Each year, 800 million short tons of U.S. domestic trade (approximately 75 percent of all domestic trade) is carried aboard barges that are either towed or pushed by tugs through our coastal and inland waters [USACE]. All boaters should be aware of the location of shipping channels, anchorages, commercial piers, draw bridges, and other congested port areas and should understand that tugs, barges, and any large commercial vessels have limited ability to steer clear of collisions or stop. In 2000, the USCG is proposing regulations that would create four sets of safety measures for towing vessels and tank barges operating in northeast waters:

1. positive control for barges,
2. enhanced communications,
3. voyage planning, and
4. areas of restricted navigation.

Commercial Vessel Operations: Growth in intermodal cargo movement using larger ships—and projected continued growth—presents a new safety challenge. Since 1975, a new generation of high-capacity container ships has emerged with double- and triple-container capacity. These new, bigger ships use radar-based Vessel Traffic Systems, navigational aids, and automated identification systems for better ship-to-shore and ship-to-ship communications to enter and leave ports safely. The new technologies allow minimal crews—as few as two—creating new challenges should these large vessels founder.

Maritime workers have a high fatality rate, and fishermen top the list. Dwindling fishery stocks, increased competition, and limited fishing seasons have increased risk-taking by fishermen. This risk-taking is compounded by the fact that fishing vessels have relatively few safety standards imposed by law or regulation. The number of fishing vessels of different sizes that operate in different locations and climates makes development of universal safety regulations difficult. The USCG has recently begun implementing a safety program aimed at the fishing industry [USDOT USCG 1999]. Its long-term recommendations include safety examinations, inspections, and operator licensing; vessel safety and stability standards; coordination of fisheries stock management with safety; and improvement of casualty investigation data. Efforts to focus on safety awareness to reduce human errors need to be combined with enforcement.

Passenger Vessels: Cruise ships are expected to attract 6.5 million passengers by 2002; and because there are only two U.S.-flag cruise ships, most of these passengers will be sailing on foreign-flag vessels [USDOC ITA 2000]. U.S. safety regulations do not always apply to foreign vessels, especially outside of U.S. waters, prompting safety concerns for Americans traveling on vessels over which the United States may have limited jurisdiction. The increased passenger capacity of cruise ships has raised questions regarding the adequacy of international passenger vessel safety requirements. These requirements will need to be evaluated to ensure the continued safety of cruise ships operating out of U.S. ports.

As conventional land transportation arteries grow more congested, ferry passenger transport is attracting renewed attention, particularly interest in fast ferries. Even though overall ferry traffic has declined slightly in recent years, fast-ferry operations have experienced some growth. From 1993 to 1997, fast-ferry passenger traffic increased at a rate of 6.8 percent per year [USDOT MARAD 1999]. The USCG's focus on targeting human errors (through domestic and international programs) as a means to reduce accidents and fatalities, likely will result in specific safety oversight of high-speed ferries and other technologically advanced vessels.

Safety Advances: Ships are required to receive broadcasts of maritime safety information, which may prevent some maritime disasters from taking place, while enhancing rescue operations for those that do occur. By 2005, the USCG will have a new generation of technology that will eliminate more than 65 existing coverage gaps and reduce search times—in essence, taking the search out of search and rescue—increasing the probability of successful rescues [USDOT USCG 2000b]. If the 2005 target is reached, then by 2025 advances in technology will completely eliminate coverage gaps and rescuing efforts will be highly successful.

Pipeline Safety

As urban sprawl has encroached deeper into surrounding land over the past 25 years, risks posed by the nation's network of nearly 2 million miles of pipelines and their impact on the environment has become a major public concern [USDOT RSPA 2000c]. Two pipeline incidents during the past two years have raised further public concerns: the Bellingham, Washington, incident in June 1999 and the Carlsbad, New Mexico, incident in August 2000. In April 2000, the Secretary of Transportation proposed new legislation that would require: a) internal inspection, pressure testing, or other best achievable technology performed on a periodic basis; b) clearly defined criteria for analyzing the inspection of testing and the repair of any problems found; c) measures (e.g., emergency flow-restricting devices or leak detection) that prevent and mitigate the consequences of a leak; and d) providing the public and local communities with access to the information they need to ensure their protection from potential pipeline accidents. The proposed legislation includes provisions for expanded partnerships with state regulatory agencies, improved collection of safety and accident data, and tougher penalties for operators found to violate safety regulations. In November 2000, the USDOT issued strong new requirements for large hazardous liquid pipeline operators to regularly inspect and promptly repair pipelines in populated and environmentally sensitive areas and to take systematic steps to detect and prevent leaks. Also, the USDOT is taking steps to implement stronger pipeline safety standards, including improved enforcement, enhanced federal-state partnerships, increased public access to information, and more innovative technology. Together, these actions will help ensure that our oil and gas pipeline system is sound, our communities safe, and our environment protected.

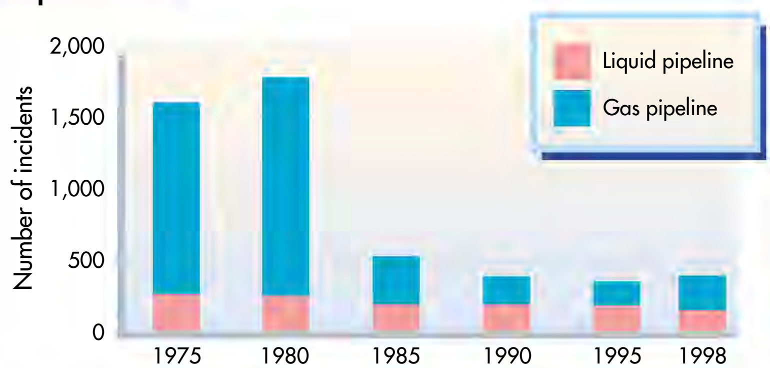
In 1975, 16 people were killed and 208 were injured in almost 1,700 pipeline incidents. During that decade, excavation damage was estimated to cause more than half of all pipeline incidents [NTSB 1998]. Other major causes of pipeline incidents included material failure and corrosion. Of particular concern were the many low-pressure natural gas distribution lines in towns and cities that were made of century-old, uncoated cast iron that was increasingly subject to failure.

During the era of pipeline construction, the industry was governed mostly by voluntary standards. But, by 1975, the USDOT had issued regulations covering pipeline design, construction, operation, and maintenance for both natural gas and interstate hazardous-liquid pipelines.

Today, there are far fewer pipeline incidents. These incidents dropped nearly 80 percent from 1975 through 1998 (figure 3-47), and the loss of product due to accidental ruptures has been cut by more than half [USDOT RSPA 2000c]. However, the number of fatalities associated with pipeline incidents has generally risen (figure 3-48).

Figure 3-47

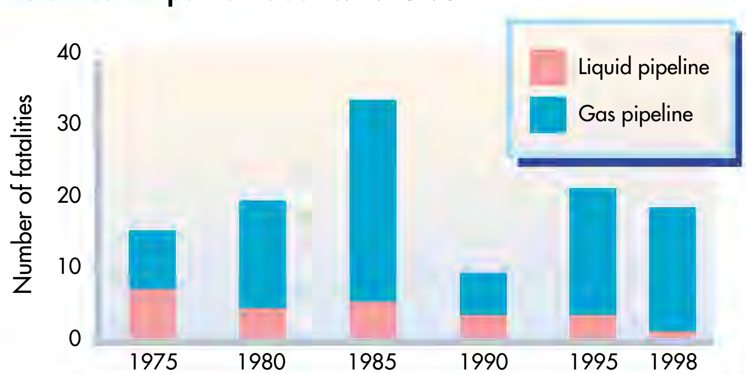
Pipeline Incidents: 1975-98



Source: U.S. Department of Transportation, Research and Special Programs Administration, Office of Pipeline Safety, personal communication, 1999, available at http://ops.dot.gov/stats.htm.

Figure 3-48

Fatalities in Pipeline Incidents: 1975-98



Source: U.S. Department of Transportation, Research and Special Programs Administration, Office of Pipeline Safety, personal communication, 1999, available at http://ops.dot.gov/stats.htm.

Outside force damage, usually from excavation, still is the leading cause of pipeline failures, averaging 39 percent of the total, followed by corrosion with an average of 20 percent [USDOT RSPA 2000c]. Other causes of failure are incorrect operation, construction, or material defect; equipment malfunction; and failed pipe. To reduce the problem of excavation damage, one-call notification centers have been established in 48 states and the District of Columbia [NTSB 1998]. Efforts are underway by the Research and Special Programs Administration (RSPA), state officials, and industry to raise awareness of the one-call centers in order to lower the number of incidents caused by excavation.

Major advances in the materials used for pipes and welding, inspections, and the installation process over the past 25 years have reduced the number of leaks and made those that take place less severe. New corrosion coatings and new application processes have produced dramatically longer lives for pipes.

Computer technology—Supervisory Control and Data Acquisition systems—continuously provides today's dispatchers with temperature, pressure, and flow rates along many pipelines. This information is vital for the daily operation of these pipelines and can help pinpoint potential and real problems as they occur.

Keys to the Future

The conflict between expanding residential communities and pipeline operations is likely to increase as the U.S. population continues to grow and metropolitan areas expand into the rural areas where pipelines are predominately located. The consequential crowding of pipelines will increase the need to identify sensitive locations in high-density population areas (which may need special attention in the unlikely event of an incident) and to prevent damage due to excavation.

Battelle

Smart pigs ensure pipeline safety by using magnetic or ultrasonic scanning to inspect the internal and external walls of a pipeline. They can be used to inspect pipe sections, as shown, or they can be inserted in to existing pipelines where they are moved by the flowing material, avoiding the need for excavating or flow stoppage to inspect pipelines.

A multiagency effort, the geographic information system-based National Pipeline Mapping System will help pinpoint where pipelines are located, providing an analytical tool to mitigate risks to environmentally sensitive and populated areas and will help educate the public about the risks of pipelines in their communities. Efforts are underway now to define the data, which will result in better information for identifying safety trends, targeting where problems are most likely to occur, and monitoring how well applied solutions are working. Further technological advances will be used to improve pipeline safety. Industry will be equipped with advanced computer control systems that monitor pipeline integrity and deliver pipeline products more efficiently. New improvements in aerial leak detection technology will complement these efforts.

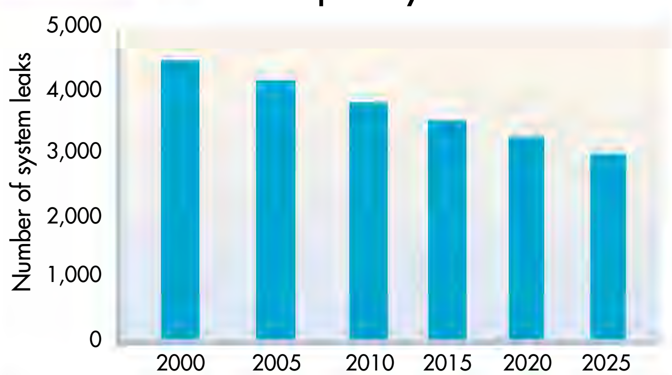
A technology known as "smart pigs" promises to be the primary inspection tool for pipelines well into the 21st century [USDOT RSPA 2000c]. Smart pigs have been used for at least 10 years, and their use and their capabilities are growing. Smart pigs will be increasingly used to detect a variety of pipeline integrity concerns such as pipe wall thinning, excavation hits to pipelines or other mechanical damage, material defects, and cracks. Efforts in the area of acoustical monitoring will provide real-time detection of excavation-related damage. Complementary to these efforts, in the future, Global Positioning System (GPS) technology will work with smart pig technology to accurately map pipelines and pinpoint potential problems so they may be corrected before incidents occur [Wilke 1998]. A longer range effort is underway to develop a single smart pig that can detect corrosion and mechanical defects.

Smart pigs are effective for about 90 percent of hazardous liquid pipelines, but they have more limited use on natural gas pipelines because these pipelines tend to have interconnected pipe segments of varying diameters. Alternative inspection technologies will be needed for pipelines that cannot accommodate smart pigs due to varying pipe sizes and configurations.

Based on historical trends, we anticipate an 8 percent reduction every five years in the number of reported natural gas transmission system leaks through the year 2025, as the chart depicts (figure 3-49), or an overall reduction of about 36 percent in the number of system leaks from the year 2000 through the year 2025.

Figure 3-49

Natural Gas Transmission Pipeline System Leaks



Source: U.S. Department of Transportation, Research and Special Programs Administration, personal communication December 5, 2000.

Box 3-13

Smart Pigs

Smart pigs—computerized magnetic or ultrasonic mechanical devices that are pushed along by flowing material inside the pipeline—inspect internal and external pipe wall conditions and the thickness of the metal wall. They allow pipeline operators to inspect for damage without excavating the pipe or stopping product flow.

Types of pigs:

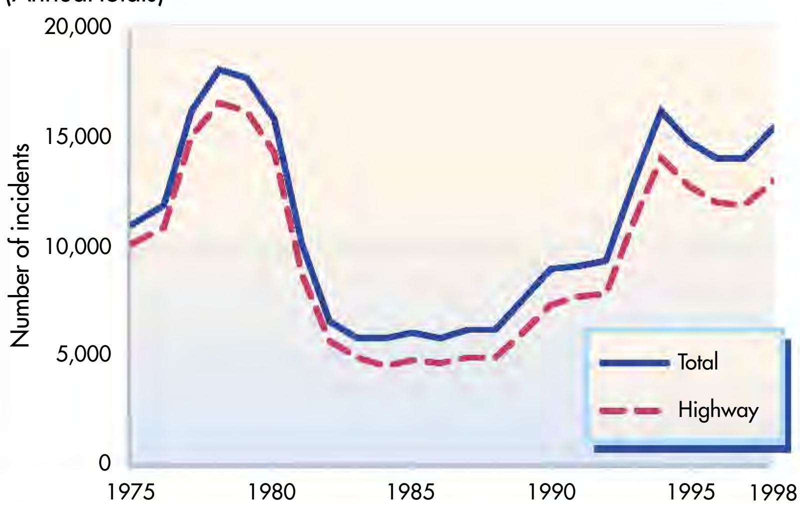
- Magnetic flux leakage pigs detect pipe wall thinning or loss of material, which usually means corrosion. Under certain conditions, they can detect some types of mechanical damage, such as gouges, but cannot characterize or size mechanical damage to determine its severity. They can be used in both gas and hazardous-liquid pipelines and have been available since the mid-1960s.

continued next page

- Ultrasonic pigs detect corrosion and cracks in the pipe wall. They also can detect mechanical damage, although they cannot determine the severity of the damage with a high level of confidence. These devices require a liquid film between the ultrasonic transducer and the pipe wall. Therefore, they can be used only in liquid pipelines.
- Elastic wave pigs detect cracks, stress corrosion cracking, external coating faults, and other axially oriented pipe defects. The ultrasonic transducers used in elastic wave tools have rolling contact with the pipe wall. They do not require a liquid film and can be used in gas pipelines as well as in hazardous-liquid pipelines.
- Geometry pigs detect changes in the internal size of new and operating pipelines. Ovality, dents, and buckles can be detected in both gas and hazardous-liquid pipelines.
- Camera pigs allow visual inspection of the inside bottom quadrant of gas pipelines by producing photographs of the inside surface.
- Pipe-curvature pigs determine position, orientation, curvature, ovality, dents, and wrinkles in gas pipelines and those that transport liquids. These devices can detect pipe movement after seismic events.

Figure 3-50

Reported Hazardous Materials Incidents: 1975-98
(Annual totals)



Source: U.S. Department of Transportation, Research and Special Programs Administration, Office of Hazardous Material Safety, Hazardous Materials Information System (Washington, DC: 1999).

Hazardous Materials Safety

Over the last 25 years, the transportation of hazardous materials (hazmat) has been the subject of increased scrutiny. Today, an estimated 800,000 U.S. hazmat shipments are made daily [USDOT RSPA 1998]. These shipments, in combination with a growing population, urban sprawl, and increasing air-, road-, rail-, and water-traffic congestion, fuel concern for the safe transportation of hazardous materials and the potential consequences of a catastrophic event.

The Hazardous Materials Transportation Act of 1974, signed into law in 1975, gave the USDOT expanded power to regulate hazmat transportation. The USDOT has the authority to determine which materials pose unreasonable transportation risks to public health and safety.

Regulations are issued by the USDOT covering training, packaging, hazard communication, operations, enforcement, emergency response, and incident reporting.

In 1975, more than 15 million barrels of petroleum products, the largest single component of transported hazmat, were being shipped daily across the country [USDOE 1997], as were hundreds of thousands of tons of hazardous chemicals [Maio & Liu 1987]. Most hazmat tonnage was carried by rail, water, and pipeline modes, but highway transport—accelerated by growth of the Interstate Highway System—resulted in the greatest number of individual shipments. Most hazardous materials incidents, defined as any unintentional release of material (or evacuation based on potential release), took place on highways (figure 3-49).

Hazmat safety regulation has undergone profound change since 1975, sparked by several major events, including the 1984 toxic gas release in Bhopal, India. That incident resulted in approximately 3,800 deaths and prompted a new subclass of hazardous materials—those that are classified as poisonous by inhalation. The Bhopal incident also led to passage of the 1986 Emergency Planning and Community Right-to-Know Act, which gave local communities a greater ability to learn what hazardous materials were being stored in their communities. Moreover, the incident catalyzed emergency response planning efforts at the federal, state, and local levels.

In 1990, the Hazardous Materials Transportation Uniform Safety Act required certain hazmat shippers and carriers to pay a fee to register with the USDOT. According to RSPA, changes in the registration and fee assessment program, authorized in the 1990 Act, have provided a projected 50 percent increase in funding, as expanded registration requirements swelled the number of registered hazmat shippers and carriers from about 27,000 to 45,000. This money has been used to fund emergency planning and training grants with enhanced capabilities for identifying, controlling, and responding to risks posed by hazmat shipments. This registration program also created a funding mechanism for federal grants to support local hazmat safety planning and training. Since 1993, these grants have provided training to about 815,000 people who respond to hazardous materials incidents [USDOT RSPA 2000a].

The May 1996 ValuJet crash, resulting in 110 deaths, again heightened public awareness of hazmat transport risks. Improperly marked and stowed chemical oxygen generators aboard the flight triggered intense heat in an inaccessible cargo bay, causing a rapid fire, smoke, and loss of aircraft control. Chemical oxygen generators were subsequently banned as freight aboard any passenger aircraft. If transported on cargo aircraft, such materials must be shipped in an inaccessible compartment that is required to have smoke and fire detection and suppression systems. Empty oxygen generators were banned from all aircraft, both cargo and passenger.

Although the number of hazmat incidents reported annually to USDOT is growing due to long-term traffic growth and better reporting compliance, the level of *serious* incidents has remained nearly constant (figure 3-51). Serious incidents are defined as one involving a fatality or major injury due to a hazardous material; closure of a major transportation artery or facility or evacuation of six or more people due to the presence of hazardous material; or a vehicle accident or derailment resulting in the release of hazardous material.

Efforts to improve data collection, management, and allocation of USDOT resources are also underway. Efforts by the Bureau of Transportation Statistics (BTS) are yielding much greater detail about nationwide hazardous materials flows, as well as better hazmat vehicle use information, and the modal distribution of hazardous materials (table 3-5).

Figure 3-51

Serious Hazardous Materials Incidents and All Hazardous Materials Incidents: 1990-98 (Annual totals)

Source: U.S. Department of Transportation, Research and Special Programs Administration, Office of Hazardous Materials Safety, Hazardous Materials Information System, 1999.

Table 3-5

Hazardous Materials Shipment Characteristics by Mode of Transportation for the United States: 1997

Mode of transportation	Ton-miles Number	Ton-miles Percent
All modes	263,809	100.0
Single modes	258,912	98.1
Truck	74,939	28.4
For-hire truck	45,234	17.1
Private truck	28,847	10.9
Rail	74,711	28.3
Water	68,212	25.9
Air (including truck and air)	95	0.04
Pipeline	n/a	–
Multiple modes	3,061	1.2
Parcel, U.S. Postal Service or courier	78	–
Other multiple modes	2,982	1.1
Other and unknown modes	1,837	0.7

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 1997 Commodity Flow Survey data; U.S. Department of Commerce, Census Bureau, *1997 Commodity Flow Survey, Hazardous Materials,* EC97TCF-US(HM) (Washington, DC: 1999).

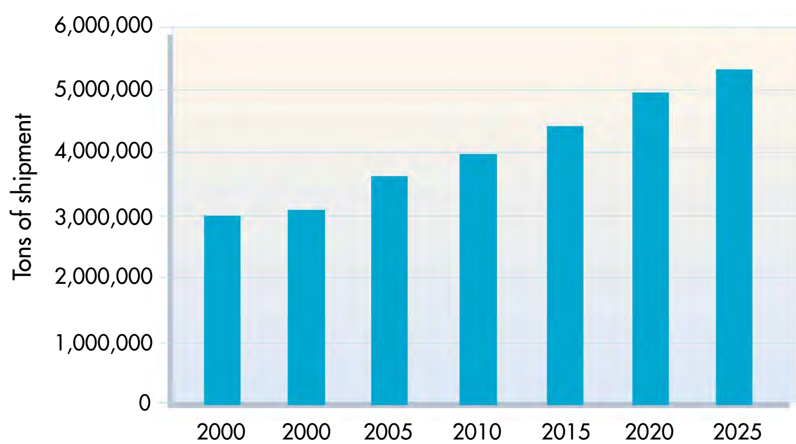
Keys to the Future

A number of current trends will continue to shape how the USDOT fulfills its hazardous materials mandate over the next 25 years. Hazmat shipment growth, continued globalization of trade, changes in the workforce, and improvements in materials technology and IT/ telecommunications applications are among these.

The number of U.S. hazmat shipments is expected to grow from about 1 million daily to well over 1.5 million per day. In terms of tonnage, the annual volume of hazardous materials transported for commerce in the United States is forecast to reach 5.7 billion tons by 2025. Using the 1996 baseline figures of 3.2 tons of hazardous materials shipments, the Chemical Manufacturers Association projects that aggregate hazmat shipments will grow at roughly at 2 percent per year (figure 3-52).

Figure 3-52

Actual and Forecast Hazardous Materials Shipments



Source: U.S. Department of Transportation, Research and Special Programs Administration, personal communication, December 5, 2000.

Curbs in fossil fuel use may slow growth in the shipment of petroleum products, the largest component of hazmat traffic. However, an expanding economy will pressure growth, and continued changes in chemical and biological technology present an ever-increasing list of products with which the government and the shipping community must be familiar.

By 2025 the modal share of hazmat transportation will change as well. By one set of forecasts (the DRI/McGraw Hill) air and intermodal shipments are expected to gain an increasingly significant share of the hazmat market. As high value-added chemical products gain market share and demand for time-definite delivery grows, hazmat is more likely to be shipped by air and truck modes.

- Over the next 25-year period, air and intermodal movements are likely to double the current growth rates to meet the increasing demand in the high value-added segments of the chemical industry. Small-package and on-bulk containers will also grow at a rapid rate.

- The shift to the air and truck modes will be balanced by a slight decline in the share of water and pipeline transportation of hazmat. Rail is forecast to maintain its market share of about 6 percent. Truckload/LTL highway transportation is anticipated to gain market share of moving chemical products. For moving petroleum, trucks are also forecast to continue to increase their market share.

Radioactive shipments, considered to be specialized hazmat traffic, will remain about 1 percent of total annual shipments. Although these shipments are a small proportion of the traffic, they still may pose increased safety challenges. Ongoing legislative efforts to establish a permanent spent fuel waste repository in the United States could increase the number of spent fuel shipments as much as fourfold annually by the year 2025, from 100 to more than 400 shipments. Combined with transport and burial of other nuclear wastes at the Waste Isolation Pilot Project site in New Mexico, an increased number of highly radioactive shipments will traverse the U.S. rail, highway and, to a lesser extent, waterway networks.

Along with growth in the U.S. economy and its hazmat traffic base, continued globalization of trade will pose additional safety challenges. Not only are export and import trade shipments expected to grow in number, but the complexity of that traffic will grow as well. Differing hazmat regulations, safety policies, and technological proficiencies will present continuing challenges to ensuring the safety of global hazmat traffic. Current efforts to harmonize U.S. hazmat regulations with internationally endorsed practices must keep pace with the safety demands placed on the transportation network.

As changes in the workforce continue, the need for education and training in the hazmat community will also increase. The U.S. transportation system, including the hazmat sector, will be characterized by an aging population and higher levels of turnover among employees. Coupled with higher demand for hazmat shipments and, consequently, increased technical knowledge, there will be an acute need for education and training of hazmat employees by the year 2025. As underscored in the 1996 Valuejet accident, the need for shipper and air carrier personnel to be knowledgeable about the USDOT's hazardous materials regulations will be critical.

Technology will play a vital role in future hazmat transportation. Offsetting continued development of new hazardous materials and growth in their traffic will be improvements in materials technology. Stronger, more durable materials will make the packaging—for example, boxes, canisters, barrels, containers, and tank cars—more resistant to damage during normal handling and transport, and even under accident conditions. Other technology advances may also help prevent hazmat incidents from occurring in the first place. Computer software, for example, may improve the ability to translate shipping papers, packaging labels, and other documentation and communication media into other languages or into a single, common trading language.

For monitoring hazmat traffic and managing incidents when they do occur, improved information and telecommunications technology will be critical. Tracking sensitive cargos will be easier and more affordable as various global satellite systems become operational and as wireless handsets become increasingly "connected" to the Internet. Similarly, wireless telecommunications and other information technology advances will improve the ability of emergency response personnel to manage events at hazardous materials accident sites.

Challenges to the USDOT's ability to manage hazmat traffic and trade will grow as globalization increases. Helping to meet these challenges will be continued improvements in hazmat education and training, aided by a confluence of technology improvements and deployment.

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chapter 4

Globalization

"In the Year 2025, all of the transportation modes will continue to play critical roles in the global economy, whether for transporting goods over long distances between nations or for shorter movements to and from intermodal terminals."

Secretary Rodney Slater
October 2000

"Transportation is the industry that connects other industries … it is the key to globalization."

Lawrence H. Summers, Secretary U.S. Department of Treasury
International Transportation Symposium
Oct. 10, 2000, Washington, DC

chapter 4

Globalization

In the last quarter-century, a host of political, economic, and technological changes noticeably accelerated the trend toward globalization. Political changes included the end of the Vietnam War (1975) and the Cold War (with the fall of the Berlin Wall in 1989 and the Soviet Union in 1991). Complementing these political developments, an increasing number of countries abandoned their policies of protectionism and lowered barriers to free trade. At the same time, technological innovations in communications and transportation facilitated the flow of goods, people, and information across the globe. Today, the rise of Internet commerce is driving the expansion of the global marketplace, underscoring the need for a transportation system that is international in reach.

Globalization involves the increasing international integration of production processes and the market for goods and services. It results from the liberalization of national economies, reduction of trade barriers, freer movement of foreign direct investment (FDI) across the world, expanding role of multinational firms in international production and growing intrafirm trade across national boundaries.

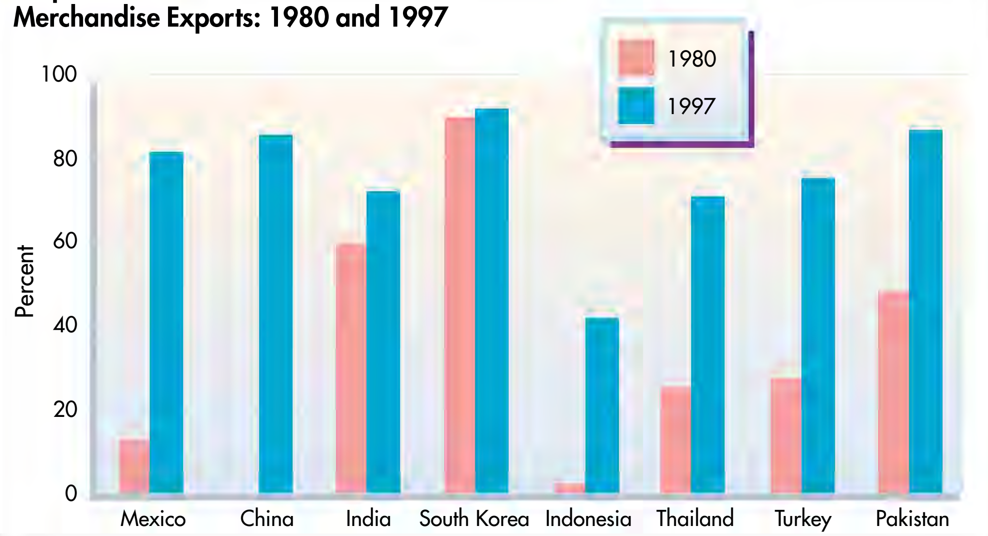
Lata Chatterjee
Transportation, Globalization and Competitiveness: A Review and Synthesis of Literature, Bureau of Transportation Statistics, August 2000.

Faster and cheaper transportation systems allow multinational corporations to build manufacturing facilities across the globe while maintaining scheduled, frequent deliveries of parts and finished products. For example, advances in the aviation system allow businesses to substitute just-in-time deliveries from remote manufacturing plants in place of large inventories. Today, about one-third of world trade consists of shipments between branches of multinational companies [UN Annual].

The extent of this manufacturing expansion is visible in many countries, including Mexico, China, India, South Korea, Indonesia, Thailand, Turkey, and Pakistan. In 1980, manufactured goods as a share of exports exceeded 50 percent only in

Figure 4-1

Proportion of Manufactured Goods as a Share of Total Value of Merchandise Exports: 1980 and 1997



Source: The World Bank, *World Development Indicators* (Washington, DC: 1999), p. 204, table 4.5.

India and South Korea, and were as low as 2 percent in Indonesia (figure 4-1). However, by 1997, manufactured goods exceeded 70 percent of exports in seven of these eight countries. The exception was Indonesia, where manufactured goods grew from 2 percent to an amazing 42 percent of exports by 1997 [World Bank 1999].

Recognizing the need for a bolder vision to realize a truly global transport system, Transportation Secretary Rodney Slater hosted two international conferences in 1999 and 2000: Aviation in the 21st Century – Beyond Open Skies Ministerial, in Chicago, and the International Transportation Symposium, in Washington, DC. Each attended by representatives from more than 90 countries, these conferences created an environment conducive to addressing global challenges of the coming decades.

"Transportation is the industry that connects other industries...it is the key to globalization."

Lawrence H. Summers
Secretary, U.S. Department of Treasury
International Transportation Symposium
Washington, DC
Oct. 10, 2000

Growth of the Global Economy

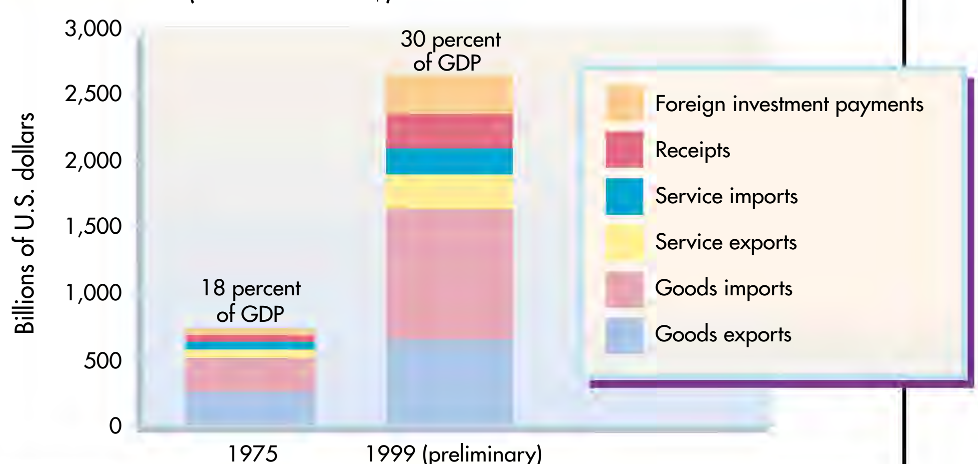
The world's economy has grown enormously, with the sum of all nations' Gross National Product (GNP) rising from $1.3 trillion in 1960 to $29 trillion in 1997 [Worldwatch Institute 2000a]. During the same period, the Gross World Product (GWP) increased from $10 trillion and $37 trillion and exports' share of the GWP grew from 7 percent to 15 percent [Worldwatch Institute 2000b]. Today, the transportation sector represents 11 percent of the overall U.S. Gross Domestic Product and accounts for "1 in 7" jobs in the U.S. economy.

This pattern was evident in the United States. According to the U.S. Department of Commerce (USDOC), in the last 25 years, U.S. imports and exports grew from $726 billion in 1975 to $2.6 trillion in 1999 —well over 300 percent (figure 4-2). Transportation equipment was the second largest import sector in 1998, accounting for 19 percent of all U.S. merchandise imports [USITC 1999].

China, with which we had limited trade in 1975, is now our fourth largest trading partner, surpassed only by Canada, Japan, and Mexico (table 4-1). South Korea, Singapore, and Taiwan have joined the top 10 list of U.S. trading partners. Iran, the Netherlands, and Venezuela have dropped from the top 10 list.

Figure 4-2

Imports and Exports as a Percent of U.S. Gross Domestic Product (GDP): 1975 and 1999 (Chained 1996 $)



Source: U.S. Department of Commerce, Bureau of Economic Analysis, International Transactions Account, available at http://www.bea.doc.gov/bea/dil.htm, as of May 5, 2000.

The Phenomenon of Globalization

During the past few decades, the most significant development in the world economy has been the globalization of economic activities. Globalization has been the outcome of four key processes that have shaped and changed the pattern of economic activities within nations and around the globe:

1. expanding political cooperation among countries,
2. changing strategies of transnational corporations,
3. dynamic interactions between businesses and states, and
4. rapid technological advancement.

Through a complex set of interactions, these processes have dramatically increased interdependence within the world economy.

The emergence of globally dispersed production networks is the eventual outcome of the open international trade initiated under U.S. leadership at Bretton Woods, N.H. in 1944 with the creation of the International Monetary Fund, the World Bank, and later the General Agreement on Tariffs and Trade, now the World Trade Organization. During the past decade, the formation of regional trading blocs such as the North American Free Trade Agreement (NAFTA), the European Union, and Mercosur, has accelerated the pace of globalization.

Transnational corporations have been key to the emergence of the global economy. These firms have expanded global production networks, increased intra-firm trade, and redefined globalization to involve more than a mere geographical extension of economic activity across national borders. It involves integrating the functions of different economic activities dispersed around the world. Decisions by transnational corporations on where and how to invest and manage their resources directly shape the geography of the world economy.

The changing relationship between governments and businesses has created economic conditions that have enhanced access to markets and resources and changed the rules of operation in the increasingly competitive global economy. Significant changes in the governance of transportation and trade policies include: economic deregulation, privatization of infrastructure, open skies agreements, and adoption of international standards and trade practices.

Recent technological developments in transportation and communications have fundamentally transformed distance and time between all parts of the world. Today, the global economy is more interrelated because of jet aircraft, growth in the mega ships, and containerization. These advancements and innovations in telecommunications have reduced the costs of interregional connections and the flow of information. In today's globalized economy, transportation is becoming increasingly faster, more flexible, and more predictable within a narrow time range.

Source: Lakshmanan, T.R., William P. Anderson, and Lata Chatterjee, Boston University, Center for Transportation Studies, personal communication, October 2000.

"Globalization involves the integration of free markets, nation-states and information technologies to a degree never before witnessed, in a way that is enabling individuals, corporations and countries to reach around the world farther, faster, deeper and cheaper than ever."

Thomas L. Friedman
NY Times Magazine, Mar. 28, 1999
Manifesto for the Fast World

Table 4-1

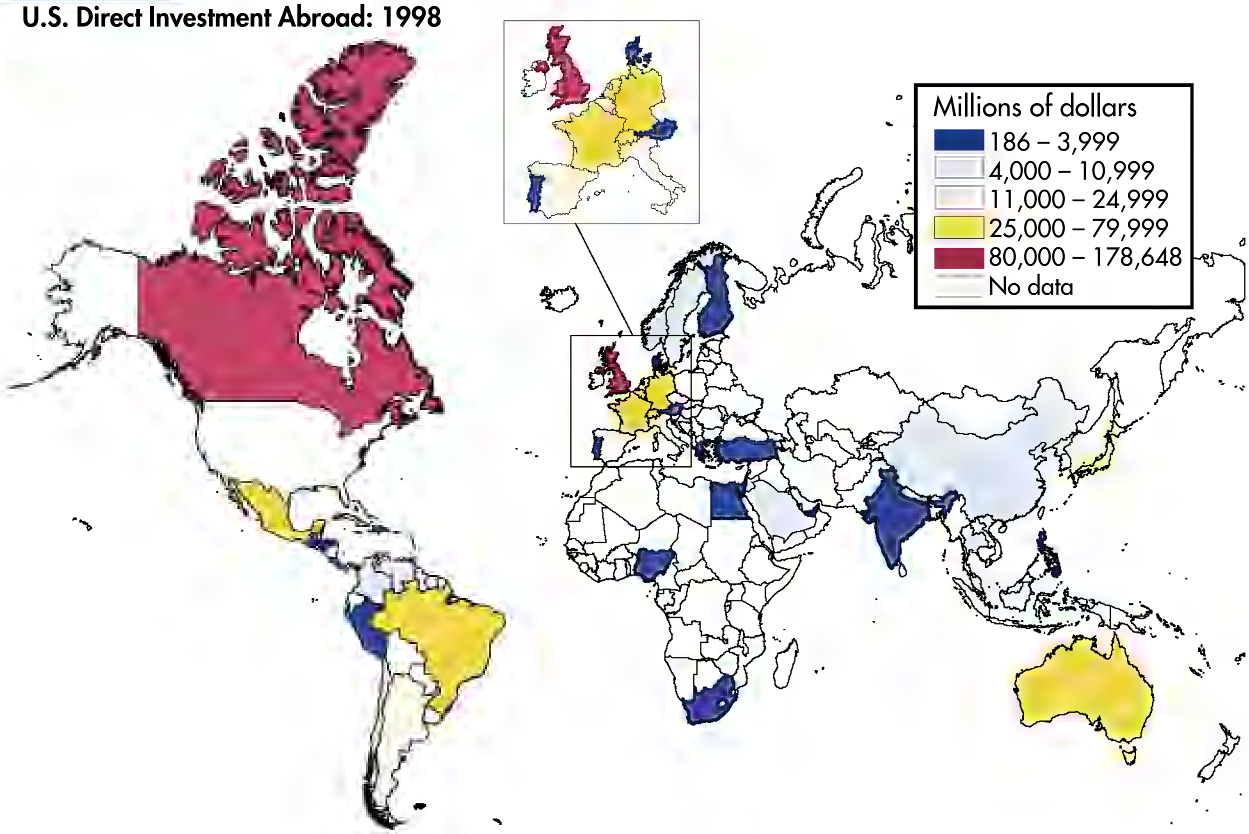
Top 10 U.S. Merchandise Trade Partners, by Value: 1975 and 1998
(Millions of chained 1996 $)

1975					1998				
Rank	**Country**	**Exports**	**Imports**	**Total**	**Rank**	**Country**	**Exports**	**Imports**	**Total**
1	Canada	54,360	55,378	109,738	1	Canada	151,618	169,598	321,217
2	Japan	23,908	28,563	52,470	2	Japan	56,151	118,322	174,473
3	Germany	12,985	13,525	26,510	3	Mexico	76,640	91,867	168,507
4	United Kingdom	11,318	9,433	20,750	4	China	13,830	69,021	82,851
5	Mexico	12,853	7,665	20,518	5	Germany	25,843	48,329	74,172
6	Venezuela	5,608	9,063	14,670	6	United Kingdom	37,898	33,749	71,647
7	Italy	7,168	6,143	13,310	7	Taiwan	17,612	32,129	49,742
8	Netherlands	10,483	2,723	13,205	8	France	17,196	23,355	40,551
9	France	7,578	5,410	12,988	9	South Korea	16,042	23,218	39,261
10	Iran	8,110	3,495	11,605	10	Singapore	15,203	17,807	33,010

Source: U.S. Department of Commerce, U.S. Census Bureau, *Statistical Abstract of the United States* (Washington, DC: Various years).

Figure 4-3

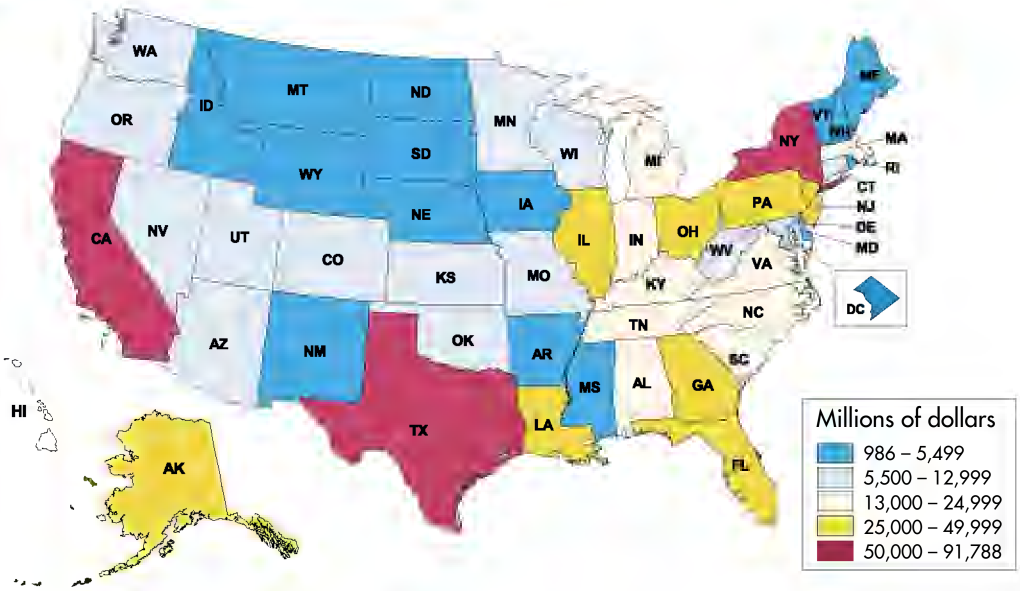
U.S. Direct Investment Abroad: 1998



Source: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (Washington, DC: July 1999).

Figure 4-4

Foreign Direct Investment in the United States: 1998



Source: U.S. Department of Commerce, U.S. Census Bureau, *Statistical Abstract of the United States 1999* (Washington, DC: 1999).

Investment by foreign companies in the United States has grown as has U.S. investment abroad. In fact, U.S. foreign investment has grown, in real terms, from an average of $45.3 billion per year in the 1970s to an average of $117.5 billion in the first half of the 1990s (in constant 1990 dollars), and from 1.04 percent of our Gross Domestic Product (GDP) to 1.64 percent [PPI 2000]. Figures 4-3 and 4-4 show U.S. investment abroad and foreign direct investment into the United States, respectively, for 1998.

In the early 1990s, about 20 percent of the total output of U.S. firms was produced outside of the country [*The Economist* 1998]; this figure seems likely to grow. In 1997, *U.S. News and World Report* reported that 82 percent of the money spent by U.S. businesses each year on fixed investment—plant and equipment—was spent in Asia, compared with only 33 percent 10 years earlier [Holstein et al. 1997]. A good example of globalization of economy is the automobile manufacturing industry—discussed in the following section.

The phenomenon of globalization is not without its drawbacks, however. As world economies become increasingly integrated and reliant on a transportation infrastructure that is responsive and flexible, transportation systems and the sophisticated electronic information and communications systems that make their day-to-day operations possible become more attractive as terrorist targets. Threats against highway, rail, transit, and aviation systems; piracy; disruption of the Internet and cyber-based information systems; and interference with Global Positioning Systems and Intelligent Transportation Systems are growing concerns that are discussed in detail in Chapter 7, National Security.

The Automobile Industry

The past quarter century was a period of turmoil and challenge for the nation's automobile manufacturers. Faced with an energy crisis that changed consumer buying habits, at least temporarily; continuing environmental pressures; and the growing success of Japanese and European imports, the industry retooled its manufacturing processes, cars, marketing, and financial structure.

In 1975, the United States had four major automobile manufacturers: Ford Motor Company, General Motors, Chrysler Corporation, and American Motors Corporation. Of these four manufacturers, Chrysler was hit the hardest by industry changes, needing both a federal intervention and wholesale management changes to survive. In 1987, Chrysler bought American Motors, and in 1998, Chrysler Corporation was acquired by Germany-based Daimler-Benz to form DaimlerChrysler. Today, only two U.S.-owned automobile manufacturers—Ford Motor Company and General Motors—remain in an industry that has global connections and cross-ownership (table 4-2). Changing the essential nature of the "Big 3" as has been historically known — while still maintaining Detroit, Michigan, as the "Automobile Capital of the World."

Despite the many challenges in the auto manufacturing industry, vehicle purchases continued at a rapid pace in the United States. The introduction of the minivan in 1983 and the sport utility vehicle (SUV) in 1990 stimulated high demand in the domestic market. However, imports and transplants—foreign cars built in U.S. plants—now make up more than half of all new car sales (figure 4-5).

Individual companies have been seeking new markets in both developed and less developed countries. They are working with foreign partners to develop cars tailored to specific markets, as well as to produce cars that can be sold in all markets. At the same time, they are advancing efforts to harmonize vehicle standards around the world.

Table 4-2

Global Brands Owned by Car Manufacturers Headquartered in the United States: 2000

Company	Global brands
DaimlerChrysler*	Mercedes-Benz, Chrysler, Plymouth, Jeep, Dodge, Smart
General Motors	Chevrolet, Chevy Trucks, Pontiac, Oldsmobile, Buick, Cadillac, GMC, Saturn, Opel, Vauxhall, Saab, Isuzu
Ford	Ford, Volvo, Mazda, Lincoln, Mercury, Jaguar, Aston Martin

* DaimlerChrysler is also headquartered in Stuttgart, Germany.
Source: Manufacturers' websites, as of May 2000.

Box 4-1

A Short Timeline of the Global Auto Industry

1970 Volkswagen exports its five-millionth vehicle to the United States. Mazda begins U.S. sales operations.

1972 American Imported Automobile Dealers Association (AIADA) is founded.

1973 Datsun dealers sell one millionth vehicle in the United States.

1976 First Honda Accord is named *Motor Trend* magazine's "Import Car of the Year."

1978 Volkswagen's Westmoreland, Pennsylvania, plant opens for production of the Volkswagen Rabbit, making it the first international automaker to build vehicles in the United States.

1980 AIADA becomes the American International Automobile Dealers Association (AIADA).

1981 BMW becomes the first European automaker to establish its own subsidiary in Japan.

1982 Honda of America Manufacturing begins U.S. auto production in Marysville, Ohio.

(continued on next page)

Box 4-1 continued

Mitsubishi Motor Sales of America, Inc., begins selling cars and trucks in the United States.
Mazda dealers sell one millionth passenger car in the United States.

1983 Nissan (formerly Datsun) begins vehicle production in Smyrna, Tennessee.

1984 New United Motor Manufacturing, Inc. (NUMMI), a joint venture between Toyota and General Motors, begins production in Fremont, California.

1985 Diamond-Star Motors Corporation is incorporated as a joint venture between Mitsubishi Motors Corporation and Chrysler Corporation.
Suzuki of America Automotive Corporation is established, and the Samurai is introduced to the U.S. market.

1986 Range Rover enters the U.S. market. Honda of America Manufacturing begins engine production in Anna, Ohio.
Hyundai introduces its first vehicle in the U.S. and sets a new sales record for an importer's first year in the U.S. market.
Toyota begins building Corollas in the United States.

1988 Honda begins export of U.S.-built automobiles to Japan.
Mazda Motor Manufacturing (USA) Corporation begins vehicle production in Flat Rock, Michigan.
Diamond-Star Motors Corporation begins vehicle production in Normal, Illinois.
Toyota Motor Manufacturing (USA), Inc., begins vehicle production in Georgetown, Kentucky.

1989 U.S. Treasury Department exempts four-door minivans and sport utility vehicles from the 25 percent tariff.
Subaru-Isuzu Automotive, Inc., a joint venture between Subaru and Isuzu, begins vehicle production in Lafayette, Indiana.
Honda of America Manufacturing begins production of vehicles in East Liberty, Ohio.
Nissan in Smyrna, Tennessee, produces one millionth vehicle.
Ford Motor Company acquires Jaguar.

1990 Honda of America Manufacturing begins U.S. production of right-hand drive vehicles for export to Japan.
Saab and General Motors establish a joint venture.

1991 Mitsubishi Motors purchases Chrysler Corporation's 50 percent stake in Diamond-Star Motors.

1992 Mazda Motor Manufacturing (USA) Corporation becomes a joint venture between Mazda and Ford, renamed Auto Alliance International, Inc.

1993 Mercedes-Benz Project, Inc., is founded in Tuscaloosa, Alabama.

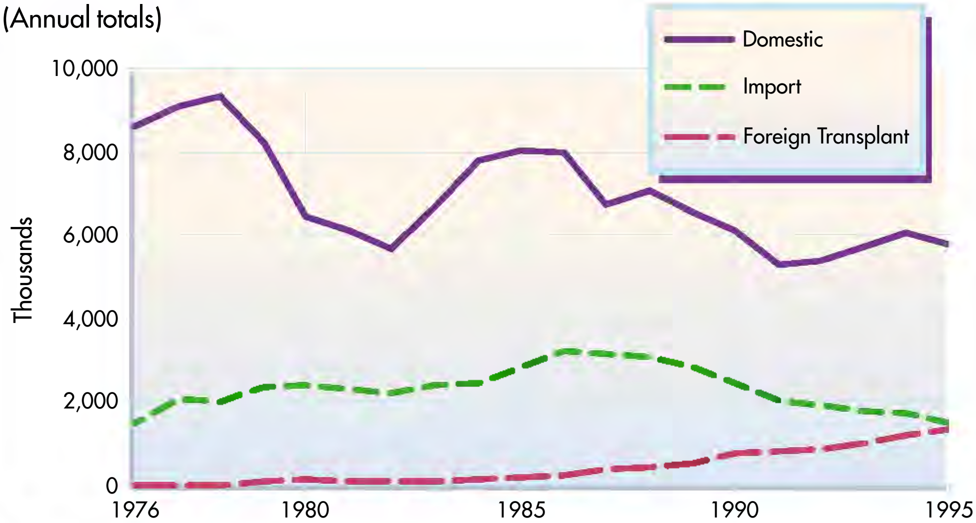
1994 Kia Motor Corporation introduces its first Kia nameplate vehicle, the Sephia, to the U.S. market.
The first U.S.-built BMW rolls off the production line in Greer, South Carolina.

1995 Honda celebrates the sale of its ten millionth car in the U.S. and introduces the new 1996 Civic, which has 93 percent domestic content, the highest ever for an international nameplate automobile.
Toyota unveils the GM-built Toyota Cavalier for sale in Japan.

1998 Toyota opens a plant in Lafayette, Indiana, to produce the Tundra Truck series.
Daimler-Benz buys Chrysler Corporation.

Figure 4-5

New Automobile Sales in the United States: 1976-95
(Annual totals)



Source: American Automobile Manufacturers Association, *Motor Vehicle Facts and Figures* (Detroit, MI: Various years); U.S. Department of Energy, Oak Ridge National Laboratory, *Transportation Energy Databook* (Oak Ridge, TN: 1999).

In 1975, the American automobile industry faced the challenge of developing cars to meet new emissions standards under the Clean Air Act of 1970 and to comply with the fuel economy requirements of the Energy Policy and Conservation Act of 1975, while still appealing to the American driving public.

By 1975, U.S. auto manufacturers were finding that higher gasoline prices and the memory of gas lines were eroding the traditional American desire for large, high-performance cars. Japanese and European imports were better suited to meet the new demand for smaller, more fuel-efficient cars. In 1975, 18 percent of the cars sold in the United States were imports, a market share almost 20 percent higher than in previous years, but well below future growth. No "foreign" cars were built in the United States [ORNL 1999]. However, the global networking of the industry had already begun with General Motors abandoning its policy against partnerships and alliances to acquire a substantial share in Isuzu Motors of Japan.

The American automobile industry continues to face the same major challenges of the last 25 years—producing fuel-efficient, low-pollution vehicles that

Table 4-3

"Foreign" Vehicles Built in the USA

Location	Manufacturer	Country association
Avon Lake, OH	Nissan	Japan
East Liberty, OH	Honda Acura	Japan
Edison, NJ	Mazda	Japan
Flat Rock, MI	Mazda	Japan
Fremont, CA	Toyota	Japan
Georgetown, KY	Toyota	Japan
Lafayette, IN	Subaru Isuzu Honda Toyota	Japan
Marysville, OH	Honda	Japan
Normal, IL	Mitsubishi	Japan
Shreveport, LA	Isuzu	Japan
Smyrna, TN	Nissan	Japan
Spartanburg, SC	BMW	Germany
Tuscaloosa, AL	Mercedes	Germany
Westmoreland, PA	Volkswagen	Germany

Source: The American International Automobile Dealers Association, available at http://www.aiada.org/pubs/poster/usa.htm, as of Apr. 26, 2000.

Table 4-4

'Domestic" Vehicles Built in Mexico and Canada: 2000

Location	Make	Manufacturer
Cuautitlan, Mexico	Contour Mystique	Ford
Hermosilla, Mexico	Escort Mercury Tracer	Ford
Lago Alberta, Mexico	Dodge Ram Club Cab	Chrysler
Saltillo, Mexico	Dodge Ram Club Cab	Chrysler
Silao, Mexico	Chevy Suburban Chevy Tahoe GMC Yukon	General Motors
Tolucca, Mexico	Sebring Neon	Chrysler
Boisbriand, Quebec	Firebird	General Motors
Brampton, Ontario	Concorde LHS New Yorker Dodge Intrepid Eagle Vision	Chrysler
Ingersoll, Ontario	Geo Metro Geo Tracker	General Motors
Oakville, Ontario	Windstar F-150 Pickup	Ford
Oshawa, Ontario	Lumina Monte Carlo Buick Regal Chevy C/K GMC Sierra	General Motors
St. Therese, Quebec	Chevy Camaro	General Motors
St. Thomas, Ontario	Crown Victoria Mercury Grand Marquis	Ford
Windsor, Ontario	Dodge Caravan Grand Caravan Plymouth Voyager Grand Voyager Dodge Ram Van Ram Wagon Van	Chrysler

Source: The American International Automobile Dealers Association, available at http://www.aiada.org/pubs/poster/mexico.htm, as of Apr. 26, 2000.

appeal to the American public and compete with increasingly popular imports.

Industry globalization has proceeded through the two-pronged trend of cross-ownership and cross-border manufacturing. In 1978, the first foreign car produced in the United States rolled off Volkswagen's assembly line in Westmoreland, Pennsylvania. Ford purchased a share of Mazda Motors in 1979. Tables 4-3 and 4-4 show data on current cross-border manufacturing facilities in the United States, Mexico, and Canada.

In 1982, the Japanese government voluntarily initiated an import control program to protect the U.S. auto industry while it retooled. These controls reduced imports from 28 percent of the market to 19 percent. However, the production of transplants rose from 1.4 percent of the market to more than 16 percent [ORNL 1999]. Japanese car manufacturers, alone, have invested more than $14 billion in U.S. manufacturing facilities. Today, excluding exports to Canada, Japanese name-brand cars comprise more than half of the vehicles exported from the United States, and Honda is the single largest exporter of cars from the United States, [Japan Auto 1999]. Imports peaked in 1986 at 4.2 million vehicles—more than 26 percent of the automobile market. Eighty percent of these imports were Japanese, which made up 20 percent of the total market [USDOC 2000].

U.S. auto manufacturers fared better in the 1980s as memories of the energy crisis faded, and much of the American public returned to larger cars and luxury vehicles, categories dominated by domestic products. The American manufacturers surpassed their foreign competitors with the introduction of the minivan by Chrysler in 1983 and the SUV by Ford in 1990. Both of these products were quickly embraced by the American public. But it was not long before foreign manufacturers followed suit. By the late 1990s, foreign minivans and SUVs of varying sizes began appearing in the market. Meanwhile, the distinction between domestic and foreign vehicles has continued to fade. Not only was the manufacturing industry becoming more global, but parts suppliers were as well. Cars built in the United States may contain parts built abroad. General Motors' recent contract with Honda to supply engines for its small cars built in the United States is symbolic of this long-term trend.

Despite the steady loss of U.S. market share during the past three decades, General Motors and Ford still rank as the top two manufacturers in the world, by production [USDOC 2000]. However, *Industry Week* ranks them behind DaimlerChrysler in revenue [*Industry Week* 2000b].

The industry has become a global network of partnerships, alliances, and joint ventures over the past 25 years. The biggest of these moves, the Daimler-Benz acquisition of Chrysler in 1998, kicked off a new round of global consolidation. This acquisition was quickly followed by Ford's purchase of the car manufacturing division of Swedish luxury carmaker Volvo. Volvo then bought Renault's U.S. Mack Truck manufacturing business, and, in turn, gave Renault a 15 percent stock ownership stake in Volvo. The combined Volvo-Mack Truck line leads the European market and is the second largest seller in the United States, with 25 percent of the large-truck market.

General Motors has alliances with three Japanese companies, owning 10 percent of Suzuki; 20 percent of Fuji Heavy Industries, maker of Subaru [Fiat 2000]; and 49 percent of Isuzu. Additionally, General Motors, Isuzu, and Suzuki together make the Opel, the most popular car in Europe [GM 1999]. General Motors also owns 20 percent of Fiat in Italy and all of Swedish Saab. General Motors is moving into the fast-growing Asia Pacific region with new plants in China, supplied by parts from Michigan in the United States, and Thailand.

Ford owns 33 percent of the Japanese company, Mazda [Ford 1999], and it has taken over Sweden's Volvo and Britain's Jaguar and Land Rover operations. Ford operates 12 major assembly plants in Europe and has moved into India [*Industry Week* 1999], with 78 percent ownership of Ford India.

Keys to the Future

The globalization trend in the automobile industry likely will continue in the coming years. With Asia-Pacific and Latin America projected as the fastest growing regions, automakers will be seeking ways to enter those markets. However, the U.S. market remains the largest, and automakers continually will seek new ways to sell cars in this country.

The global auto market continues to be determined by consumer preferences and government regulation. The divergence between the two sometimes creates problems for auto manufacturers attempting to develop a global brand and to cut costs by producing the same vehicle worldwide. The American consumer preference for larger vehicles with luxurious interiors is shared only in Canada, Mexico, and Saudi Arabia. Consumers in the rest of the world buy smaller cars that are more fuel efficient and have more modest interiors. Attempts are underway to develop global vehicle standards.

The U.S. Department of Commerce projects that auto imports will rise in the United States during the next several years with improved products offered at competitive prices [USDOC 2000]. American consumers have shown an increased willingness to pay more for import cars than for domestic vehicles, paying 63 percent more in 1999, compared to 20 percent in 1992 [USDOC 2000]. Table 4-5 shows sales of the top 10 cars and trucks in the United States, including imports.

Table 4-5

Top Selling Cars and Trucks in the United States: 1998

Top 10 cars	Cars sold	Top 10 trucks	Trucks sold
Toyota Camry	429,575	Ford F-Series	836,758
Honda Accord	401,071	Chevrolet C/K Pickup	538,254
Honda Civic	371,074	Ford Explorer	431,488
Ford Escort	334,562	Dodge Ram Pickup	410,130
Chevrolet Cavalier	256,099	Ford Ranger	328,136
Toyota Corolla	250,501	Dodge Caravan	293,819
Saturn	231,522	Jeep Grand Cherokee	229,135
Chevrolet Malibu	223,703	Chevrolet S10 Pickup	228,093
Pontiac Grand Am	180,428	Ford Expedition	225,703
Chevrolet Lumina	177,631	Chevrolet Blazer	219,710

Source: Ward's Communications, *Ward's Motor Vehicle Facts and Figures 1999* (Detroit, MI: 2000).

The Council on Competitiveness has expressed concerns that higher demand for fuel-efficient or advanced-fuel vehicles outside the United States could lead to greater investment in research, and result in faster marketing opportunities there. Although U.S. manufacturers have joined with the government to produce fuel-efficient vehicles, the relative low cost of fuel—if it continues—is unlikely to lead to massive consumer demand. Except for China, fuel costs are higher in other major nations because of higher taxes.

Also in the coming years, the auto industry may face the challenge of surplus production capacity, particularly in Europe, while production growth is taking place in Asia and Latin America.

International Passenger Travel by Air

Over the past 25 years, U.S. policy has favored a more open international aviation system, and much of the world has followed. In 1975, flying between countries was governed by bilateral agreements that were restrictive and designed to protect national flag carriers from competition. While the basic framework of bilateral agreements remains in effect, the U.S. government has advocated "open skies" agreements aimed at increasing competition, lowering fares and cargo rates, and increasing service.

"The world economy today is fifteen times its size 40 years ago. And travel and tourism have already become the world's largest industry."

Rodney E. Slater
Secretary, U.S. Department of Transportation
International Transportation Symposium
Washington, DC
Oct. 10, 2000

Changes in global aviation began in 1978 when U.S. airlines were deregulated, while the international system remained tightly regulated. The International Air Transport Association (IATA) set fares and rates, subject to government approval, until 1979 when the Civil Aeronautics Board (CAB) withdrew "blanket" antitrust protection from IATA. International fare-setting continued to be subject to case-by-case approval of the CAB and, later, the U.S. Department of Transportation (USDOT). But, as competition improved, the USDOT cut back its supervision of international pricing, effectively deregulating first charters, then cargo transportation. Today, after decades of pressing for marketplace fare setting, foreign governments rarely attempt to disapprove U.S. carrier pricing initiatives and pricing regulation in U.S. international markets is largely a thing of the past.

In 1975, only four U.S. carriers—Pan American (PanAm), Trans World Airlines (TWA), Northwest, and Braniff—had authority to fly overseas. Departure points for overseas flights were Kennedy Airport in New York for transatlantic destinations; Los Angeles or San Francisco for transpacific flights; and Miami for Latin American flights.

"This is an extrordinary time to be in transportation — and I would say — in aviation. It is a time that is at once exhilarating, exciting, sometimes exhausting, but always challenging. We live in an era of globalization, that in the words of one economist, is 'turbocharged'."

Jane F. Garvey
Administrator,
Federal Aviation Administration

After deregulation, several more U.S. carriers—American, United, Delta, and, for a time, Eastern—obtained new international authority from CAB/USDOT and acquired some international routes from PanAm, TWA, and Braniff. Domestic flights linked up to the international flights at the four traditional gateways. American, United, Braniff, and Delta also brought international flights to other hubs, expanding the number of U.S. gateways.

Over the past quarter century, U.S. airlines have extended their reach. For example, between 1983 and 1993, the number of international city-pair markets flown by U.S. airlines grew by more than one-third [60 *Federal Register* 21841]. New technology made new gateways possible with smaller planes, which could fly longer and more frequently to more distant locations. These flights replaced the use of fewer, larger planes, which only flew to a few major airports.

During the last 25 years, a number of airlines throughout the world, including British Airways, went from "state" to private control. A 1997 *Foreign Policy* article estimated that while "the state was the majority owner of most airlines in the 1950s and 1960s, private investors now control 75 percent of the airline industry." It predicted that "the remaining holdovers will likely be privatized within the next few years [Juan 1997-98]."

Box 4-2

Changing Markets, Changing Aircraft

In the past 25 years, airlines have moved from using a few large airplanes for international flights to using numerous smaller planes. More flights, combined with extended nonstop flying ranges, have changed the system. Boeing, in its "Current Market Outlook," notes the importance of the change in aircraft: "Twenty years ago, the performance, capacities, and economics of airplanes then available dictated the business strategies of transatlantic carriers. They could either operate single-aisle Boeing 707s and DC-8s with fewer than 200 seats or fly widebodied B747s and DC-10s with more than 300 seats. With lower seat-mile costs and newer technology, the widebodies predominated, forcing airlines to a business strategy of fewer, high-capacity flights linking only a few transatlantic gateways.

Today, an ongoing shift to smaller, highly fuel-efficient and long-range airplanes is fundamentally transforming North Atlantic air travel. Introduced in the 1980s, the B767 and A310 have freed airlines to pursue flexible business strategies, offering consumers greater choice. As a result, travelers now fly to and from more cities on both sides of the Atlantic. They save time and money because their travel is more direct, and they have a greater choice of convenient departure times because today's traffic is divided among a greater number of smaller capacity jets." [Boeing 2000]

The increase in aircraft range also has popularized nonstop flights between Europe and the Pacific basin. Boeing predicts that the Pacific market will continue to grow as political restrictions are eased and more use is made of smaller capacity A340 and B777 jetliners that can fly as far as, or significantly farther than, the B747-400.

Source: The Boeing Company, *Current Market Outlook*, available at http://www.boeing.com/commercial/cmo/1eo00.html, as of July 10, 2000.

The European Union (EU) achieved full-airline deregulation for intra-EU service in 1998. Throughout the world, airlines are becoming less of a national political symbol and more of a business, with increasing cross-border investments. However, most countries still retain national ownership rules.

Box 4-3

Cross-Border Ownership

Airlines are considered national assets, and therefore, many nations, including the United States, have strict rules against foreign ownership. These rules fit the existing general structure of bilateral treaties that require airlines to be identified by national origin.

Many airlines have moved from state ownership to full or partial privatization in recent decades, but the next step of opening ownership to foreign interests generally has not been taken. For the U.S. system, one key consideration is the need for U.S. airlines to commit planes to the Civil Reserve Air Fleet (CRAF) during national emergencies; CRAF provides up to half of the military's airlift capabilities (see Chapter 7 for a detailed discussion on CRAF).

Some cross-border ownership has taken place. Examples include SAirGroup, the parent of SwissAir, which acquired 85 percent of the Belgian Sabena Air [SAirGroup 2000], formerly a state airline, and KLM Royal Dutch Airlines, which purchased 25 percent of U.S.-based Northwest Airlines (later divested). But, cross-border ownership still remains rare in an industry that is rapidly becoming more global. As globalization becomes more dominant in the 21st century, the issue of cross-border ownership may be compelling.

Other issues that continue on an international scale are cabotage and right of establishment. Cabotage is the carriage of domestic traffic by a foreign carrier. Historically, this has been prohibited by national laws in order to reserve domestic traffic for homeland carriers, for both economic and security reasons. In 1998, the European Union integrated its Member States' domestic markets, permitting a carrier of any Member State to carry traffic within and among all other Member States, performing what would ordinarily be considered cabotage.

The right of establishment would allow airlines or others to create or purchase airlines within a foreign nation; this is an element of the EU's internal liberalization. Although there has been little movement on cabotage or right of establishment, both are likely to be discussed during the coming years.

Box 4-4

Code Sharing

Code sharing is a common industry practice wherein one airline offers services in its own name for a particular city-pair, but some, or all, of the transportation is provided by another carrier. Globalization of the airline industry is making this practice increasingly common in international travel.

While code sharing allows carriers to provide more convenient service to travelers, the USDOT requires disclosure to passengers and has recognized the need to ensure that foreign partners meet the highest safety and security standards. The Federal Aviation Administration (FAA) does not, however, directly certify and oversee the safety of foreign carriers. Under international law, such direct safety oversight is the responsibility of foreign civil aviation authorities.

Therefore, one indication of the level of safety of the foreign code-share carriers is the FAA's International Aviation Safety Assessment (IASA) Program. Under this program, the FAA determines whether a country's aviation safety oversight meets minimum international oversight standards.

A code share with a foreign carrier will be approved only if the foreign carrier is from a country that meets such standards or is using aircraft and crew from such a country.

Another important safety measure is the program of audits conducted by U.S. air carriers of their code-share operations. Under recent USDOT guidelines, a U.S. air carrier will perform initial and periodic safety audits of each foreign carrier having a U.S. code-share service. The FAA reviews these results and advises USDOT, which determines whether the code-share service is in the public interest. Such a public interest determination is a required part of the code-share approval process.

To overcome the barriers of national ownership rules, airlines have turned to global alliances (table 4-6) to help compete in the emerging global market. Using joint marketing and service arrangements—and, sometimes, *code-sharing* (box 4-4)—these alliances provide the means with which airlines can develop worldwide networks for their passengers and offer global service. In 1998, more than half of the world's airline capacity, based on available seats per kilometer, was involved in alliances [Boeing 2000].

In recent years, bilateral agreements have accommodated globalization through alliances, including code-sharing, and are beginning to be overtaken by *open skies* agreements. So far, the United States has signed 51 "open skies" agreements, which eliminate all restrictions on airline service between the signing countries (figure 4-6 and box 4-5).

In addition, the first ever multilateral open skies agreement was initialed in November 2000 by the United States and four other Asia-Pacific Economic Cooperation (APEC) economies (Chile, Brunei, New Zealand, and Singapore). With this agreement, we are beginning to move beyond the current system of bilateral aviation agreements and into the international aviation environment of the 21st century while still maintaing the highest levels of safety as well as ensuring the needs of the workforce.

"Alliances will become a master brand where customers will begin to relate to the system rather than its parts . . . I see a future of seamless travel from ordering and paying for tickets online to electronic check-in to destinations reached through the smooth coordination of different components of the alliance brand. This is not fantasy. It's already happening."

Jim Goodwin
President, United Airlines
Aviation Club of Great Britain
Nov. 11, 1998

Table 4-6

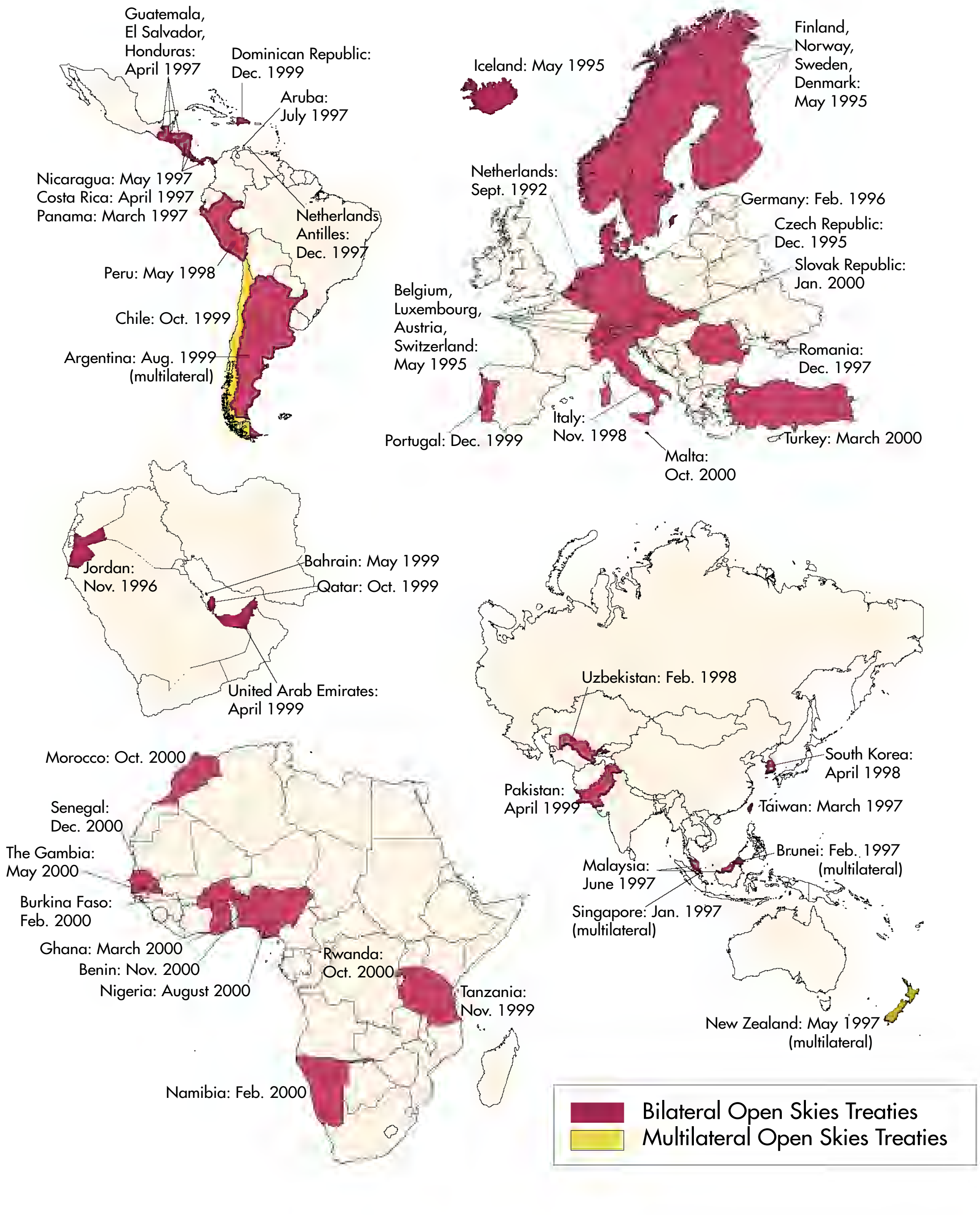
Major International Airline Alliances

Alliance	Started	Members
Star Alliance	May 1997	Air Canada Air New Zealand All Nippon Airways Ansett Australia Austrian Airlines British Midland Lauda Air (Austria) Lufthansa (Germany) Scandinavian Airline System Singapore Airlines Thai Airways (Thailand) Tyrolean Airways (Austria) United Airlines (U.S.) Varig (Brazil)
One World	February 1999	Aer Lingus and Lan Chile (will join in 2000) American Airlines (U.S.) British Airways Canadian Airlines Cathay Pacific (Hong Kong) Finnair (Finland) Qantas (Australia) Iberia (Spain)
Qualiflyer Group	March 1998	Air Europe (UK) Air Portugal AOM & Air Littoral (France) Crossair (Switzerland) LOT (Poland) PGA (Portugal) Sabena (Belgium) Swiss Air Turkish Airlines Volare Airlines (Italy)
Wings Alliance	1999	Continental Airlines (U.S.) KLM Royal Dutch Airlines Northwest Airlines (U.S.)
Global Alliance	October 1999	AeroMexico Air France Delta Airlines (U.S.)

Source: Commercial Air Carrier websites, as of May 1, 2000.

Figure 4-6

Open Skies Agreements with the United States: 2000



Source: U.S. Department of Transportation, Office of International Aviation, personal communication, Apr. 20, 2000.

Box 4-5

"Open Skies" Bilateral and Multilateral Agreements

Air services between the United States and foreign destinations in the world are governed primarily by government-to-government bilateral aviation agreements. Most of these agreements impose significant restrictions on airline operations by limiting the destinations served, the airlines and services available, and prices charged. The Clinton Administration has developed and implemented a comprehensive program for eliminating these restrictions. Open-Skies agreements are central to this program because they replace government regulation with a system in which the market determines airline destinations, services, and prices.

Open-skies agreements permit unrestricted international air service between participating countries, allowing each country's airlines to fly between any city in its home country and any city in participating countries. This type of agreement maximizes potential competition and facilitates new services through cooperative arrangements among the participating countries' airlines. To date, there have been 52 Open-Skies agreements; the first one was signed with the Netherlands in September 1992.

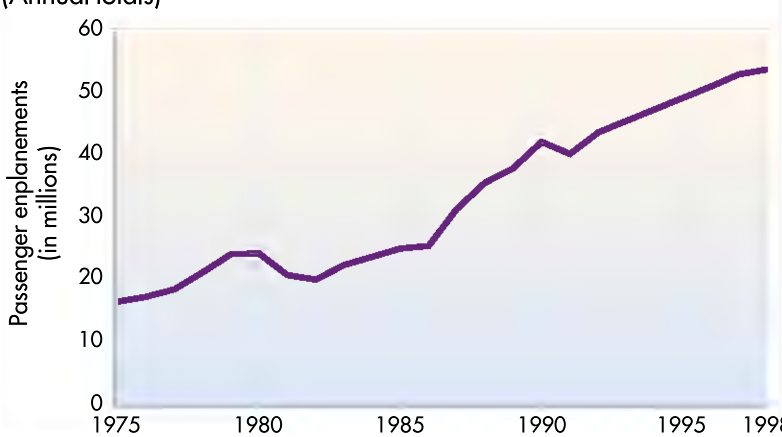
In November 2000, the United States and four Asia-Pacific Economic Cooperation (APEC) economies (Chile, Brunei, New Zealand, and Singapore) initialed the first ever multilateral open skies agreement. With this agreement we are beginning to move beyond the current system of bilateral aviation agreements and into the international aviation environment of the 21st century. This historic agreement, is a direct result of the concepts we explored and the vision we established at the Beyond Open Skies Conference held in Chicago in 1999.

In 1975, 16.3 million passengers boarded international flights in the United States [ATA 1999b]. By 1998, that number had tripled to more than 53 million passengers (figure 4-7). Figures 4-8 and 4-9 show the extent of international air travel to and from the United States in 1998.

In 1975, the load factor—a measure of revenue-passenger "load" divided by passenger capacity for an aircraft—for international flights was 50 percent, and it has steadily increased during the past 25 years (figure 4-10). In recent years it has exceeded 70 percent [ATA 1999a]. This growth has substantially improved profitability and, therefore, reduced costs to consumers. U.S. flight destinations also have changed. Although Atlantic routes carry the most passengers, the Latin American and Pacific markets are expected to grow at a much faster annual growth rate between 2000 and 2011 [USDOT FAA].

Figure 4-7

International Passengers Enplaned in the United States: 1975-98
(Annual totals)



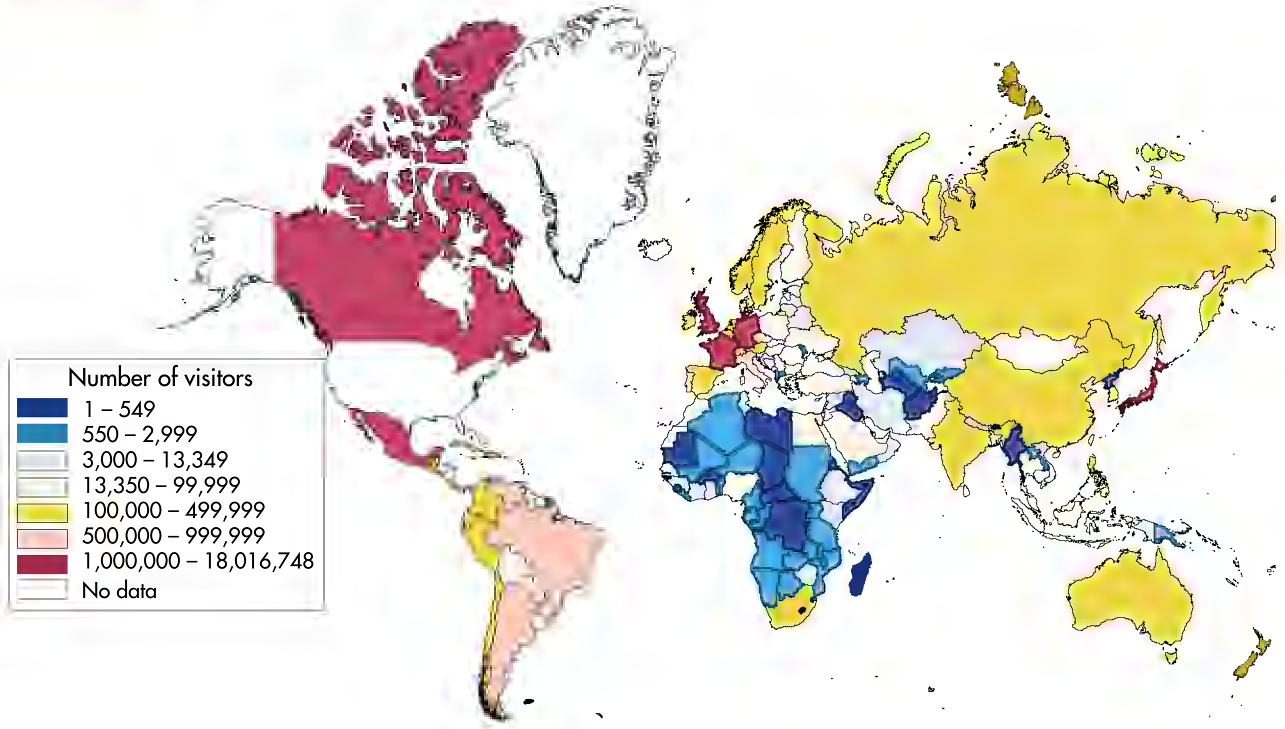
Source: Air Transport Association, available at http://www.air-transport.org, as of Apr. 25, 2000.

"Just as the Hubble Space Telescope has opened up the universe to millions, the aviation system of the future will open the corners of the world to more and more people, ensuring that the new millennium is the Aviation Millennium."

Daniel S. Goldin
Administrator, National Aeronautics and Space Administration, Aviation in the 21st Century—Beyond Open Skies Ministerial Conference, 1999.

Figure 4-8

Foreign Residents Visiting the United States: 1998

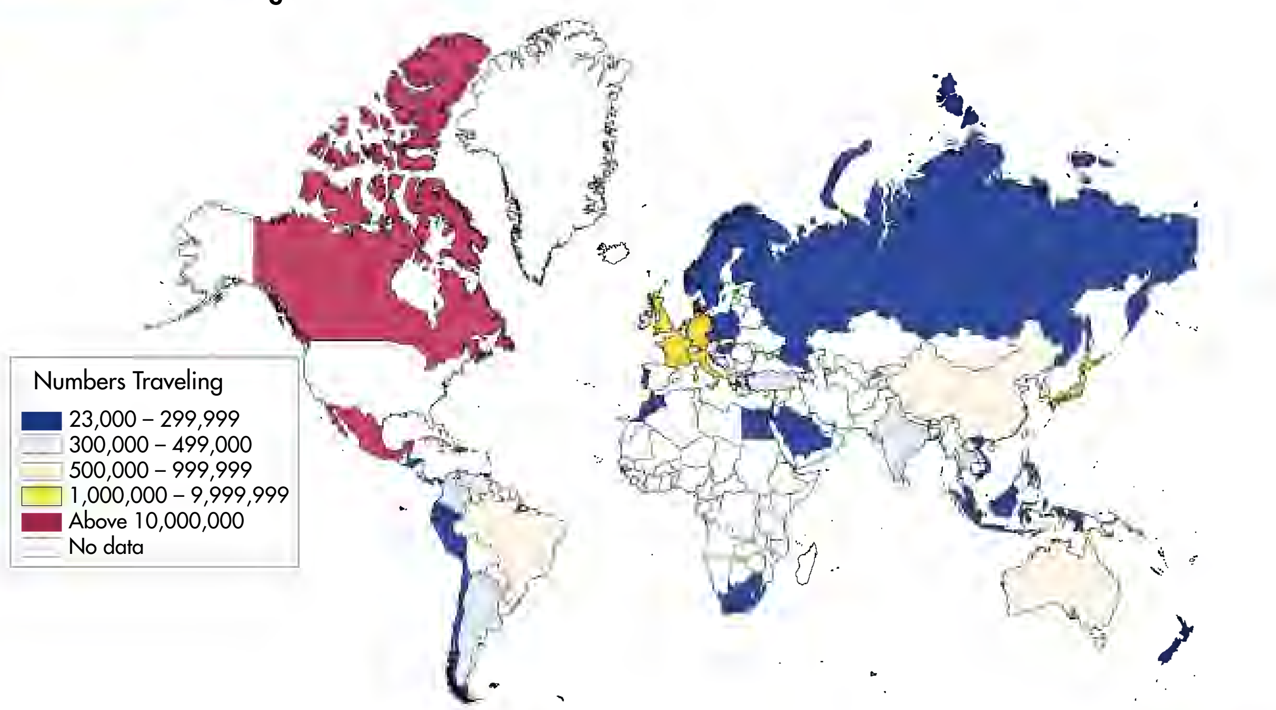


Notes: Overseas excludes Canada and Mexico (for those two countries, visitation estimates include all modes; for all other countries, estimates are available only for air travel to that country). The visitation estimates are made based on the airlines that voluntarily participate in this program. If a major carrier does not participate and we do not have access to other carriers who generate passenger travel to that destination, our estimates will be affected.

Source: U.S. Department of Commerce, International Trade Administration, Tourism Industries (Washington, DC: 1999).

Figure 4-9

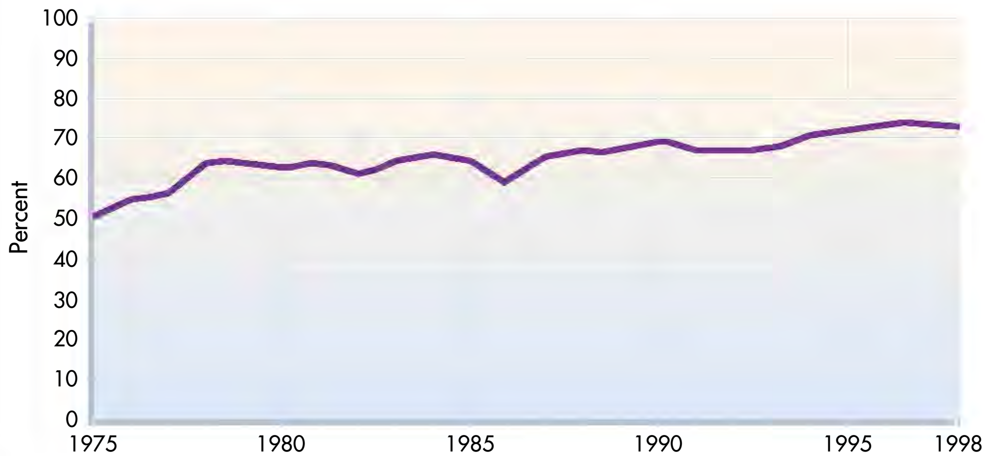
U.S. Residents Traveling to Overseas Countries: 1998



Source: U.S. Department of Commerce, International Trade Administration, Tourism Industries (Washington, DC: 1999).

Figure 4-10

International Aviation Load Factor: 1975-98



Source: Air Transport Association, available at http://www.air-transport.org, as of Apr. 25, 2000.

Keys to the Future

The Boeing Company projects an annual growth of 4.7 percent in international air travel over the next 20 years [Boeing 2000]. According to Boeing, the greatest growth potential is in Asia, which has become an important tourist destination and also is home to emerging strong economies, such as those of India, China, and South Korea. To accommodate increasing passenger traffic, countries across the world, especially Asia, are enhancing capacity at existing airports and building new ones. For example, the Chek Lap Kok airport, built in Hong Kong at a cost of nearly $20 billion, went into operation in 1999.

A key challenge facing international aviation today and in the coming years is to create a system that fits the global economy. To address this challenge, public officials are looking beyond bilateral treaties that have governed international aviation relations for the past 55 years, to establish multilateral groupings of "open skies" nations. In 1999, the USDOT hosted an "Aviation in the 21st Century—Beyond Open Skies Ministerial" Conference in Chicago, attended by representatives of 93 nations, to discuss a new international aviation policy architecture. The conference created new opportunities for growth in international aviation to pursue air service liberalization beyond the current bilateral system to foster the creation of expanded international multilateral partnerships. It also helped us create a bold new vision for international aviation—one that capitalizes on communications, information, and technological revolution of the 21st century. This will help us achieve the safest, most secure, environmentally friendly, and efficient aviation system possible by 2025.

Box 4-6

Superjumbo Aircraft

The projected growth of the volume of passenger traffic and increasing congestion at European and Asian airports has encouraged the development of a new generation of higher capacity superjumbo airliners. Boeing has announced it is developing the 747X (capable of seating more than 500 passengers), while Airbus is developing the A3XX (capable of seating 481 to 656 passengers).

Source: K. Done, Survey—Aerospace 2000: One Challenge That Could Not Be Refused: AIRBUS A3XX, *The Financial Times*, July 24, 2000.

The record growth of world travel has also created heightened sensitivity to the safety and security of the global aviation system. To maximize safety, international standards need to be applied around the globe, and trouble spots need to be identified and addressed.

The operating structure of the scheduled passenger airline industry will change through further refinement of existing business models and the development of totally new business models. For example, low-fare carriers have fundamentally changed the competitive dynamic in U.S. and European domestic aviation markets, and it is entirely possible that low-fare airlines could expand to link continents. Airlines have learned that to maximize profits and shareholder value they must select the traffic segment that fits their cost structure and corporate strengths, rather than simply chasing all passengers in an effort to improve market share. In the next 25 years, the evolution of the industry structure will be guided by airlines optimizing the relationship between targeted passenger segments and their cost and business structures.

Aviation in the year 2025 will be marked by characteristics that differ from today's environment. These changes will be driven by consumer demand and the industry's need to meet those demands while creating shareholder value.

- The distinction between domestic and international aviation will be nearly nonexistent in the key forms it exists in today: ownership and control, licensing, and competition policy. The thousands of bilateral air transport agreements between national governments will give way to regional/plurilateral pacts that will probably evolve toward a multinational regime. By 2025, the airline industry will have followed other industries in becoming truly global, even on the production side. In short, we will see the complete deregulation of the industry on a global basis and normalization of the airline industry as an economic sector.

- In an effort to enhance productivity and efficiency, airlines will substantially rationalize hub-and-spoke systems. This will be done not only through consolidation, but also through airline planning and operating changes and innovations, such as dynamic scheduling, which provides for capacity management changes close to flight time. Long-term efficiency gains will be possible by operating fewer, larger aircraft into permanently constrained hubs.

- Airlines will successfully use new aircraft and information technologies to transition from planning their business based on traffic pools to focusing on passenger profiles, seeking to provide a range of products and services that more effectively match a passenger's needs, not just his/her willingness to pay. Airlines may evolve into "lifestyle" management companies in an effort to further leverage their individual brands and effectively meet the needs of more granular market segments.

- As airlines become comfortable with not competing for every passenger segment, the rationalization of the hub-and-spoke networks on a global scale will create new opportunities for other innovative services that will be largely point-to-point, but will have the ability to focus on the needs of a particular market segment.

The role of the government will be to facilitate this process, providing leadership to steer toward promising regional/plurilateral arrangements and away from forums that might regress from the open-skies standards. Where stakeholder interests are mutually exclusive, the Department should secure the public interest on the basis of a long-term vision, ameliorating the long-term negative effects of short-term corporate policies—both of which are inherent when an industry is in fundamental transition.

Box 4-7

International Aviation Safety and Security

Exposure to risk varies greatly around the world. Aviation accident rates are among the lowest in the United States and Canada (figure 4-11). With aircraft loss rates in Latin America, Africa, and Asia up to 19 times as high as the North American rates, it will be a challenge to reduce the accident rate throughout the world.

The FAA's assessments of safety oversight found weaknesses in the safety/regulatory environment in various regions of the world. The IASA program, which released its first results in 1994, focuses on whether a country's safety oversight for aircraft operations and maintenance meets International Civil Aviation Organization (ICAO) standards. As a direct result of this program, many countries have improved safety oversight efforts. These improvements have made travel safer, not only on foreign carriers with operations to the United States, but to other destinations worldwide.

The White House Commission on Aviation Safety and Security, established in July 1996 and chaired by Vice President Al Gore, strengthened security requirements and certifications and recommended procedures to improve aviation security.

Safe Skies for Africa, and the Partnership for Safer Skies with Latin America, and the Western Hemisphere aviation initiative are three FAA-initiated regional safety efforts aimed at spreading a model set of aviation laws, regulations, and standards that nations around the world can use to meet international safety standards. The FAA's technical assistance programs may be insufficient, however, to meet growing demand. Greater efforts may be needed to harmonize certification standards, air traffic control procedures, and navigational capabilities.

Beginning in 2000, ICAO is taking steps, through its Universal Safety Oversight and Audit Program, to ensure that countries provide adequate safety oversight in the areas of personnel licensing and aircraft operation and airworthiness. To help ensure global aviation safety, the FAA has:

- introduced Bilateral Aviation Safety Agreements in 1995 to allow reciprocal acceptance of various approvals, reducing the industry's burden of duplicate certifications;
- moved to harmonize civil aviation regulations, practices, and procedures with the Joint Aviation Authorities of Europe, and with certification authorities in the Former Soviet Union, China, and other countries that manufacture aircraft; and
- provided technical assistance to authorities around the world.

Source: U.S. Department of Transportation, Office of the Inspector General, Audit report: Aviation Safety Under International Code Share Agreements, number AV-1999-138, available at www.oig.dot.gov/audits/av1999138.pdf, as of July 21, 2000.

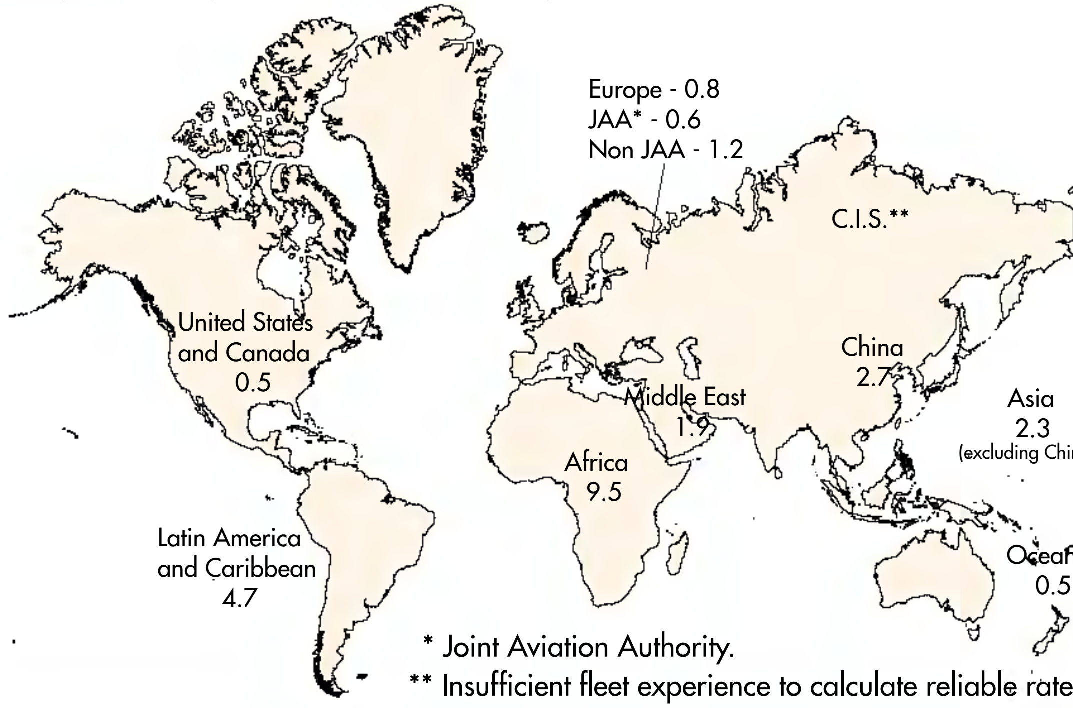
Air Cargo and Express Services

One of the most significant transportation developments of the past quarter century has been the rapid growth of air cargo, and, as a result of that growth, development of global integrated express carriers. Lower shipping costs and more frequent service have made air cargo a major factor in the way business is conducted. Consequently, air freight's share of U.S. international merchandise trade grew from 16 percent by value in 1980 [USDOT BTS 1999] to 28 percent in 1997, valued at $433 billion (figure 4-12). Although this represents less than 1 percent of tonnage, domestic ton-miles of air freight have tripled since deregulation in 1977, and international ton-miles have grown nearly fivefold [ATA 1999b].

Air cargo has grown in importance as more U.S. businesses replace traditional inventory stockpiling practices with lean inventories and just-in-time deliveries. Electronics and computers are the largest single air-freight category, comprising nearly 20 percent of the market (table 4-7). While high-value, time-sensitive goods are moved by air, especially critical goods may be sent by integrated express carrier, such as Federal Express, United Parcel Service (UPS), DHL, Airborne Express, CF/Emery, Burlington, and, increasingly, by the U.S.

Figure 4-11

Hull Loss Accident Rates by World Region: 1988-97 (10 year averages)
(Accidents per million departures for western-built transports)

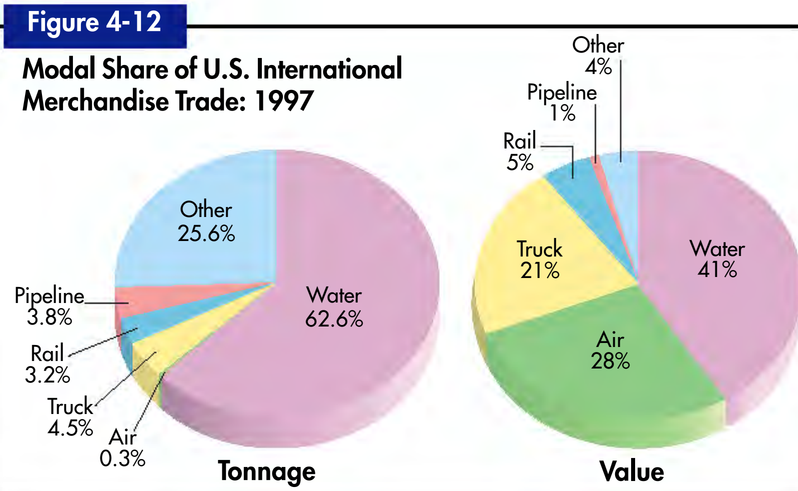


* Joint Aviation Authority.
** Insufficient fleet experience to calculate reliable rate.

Source: U.S. Department of Transportation, Federal Aviation Administration data, personal communication (Washington, DC: 2000).

Figure 4-12

Modal Share of U.S. International Merchandise Trade: 1997



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Freight USA, draft, 2000.

Table 4-7

Top 10 Shipments by Air, Ranked by Value: 1997

SCTG	Commodity	Value ($ millions)	Tons (thousands)	Ton-miles (millions)
35	Electronic and Other Electrical Equipment and Components and Office Equipment	89,325	634	863
37	Transportation Equipment, NEC	55,500	78	100
38	Precision Instruments and Apparatus	17,475	135	151
40	Miscellaneous Manufactured Products	16,373	200	325
34	Machinery	12,055	305	474
21	Pharmaceutical Products	10,524	71	98
29	Printed Products	7,090	337	418
36	Motorized and Other Vehicles (Including Parts)	5,387	370	376
30	Textiles, Leather, and Articles of Textiles or Leather	3,699	115	185
33	Articles of Base Metal	1,976	355	507
Total		**229,062**	**4,475**	**6,233**

Key: NEC = Not Elsewhere Classified; SCTG = Standard Classification of Transported Goods.

Source: U.S. Department of Commerce, Census Bureau; and U.S. Department of Transportation, Bureau of Transportation Statistics, *1997 Commodity Flow Survey,* EC97TCF-US (Washington, DC: 1999).

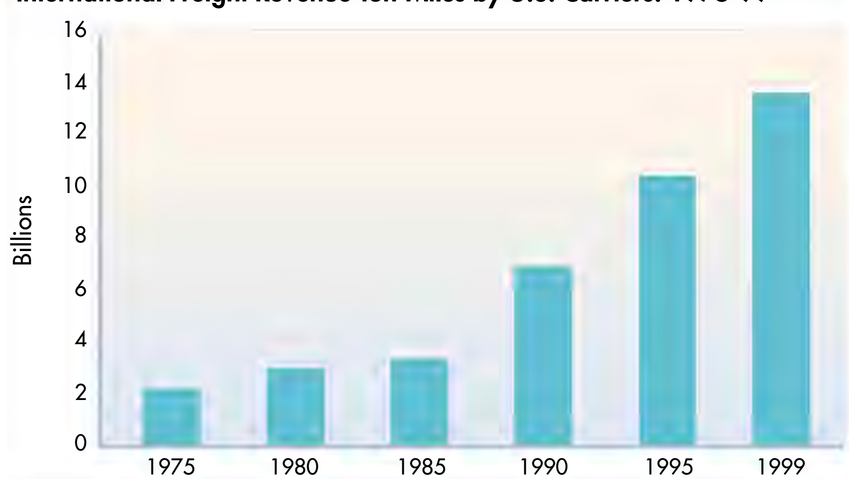
Postal Service (USPS). Modern information technology allows customers to receive door-to-door tracking information from integrated express carriers.

In 1975, the express services industry was just getting started, and its potential was not widely foreseen. Domestic air cargo, already growing rapidly in 1975, amounted to about 2.8 billion revenue ton-miles that year—five times greater than in 1960 [USDOT 1977]. By 1999, revenue ton-miles had grown to 11.5 billion, at an annual growth rate of 6.1 percent. At the same time, international revenue ton-miles by U.S. carriers increased from 2.2 billion to 13.6 billion (figure 4-13). This phenomenal success of both air cargo and express carriers was spurred by the Airline Deregulation Act of 1978, discussed in chapter 2, which created conditions that allowed both competition among carriers and basic changes to the air-industry structure.

FedEx was founded in 1973. It used a then novel hub-and-spoke method to move air cargo at night to a central hub and distribute it before the end of the next business day through

Figure 4-13

International Freight Revenue Ton-Miles by U.S. Carriers: 1975-99



Source: U.S. Department of Transportation, Federal Aviation Administration, Working Paper on Aerospace Capacity and Demand, draft (Washington, DC: 2000).

integrated air and truck service. At that time, FedEx was delivering to 25 U.S. cities. UPS (founded in 1907) gained permission in 1975 for its trucks to deliver in all 48 contiguous states. At that time, it was still a ground-based North American company; its first venture into Europe did not come until the following year. DHL pioneered door-to-door foreign express deliveries in the early 1970s, starting service to the Philippines, Japan, Hong Kong, Singapore, Australia, and Europe.

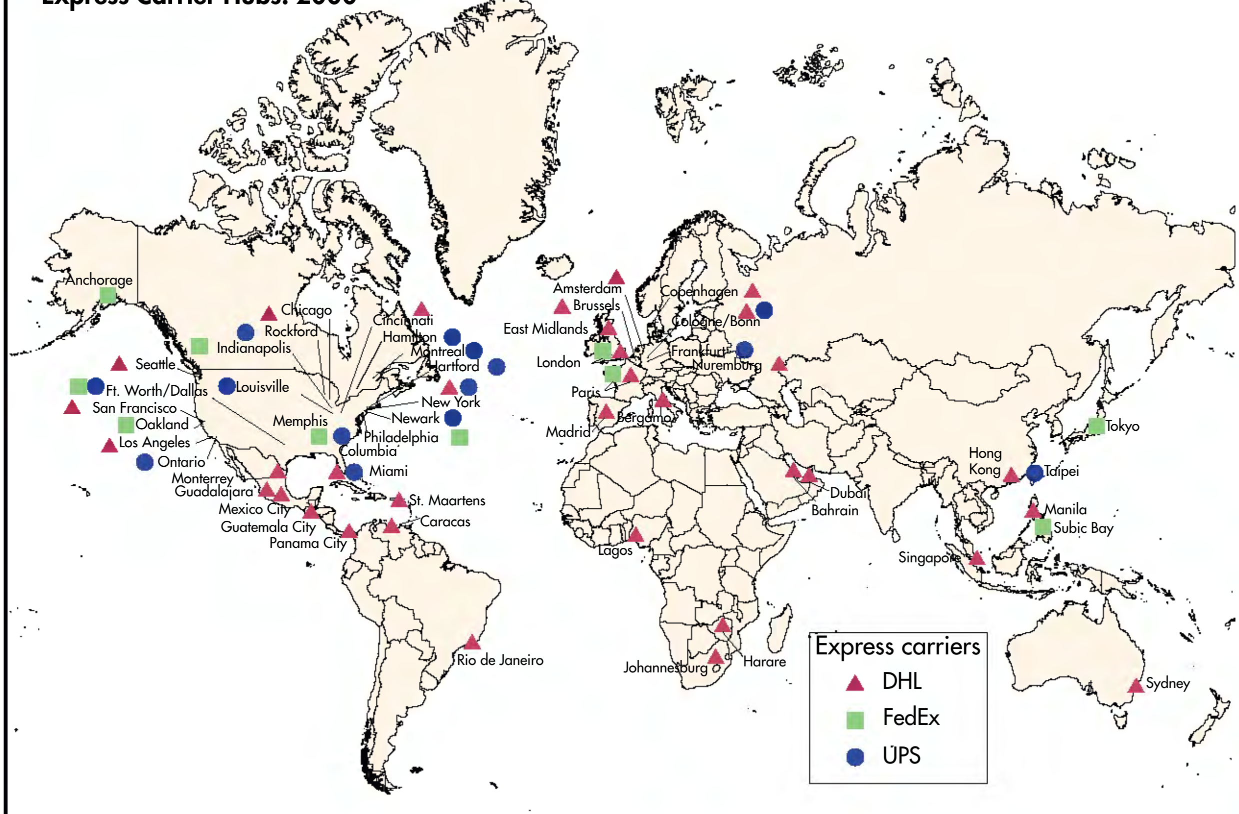
Since 1975, the express business has become a global enterprise. UPS began its European operations in 1976, expanding to Asia in 1988 and Latin America in 1989; FedEx began its service to Asia and Europe in 1984; and DHL expanded to Latin America, Africa, the Middle East, and China by 1986. While these three companies are not the only ones providing domestic or international express service, they are the largest in the world.

With hubs across the globe, integrated carriers have perfected the use of the hub-and-spoke system for cargo transport (figure 4-14). Their delivery systems and schedules bypass airport congestion, which can be the source of many delays. UPS, the largest carrier, moves cargo through primary international hubs in Cologne, Germany, Hong Kong, Singapore, and Taiwan. FedEx has primary international hubs in Paris and the Philippines; DHL operates primary hubs in Brussels and Hong Kong.

According to a report by BT Alex. Brown, even with such extensive operations by cargo carriers, passenger planes still carry about half of all air cargo [*Logistics Online* 1999]. As a result, several passenger airlines are now separating their cargo operations from their passenger business to more efficiently accommodate increasing cargo traffic.

Figure 4-14

Express Carrier Hubs: 2000

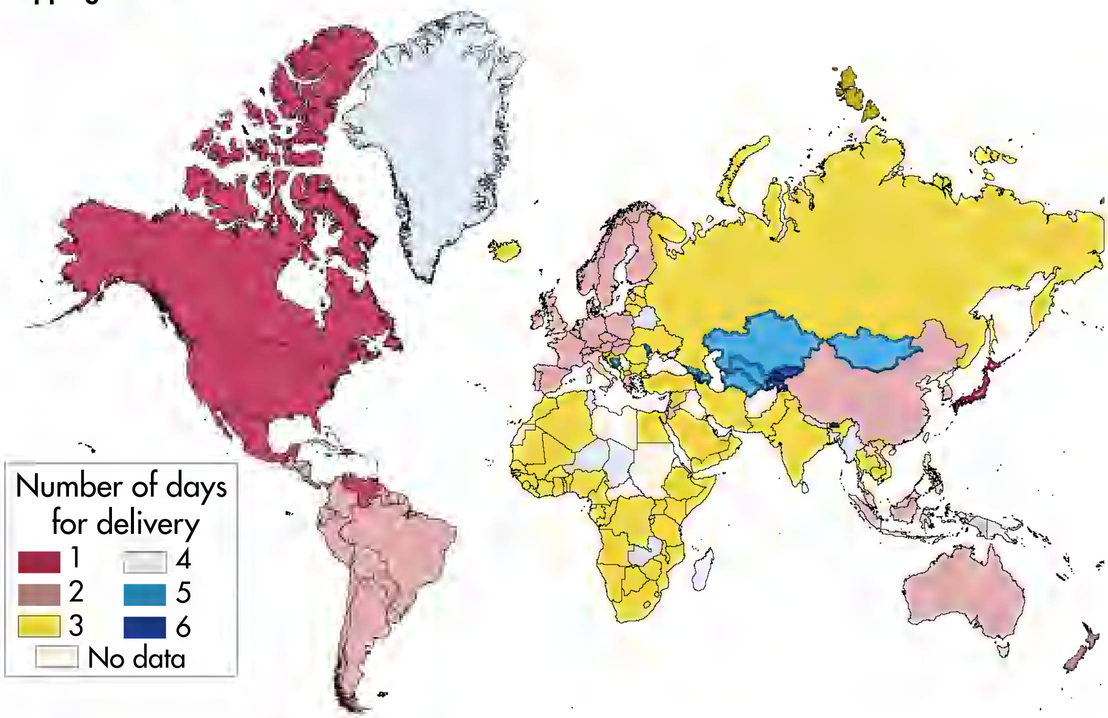


Sources: FedEx, personal communication, 2000; DHL, available at http://www.dhl-usa.com; UPS, company fact sheet, 2000.

Express services continue to grow at a rapid pace; annual growth averaged nearly 20 percent from 1992 to 1997, and total volume doubled. Although it comprises only about 5 percent of the international air cargo market, express is the fastest growing segment. In 1999, FedEx reported delivering an average of nearly 2 million overnight packages and 282,000 international priority packages each day. UPS ranks as the ninth largest airline in North America based on number of jets [UPS 2000], while *Industry Week* places FedEx as the fifth largest airline in the world, based on operating revenue [*Industry Week* 2000a]. Today, these express carriers (UPS, FedEx, and DHL) deliver to more than 200 countries (figure 4-15).

Figure 4-15

Shipping Times from the United States: 2000



Sources: FedEx, personal communication, May 15, 2000; DHL, personal communication, May 2000.

Keys to the Future

Boeing projects an average annual growth of 6 percent in international air cargo during the next decade and 6.4 percent average annual growth for the next 20 years [Boeing 1998-99]. The most rapid growth is expected in Asian markets. MergeGlobal predicts at least 8.9 percent growth per year in the Intra-Asian market through 2004 [Clancy & Hoppin 2000]. But to continue to move cargo rapidly, growth in international air cargo may require airport construction and expansion. To avoid delays, companies will probably continue to seek cargo facilities that are separate from congested passenger airports.

To expand U.S. presence in the Asian market, USDOT in November 2000, proposed expansion in United States-China air service that will eventually lead to full liberalization. In a show-cause order, USDOT tentatively selected UPS as the fourth U.S. carrier authorized to serve China and extended the roundtrip flights of the other three airlines (United Airlines, Northwest Airlines, and Federal Express). These efforts will eventually result in "open skies" agreement with China after 2004.

The continued expansion of air cargo also will require additional aircraft. This projected growth in air cargo, coupled with a trend to seek airports that are clear of passenger aircraft traffic, will likely result in the spread of noise pollution to areas that had previously enjoyed minimal disruptions. Although today's aircraft are about 80 percent quieter than their 1950s counterparts (see chapter 5), aircraft noise pollution can still interrupt conversations and disrupt sleep.

Boeing predicts that used and converted passenger aircraft will be the primary source of freighters. Boeing also projects:

- continued use of lower hold cargo capacity on passenger airplanes; and
- a need for 190 additional large-capacity freighters, 155 medium-capacity widebody freighters, and 140 small freighters (Airbus has forecast the need for 300 additional freighters) [Sobie 2000].

Others in the freight field are considering new designs to save unloading time. Some are also discussing the possibility of an amphibious freighter as another solution to airport capacity concerns. Overall, it is clear that overcoming capacity constraints will drive creative solutions and investment decisions.

Maritime Shipping

The ocean shipping industry has been dramatically transformed in the past 25 years. Ships have generally become faster and larger, and intermodal container shipping has replaced breakbulk cargo on many routes. And, although the United States continues to conduct most of its foreign trade by ship, our rank among the world's maritime fleets has dropped. Figures 4-16 and 4-17 show the size of the world shipping fleet and U.S. share of the world fleet from 1975 to 1997. Even though productivity in the U.S. shipbuilding industry has improved, new shipbuilding activity has declined.

Waterborne trade has grown in the last quarter century with the expansion of the world's economy, and it is expected to double over the next 20 years . The primary commodities include semimanufactured products; dry cargoes, such as grains, coal, steel, and iron ore; and liquid-bulk products, such as petroleum and petroleum products.

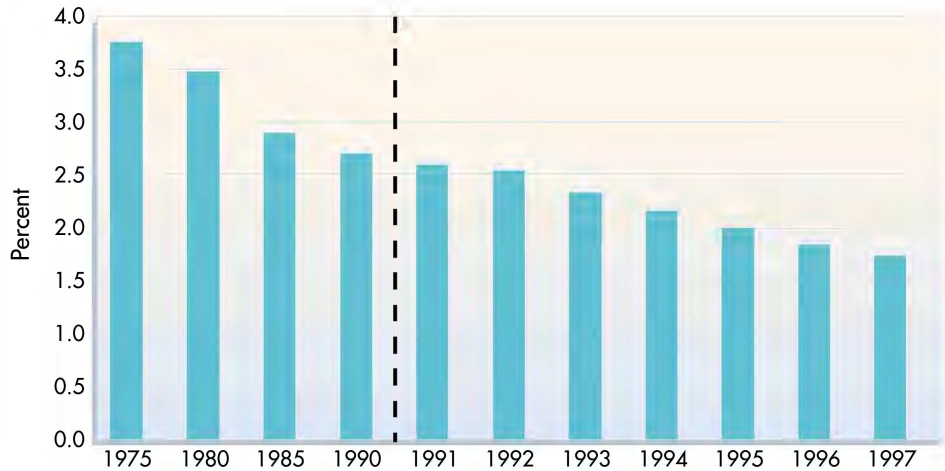
Figure 4-16

World Shipping Fleet: 1975-97

Source: U.S. Department of Transportation, Maritime Administration, *Merchant Fleets of the World* (Washington, DC: Annual issues) and unpublished revisions.

Figure 4-17

U.S. Share of World Shipping Fleet: 1975-97



Source: U.S. Department of Transportation, Maritime Administration, *Merchant Fleets of the World* (Washington, DC: Annual issues) and unpublished revisions.

In 1975, oceangoing shipping was growing, due in part to growth in the crude oil trade. As a result, the shipping capacity of the world merchant fleet (oceangoing steam and motor ships of 1,000 gross tons and over) more than quadrupled to 557 million deadweight tons (dwt) in 1975 [USDOC MARAD 1976] from 130 million dwt in 1955 [USDOC MARAD 1956]. Also in 1975, new construction additions to the world merchant fleet increased to 791 vessels [USDOC MARAD 1976], compared to 470 vessels in 1955 [USDOC MARAD 1956].

In 1975, Japan and West Germany led the world in shipbuilding (figure 4-18). The number of vessels on order or under construction reached an all-time high at the close of 1975, although the rate of growth for new shipbuilding orders had begun to decline. By the 1970s, the crude oil boom ended, and the capacity created during the previous decade stifled demand for new tonnage.

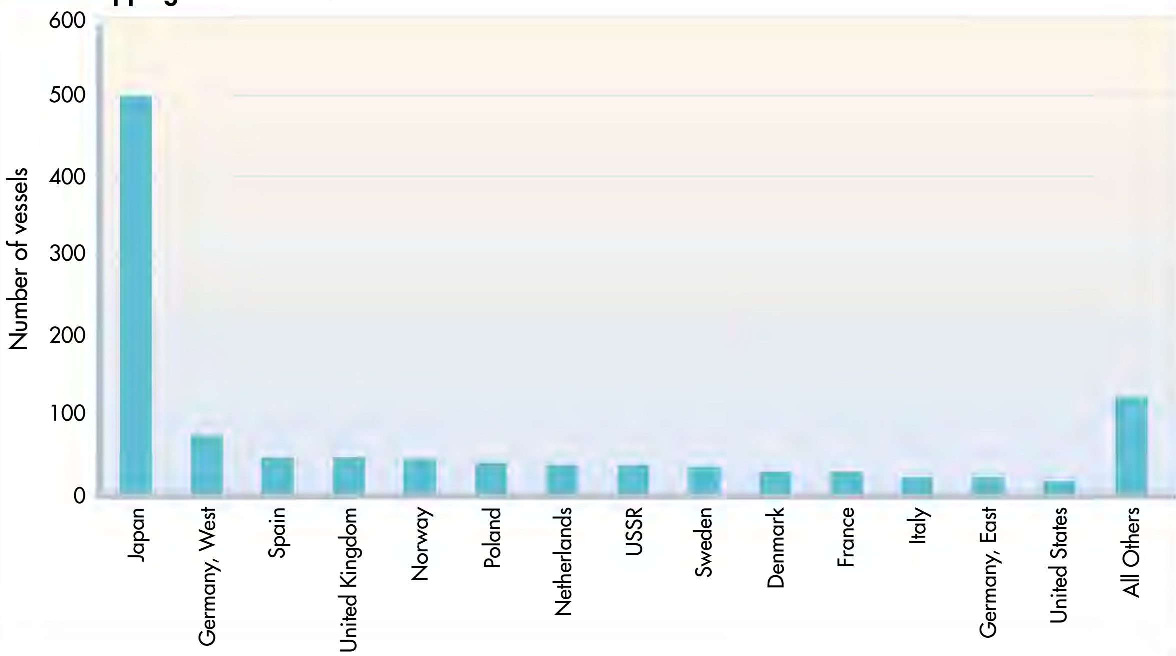
In 1975, oceangoing ships carried 625 million metric tons of foreign trade. By 1999, this trade had almost doubled to 1.13 billion metric tons. Figure 4-19 shows the U.S. oceanborne foreign trade by different types of cargo ships. However, the U.S.-flag fleet carried only 5.1 percent by volume and 17.5 percent by value [USDOC MARAD 1978]. Figure 4-20 shows the country shares of world maritime trade by cargo value in 1998.

The world's general cargo trades were being revolutionized, largely by U.S. shipbuilding innovations in advanced containerships and roll-on/roll-off vessels. At the end of 1975, the United States held 25 percent of the world's fleet of general cargo ships and 30 percent of the tonnage [USDOC MARAD 1976]. But there was growing worldwide competition between the expanding fleet of containerships and traditional general cargo vessels.

A quarter century ago, our foremost trading partner in oceanborne foreign trade, in both tonnage and value, was Japan (figure 4-21). U.S. purchases of consumer goods from Japan drove the Asia-Pacific trade in the late 1970s, and were largely responsible for the growth in liner trade vessels—those operating on fixed itineraries or regular schedules and with established rates. The continuing growth in the liner industry greatly contributed to the overall globalization of the maritime industry.

Figure 4-18

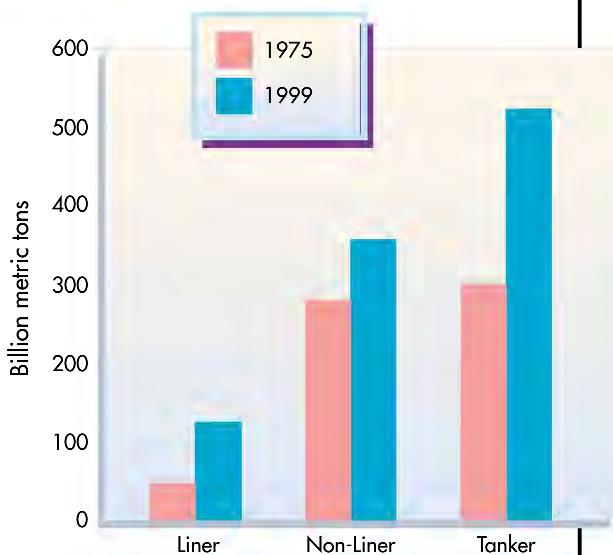
World Shipping Deliveries: 1975



Note: The Maritime Administration moved from the Department of Commerce to the Department of Transportation in 1982.
Source: U.S. Department of Commerce, Maritime Administration, data on new ship construction as of Dec. 31, 1975.

Figure 4-19

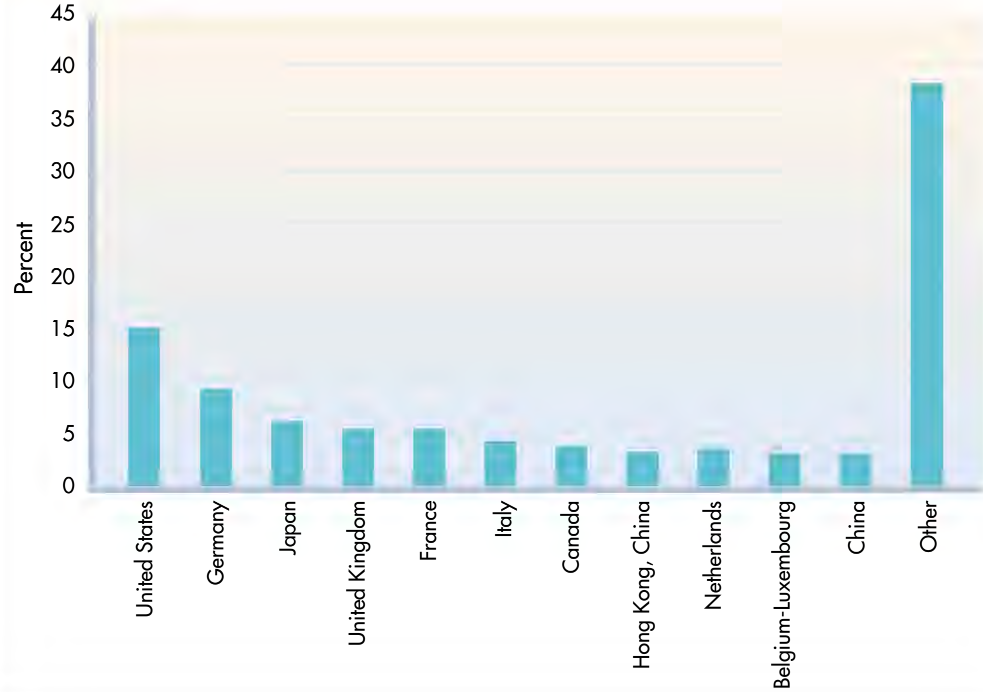
Oceanborne Foreign Trade: 1975 and 1999



Source: U.S. Department of Transportation, Maritime Administration, Office of Statistical and Economic Analysis, data available at http//www.marad.dot.gov/statistics, as of Aug. 8, 2000.

Figure 4-20

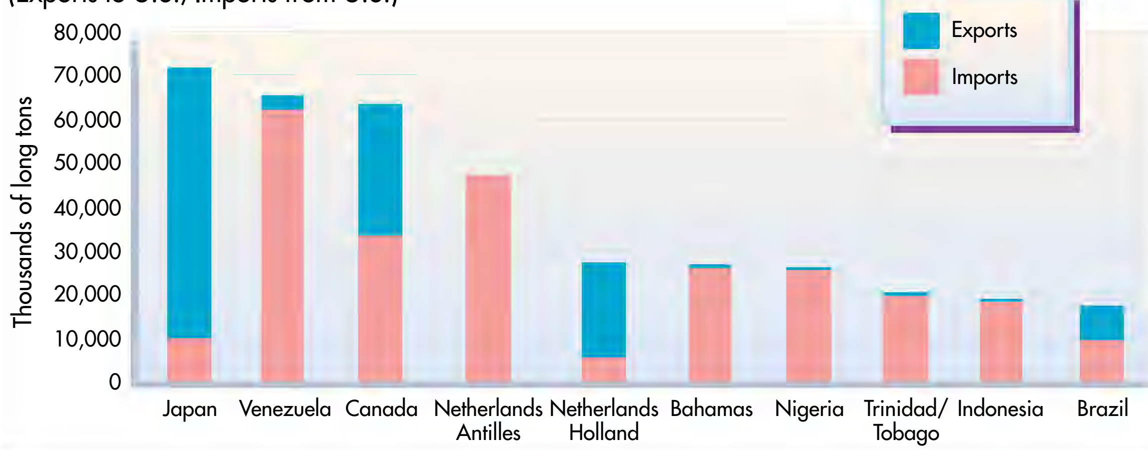
Country Shares of World Maritime Trade by Cargo Value: 1998



Source: United Nations Conference on Trade and Development, Review of Maritime Transport 1999 (New York, New York: 1999).

Figure 4-21

Top 10 U.S. Oceanborne Foreign Trade Partners: 1978
(Exports to U.S./Imports from U.S.)



Source: U.S. Department of Commerce, Maritime Administration, *United States Oceanborne Foreign Trade Routes* (Washington, DC: March 1978).

Even though Japan was our foremost trading partner a quarter century ago, in both tonnage and value, transatlantic trade was the primary traffic route. Today, major U.S. trade routes have shifted. Transpacific trade is now the primary traffic route for U.S. oceanborne commerce. Our top five trading partners account for approximately 42 percent of the tonnage and value [USDOT MARAD 1998]. Currently, Venezuela is our leading trading partner in terms of tonnage (primarily oil), but Japan is still our leading trading partner in terms of value. Mexico and Saudi Arabia joined the ranks of our top trading partners in terms of tonnage.

The world merchant fleet in 1975 consisted of 22,872 ships of 556,572 thousand deadweight tons. The United States ranked eighth in terms of deadweight tonnage. Liberia was ranked number one in vessel registries (by number of ships) and was considered a country flag of convenience. [USDOC MARAD 1975].

Box 4-8

Flags of Convenience

Some ship owners register their shipping companies in foreign countries to avoid taxes, higher labor costs, and/or stringent safety regulations than might be imposed by the ship owner's home country. These ships are operated under the flag of a foreign nation—known as a flag of convenience. More than 5,400 ships—one-fourth of the world's merchant ships and nearly one-third of the total tonnage—were registered under a flag of convenience in 1975. Most of these were bulk cargo carriers and tankers.

In 1975, Liberia was the most-used flag of convenience, followed by Panama and Singapore. In 1999, Panama was the top flag of convenience with more than twice as many registries as any other nation; following were Liberia, Greece, and the Bahamas.

Studies have found that ships bearing a flag of convenience are more likely to suffer from poor material condition, lack of maintenance, inadequately trained crews, and more frequent casualties. This is due to both poor flag state enforcement and to operating companies lowering costs by evading their responsibility to run safe ships. More economically advanced nations in Europe, North America, and on the Pacific Rim have launched Port State Control (PSC) initiatives, coordinated through multinational Memorandums of Understanding, with the objective of forcing sub–standard ships out of trade. While these PSC efforts seem to be resulting in fewer casualties in PSC country waters, the problem of substandard ships has not gone away. According to the British Broadcasting Corporation, 46 percent of all ships lost in 1997 sailed under flags of convenience. The worst record for losses as a percentage of the fleet belonged to ships registered under the Cambodian flag.

In 1999, the United Kingdom revised its tax laws affecting shipping to attract British-owned ships and others to transfer their registrations. Maritime unions in Australia and Japan have mounted protest campaigns against flags of convenience. The United States has pushed aggressively to raise international standards overall through the International Maritime Organization and has developed its own PSC system, which is a model for many countries.

The number of containerships is expected to grow at a significantly higher rate (8 to 10 percent) than other vessels types (1 to 4 percent) in the near term [USDOT 1999]. Container ships are also becoming larger. Approximately 40 percent of the new capacity on order is for vessels with a capacity of 4,500 or more TEUs. These vessels have design drafts approaching 50 feet, which will require channel deepening at the ports where they call. In order to reduce the time vessels spend in port, liner operators are developing routes based on a hub-and-spoke system.

The Panama Canal is now less critical to global maritime trade because it cannot accommodate the newest generation of container vessels. Another factor that has reduced the importance of the Panama Canal is that transcontinental rail serves as a cost-effective land bridge. This could change if the Panama Canal were to be expanded.

By the end of 1997, Japan, South Korea, and China led the world in shipbuilding, the latter rising from its 1980 ranking of 17th. Today, the United States ranks 12th, with about 1.3 percent of the world's gross tonnage on order [USDOC 2000]. Reduced demand for new ship construction has led to a steady decline in world new shipbuilding prices since the early 1990s [Journal of Commerce 2000].

As the size and prominence of the U.S. merchant fleet decreased, the U.S. transitioned from being a "flag state" becoming a "port state," as well. A "port state" is a nation whose interactions with merchant shipping come about primarily through port calls and coastal accidents involving ships whose safety is overseen by other governments. Today, fully 95 percent of U.S. foreign trade is carried in ships flying the flags of other nations. The United States is no longer able to carry out the same kind of risk reduction measures as was possible when the majority of ships in our ports flew the American flag. Further, not all nations are as conscientious in their flag state duties as the United States had been. Accordingly, the USCG has pursued a two-tiered approach to protecting public and environmental safety from the threats posed by inadequately supervised foreign shipping. The first tier is has been to promote increasingly rigorous international standards at the International Maritime Organization (IMO). The IMO is a specialized branch of the United Nations, responsible for a wide range of safety and environmental protection standards issued under several international conventions. In recent years, IMO standards have been made far more stringent, for both the protection of life and the marine environment. These improvements have been largely at the instigation of the United States, and the USCG is recognized at IMO and elsewhere as the world leader in maritime safety and environmental protection issues. Rigorous standards are meaningless, however, if they are not adequately enforced. Therefore, the United States, acting in concert with other nations, has embarked on an aggressive Port State Control program to ensure foreign flag vessels calling in our ports meet applicable IMO standards and any additional measures required for entry into U.S. ports. The United States, again in cooperation with other nations, is working to improve flag state enforcement capabilities through technical assistance and international training programs and by developing the Model Maritime Code to guide developing nations' efforts in building effective enforcement capabilities.

Keys to the Future

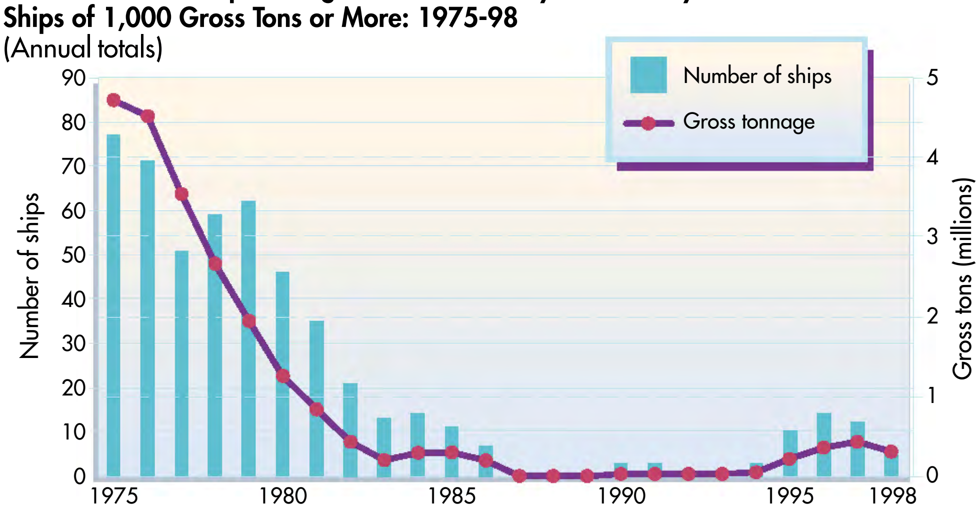
The U.S. maritime industry is challenged to remain competitive in the face of industry consolidation during an era of deregulation (discussed in Chapter 2). At the same time, the commercial fleet provides critical capacity for military sealift during national emergencies, which may have important implications for national security (see Chapter 7).

The U.S. trade deficit causes additional problems for shipping companies. Imbalance of cargo flows—more imports than exports and differences in the type of cargo and the kinds of ships needed in each direction—causes some routes to be largely one-directional, and leads to costly repositioning of empty containers.

The U.S. shipbuilding industry faces an even more serious challenge as commercial orders have declined to record lows (figure 4-22). A continuing lack of U.S.-built ships may threaten both the viability of the commercial U.S. fleet and our nation's security.

Figure 4-22

U.S. Commercial Shipbuilding Orderbook History-Nonmilitary Ships of 1,000 Gross Tons or More: 1975-98
(Annual totals)



Source: U.S. Department of Transportation, Maritime Administration, Shipyard Activity Reports data (Washington, DC: Various years).

By 2025, U.S. ports must be prepared to accommodate larger, next-generation oceangoing vessels and to provide efficient intermodal connections to rail and truck. Secretary Slater's Marine Transportation System initiative is intended to address these issues in a comprehensive, multidisciplinary way with active involvement of all agencies and stakeholders. The U.S. Coast Guard interagency collaborative deepwater capability replacement project will also help in upgrading the infrastructure over the next decade.

North American Free Trade Agreement (NAFTA)

On December 8, 1993, the United States, Canada, and Mexico joined together in an historic agreement to form a North American Free Trade Agreement—NAFTA. Trade among the three North American nations was already on the rise in the early 1990s, but growth accelerated when the treaty went into effect on January 1, 1994. Between 1995 and 1999, U.S.- Mexico surface trade increased by 75 percent (by value), while U.S. - Canada surface trade grew by 20 percent. Figure 4-23 shows the increase in surface trade with Canada and Mexico between 1995 and 1999. Mexico has now become our third largest trading partner (by value), up from its fifth position in 1975 [USDOC Annual]. Figures 4-23 through 4-27 show the trade flow between the United States, Mexico, and Canada in 1998.

In the six years since the three governments decided to loosen trade restrictions, foreign investment into Mexico has increased from companies hoping to take advantage of a low-cost labor market with duty-free access to the United States. One result of that investment—increased Mexican production and exports to the United States—has changed the trade patterns in North America and brought renewed attention to the need to upgrade trade corridors among these three countries.

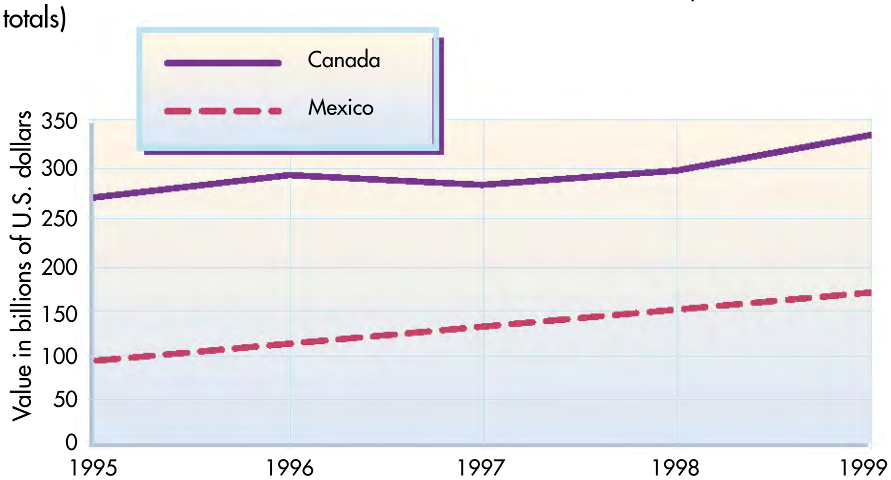
Rapid trade growth, especially with Mexico, means a greater flow of goods in specific trade corridors, many of which were unprepared for increased traffic. For example, between 1994 and 1999, the value of Mexican imports by land modes passing

"I believe we have made a decision now that will permit us to create an economic order in the world that will promote more growth, more equality, better preservation of the environment, and a greater possibility of world peace. We are on the verge of a global economic expansion that is sparked by the fact that the United States at this critical moment decided that we would compete, not retreat."

President William J. Clinton
remarks on the signing of NAFTA agreements, December 8, 1993

Figure 4-23

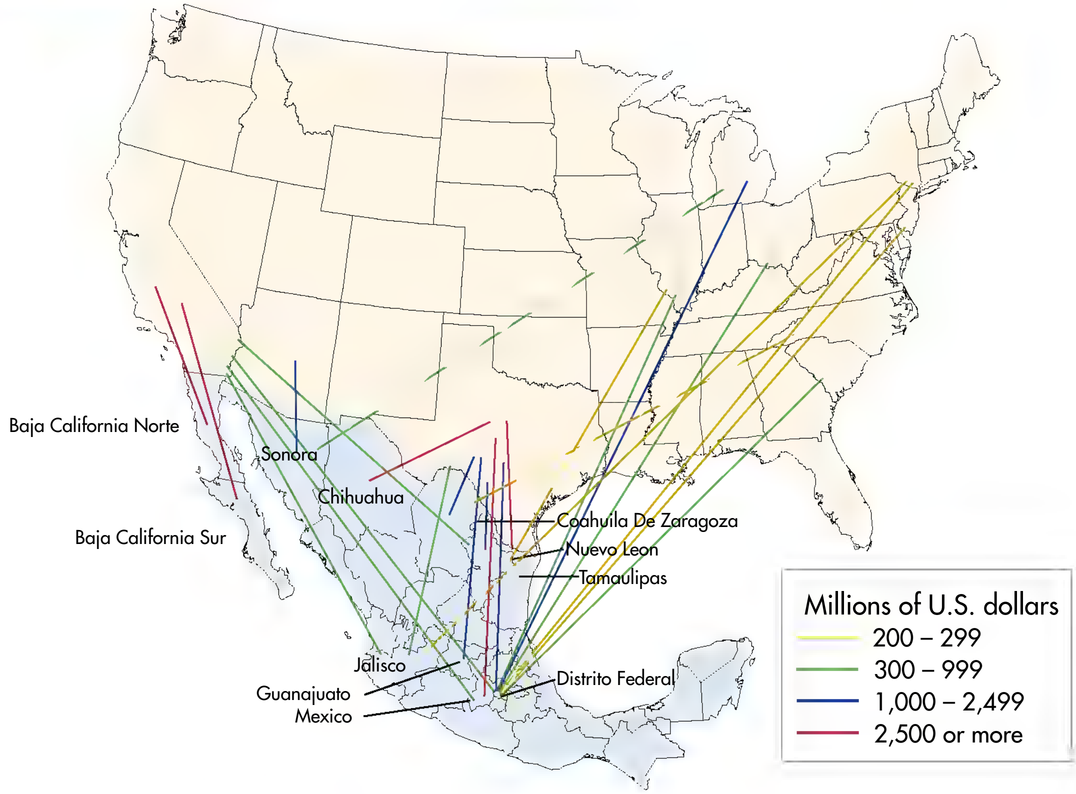
Total U.S. Surface Trade with Mexico and Canada: 1995-99 (Annual totals)



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight data (Washington, DC: Various years), available at http://www.bts.gov/transborder, as of October 2000.

Figure 4-24

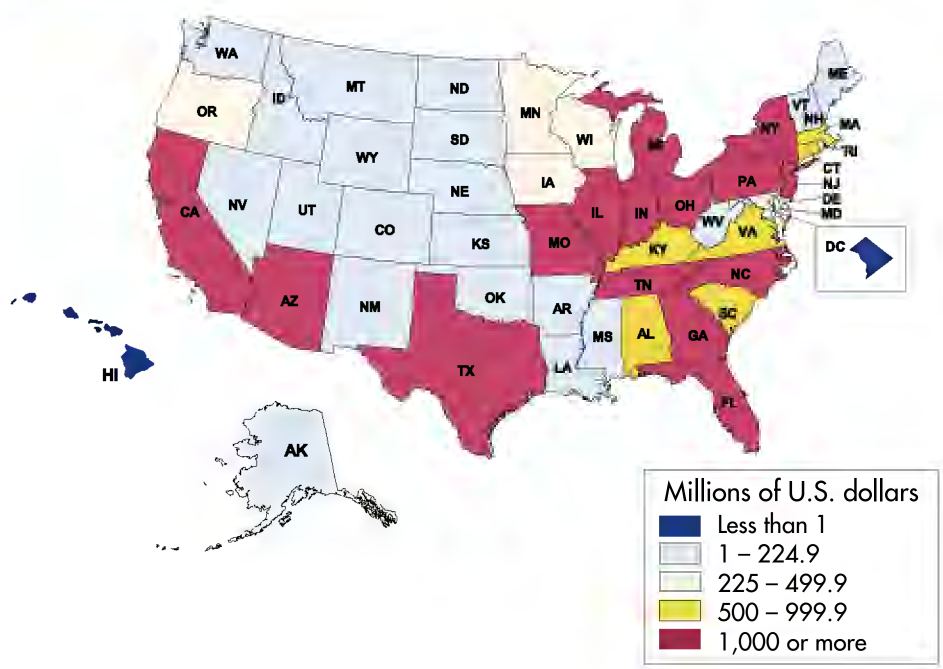
Merchandise Exports to Mexico: 1998 (Surface modes)



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight data (Washington, DC: Various years), available at http://www.bts.gov/transborder, as of October 2000.

Figure 4-25

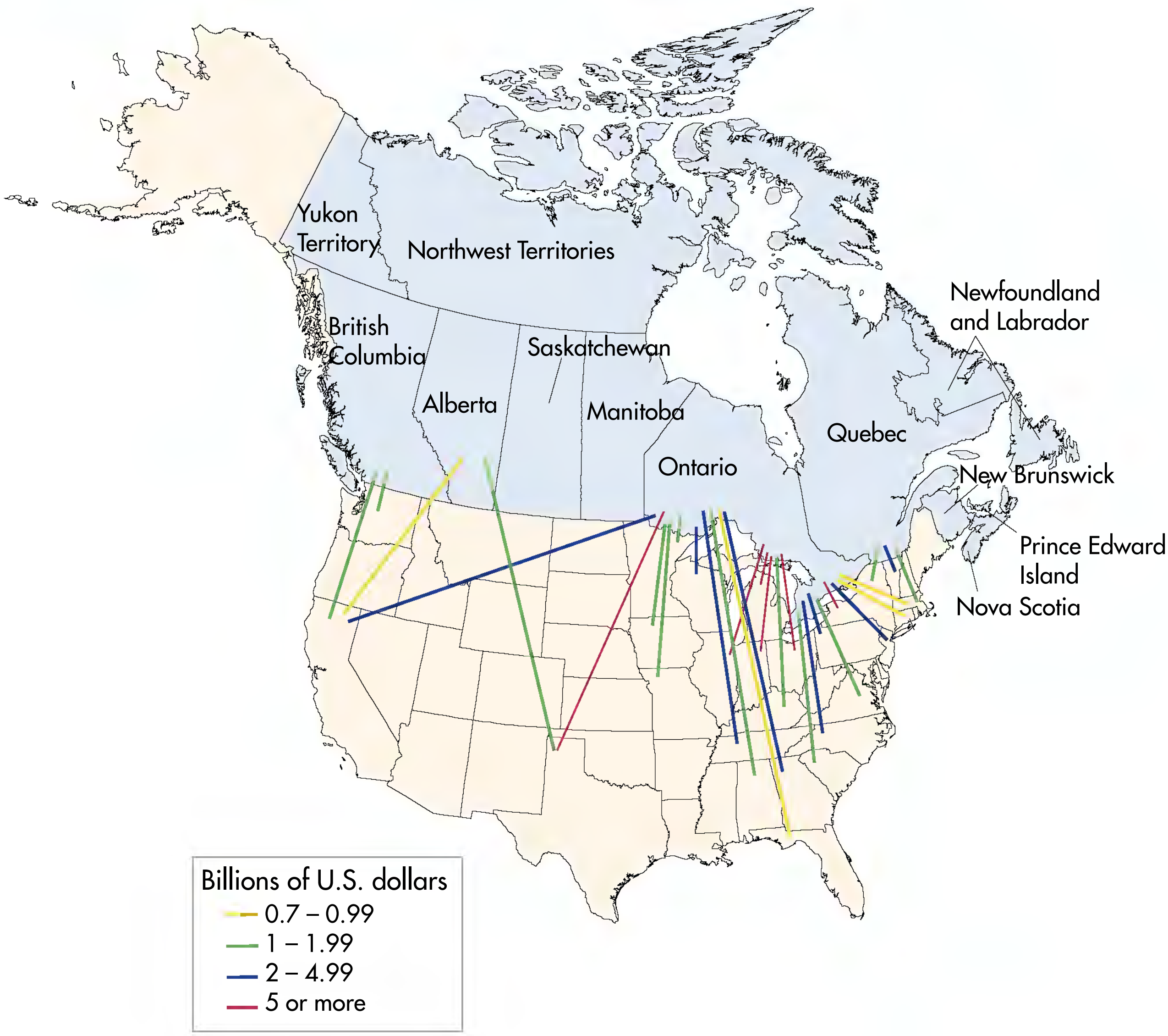
Merchandise Imports from Mexico: 1998 (Surface modes)



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight data (Washington, DC: Various years), available at http://www.bts.gov/transborder, as of October 2000.

Figure 4-26

Merchandise Exports to Canada: 1998 (Surface modes)



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight data (Washington, DC: Various years), available at http://www.bts.gov/transborder, as of October 2000.

Figure 4-27

Merchandise Imports from Canada: 1998 (Surface modes)

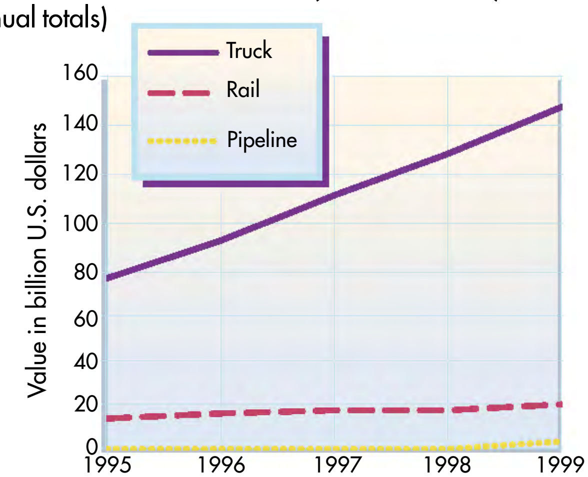
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight data (Washington, DC: Various years), available at http://www.bts.gov/transborder, as of October 2000.

through Laredo, Texas, increased 248 percent. Otay Mesa, California, experienced a 95 percent increase. In the gateway port of Detroit, Michigan, total surface trade with Canada increased 25 percent, and in Buffalo, New York, trade increased 53 percent [USDOT BTS 2000].

Even though the United States has delayed full implementation of the NAFTA trucking provision because of concern about truck compliance with U.S. safety standards, more than 70 percent, based on value, of the U.S.-Mexico trade is carried by trucks [USDOT BTS 1999]. Figures 4-28 and 4-29 show the U.S. surface trade with Mexico and Canada by different modes. Cross-border delays to and from Mexico have been blamed on inadequate infrastructure, lengthy inspection procedures, heavy traffic, and U.S. efforts to stop the influx of drugs and illegal aliens.

Figure 4-28

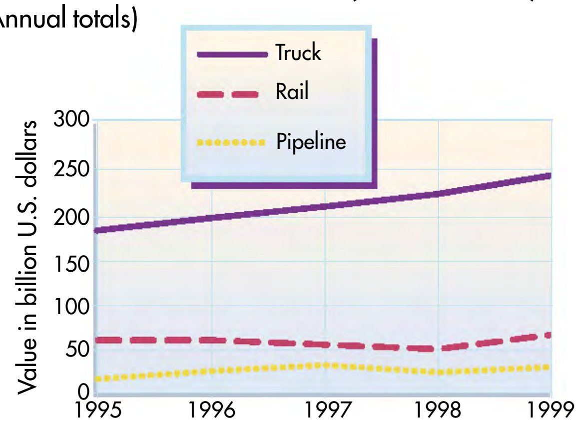
U.S. Surface Trade with Mexico (selected modes): 1995-99
(Annual totals)



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight data (Washington, DC: Various years), available at http://www.bts.gov/transborder, as of October 2000.

Figure 4-29

U.S. Surface Trade with Canada (selected modes): 1995-99
(Annual totals)



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight data (Washington, DC: Various years), available at http://www.bts.gov/transborder, as of October 2000.

In the United States, traditional trade routes have been east-west, serving the coastal ports. However, with NAFTA, new north-south trade corridors are emerging. Texas is concerned about the truck traffic on its segment of Interstate 35, which is expected to increase 85 percent by 2005. Concerns also have been raised about air quality at congested border crossings. Simply adding capacity to existing systems is no longer seen as a salve for these problems. Intelligent Transportation Systems (see chapter 6), which incorporate the use of advanced communication and information technologies in managing day-to-day traffic operations, can enhance safety, ease congestion, and reduce pollution by monitoring and coordinating traffic flow.

Under TEA-21, a National Corridor Planning and Development Program and Coordinated Border Infrastructure Program was established to fund improvements in national highway corridors and border facilities. The program aims to improve border infrastructure and transportation telecommunications to facilitate the safe and efficient movement of people and goods at or across the U.S.-Canada and the U.S.-Mexico borders. The National Corridor Planning and Development Program provides USDOT authority to allocate dollars to states and metropolitan planning organizations (MPOs) for coordinated planning, design, and construction of highway corridors.

Ports also are seeking NAFTA business. The Port of Mobile is starting high-speed intermodal ferry service with the Canadian National Railroad and two Mexican partners, while the Port of Galveston is initiating rail-barge service to Mexico's east coast.

To the north, Canadian railroads have geared up to move more goods. Canadian National, an east-west route, purchased Illinois Central, giving it access to the Port of New Orleans and the Gulf of Mexico. Canadian Pacific purchased the Susquehanna Railroad for access to the Port of New York and New Jersey.

In trucking, U.S. companies are restricted to a 49 percent ownership share in Mexican companies. Because of this restriction, American companies have formed alliances, joint ventures, and partnerships with Mexican companies. Under NAFTA, full ownership would be permitted in 2004, but that provision may not be implemented as long as the United States delays entry of Mexican trucks. NAFTA also will permit U.S. bus companies to own 100 percent of Mexican companies, beginning in 2004.

To promote safety, the three countries have reached an agreement on comparable standards for commercial driver's licenses. To ensure that Mexico-domiciled motor carriers comply with U.S. statutes, USDOT and states are establishing controls and enhancing safeguards, including verifying registration information, using automated data and state safety inspectors to monitor compliance, implementing consistent enforcement policies, and allocating additional resources for the border program. California has hired additional inspectors and is working to provide adequate mechanisms to control access of Mexico-domiciled motor carriers into the United States. Texas, which receives two-thirds of the truck traffic from Mexico, has also hired more than 100 additional inspectors, while Arizona has opened new inspection facilities. In addition, the new Federal Motor Carrier Safety Administration has hired additional border personnel.

The NAFTA agreement did not cover aviation, but the United States has signed liberalizing agreements with both Canada and Mexico. The 1995 agreement with Canada replaced a restrictive treaty and, after an initial period of slow growth, resulted in a 37 percent increase in passenger traffic in the first 3 years, with 42 percent more nonstop destinations. Today, the U.S.-Canadian market is the world's largest bilateral aviation market. A 1999 agreement with Mexico expanded code-sharing rights for U.S. and Mexican airlines. Six U.S. airlines were approved for partnerships that would, together, serve 50 markets in both countries, creating the largest code-share market in the world.

Keys to the Future

The North American Free Trade Agreement (NAFTA) should continue to provide the basis for an improving continental trade and transportation environment well into the new century. To realize this promise will require continuing progress in a number of key areas including:

1. intergration of national transportation policies amd practices for air, lan and sea

2. sharing and transferring of transportation knowledge and technology;

3. improvement of transportation safety and security through the achievement of greater compatibility among regulatory standards;

4. improved cooperation among the parties in the deployment and use of interoperable advanced technologies; and

5. increased exploitation of multimodalism to achieve greater transportation efficiency, reduced congestion, and lower costs.

NAFTA provides the framework and the resulting improvements in social welfare will provide continuing motivation to practice open trading policies. An efficient and responsive North American transportation system is a derived demand from this trading environment.

NAFTA however, represents only one liberalized trade arrangement in the Western Hemisphere among a number of others that include various countries in Central and South America, as well as the Caribbean region. Each of these trade relationships places inevitable requirements on transport systems to be more safe and efficient. The first quarter of the 21st century is likely to see these efforts expand and merge within a broader Western Hemispheric trade initiative that brings the same transportation benefits and challenges to the hemisphere as are anticipated for North America.

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chapter 5

People, Energy, and the Environment

"The transportation enterprise must be equitable, flexible, and sensitive to environmental issues. We must keep in mind that transportation is a means—not an end; the common good must take priority over specific group's opposition to projects."

Christopher Zearfoss
Acting Deputy Mayor, City of Philadelphia
2025 Visioning Session, Sept. 14, 2000, Philadelphia, PA.

"25 years from now, alternative fuel vehicles, hybrid electrics, and fuel cells will have a large market share"

Vision of the Denver Roundtable
2025 Visioning Session, Denver CO, Apr. 4, 2000

"Transportation needs to focus more on 'how can it best accommodate and work for people with disabilities,' instead of 'how can we comply with the rules and regulations'."

Debbie Kaplan, World Institute on Disability
2025 Visioning Session, Berkeley, CA, June 24, 2000

chapter 5

People, Energy, and the Environment

Patterns of demographic change stamp their image indelibly on the transportation system. By 2025, the U.S. population is expected to grow by nearly 23 percent, and the number of Americans in older age groups will multiply as "baby boomers" continue to enter their senior years. For these aging Americans, funds formerly devoted to buying homes, raising children, and paying for college are becoming available as discretionary income, increasing the freedom to travel. These household composition shifts, changes in labor force participation and household income, and shifts in licensing and vehicle ownership all affect transportation and individual mobility.

These demographic changes are transforming the day-to-day life of American households and altering the demands and challenges facing the transportation enterprise. Increased awareness of other peoples and increased global activity create a greater interest in travel. At the same time, Americans share a greater sensitivity to the importance of the environment and the close interaction between transportation activities and environmental impacts, as well as the use of energy and other natural resources.

Transportation, as the major energy-using sector of the U.S. economy, plays a major role in both energy conservation and the environment. As demographic shifts occur, levels of energy use will change, and their combined impact on the environment will shift. Although an adequate fuel supply is available to American consumers, the United States is becoming increasingly dependent on imported oil. Patterns of energy use, petroleum dependence, and the sustainability of energy supplies will greatly influence our future transportation options.

Addressing concerns over the environmental impact of transportation is now a fundamental part of transportation decisionmaking. The interdependence between transportation and the environment continues to require great care in keeping the two appropriately balanced. For example, automobiles are more fuel efficient and emit significantly fewer pollutants than did their 1975 counterparts, and the use of transportation funding in the nation's metropolitan area is tied directly to the steps needed to maintain air quality. The Transportation Efficiency Act for the 21st Century (TEA-21) strengthens metropolitan and statewide planning and has been called one of the most important pieces of legislation passed by Congress in recent years. TEA-21 continues and strengthens the Intermodal Surface Transportation Efficiency Act's (ISTEA's) emphasis on the environment. It improves communities and quality of life through transportation and transit enhancements and protects and

"This is truly a mountaintop moment for America. We are strong and prosperous. Our automotive and related industries – which employ about one out of seven Americans – are leading the world. I believe we have to use this moment to make the investments that will keep our progress and prosperity going far into the future. By reducing our dependence on foreign oil; by reducing greenhouse gas emissions; and by positioning the American auto industry as the world leader in a crucial new market in this new economy."

Vice President Al Gore
Mar. 30, 2000

enhances the environment through several programs, including the Congestion Mitigation and Air Quality Program (CMAQ). TEA-21 significantly increases funding for the CMAQ program, creates new transit enhancements program, provides additional incentives to foster use of alternative modes of transportation, and increases funding for recreational trails program.

Each of these factors—people, energy, and the environment—influence transportation demand, some positively, some negatively, and each leads to changes in the markets served by the transportation enterprise. This chapter looks at mobility trends and access for people, energy use, and impacts of transportation on our environment over the last 25 years. It also highlights key issues for the future.

"Regardless of where we Americans live or where we stand on the economic scale, one thing that unites us is our desire for a high quality of life, safe communities, healthy open spaces, and reduced congestion."

Vice President, Al Gore
Livable Communities Initiative
Feb. 4, 2000

Mobility and Access

Mobility—the freedom to travel without undue restraint—must be available to all Americans. Travel has always contributed to Americans' enjoyment of their lives and leisure. When transportation does not work well, it can be a source of great personal frustration and economic loss. Safe and efficient transportation, by contrast, supports the freedom and access Americans have always cherished. Travel includes local, long-distance, and international travel by all modes of transportation. Local travel includes daily activities—work, school, shopping, personal business, social activities, and recreation. Intercity travel generally includes long-distance travel or an overnight stay away from home. Taken together, local and intercity travel represent total national travel. International travel encompasses travel by air and water, as well as travel by highway and railway to and from Canada and Mexico. This section summarizes national trends in the demand for and use of transportation services by household and demographic characteristics. Discussions focus on the various transportation users and the implications of past and current trends for future transportation services.

Local Travel: America is a nation of prodigious travelers. Local travel has grown by 50 percent since the mid-1970s. In the mid-1990s, people traveled an average of 14,000 mile per year in and around their communities (table 5-1) [USDOT FHWA Various years]. Local travel activity focuses on the household and involves many different daily activities. For the past two decades, growth in local travel has exceeded population growth for several reasons, including household income, household composition shifts, changes in labor force participation, and shifts in licensing and vehicle ownership.

Demographic Trends: Demographic factors are among the most important considerations in any projection of future transportation demand. Changes in the size and composition of the American population have a major impact on the growth of our labor force and on demands for a variety of consumable items, including transportation. The dominant demographic story of the post-World War II period has been the birth and aging of the baby boom generation. The movement of this generation from early adulthood through the beginning of their retirement years provided the demographic theme for the past quarter century.

Lower birth rates, the maturation of the baby boomers' offspring, and changing trends in society (e.g., later marriage, greater longevity, and higher divorce rates) have all served to decrease household sizes in the later years of the 20th century (table 5-2). If our current population of 275 million people were contained in households of the size prevalent in 1975, they would comprise 88 million households instead of the 100 million households in America today. Because much of the demand for transportation is household-based, implications for

Table 5-1

Population and Passenger Travel in the United States: 1977 and 1995

	1977	1995	Percentage increase 1977 to 1995
Resident population (thousands)	219,760	262,761	20
Annual local person trips (travel day) (millions)[1]	211,778	378,930	79
Annual long-distance person trips (millions)	521	1,001	92
Local person trips per capita, one way (per day)[1]	2.4	4.3	47
Long-distance trips per capita, roundtrip (per year)	2.5	3.9	56
Local person-miles (millions)[1]	1,879,215	3,411,122	82
Long-distance person-miles (millions)	382,466	826,804	116
Local person-miles per capita[1] (annually)	9,470	14,115	49
Long-distance person-miles per capita (annually)	1,796	3,129	74
Local mean trip length (miles)	8.9	9.0	1
Long-distance mean trip length (miles)	733	826	13

[1] Persons over 5 years of age.

Notes: Data used for local travel are from the travel-day file and include trips of all lengths made by respondents on a single day. About 95 percent of these trips were 30 miles or less.

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 1995 American Travel Survey, data; U.S. Department of Commerce, Census Bureau, *National Travel Survey, Travel During 1977* (Washington, DC: 1979); U.S. Department of Commerce, Census Bureau, *Statistical Abstract of the United States 1998* (Washington, DC: 1998); U.S. Department of Transportation, Federal Highway Administration, *Summary of Travel Trends: 1995 Nationwide Personal Transportation Survey* (Washington, DC: 1999).

the transportation enterprise are immense. Food shopping and other household chores generate substantial travel. The estimated 12 million additional households spawned by today's demographic trends contribute greatly to the increase in both local and long-distance travel.

Table 5-2

Average Household Size: 1970-98

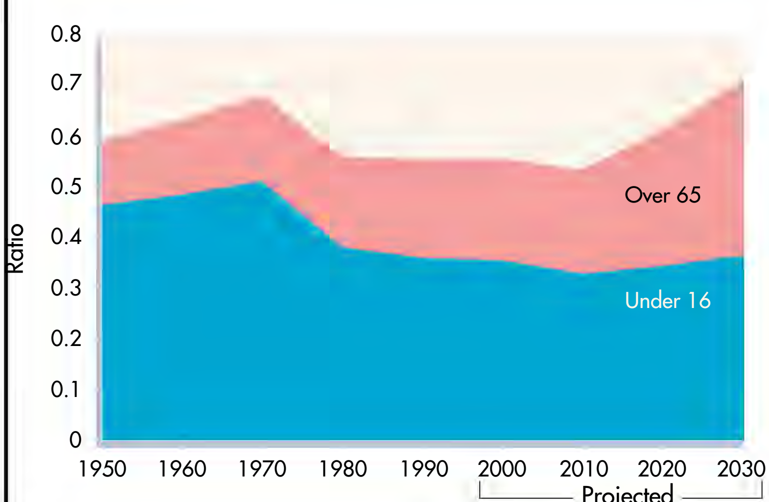
Year	Number of persons
1970	3.14
1980	2.76
1990	2.63
1998	2.62

Source: U.S. Department of Commerce, U.S. Census Bureau, *Statistical Abstract of the United States* (Washington, DC: 1998).

Further, the smaller size of households reflects lower dependence ratios—the ratio of those not of working-age (under 16 and over 65), to those of working age (figure 5-1). This means that more persons in each household are fundamentally responsible for supporting themselves rather than also supporting spouses, children, or parents. This has been the most important factor responsible for increases in discretionary time and discretionary income, leading to more leisure travel. Figure 5-1 illustrates the dependence ratio in 1970 where the baby

Figure 5-1

Dependence Ratio: 1950-2030



Source: U.S. Department of Commerce, U.S. Census Bureau, *Statistical Abstract of the United States* (Washington, DC: Various years); U.S. Census Bureau, *Projections of the Resident Population by Age, Sex, Race, and Hispanic Origin: 1999 to 2100* (Washington, DC: 2000).

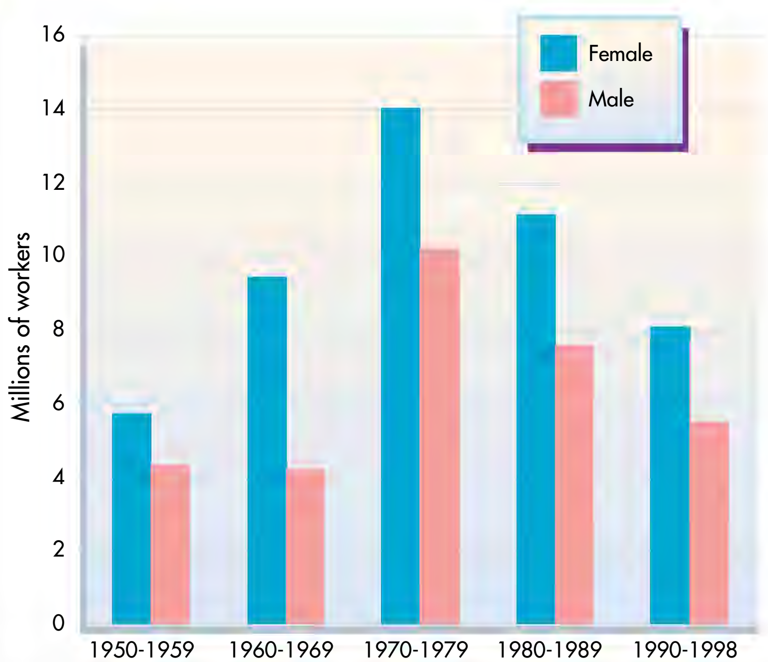
boomers, as children, dominated the dependence structure and in 2010 where they begin to dominate again as the older population.

One of the most impressive trends of the U.S. economy over the past 25 years has been the absorption of an expanding working-age population into the labor market as the baby boom generation moved from childhood into adulthood. Since the 1970s, the economy has been creating jobs at about twice the rate of population growth.

One facet of the trends in this period was the growth in workers that resulted from baby boomers coming of working age from the mid-1960s through the mid-1980s. Another facet was the enormous growth in women joining the labor force during that period (figure 5-2). In the 1980s, we added more people to the labor force than to the total population. In the 1970s and 1980s there was a discernible spike in the growth of the workforce and, therefore, in the number of commuters. From 1990 through 1999, another 13.5 million workers were added to the labor force [USDOL BLS 2000]. The female share of the labor force rose from 29 percent to about 47 percent from 1950 through 1999 [USDOC Census 1978; USDOL BLS 2000].

Figure 5-2

Additions to the Labor Force per Decade: 1950-2000



Source: U.S. Department of Commerce, U.S. Census Bureau, *Statistical Abstract of the United States* (Washington, DC: 1998); U.S. Department of Labor, Bureau of Labor Statistics, *Employment Status of the Civilian Noninstitutional Population 16 Years and Over by Sex, 1967 to Date*, available at http://www.bls.gov/pdf/cpsaat2.pdf, as of Aug. 9, 2000.

Since 1975, traffic volume and transportation characteristics, including trip chaining, have been affected by the labor force trends. Trip chaining is a term used to describe a pattern of travel first evident during the early 1970's energy crisis when households began to incorporate a number of stops for different purposes into one trip to save fuel. Both men and women began to conduct their household chores (i.e., dropping off children and dry cleaning) on the way to and from work and making stops on the way home (i.e., grocery shopping and picking up children).

In 1995, about 33 percent of women made stops on their way to work, compared with 19 percent of men; 61 percent of women made stops on their way home from work, compared with 46 percent of men [McGuckin & Murakami 1999]. While trip chaining represents a time- and fuel-efficient approach to travel, it adds to congestion in peak commuter periods and makes carpooling and transit use difficult.

Another key change in travel from women's increased labor force participation was that by 1990, 70 percent of workers lived in households with two or more workers. Having these dual-worker households has changed the character of local travel. One effect is that many carpools are now really family activities with two or more household members participating. But more significantly, multiworker households change the nature of the work-home relationship. Both the potential for and impact of living near the workplace are changed when one worker chooses to move. As a result, the other worker or workers in the household may be located further from their work. It also creates the need for joint leisure travel planning, which has changed to more frequent trips of shorter duration. Multiworker households also may choose to be located in larger metropolitan areas where more job opportunities are available.

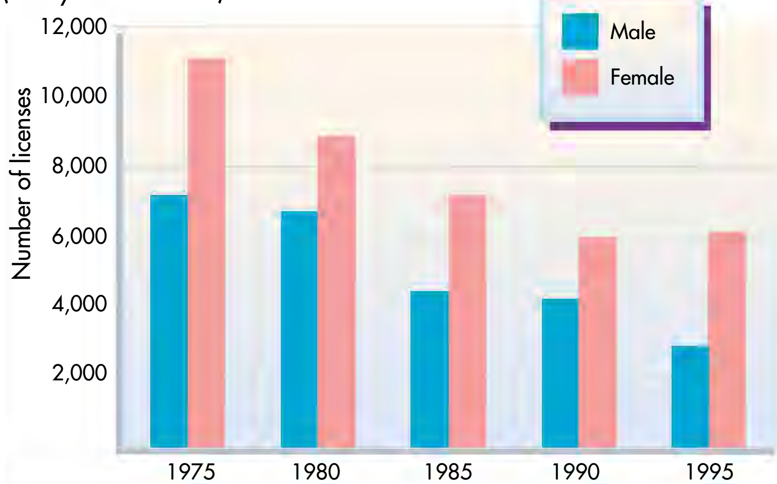
Household Income: One measure of the value that Americans place on mobility is that they spend a relatively large share of their incomes on transportation. Only expenditures on housing exceed those for transportation in the typical household budget [USDOL BLS 1998]. A key factor in recent travel growth is increased household income, which has a substantial impact on both trip frequency and trip length. Study of income and travel behavior relationships supports the observation that transportation is both a necessity and a discretionary good. For many lower income households, transportation spending is a necessity that consumes a significant share of total expenditures. Transportation spending ranges from about $2,500 for the lowest income quintile to nearly $12,500 per year for households with the highest income quintile. About 94 percent of all spending is related to the acquisition, operation, and upkeep of motor vehicles. The remainder goes to air travel, local transit, and miscellaneous purchases and rentals.

Licensing and Vehicle Ownership Patterns: On average, the adult population of the United States has reached saturation levels in drivers licenses. Saturation is a term used to describe the point at which the number of drivers licenses equals or nearly equals the number of people legally eligible to obtain a license. Older age groups—those born before the advent of the auto age—still have low levels of licensing, but these groups are being replaced by high license-holding groups as they age. In the past three decades, the number of people holding licenses increased by more than 70 percent—men by 50 percent and women by nearly 100 percent [USDOT FHWA, Various years]. However, the rate of growth in the number of new licensees has decreased within the same time period (figure 5-3) [USDOT FHWA Annual issues].

Although the number of people holding a license, on average, has greatly increased since 1975, licensing levels remain skewed by racial and ethnic group. For the most part, license saturation has occurred among the white population. Among most minority groups, there still is significant potential for growth, particularly among minority women (table 5-3). The

Figure 5-3

Drivers Licenses by Sex: 1975-95
(Five-year increases)



Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics, Summary to 1995* (Washington, DC: 1997).

Table 5-3

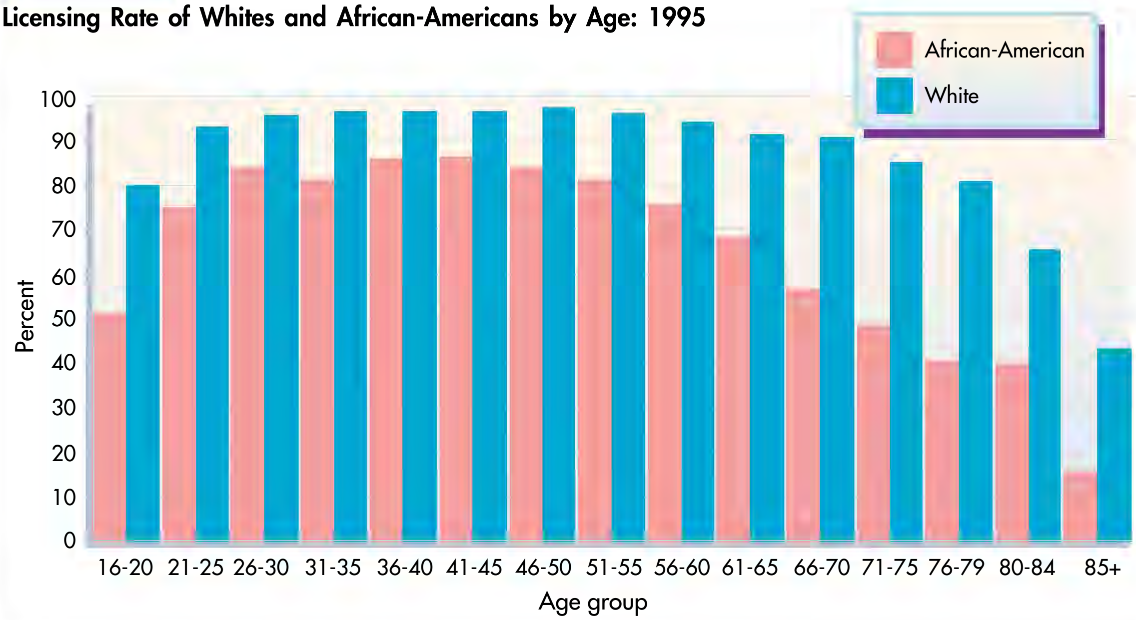
Licensing by Race/Ethnicity: 1995
(Percent)

	Male	Female
White	95	90
African-American	81	69
Asian	93	80
Hispanic	87	74

Source: U.S. Department of Transportation, Federal Highway Administration, 1995 Nationwide Personal Transportation Survey data (Washington, DC: 2000), available at www.cta.ornl.gov/npts, as of October 2000.

Figure 5-4

Licensing Rate of Whites and African-Americans by Age: 1995



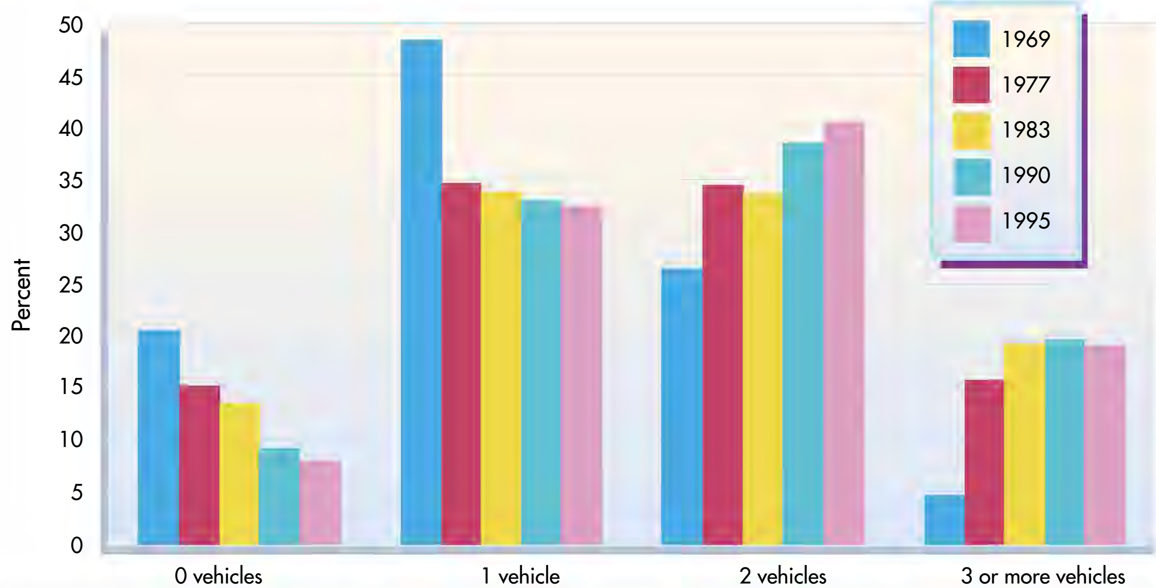
Source: U.S. Department of Transportation, Federal Highway Administration, 1995 Nationwide Personal Transportation Survey data (Washington, DC: 2000), available at www-cta.ornl.gov/npts, as of October 2000.

gap in licensed minorities is most pronounced among those over age 60, but even among young adults, there are significant differences (figure 5-4). The most notable are the youngest groups of African-Americans, among whom only one-half have licenses. Given that a drivers license often is a passport to job opportunities, this has broad significance.

In 1977, the household vehicle fleet of America numbered about 120 million vehicles. But, after a decade in which the nation added more vehicles than people—23 million vehicles and 22 million people between 1980 and 1990—Americas' household vehicle fleet surpassed 175 million vehicles in 1995 as more than 50 million vehicles were added in less than 20 years [USDOT FHWA Various years]. Vehicles per household rose from 1.59 in 1977 to 1.78 in 1995, despite declining household sizes in this period. More significantly, vehicles per household surpassed licensed drivers per household by 1990, essentially producing saturation. In addition, most households have more vehicles per household than workers per household, indicating that almost all American workers have access to a vehicle for work travel. However, while the proportion of households with no vehicle has dropped sharply in the past 25 years, there were still about 8 million American households without vehicles in 1995 (figure 5-5).

Figure 5-5

Household Vehicle Ownership: 1969, 1977, 1983, 1990, and 1995

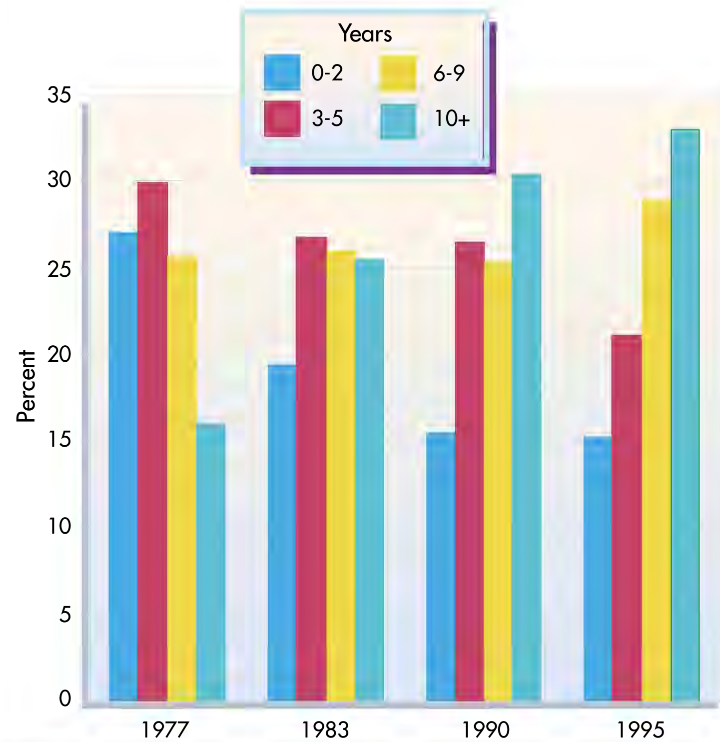


Source: U.S. Department of Transportation, Federal Highway Administration, *Summary of Travel Trends: 1995 Nationwide Personal Transportation Survey* (Washington, DC: 1999).

As a direct result of improvements in vehicle quality and longevity, affordable and effective older vehicles were available to purchasers who may not have been able to afford a vehicle otherwise. In effect, increased vehicle longevity lowered the threshold costs of owning and operating a vehicle. Since the 1970s, the fleet of private vehicles six or more years old has grown substantially (figure 5-6). In 1977, the average age of the private vehicle fleet was 6 years—in 1995, it was 8 years [USDOT FHWA Various Years]. Older vehicles are being used at increasing levels. New vehicles, or those less than three years old, cover about the same distance annually as they did in the past, approximately 16,000 miles per year. But, there have been significant increases in annual miles of travel for vehicles 10 years or older, from roughly 6,800 miles per year in 1977 to 8,800 miles in 1995 [USDOT FHWA Various years].

Figure 5-6

Distribution of the Private Vehicle Fleet by Age of Vehicle: 1977, 1983, 1990, and 1995



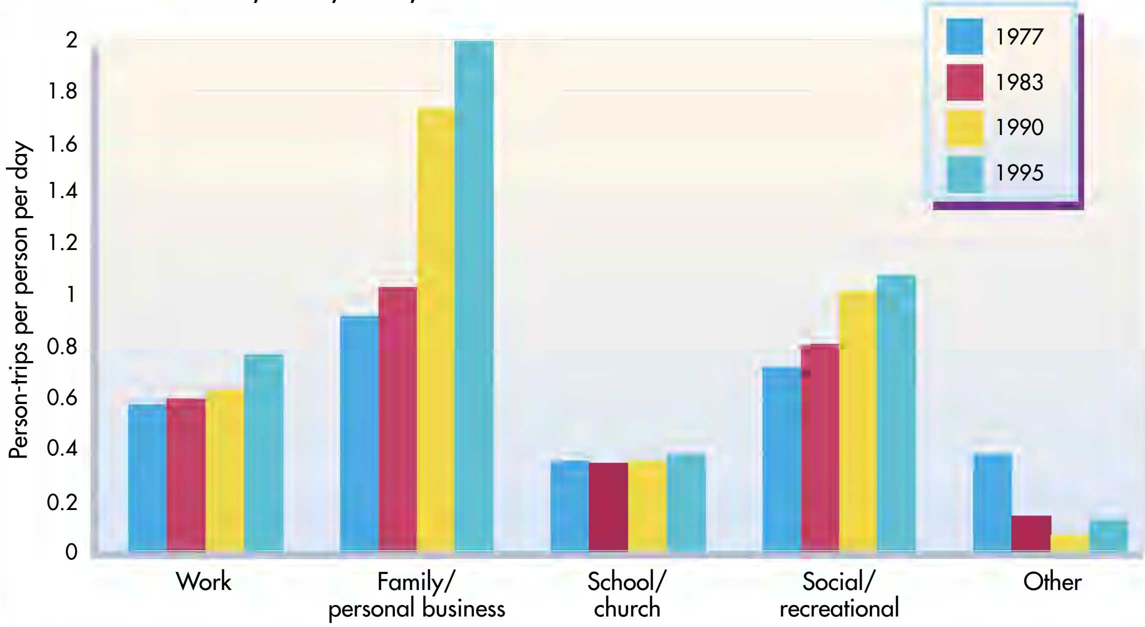
Source: U.S. Department of Transportation, Federal Highway Administration, *Nationwide Personal Transportation Survey* data (Washington, DC: Various years).

The improved longevity of vehicles combined with lower relative costs of owning and operating a vehicle has resulted in their pervasive use for all travel purposes. One of the effects of this increasing availability of vehicles was a marked decline in carpooling for work travel and declining auto occupancy rates for other trip purposes. Average vehicle occupancies for work travel declined from about 1.3 per vehicle in 1977 to about 1.1 by 1995. Occupancies for all purposes dropped from 1.9 to 1.6 in the same period [USDOT FHWA NPTS Various years].

Changing Trip Purposes and Patterns: One important change over the past 25 years has been the purpose of travel. In the early 1970s, work was the major factor influencing travel. However, since then, while commuting has grown rapidly, trips for household chores and personal business have grown even faster (figure 5-7) [USDOT FHWA Various years].

Figure 5-7

Personal Travel: 1977, 1983, 1990, and 1995

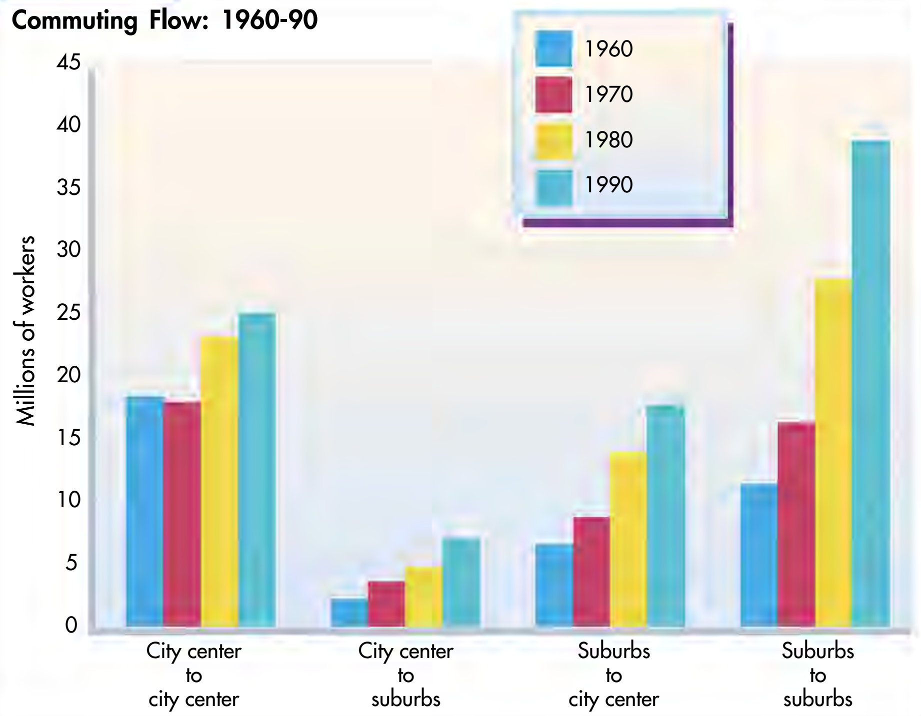


Note: The Nationwide Personal Transportation Survey (NPTS) was first conducted in 1969, and then again in 1977, 1983, 1990, and 1995. Numerous methodological improvements in the NPTS make exact comparisons across time difficult, but travel behavior for these two points in time are adequately reflected in the survey data.
Source: U.S. Department of Transportation, Federal Highway Administration, *Nationwide Personal Transportation Survey* (Washington, DC: Various years).

As households and jobs have shifted to the suburbs, commuting, as well as other trip purposes, have increasingly taken on a circumferential rather than a radial pattern. Contemporary commuting flows are dominated by suburb-to-suburb flows (figure 5-8), which accounted for half of all commuting growth between 1980 and 1990. The dominance of the suburb-to-suburb pattern tends to increase with the size of metropolitan area and has been strongest in areas where population exceeds two million. In contrast, smaller metropolitan areas tend to retain the importance of their center [Pisarski 1996].

Another flow pattern that has increased is "reverse-commuting," as city residents commute outward to suburban jobs. This is a critical commuting concern because of the difficulties in serving the growing transportation needs of this population, particularly those with low income (box 5-1). As metropolitan areas grow closer together, there also has been a small, but rapidly growing, flow pattern from rural areas into suburbs and from suburbs of one metropolitan area into the suburbs of another as edges of metropolitan areas grow closer together. The net result is a complex commuting pattern comprised of many cross-directional flows.

Figure 5-8



Source: A. Pisarski, *Commuting in America II* (Lansdowne, VA: Eno Transportation Foundation, Inc., 1996).

Box 5-1

Access to Jobs

Changes in the nation's welfare system in 1996 have promoted aggressive public- and private-sector actions to provide employment opportunities for welfare recipients. More than 5.6 million Americans left the welfare rolls between August 1996, when President Clinton signed a sweeping welfare overhaul into law, and September 1999. There were 46 percent fewer individuals and 44 percent fewer families on welfare in September 1999 than in August 1996. Welfare rolls dropped in every state during this period, in some cases, by as much as 90 percent [USDHHS 2000].

With these changes, communities are becoming increasingly aware that one of the keys to moving people from welfare to work and helping them keep a job is providing adequate and reliable transportation. Obtaining reliable transportation to and from work, and often to and from childcare facilities, is a challenge that employees and employers struggle to meet. Transportation is the "to" in welfare to work. We have strived to make our transportation system inclusive in service, leaving no one behind.

According to a 1998 survey conducted by Wirthlin Worldwide [Welfare to Work Partnership, 1998], more than half of businesses participating in the Welfare to Work Partnership, a public-private initiative to help workers make the transition, found that employee transportation is a problem. The most common problems reported were deficiencies in public transportation. Thirty-three percent of employers surveyed said that there are no public transportation routes near their businesses, and 18 percent said that public transportation does not operate during the hours necessary to transport workers to and from work.

Many entry-level jobs, especially in the service and retail sectors, require employees to work late hours and weekends. People in these jobs may find that their needs are not met by transit service geared to the standard "9-to-5" workday. Additionally, job growth has increasingly occurred in

(continued on next page)

Box 5-1 continued

suburbs, forcing many central-city residents to rely on "reverse commute" transit services and vanpools that go to suburban office parks, shopping malls, and other sites. In rural areas, transit service is a lifeline for millions of residents.

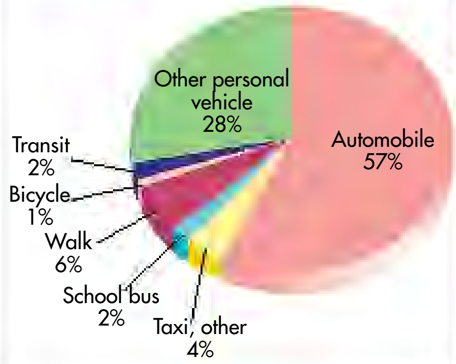
Access to Jobs

One response to the problem has been the federal Job Access and Reverse Commute grant program. A part of the Transportation Equity Act for the 21st Century (TEA-21), the program assists states and localities in developing new or expanded transportation services that connect welfare recipients and other low-income persons to jobs and other employment-related services. Job Access projects are targeted at developing new or expanded transportation services such as shuttles, vanpools, new bus routes, connector services to mass transit, and guaranteed-ride-home programs for welfare recipients and low-income persons. Reverse Commute projects provide transportation services to suburban employment centers from urban, rural, and other suburban locations for all populations.

Changing Modal Choice: Automobiles and other private vehicles are used for most local trips (figure 5-9). This share has increased since 1977. Moreover, when people drive they now are more likely to have fewer passengers with them. For example, car-pooling to work has declined from about 15 percent of commuters in 1977 to 10 percent in 1995. Additionally, average per-vehicle occupancy for work travel declined by 15 percent per vehicle in 1977 to about 1.1 in 1995. Occupancies for all purposes dropped from 16 percent during this same period [USDOT FHWA Various years]. Trends in the annual number of trips taken by each house hold and their choice of transportation are shown in figure 5-10.

Figure 5-9

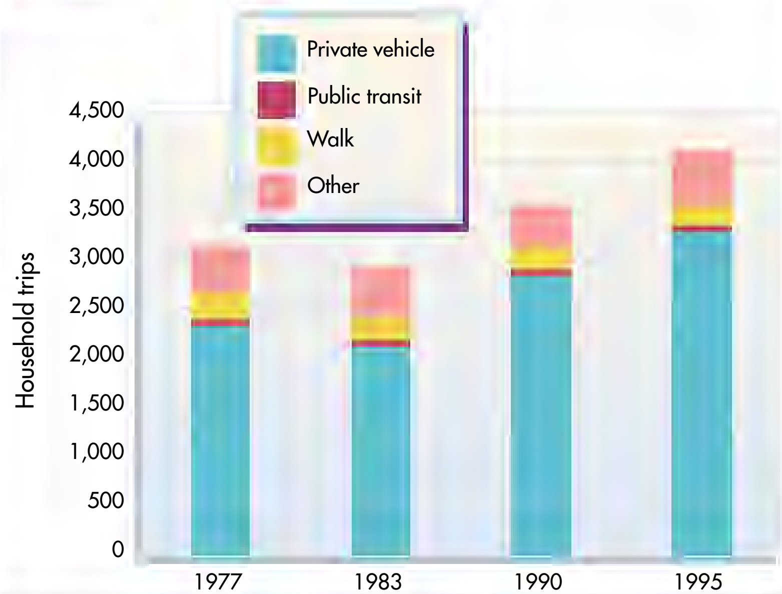
Transportation Choice for Trips Under 50 Miles: 1995



Source: U.S. Department of Transportation, Federal Highway Administration, 1995 Nationwide Personal Transportation Survey data (Washington, DC: 2000), available at www-cta.ornl.gov/npts, as of October 2000.

Figure 5-10

Annual Household Trips by Mode: 1977, 1983, 1990, and 1995



Note: The Nationwide Personal Transportation Survey (NPTS) was first conducted in 1969, and then again in 1977, 1983, 1990, and 1995. Numerous methodological improvements in the NPTS make exact comparisons across time difficult, but travel behavior for these two points in time are adequately (if not perfectly) reflected in the survey data.

Source: U.S. Department of Transportation, Federal Highway Administration, 1995 Nationwide Personal Transportation Survey data (Washington, DC: 2000), available at www-cta.ornl.gov/npts, as of October 2000.

Box 5-2

Access to Transportation for Americans with Disabilities

Many people have disabilities that make it difficult or impossible for them to operate a motor vehicle or to use public transportation without special equipment or assistance. Such disabilities can include problems with walking or other motor functions, hearing or sight impairments, and/or various cognitive and mental difficulties. People who are unable to fully use the transportation system may experience reduced access to opportunities for employment, health care, education, shopping, social and cultural events, and recreation. But our transportation system must be inclusive in service, providing access to opportunities for all Americans.

In 1990, Congress passed the Americans with Disabilities Act (ADA), which protects persons with disabilities from discrimination in employment, provision of public services and accommodations, and transportation. The ADA defines a disability as a physical or mental impairment that substantially limits one or more of an individual's major life activities. The Census Bureau estimates that, at the end of 1994, about 1 in 5 people in the United States, including both adults and children, had some form of disability (54 million), while 1 in 10 had a severe disability (26 million) [McNeil 1997].

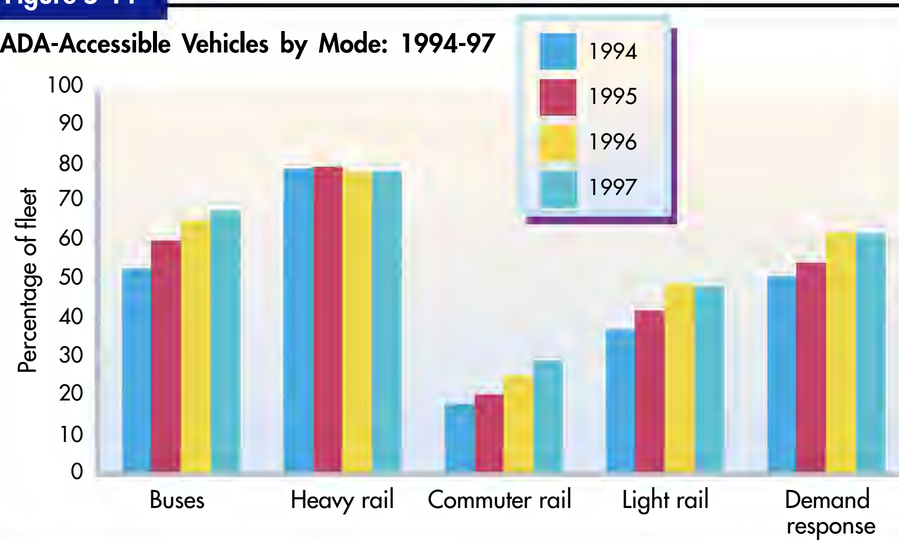
Under the ADA, it is a violation of civil rights law to discriminate against people with disabilities in providing public transportation. When federal funds are involved, accessibility guidelines are also governed by Section 504 of the Rehabilitation Act of 1973. Although the ADA applies nationwide, about 600 public transportation agencies and 700 key railroad stations have been the focal point for most transportation compliance activities. Figure 5-11 shows the general improvement in accessible transit vehicles. Today, 83 percent of transit buses are ADA accessible, an increase of nearly 30 percent since 1994. It is expected that 100 percent of transit buses will be accessible by 2002. (Additional ADA requirements apply to intercity bus lines, Amtrak, and other public and private carriers. A separate law, the Air Carriers Access Act of 1986, makes it illegal for air carriers to discriminate against people with physical or mental impairments.)

One of the main effects of the ADA is that paratransit (e.g., alternative transportation arrangements for the disabled) is no longer to be used as a substitute for fixed-route service. Under the ADA, fixed-route service must be made available to the disabled; paratransit is to be provided only when fixed-route transit does not meet a customer's needs or is inappropriate to the situation. Moreover, paratransit eligibility is no longer based on a person's disability, but on whether or not the person has the ability to use the fixed-route system.

In 1998, the U.S. Department of Transportation (USDOT) amended its ADA regulations to require accessibility for new over-the-road buses (OTRBs). The new rule applies both to intercity and other fixed-route bus operators and to charter- and tour-bus operators. The rules require operators to ensure that passengers with disabilities can use OTRBs.

Figure 5-11

ADA-Accessible Vehicles by Mode: 1994-97



Source: U.S. Department of Transportation, Federal Transit Administration, *Federal Transit Summaries and Trends* (Washington, DC: 1998), p.25.

Long-Distance Travel: Initiated for a variety of purposes, long-distance travel—both intercity and international—has increased dramatically in the past 25 years. Long-distance travel has become more international in reach, linking us to destinations around the world. Long-distance travel trips—over 100 miles one-way from home—include more frequent, shorter duration trips and more travel around weekends than did long-distance travel trips of two decades ago. In addition, as female labor-force participation rates have increased, women are traveling more.

On average, each American makes about 4 long-distance trips per year averaging about 830 miles each, up from the 1977 average of about 2.4 trips per year. In 1995, Americans generated about a billion long-distance roundtrips per year within the United States (table 5-1). Long-distance travel accounts for only a small fraction of trips, but nearly 25 percent of total national travel in terms of miles traveled. The transportation system also is used by approximately 50 million foreign visitors who come to the United States by air each year, and millions more who arrive by land and sea [USDOT BTS 1999].

"Transportation is only a means to an end: getting people, products, and information where they need to go. We need to encourage forms of transportation that fulfill this mission without harming the environment, including public transit, carpooling, bicycles, walking, and telecommuting."

Mortimer Downey
Deputy Secretary of Transportation
Fifth Conference on U.S.–Japan Cooperation In Transportation
June 2, 1998, Washington, D.C.

Some of the same factors that have spurred local travel have also led to an increase in long-distance travel over the past 25 years, including population and household growth, higher median income, and greater vehicle availability. Other factors, such as increasing regional interdependencies (including globalization) of economic production and consumption, and lower airfares (adjusted for inflation), have also caused this growth. The critical attributes of long-distance trips are purpose of the trip and length of the trip. These two factors determine the trip's time and cost sensitivities, and, thereby, affect the mode of transportation chosen. Traveler characteristics are also important, partly because of the substantial variation in long-distance trips. Characteristics of significance include gender, age, income, race and ethnicity, and family composition.

Long-distance travel can have multiple purposes, such as a work trip that includes a vacation and even a visit to local friends and relatives. The broad-purpose categories used in the American Travel Survey are business, which accounts for about 23 percent of domestic long-distance travel; pleasure travel, accounting for about 63 percent of the trips; and personal business trips, with about 15 percent of the trips [USDOT BTS 1997a].

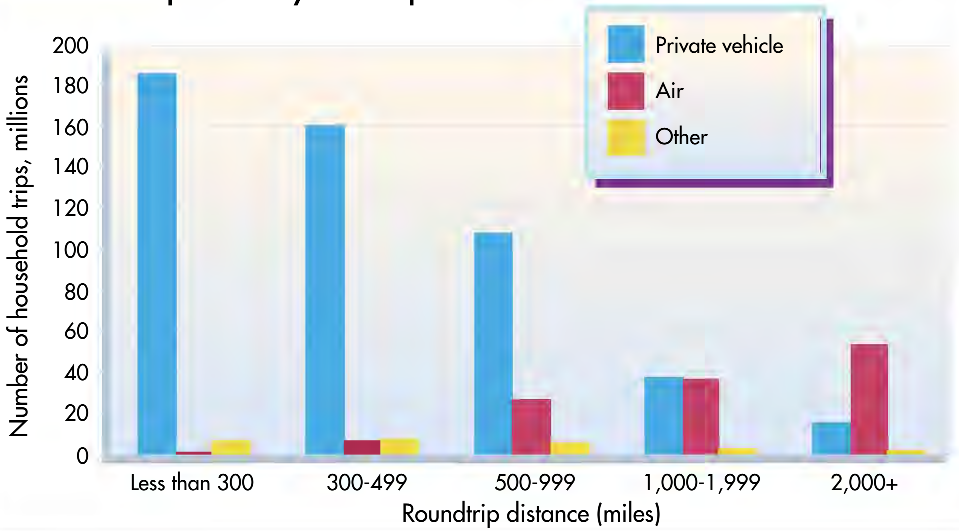
Modal choice is greatly influenced by the distance of the trip (figure 5-12). For roundtrips up to 1,000 miles, the automobile dominates; thereafter, air travel gains an increasing share. The other modes—scheduled intercity bus, charter bus, and Amtrak passenger rail service—have short- to intermediate-distance roles, but their combined share of all trips is less than 5 percent.

Travel by personal vehicle accounts for more than 80 percent of all domestic trips, but only about 55 percent of miles; air travel accounts for only 16 percent of all trips, but 43 percent of miles traveled. Intercity bus travel, including charter trips, is 2 percent of all trips and 1.6 percent of the miles. Amtrak's share is about one-half of one percent for both number of trips and miles traveled. Ships have a negligible share [USDOT BTS 1997a].

Intercity transportation modes serve very different trip purposes (figure 5-13). For example, business travel is a major factor in air travel services, but less so in other modes. The "visit friends and relatives market" is critical to the scheduled bus industry, and leisure travel is critical to the charter bus market. The personal-use vehicle has significant roles in all travel purposes.

Figure 5-12

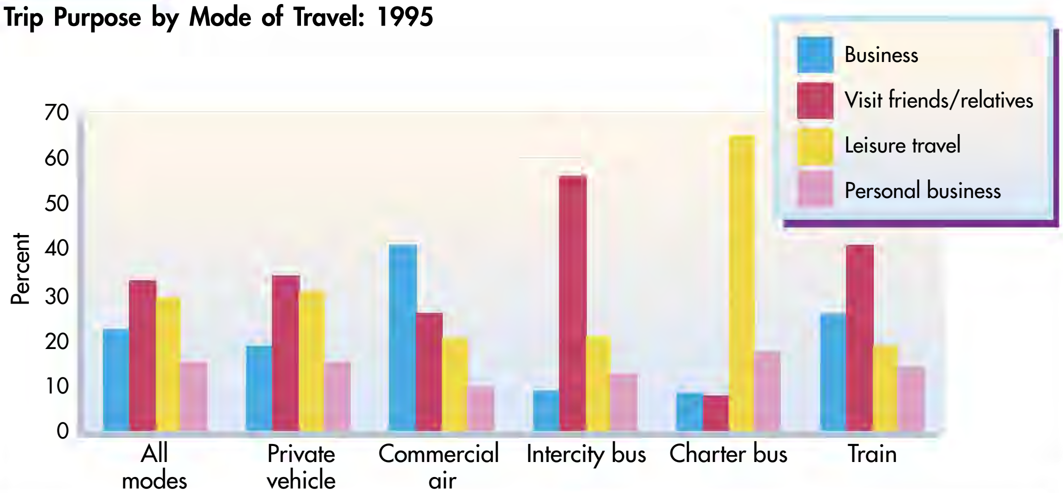
Mode of Transportation by Roundtrip Distance: 1995



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 1995 *American Travel Survey: U.S. Profile* (Washington, DC: 1997).

Figure 5-13

Trip Purpose by Mode of Travel: 1995



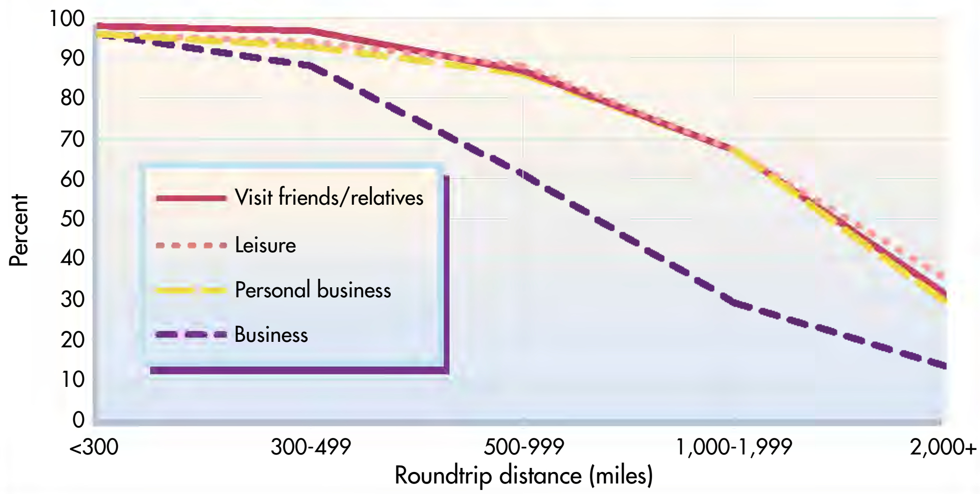
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *1995 American Travel Survey: U.S. Profile* (Washington, DC: 1997).

In travel for all purposes, the use of the private vehicle declines as the distance of the trip increases. However, it declines much more quickly and sharply in business travel (figure 5-14). This is undoubtedly due to the time sensitivities of business travel.

There is substantial variation in trip making among men and women. Although there has been substantial growth in women's long-distance travel in some areas, their travel still lags behind men's. Both men and women have increased their long-distance trip making rates by about 60 percent over 1977 rates. But overall, women make only 80 percent as many long-distance trips as men, unchanged from 1977 (figure 5-15). This is most notable in two areas: women still make only 40 percent as many long-distance business trips as men; and they make only about 85 percent as many long-distance leisure trips as men, primarily because women take fewer outdoor recreational trips for activities such as camping and fishing. Women do, however, make more trips to visit friends and relatives [USDOC 1979; USDOT BTS 1997b].

Figure 5-14

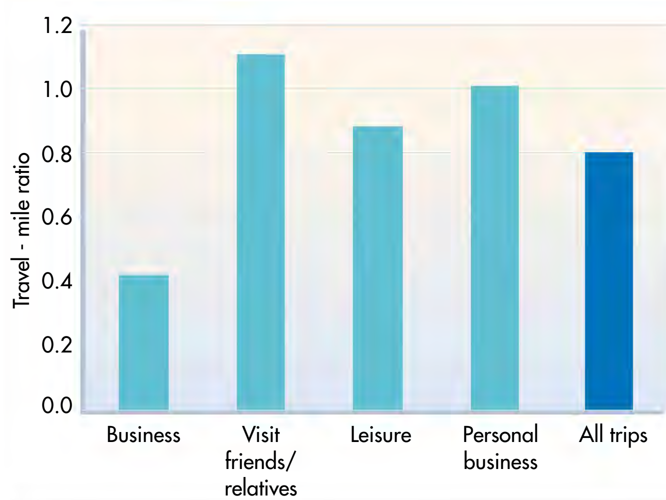
Vehicle Use by Distance and Trip Purpose: 1995



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 1995 American Travel Survey data (Washington, DC: 2000), available at http://www.bts.gov/ats, as of October 2000.

Figure 5-15

Female-to-Male Ratios of Long-Distance Travel-Miles by Purpose: 1995



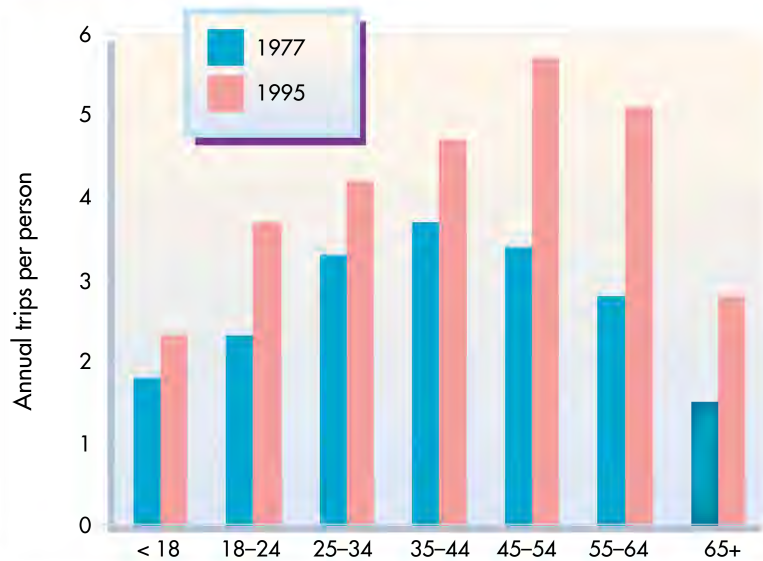
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 1995 American Travel Survey data (Washington, DC: 2000), available at http://www.bts.gov/ats, as of October 2000.

Age is, and will continue to be, a significant factor in long-distance travel. But the age distribution of travelers has shifted significantly since 1977 (figure 5-16). The peak travel age has shifted from the 35-to-44 age group in 1977 to the 45-to-54 age group (the age group into which the baby boomers are moving) in 1995. Those above age 55 also had a noticeable increase in travel, compared to 1977 figures [USDOC 1979; USDOT BTS 1997b].

Travel by African-Americans increased more than for whites and Hispanics between 1977 and 1995. African-Americans made about 80 percent more long-distance trips in 1995 than in 1977, compared with about a 60 percent increase for both whites and Hispanics (figure 5-17). But travel activity for whites is still double that of Hispanics and African-Americans [USDOC 1979; USDOT BTS 1997b].

Figure 5-16

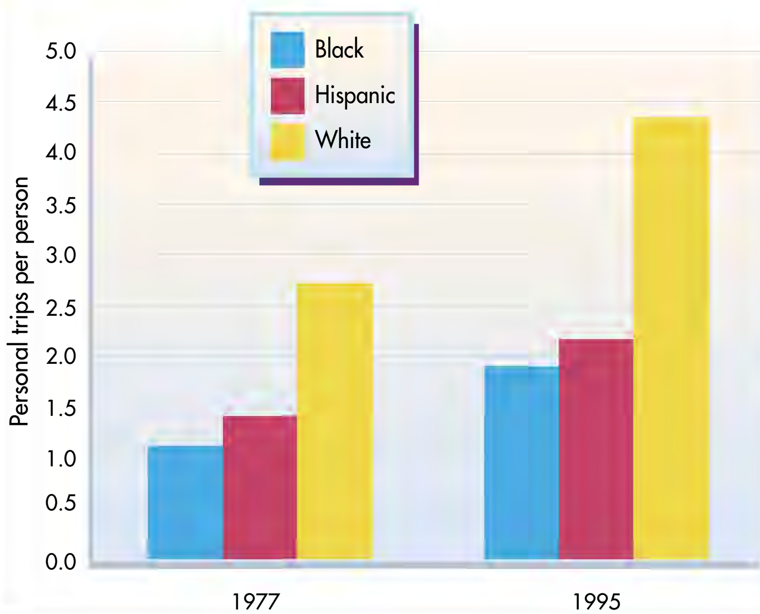
Long-Distance Trip Making Rates by Age Group: 1977 and 1995



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 1995 American Travel Survey data (Washington, DC: 2000), available at http://www.bts.gov/ats, as of October 2000.

Figure 5-17

Annual Long-Distance Trip Rates: 1977 and 1995



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 1995 American Travel Survey data (Washington, DC: 2000), available at http://www.bts.gov/ats, as of October 2000.

Income also has a major impact on the propensity to travel long distances. Those with incomes greater than $50,000 per year in 1995 made 5.6 long-distance trips per year, compared with 2.2 long-distance trips per year for those earning under $25,000 and 3.8 long-distance trips for those in the middle income group [USDOT BTS 1997b]. Most of the growth in long-distance travel between 1977 and 1995 occurred in higher income groups [USDOC 1979; USDOT BTS 1997b].

Keys to the Future

The future of passenger transportation over the next 25 years will depend on a wide range of factors: demographics, immigration, social equity, affluence, and urban decentralization.

The changing age profile in America will facilitate growth in both local and intercity passenger travel in the near term, but reduce growth over the long term (figure 5-18). As the baby boom generation passes through the ages when people travel most (in their 40s and 50s), passenger travel will increase. However, beginning in 2011, the eldest of this group reaches the traditional retirement age of 65. After retirement, personal travel tends to remain the same, while work travel is reduced substantially. As people become increasingly physically and mentally frail in their 70s and 80s, all travel declines.

Counteracting the aging population will be the number of new immigrants entering the country. Future population growth will result largely from immigration. Because most immigrants are adults, they have an immediate impact on the transportation system. These individuals tend to use the transit system more than other sectors of the population because of lower income and because they tend to locate in urban areas. Transit use tends to decline the longer an immigrant is in the country, and subsequent generations tend to adopt the same transit profile as the rest of the population.

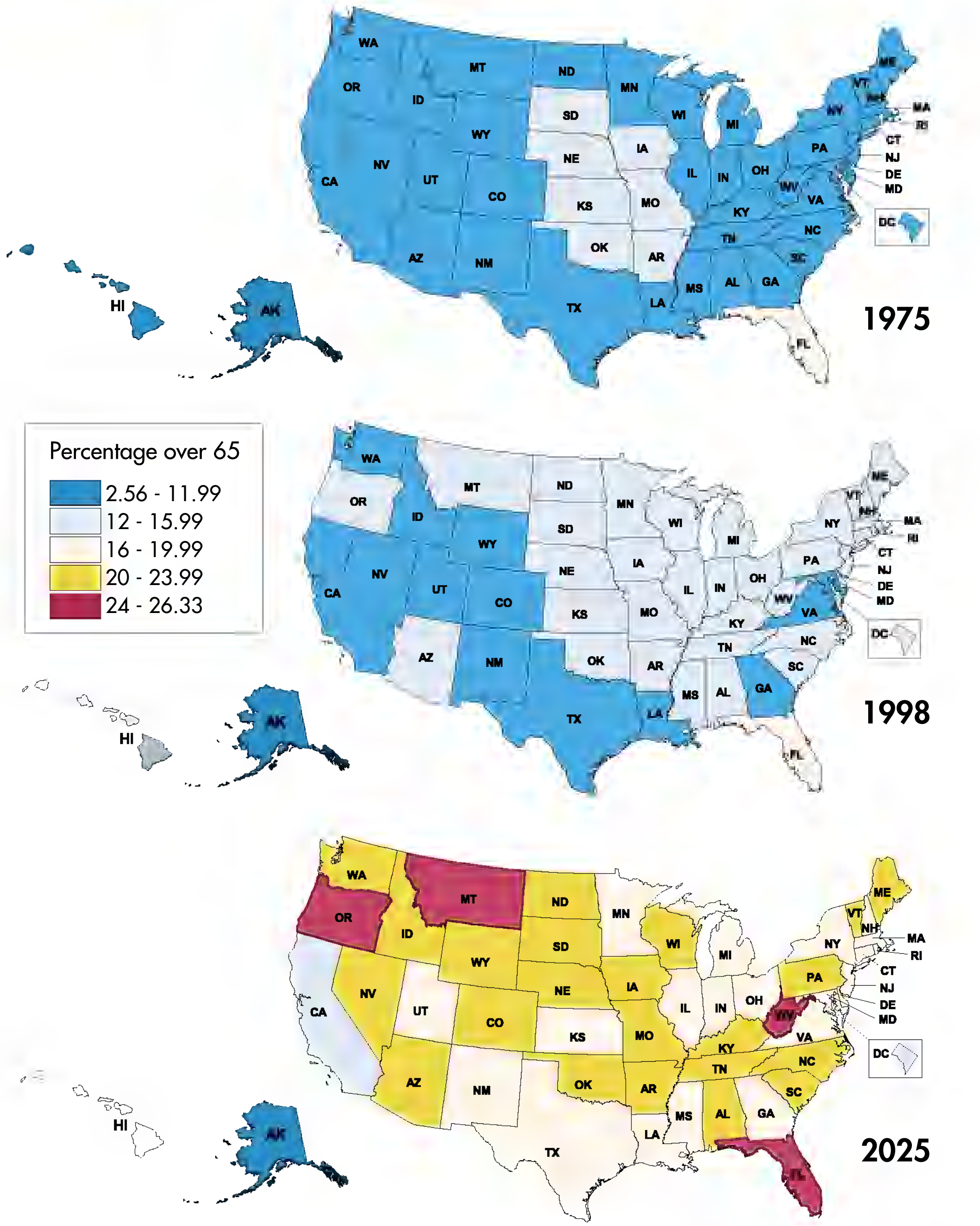
Another possible source of travel growth is social equity, particularly growth in vehicle ownership and, therefore, vehicle travel among racial and ethnic minorities. About 95 percent of white households have at least one vehicle, compared with about 88 percent of Hispanic households and about 75 percent of African-American households. Increases in vehicle use among these groups will be a function of vehicle cost, income, and geographic location.

Cyclical and long-term changes in economic activity have a strong impact on the level of local and long-distance travel. Income growth generally increases the propensity to make more frequent and longer trips. But increased affluence also tends to increase the value people place on time, generally pushing them to faster means of transportation, such as the single-occupant vehicle and (on longer trips) aircraft. The interaction of an aging population, smaller households, and time pressures may, in some places, influence people to live in smaller, higher density neighborhoods that have more potential for transit use and walking.

On the whole, the dominant trend will still be urban decentralization, spurred by technology that allows people to set up home-based businesses in order to work at home, or to have multiple places of work—which will include private vehicles. Technology also will increasingly allow employers to locate facilities near skilled employees and in places with spare road and airport capacity. Increases in the share of workers who telecommute part or full-time imply that the location and type of transportation necessary to support a given level of economic activity will change. Increasing use of the Internet for the purchase of goods and services will affect the nature and location of shopping travel, with increased freight deliveries to residences.

Figure 5-18

Estimated Percentage of Total State Population Over the Age of 65: 1975, 1998, and 2025



Sources: U.S. Department of Commerce, Census Bureau, *Statistical Abstract of the United States* (Washington, DC: 1999).

The USDOT's mobility goals are directed toward improving the physical condition of the infrastructure, reducing transportation time from origin to destination, increasing accessibility, reducing costs, and increasing reliability. To achieve these goals, the USDOT will address the efficient use of transportation resources; anticipate the needs of low-income, minority, and older Americans; address transportation needs in key geographic areas; ensure mobility in response to emergencies and disruptions; address feedback from customers; and improve information collection.

All mobility outcomes present complex measurement issues. Accordingly, the USDOT will:

- develop a means of measuring user transportation cost, time, and reliability with time-series data;
- develop better approaches for measuring access;
- develop a straightforward measure of congestion and its costs;
- produce more timely and comprehensive data on the condition and use of the transportation system; and
- develop a more complete understanding of variables influencing travel behavior.

Energy

Transportation cannot occur without energy, which is a major concern for the transportation industry because of the environmental consequences of using energy and because the world's resources of petroleum, on which most modern transportation systems rely, are limited. This section focuses on the nature of transportation energy use, the industry's dependence on petroleum and the consequences thereof, and the sustainability of energy supplies for future transportation needs.

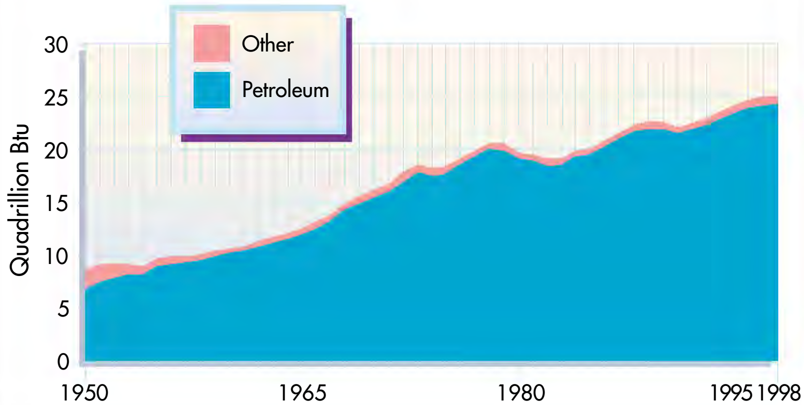
Transportation is a major energy-using sector of the U.S. economy. Transportation used 26 quadrillion Btu (British thermal unit) (quads) of energy in 1999, 27 percent of the 97 quads used by the entire U.S. economy [USDOE EIA 1999a]. This approximate energy use by transportation has not varied by more than three or four percentage points since 1950. Total transportation energy use, however, has nearly tripled since 1950 (figure 5-19). From 1950 until the first oil price shock in 1973, transportation energy use increased steadily, at an average annual rate of 3.5 percent. Since then, the average rate of growth has slowed to 1.2 percent, partly due to improved energy efficiency [USDOE EIA 1999a].

Petroleum supplies more than 95 percent of the energy used in transportation and has done so for the past 40 years (figure 5-19). The largest nonpetroleum energy uses in transportation are natural gas and electricity for pipelines and natural gas-derived liquids blended with gasoline. While other sectors of the economy reduced their petroleum dependence after the oil supply upheavals of the 1970s and 1980s, transportation has remained nearly totally dependent on petroleum, despite significant efforts to promote alternative fuels. The Alternative Motor Fuels Act of 1988 and the Energy Policy Act of 1992 provide a combination of tax incentives, fuel economy credits, and fleet mandates that have helped increase the numbers of alternative-fuel vehicles on U.S. roads from an estimated 251,000 in 1992 to 430,000 in 2000 [USDOE EIA 1999b]. Over the same period, use of alternative fuels grew by 49 percent, to 341 million gallons in 1999. Still, this number is slight, less than 1 percent, compared with the 155 billion gallons of fuel consumed by 215 million motor vehicles on U.S. highways in 1998 [USDOT FWWA 1999a]. As a result of its continuing dependence on petroleum, transportation's share of U.S. petroleum use has risen from 51 percent in 1973 to 66 percent in 1998 [Davis 1999]. Moreover, the transportation sector demands a disproportionate share of the lighter, higher value petroleum products that drive the market.

Within transportation, the highway mode dominates energy use, with an 82 percent share in 1997 (figure 5-20). Energy use by aircraft, the fastest growing component of transportation energy use, comes next with an 8 percent share [USDOT BTS 1999].

Figure 5-19

U.S. Transportation Energy Use: 1950-98 (Annual totals)

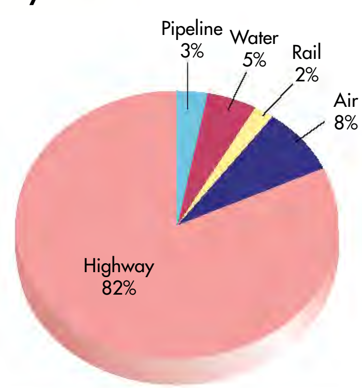


Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1999* (Washington, DC: 2000).

Water transport accounts for five percent of transportation energy use, one percent of which is attributable to recreational boating. Pipelines require four percent of transportation energy, but nearly four-fifths of that is natural gas used by natural gas pipeline pumps. The remainder is electricity used by crude oil and petroleum product pipeline pumps, but their 0.2 quads of electricity consumption makes them the largest electricity-using mode. Finally, rail accounts for 2 percent, of which more than 85 percent is for freight movement [Davis 1999].

Figure 5-20

Transportation Energy Use by Mode: 1997



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999*, BTS99-04 (Washington, DC: 1999), pp. 289-90.

Energy-Efficiency Trends: The energy market upheavals from 1973 to 1985 greatly slowed the growth of transportation energy use in the highway, air, and pipeline modes (table 5-4). As a consequence of the oil embargo of 1973 to 1974 and related events, oil prices more than doubled from $11.76 per barrel in 1973 to $23.56 in 1974. Oil supply shortages associated with the Iran-Iraq War and subsequent OPEC supply restrictions caused oil prices to jump again, from $24.48 in 1978 to $53.39 in 1981 (in 1992 dollars). Both oil-price shocks slowed the growth of transportation activity and led to major energy-efficiency improvements across all modes.

Table 5-4

Transportation Energy Use by Mode: 1960-97
(Trillions of Btu)

	1960	1970	1980	1990	1997
Air	293	1,155 14.7%	1,394 1.9%	1,811 2.6%	1,965 0.7%
Rail	480	492 0.2%	551 1.2%	445 −2.1%	507 1.9%
Water	701	753 0.7%	1,677 **	1,396 −1.8%	1,230 − 0.9%
Pipeline*	358	745 7.6%	654 −1.3%	680 0.4%	775 1.3%
Transit	55	70 −1.3%	111 2.4%	117 4.8%	122 0.9%
Highway	5,261	11,707 8.3%	14,657 2.3%	16,692 1.3%	19,215 2.0%

**Pipelines include natural gas only. Crude oil pipeline energy use not shown here.*
***The source of water data changed between 1980 and 1990, making these estimates non comparable.*

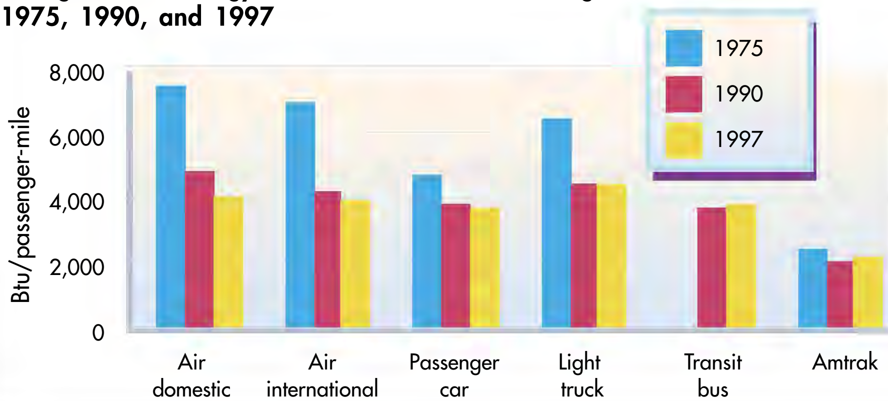
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999,* BTS99-04 (Washington, DC: 1999), pp. 291-292.

Most transportation modes responded to higher fuel prices and the conservation policies they spawned by reducing the amount of energy required to carry a passenger or a ton of freight (called energy intensity). From 1975 to 1997, the energy required for a passenger-mile of travel by car fell more than 20 percent, from 4,700 to 3,700 Btu [USDOT BTS 1999]. During the same period, the energy needed to transport a passenger one mile by commercial aircraft domestically decreased by more than 40 percent, from 7,500 to 4,100 Btu [USDOT BTS 1999]. The energy intensity of Amtrak intercity rail travel also declined, from 2,380 Btu per passenger-mile in 1975 to 2,070 in 1990 [USDOT BTS 1999]. Energy intensities of urban bus transit actually increased. The somewhat remarkable result was a convergence in the energy intensity of travel by most modes (figure 5-21). Intermodal comparisons are generally misleading, however, because the modes perform different functions and serve different travel markets. Since 1990, improvements in energy efficiencies have generally slowed or stopped, due to falling energy prices and constant fuel economy standards.

Less is known about the energy intensiveness of freight transport. Rail freight energy use per ton-mile has been declining consistently over the past 30 years, from roughly 840 Btu per ton-mile in 1960 to about 370 Btu per ton-mile today [USDOT BTS 1999]. The data for domestic waterborne commerce are more volatile for reasons that are not well understood, and it is difficult to draw conclusions from them. Reliable data on heavy truck ton-miles do not exist, but it is clear that energy use per vehicle-mile has decreased, albeit more slowly than for other modes. Between 1970 and 1997, energy use per tractor-trailer truck-mile decreased at an average annual rate of 0.8 percent [USDOT BTS 1999; USDOT FHWA 1999a]. This, combined with a general increase in truck size and weight limits, suggests that truck energy use per ton-mile has probably also decreased.

Figure 5-21

Changes in the Energy Intensiveness of U.S. Passenger Travel: 1975, 1990, and 1997



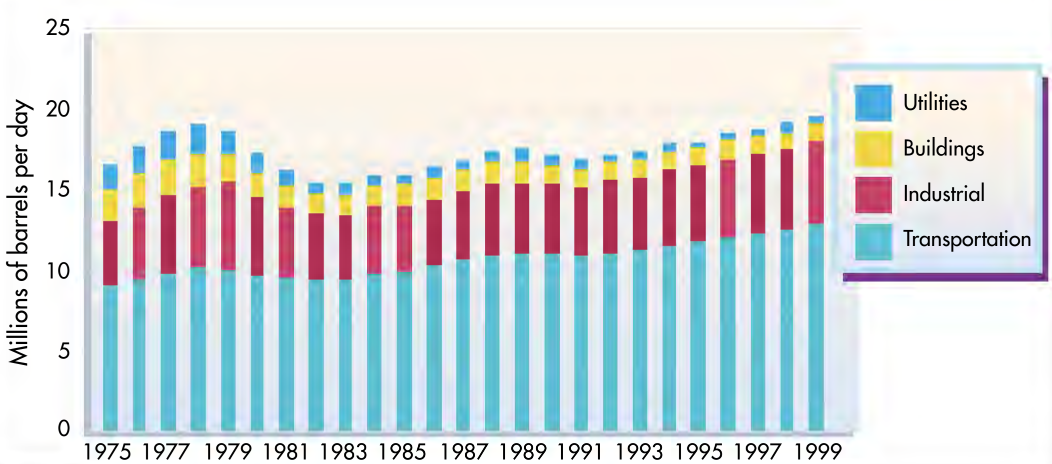
Note: 1975 Passenger bus data are not available.
Source: U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 1999*, BTS99-04 (Washington, DC: 1999), p. 309.

Oil Dependence: The U.S. economy's dependence on petroleum is driven principally by the transportation sector's dependence on it. The risks of oil dependence was a major theme of the 1977 *National Transportation Trends and Choices* report [USDOT 1977]. Not only is transportation nearly totally dependent on petroleum as an energy source, but it also is the largest and fastest growing consumer of petroleum products. According to the Department of Energy, transportation derives 97 percent of its energy from petroleum (figure 5-19), although this includes a small percentage of nonpetroleum gasoline blending stocks such as ethanol [USDOE EIA 1999a].

Transportation consumes 66 percent of the petroleum products supplied to the U.S. economy, up from 55 percent in 1975. As a result of the oil price shocks of the 1970s and 1980s and the deregulation of U.S. natural gas markets, oil use in residential and commercial buildings and by utilities to generate electricity has fallen to about half of its 1975 level (figure 5-22). Industrial use of petroleum is up by 26 percent over 1975 consumption, but transportation oil use is up 93 percent over the same period [USDOE EIA 1999a].

Figure 5-22

Petroleum Use in the U.S. Economy: 1975-99 (Annual totals)



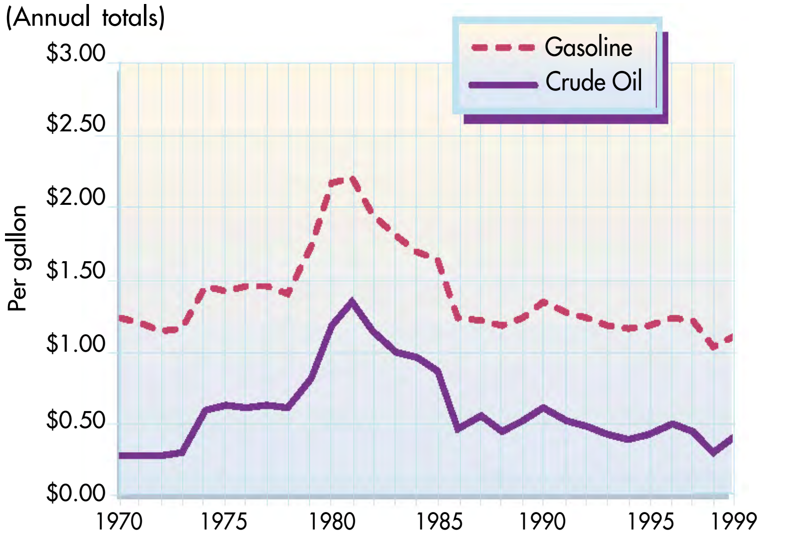
Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1999*, table 5.12, available at www.eia.doe.gov/emeu/aer/petrol.html, as of June 23, 2000.

The continuing growth of petroleum use by transportation, combined with declining domestic oil production, has resulted in increasing U.S. dependence on imported petroleum. In 1998, for the first time in U.S. history, net imports exceeded 50 percent of U.S. petroleum supply [USDOE EIA 2000]. In 1973, the year of the first OPEC-driven oil price shock, net imports to the United States totaled 6 million barrels of oil per day (mmbd), while the United States produced 11 mmbd. In 1999, domestic production was down to 7.8 mmbd, while net imports were 9.6 mmbd [USDOE EIA 2000]. Still, today there is much less public concern over the issue of petroleum imports than there was at the time of the 1977 *Trends and Choices* report.

More than a decade of lower oil prices, as low as $10 a barrel (bbl) during the winter of 1998-1999, and abundant supplies during most of the 1990s may explain the apparent lack of concern by U.S. citizens (figure 5-23). The realization that oil prices are unlikely to rise forever, that what went up could also come down, and a strong economy also helps explain our relative complacency in the face of the highest levels of oil imports on record, even in the face of recent gasoline price increases. But, higher prices for petroleum products in 2000 have raised the issue of oil dependency in the public consciousness, once again.

Figure 5-23

Crude Oil and Gasoline Prices: 1970-99 (Chained 1996 U.S. dollars)
(Annual totals)



Note: Gasoline prices are for regular leaded (1970-75) and for regular unleaded (1976-99).
Source: U.S. Department of Energy, Energy Information Administration, available at http://www.eia.doe.gov/emeu/aer/petro.html, tables 5.19 and 5.22, as of June 23, 2000.

The costs of past oil dependence were real and substantial, and the doubling of world oil prices between January 1999 and January 2000 as a result of production cutbacks by Organization of Petroleum Exporting Countries (OPEC), with the cooperation of Mexico, Norway, and Russia, suggest that oil dependence may reemerge as a serious concern for transportation and the economy in the not-too-distant future. Estimates of the economic costs of past oil price shocks and the anticompetitive influence of OPEC on world oil markets are numbered in the trillions of dollars, and prospective analyses indicate that a single future shock could cost hundreds of billions of dollars [Greene, Jones, & Leiby 1998]. When oil prices are suddenly increased by the exercise of market power, oil consumers suffer three kinds of economic costs [Greene 1997]. First, an energy price increase, whether due to geologic scarcity or cartel-created scarcity, signals to the economy that less can be produced with the same amount of capital, labor, and materials. The increased economic scarcity of a basic resource reduces the Gross Domestic Product (GDP) the economy is able to produce when all resources are fully employed. Second, when prices increase suddenly, the economy is unable to respond immediately to the changed price regime. As a result, there is less than full employment of productive resources and a further, temporary loss of GDP. The size of these economic losses will depend on the importance of oil in the economy and its ability to substitute other energy sources for oil. The transportation sector has so far shown little capacity to replace oil with alternative energy sources.

Finally, a cost to the U.S. economy (but not to the world economy) is the transfer of wealth from oil consumers to oil producers, which is caused by the noncompetitive price increase. The loss to the U.S. economy is equal to the price increase times the amount of oil imported. For example, the recent OPEC-orchestrated price increase from approximately $10/bbl in the winter of 1998/1999 to $25/bbl in the fall of 1999 increased U.S. wealth transfer by approximately $15/bbl. With imports exceeding 9.5 mmbd, the daily loss of wealth amounted to $142 million or over $50 billion on an annual basis. For comparison, total expenditures on the nation's highways by all levels of government are approximately $100 billion per year [USDOT FHWA].

There are military, strategic, and geopolitical costs of oil dependence as well. Though these components are less readily measured, their importance should not be underestimated. In addition, inappropriate responses to oil price shocks can increase their cost. For example, tightening money supply to curb the inflation caused by an oil price increase, rather than accommodating it, can unnecessarily slow economic growth.

Global Trends: Around the world, the rates of growth of motorized transport and its energy use exceed those in the United States. From 1973 to 1996, world transportation energy use (of which petroleum comprises 96 percent) increased by 66 percent, from 950 million metric tons (Mtoe) to 1,580 Mtoe [IEA 1999]. Over the same period, U.S. transportation energy use grew by only 32 percent. Petroleum's share of world transportation energy use also increased slightly, from 94.7 percent to 96.0 percent. Globally, road transport accounts for more than 70 percent of transportation energy use, and light duty vehicles are responsible for about 50 percent, very similar to the U.S. statistics [IEA 1999].

The growth of world transportation energy use and its petroleum dependence is driven by the long-term trend of increasing motorization of the world's transportation system and the ever-growing demand for mobility. Just after World War II, the world's motor vehicle fleet numbered 46 million vehicles, of which 75 percent were in the United States. In 1996, there were 671 million motor vehicles in the world, and the U.S. share was only 30 percent. Whereas the U.S. motor vehicle population has been growing at 2.5 percent per year since 1970, the rest of the world's stock has been growing at nearly twice that rate to 4.8 percent per year [MVMA 1998].

Keys to the Future

Future Energy Requirements: Projections of future transportation energy requirements foresee continually expanding energy needs. The U.S. Energy Information Administration anticipates a 77 percent increase in total world transportation energy use over 1996 levels by 2020, an average annual rate of growth of 2.4 percent [USDOE EIA 1999d]. Continued petroleum dependence is expected as world motor vehicle stocks surpass 1.1 billion in 2020.

Vice President Al Gore has been instrumental in new initiatives to meet key energy challenges. With his leadership through the Partnership for a New Generation of Vehicles and the 21st Century Truck Initiative, businesses are developing innovative technologies that promise dramatic increases in automotive fuel economy – reducing our reliance on imported oil while saving consumers money. Pursuing the strategies of promoting clean energy alternatives and reducing fuel use in the federal government vehicle fleet by 20 percent by 2005 will help ease reliance on imported oil.

The World Energy Council has produced a series of scenario projections for future world transportation energy use, with annual growth rates ranging from 0.9 percent to 2.2 percent, implying 26 percent and 92 percent increases, respectively, in 2020 over 1990 [WEC 1993]. Passenger travel and associated energy use have been projected over a much longer period, to 2050, using the concepts of constant travel time and money budgets [Schafer & Victor 1999]. Their analysis foresees global passenger travel growing from 23 trillion passenger-kilometers in 1990 to 105 trillion in 2050. Increasingly wealthy travelers are expected to shift to faster modes of transportation.

All of these forecasts foresee ever increasing demands for energy by the world's transportation systems—systems that, today, are all but totally dependent on petroleum for energy. Experts disagree over whether there will be adequate sources of low-cost, environmentally acceptable energy for transportation well into the 21st century. But, few would disagree that continued advances in the technologies of energy supply and transportation energy efficiency must be achieved.

Available Energy Resources: Running out of energy is not a problem for transportation as it enters the 21st century. The world's hydrocarbon resources appear to be sufficient to last for a century, but at a potentially high cost to environmental damage, potential climate change, and vulnerability to the costs of oil market manipulation. Conventional oil reserves total about 1 trillion barrels, but reserves measure known amounts ready to be produced at prevailing prices and are more a measure of the oil industry's inventory than an estimate of the total geologic resources.

The U.S. Geological Survey (USGS) [Masters et al. 1994] puts the world's ultimate resources of conventional petroleum at 1.7 trillion barrels, enough to last 46 years at current consumption rates, 33 years if oil consumption continues to grow at 2 percent per year (table 5-5). Some geologists point out that it is unreasonable to expect a smooth drawdown of resources to the last drop [Campbell & Laherrère 1998]. These analysts predict that when cumulative oil production exceeds 50 percent of the world's ultimate resources, oil production will decline. There is general agreement that the 50 percent point will be passed during the first two decades of the 21st century. If production does begin to decline, higher prices and greater market power for OPEC producers can be anticipated.

Oil industry analysts point out that, presently, only an average of 34 percent of the oil in the ground is recovered and that technological advances have and likely will continue to increase recovery rates, perhaps to 50 percent [Porter 1995]. This would expand ultimate resources of conventional oil to 2.8 trillion barrels, enough to last 117 years at current consumption rates, but only 60 years if consumption continues growing at 2 percent per year (table 5-5). But conventional oil is not the only resource from which transportation fuels can be made.

Table 5-5

World Petroleum Resources

Resource	Cumulative quantity (Trillion barrels)	Years remaining: Current consumption	Years remaining: Consumption growing 2% annually
Proven reserves	1	42	30
USGS identified reserves	1.1	46	33
Ultimate resources	1.7	71	44
Enhanced recovery 34% to 50%	2.8	117	60
Unconventional oil resources	3.4	142	67
Oil shale and tar sands	17.4	725	137

Current consumption rate of 0.024 trillion barrels per year.

Source: C.D. Masters, E.D. Attanasi, and D.H. Root. "World Petroleum Assessment and Analysis," *Proceedings of the 14th World Petroleum Congress* (New York, NY: John Wiley and Sons, 1994).

Venezuelan heavy oils are already beginning to be produced and processed into fuels as are Canadian oil sands. The United States contains vast deposits of oil shale that, at a higher cost and with greater environmental damage, can be made into gasoline or distillate fuel. If these resources are considered usable, 137 years of growing world petroleum demand could be accommodated. Moreover, natural gas can be converted into clean, low-emission distillate fuel and even gasoline, but growing demand for natural gas by other users will have to be outbid, or ways will have to be found to make use of the vast methane deposits in coal seams and in the form of methane hydrates [USDOE 1998]. The USGS estimates that the United

States' gas hydrate resources alone range from 100 to 700 quadrillion cubic feet with a mean estimate of 200 quadrillion, 20 times the optimistic estimate of remaining world reserves of conventional gas, roughly equivalent in energy content to conventional petroleum reserves.

Technology and Policy Options: Transportation can improve its energy sustainability by increasing the energy efficiency of transportation vehicles, developing the ability to use cleaner alternative energy sources, reformulating existing fuels and developing improved emissions control technologies for existing power plants, and increasing system efficiency.

The future holds enormous potential for both energy-efficiency improvements and alternative fuels. As a result of industry and governmental research and development, transportation technology has progressed substantially, especially for light-duty highway vehicles [Greene DeCicco 2000]. The U.S. Partnership for a New Generation of Vehicles (PNGV) has made considerable progress toward its goal of tripling fuel economy while reducing pollutant emissions and maintaining safety and all consumer amenities [NRC 1999].

Similar research and development efforts are underway in Europe and Japan. Japanese manufacturers have introduced lean-burn gasoline, direct-injection engines capable of improving fuel economy on the order of 20 percent. In Europe, direct-injection, light-duty diesel engines, which improve fuel economy 40 percent over modern gasoline engines, have captured nearly half of the passenger car market. One European manufacturer offers such engines in the United States. And, for the first time, an ultra-low emission hybrid vehicle is being offered for sale in the United States in model year 2000, following the success of a hybrid passenger car introduced in 1997 in Japan. The U.S. hybrid achieves 65 miles per gallon, making it the most efficient passenger car in the United States. Pollution-free fuel cell vehicles seemed a remote possibility just a decade ago. But rapid advances in power density, cost, and systems improvements have led to fully functional prototype fuel cell cars being demonstrated by major manufacturers around the globe and promises of commercial models by 2005. The successes of light-duty vehicle technology research and development suggest that other modes might achieve similar advances. At present, promising technologies have been identified for heavy trucks, aircraft, rail, and marine transport, but these receive far less attention, even though their combined energy use accounts for 40 percent of transportation's total.

Public policy will play a critical role in creating a sustainable transportation energy future; technological progress may need policies to speed implementation in the short term. At present, all of the advanced technologies mentioned above face one or more barriers to success in the marketplace. In the case of direct-injection gasoline and diesel engines, the hurdle is meeting ever tighter emissions standards. In the case of hybrid vehicles, cost reduction is the key issue, and fuel cells still face a number of technical and economic challenges. In an environment of relatively low fuel prices, even with recent price increases and abundant supplies, consumers are, generally, more interested in acceleration and size of their vehicles and less sensitive to fuel efficiency. If hydrogen fuel cell vehicles are to succeed, considerable effort will be needed to create an efficient and safe transition to such a radically different energy source. History suggests that different policies will work best for different modes and circumstances. Moreover, history also suggests technological and institutional evolution work best in concert with market forces and when they reinforce other important societal goals.

Transportation will always require energy. Achieving sustainable energy for transportation will require that pollutant emissions fall faster than traffic grows, that greenhouse gas emissions are controlled to acceptable levels, that dependence on oil is reduced, and that energy resources for transportation expand faster than they are consumed.

Environment

The effects of transportation on the environment are complex and widespread. Air, water, land use, and animal habitats, are just a few of the areas affected by transportation. Often, these impacts are not fairly distributed—a fact that is taken into consideration in many planning processes today (see box 5-4 on environmental justice). But, we have come a long way in recognizing and dealing with environmental impacts over the past 25 years, in large part reflecting environmental laws enacted in the late 1960s and early 1970s. These include the National Environmental Policy Act (NEPA) of 1969—the basic charter for environmental protection—requiring an environmental impact statement for every major federal government project; the creation of the U.S. Environmental Protection Agency (EPA) in 1970 to oversee the nation's efforts to clean up the air and water; the Clean Air Act and the Resource Recovery Act, both enacted in 1970; the Clean Water Act and the Ocean Dumping Act, both of 1972; the Endangered Species Act of 1973; and the Safe Drinking Water Act of 1974.

"In the new century, innovations in science and technology will be the key not only to the health of the environment, but to miraculous improvements in the quality of our lives and advantages in the economy"

President William J. Clinton
State of the Union Address
Jan. 27, 2000

This section outlines several problem areas with which we grappled over the past 25 years, including air quality, global climate change, water quality, noise, solid waste, and land-use and habitat.

Box 5-3

Sustainability

As we enter the 21st century, it is apparent that we must not only consider the ramifications of transportation for relatively short-term problems such as air and water quality; we must also consider the relationships between our transportation systems and the degree to which natural ecosystems and livable communities can be nurtured and sustained in the long term.

The most frequently cited definition of sustainability was adopted by the World Commission on Environment and Development (known as the "Brundtland Commission"): "A sustainable condition for this planet is one in which there is stability for both social and physical systems, achieved through meeting the needs of the present without compromising the ability of future generations to meet their own needs." This definition acknowledges that sustainability has social and community, as well as physical dimensions, and is the most broadly accepted definition of "sustainability."

Transportation systems produce environmental, economic, and social equity effects, characterized as the "Three Es." Transportation systems can be considered sustainable to the extent that they contribute, in the short- and long-term, to national goals, including reduced greenhouse gas emissions, healthy ecosystems, enhanced biodiversity, reduced air and water pollution, reduced dependence on finite fossil fuel supplies, and affordable access to economic and social opportunity. Transportation decisions can be considered more or less sustainable in terms of how they produce and balance these effects. The challenge for decisionmakers is to achieve an appropriate balance.

The USDOT is laying the foundation for this broad-based approach to sustainability as related to transportation. The Department has formed a Center for Climate Change and Environmental Forecasting, which is conducting research and development solutions that can address long-term environmental problems while accomplishing other national transportation goals. The Center is the USDOT's focal point for technical expertise on transportation and climate change. One of its primary goals is to develop compliance and multimodal approaches to reduce transportation-related greenhouse gases. The USDOT also has launched Smart Growth initiatives focused on the interaction between transportation investments and land use. These, and related initiatives, will address both current and future challenges in enhancing and preserving communities and the natural environment.

Box 5-4

Environmental Justice

Community groups have raised concerns and challenges about the disparate impacts from and inequities in transportation services, including environmental quality effects on minority populations and low-income populations.

In 1994, President Clinton issued an executive order to address environmental justice. The order directs each federal agency to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." The executive order and accompanying presidential memorandum emphasize that agencies should use existing laws to achieve this goal.

The USDOT issued an order in 1997 that incorporates environmental justice principles throughout its programs, policies, and activities. The order also sought to integrate the executive order's goals with the existing requirements of such laws as NEPA, Title VI of the Civil Rights Act of 1964, and the Uniform Relocation Assistance and Real Properties Acquisition Policies Act.

Environmental justice principles must be considered during the transportation planning process. Proposed new planning and environmental regulations will provide guidance on how states can demonstrate consistency in environmental justice principles.

Air Quality

Over the past 25 years, the United States has made significant progress in reducing air pollution. For highway vehicles, this success resulted primarily from improvements in vehicle fuel systems, the use of catalytic converters to treat combustion products, and the development of cleaner burning fuels. These changes have occurred because of a combination of scientific and engineering innovations and regulations. Aircraft emissions also have been reduced, largely through international standards.

Federal standards for light-duty vehicle emissions were put in place in the 1960s and have become increasingly stringent over time, covering not only tailpipe emissions but also fuel evaporation. Standards for heavy-duty highway vehicles were adopted in the 1970s; they, too, have become more stringent over time. The EPA has proposed new emission standards for heavy-duty vehicles to take effect in 2001 and diesel fuel requirements, lowering sulfur levels from the current 500 parts per million (ppm) to 15 ppm by 2006. In the 1990 Clean Air Act Amendments, the EPA's responsibility for mobile source regulation was expanded to cover "nonroad engines and vehicles," including ships and locomotives.

Box 5-5

Cold Starts

Motor vehicle exhaust emissions are controlled by catalytic converters. The catalyst requires heat to reach the temperature at which it functions most efficiently; thus, there is a delay before it reaches operating temperature. Since emissions during normal operation have been dramatically reduced, now about 70 to 80 percent of the nonmethane hydrocarbons that escape conversion by the catalysts are emitted during the first two minutes after a cold start. Several engineering techniques are being developed to warm catalysts up more quickly so they can better control emissions. In the absence of such technologies, many transportation specialists recommend strategies such as reducing the number of trips or chaining trips to reduce cold starts. In 1998, eligibility under the Congestion Mitigation and Air Quality Improvement Program was expanded to allow funding for projects intended to reduce emissions from extreme cold-start conditions.

For the first time, the EPA published regulations this year in February 2000 covering both vehicles and fuels as an integrated system under the "Tier II" standards. These standards require a reduction in tailpipe emissions and lower sulfur content. The regulations specify acceptable ranges for some fuel qualities (e.g., volatility, sulfur content). And in areas of the country with severe ozone problems, the EPA requires the use of reformulated gasoline to reduce emissions.

For the six air contaminants known as criteria pollutants, EPA establishes air quality standards based on maximum acceptable atmospheric concentrations. The six contaminants are:

1. carbon monoxide (CO),
2. sulfur dioxide (SO_2),
3. lead (Pb),
4. nitrogen dioxide (NO_2),
5. ozone (O_3), and
6. particulate matter less than 10 microns (PM_{10}).

States that fail to meet the standards must develop State Implementation Plans (SIPs) specifying how they will reach these standards. These SIPs must also contain enforceable requirements to keep emissions within necessary levels.

Since 1990, regulatory developments have been complemented by significant changes in transportation planning. These changes have occurred because of provisions in the 1990 Clean Air Act Amendments and the 1991 Intermodal Surface Transportation Efficiency Act

Box 5-6

Air Quality and Transportation Planning

In many areas, transportation planning is subjected to the conformity process. Transportation emissions must remain within levels projected by State Implementation Plans (SIPs) that, when implemented, will lead to attainment of air quality standards. Transportation plans and programs, therefore, must "conform" with air quality goals. This process is the result of more than three decades of legal and regulatory evolution. The current Transportation Conformity regulation was adopted in 1993 and amended in 1997.

The enaction of the National Environmental Policy Act (NEPA) in 1969 established a framework for collaboration between federal agencies and those who will bear the environmental, social, and economic impacts of agency decisions. NEPA further established a requirement that decisions about development projects, such as highway and airport construction, be informed by analyses of environmental impacts. Although this law established procedures for such analyses, it provided little guidance about how project decisions should be made. It also had a project-specific focus that did not necessarily lead to consideration of the integrated impact of multiple projects in a region.

Amendments to the Clean Air Act in 1977 added a requirement prohibiting metropolitan planning organizations from adopting plans that did not conform to an approved SIP and authorized the USDOT to withhold federal highway funding in cases of nonconformity. Guidance from the USDOT and the EPA required the timely implementation of any transportation control measures included in a SIP. Clean Air Act Amendments in 1990 provided more specific requirements for conformity determination. The Intermodal Surface Transportation Efficiency Act of 1991 solidified the connection between conforming requirements and the use of transportation funding.

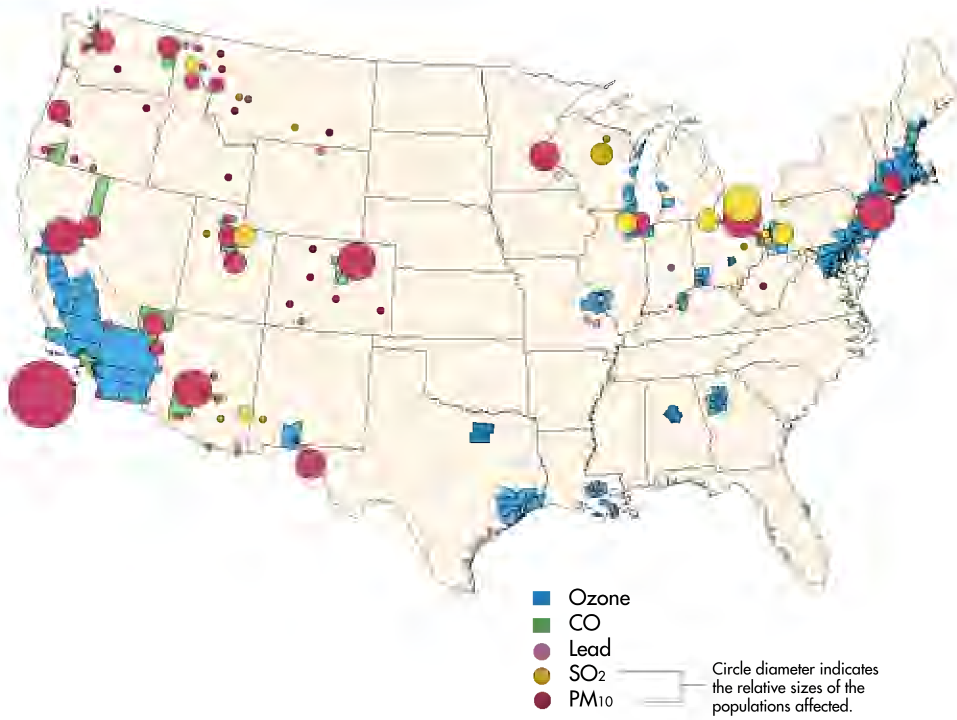
Subsequent regulations and legislation have further defined these requirements and made them more flexible. However, the underlying philosophy that transportation plans and programs must conform to air quality plans has not changed.

(ISTEA), which was subsequently updated by the Transportation Equity Act for the 21st century (TEA-21) in 1998. ISTEA and TEA-21 also allow a portion of fuel tax revenues to be used to fund public transit systems and other specific projects to reduce congestion and improve air quality.

Despite dramatic reductions in air emissions by mobile sources and measurable improvements in the nation's air quality, some areas do not meet the standards set by the EPA for the six criteria pollutants. These nonattainment areas, as of 1998, are shown in figure 5-24. At that time, 113 million people were affected by the air quality in these areas.
Historical trends vary for criteria air pollutants emitted by transportation. For example, lead has been virtually eliminated since the late 1980s, while nitrogen oxide (NO_x) has generally increased since the late 1980s.

Figure 5-24

Nonattainment Areas for Criteria Pollutants: 1998



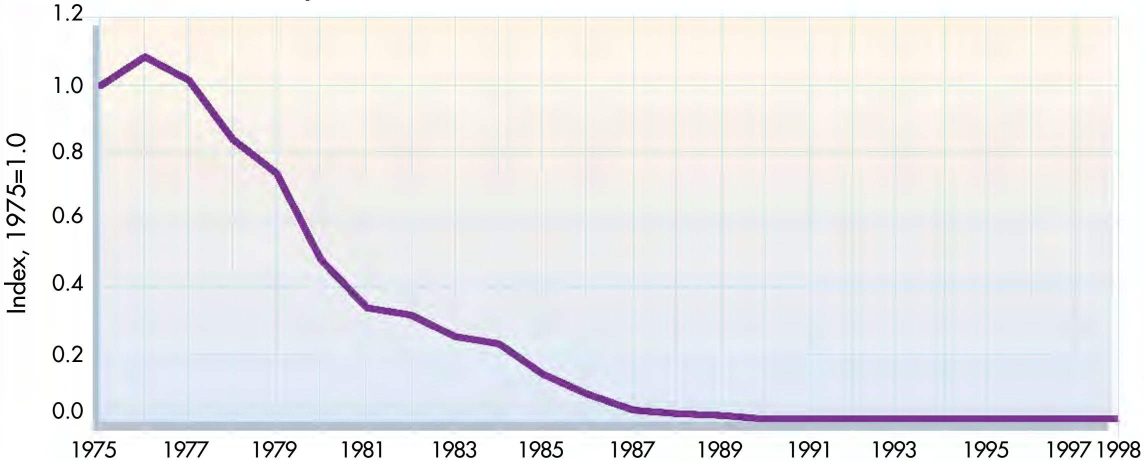
Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *National Air Quality and Emissions Trends Report, 1998* (Washington, DC: 1999).

By banning the use of lead in gasoline, the United States has virtually eliminated transportation sector emissions of lead (see figure 5-25) [USEPA 1998]. As a result of this ban and other lead control measures, such as restrictions on the use of lead in paint, lead levels in children's blood are down more than 80 percent from levels experienced in the late 1970s [Jacobs 1999].

In a period during which vehicle-miles traveled (VMT) rose considerably, emissions of volatile organic compounds (VOCs) and carbon monoxide (CO) have declined since the mid-1970s. However, emissions of NO_x have not declined (see figure 5-26). NO_x and VOCs contribute to the formation of ground-level ozone (i.e., smog), which causes pulmonary health problems. Ozone and NO_x also damage aquatic ecosystems, forests, and agricultural crops. CO contributes to cardiac health problems. These data reflect national emissions. Emissions in many areas of the country have fallen further and faster in response to the implementation of regional strategies such as vehicle inspection and maintenance and clean fuel programs. Emissions of particulate matter smaller than 10 microns (PM_{10}) can contribute to pulmonary health problems (figure 5-27). Much of the improvement over the years is attributable to improvements in diesel engine technology and diesel fuel quality.

Figure 5-25

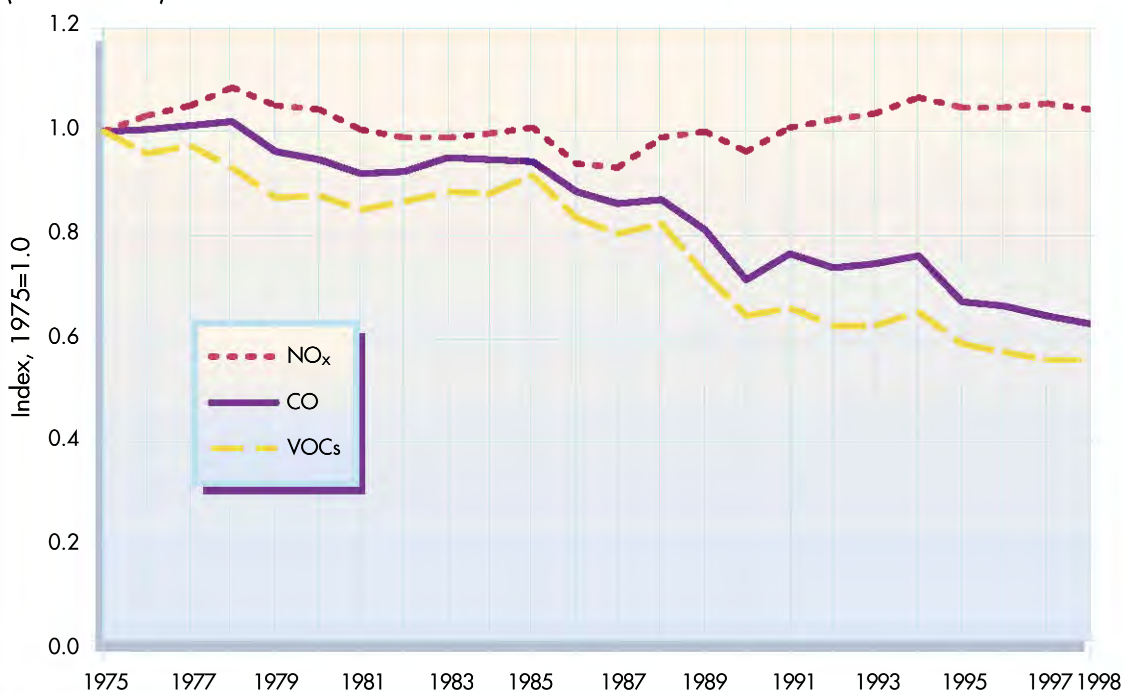
Lead Emissions from Transportation: 1975-98 (Annual totals)



Source: U.S. Environmental Protection Agency, Office of Air and Radiation, Air Quality Planning and Standards, *National Air Pollution Emission Trends, 1900-1998*, EPA 454/R-00-002 (Washington, DC: 2000), available at http://www.epa.gov/ttn/chief/trends98/trends98.pdf, as of June 28, 2000.

Figure 5-26

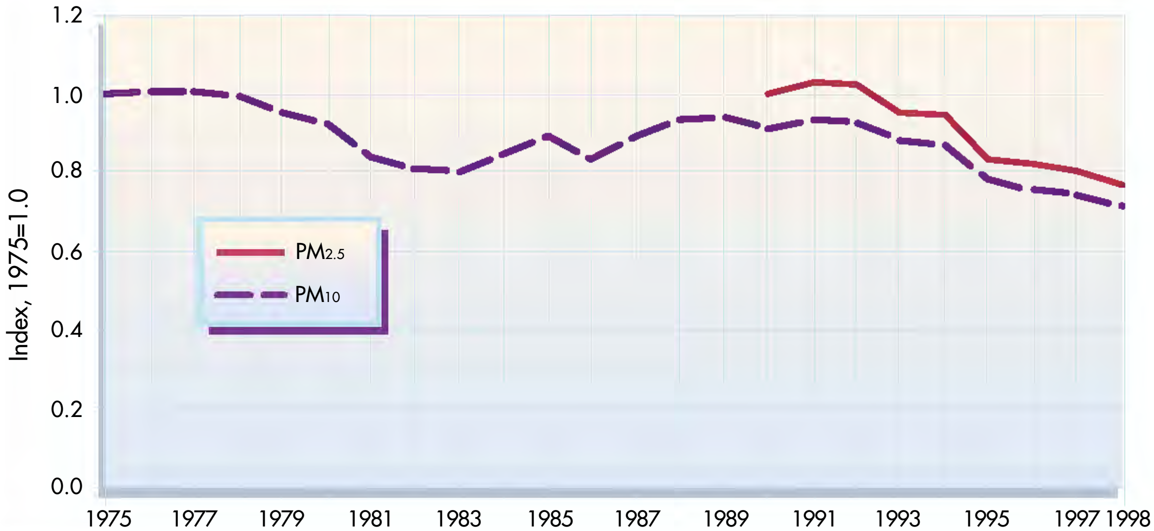
VOCs, NO_x, and CO Emissions from Transportation: 1975-98
(Annual totals)



Source: U.S. Environmental Protection Agency, Office of Air and Radiation, Air Quality Planning and Standards, *National Air Pollution Emission Trends, 1900-1998*, EPA 454/R-00-002 (Washington, DC: 2000), available at http://www.epa.gov/ttn/chief/trends98/trends98.pdf, as of June 28, 2000.

Figure 5-27

Particulate Emissions: 1975-98
(Annual totals)



Source: U.S. Environmental Protection Agency, Office of Air and Radiation, Air Quality Planning and Standards, *National Air Pollution Emission Trends, 1900-1998*, EPA 454/R-00-002 (Washington, DC: 2000), available at http://www.epa.gov/ttn/chief/trends98/trends98.pdf, as of June 28, 2000

Reductions in emissions from the transportation sector, as well as from other sectors (in particular, electric utilities), have resulted in improvements in measured urban air quality from 1988 to 1997. Although directly comparable air quality measurements from the 1970s are scarce, emissions trends suggest that improvements from the late 1980s to the late 1990s represent a continuation of air quality improvements [USEPA 2000b].

In 1997, EPA tightened the standards for ozone and particulate matter. A court decision has prevented EPA from implementing the tighter ozone standard; however, the agency has appealed the decision. The Supreme Court has agreed to hear the case in the 2000-2001 timeframe.

Box 5-7

Transportation Demand Management and Air Quality
Transportation Demand Management (TDM) is a strategy used to reduce travel on the nation's roadway system in large urban areas that have both high levels of traffic congestion and poor air quality. The strategies typically include carpooling, transit use, pedestrian, and cyclist programs. TDM is not a new concept, having been first used during World War II to reduce civilian fuel consumption and, again, during the energy crisis of the 1970s.

The Clean Air Act Amendments of 1970 included a reduction of auto emissions through the promotion of ridesharing and public transit. Large metropolitan areas submitted transportation control plans that included regulatory measures, including driving reductions.

Box 5-7 continued

Transportation Demand Management and Air Quality

The 1974 Emergency Highway Energy Conservation Act authorized the creation of regional rideshare programs, high occupancy vehicle (HOV) lanes, and park-and-ride lots. The Federal Energy Act, also passed in 1974, provided corporate tax incentives for the purchase of ride-sharing vans. The 1992 Comprehensive Energy Policy Act added more incentives through the Commuter Choice incentive program. This program was expanded in 1999 to include a pretax option that employers could offer as an incentive to transit and ridesharing employees. The federal government as an employer has spearheaded attempts to encourage telecommuting, transit use, and alternative work schedule arrangements. For instance, on October 1, 2000, by executive order, all federal employees in the National Capital region became eligible for up to $65 per month in transit benefits.

Mandatory programs requiring businesses to reduce their employees' commuting trips began to spring up in the mid-1980s. These programs were included in the 1990 Clean Air Act Amendments as a mandated measure for areas with the worst pollution and as an optional measure for those with less serious problems. These mandates were changed to voluntary options under legislation passed in 1995. Some metropolitan areas, such as Washington, D.C., now include voluntary trip reduction programs in their transportation and air quality planning processes. Trip reduction has been part of the debate surrounding urban sprawl; sustainability; and, lately, the push for "livable communities."

Box 5-8

Bicycle and Pedestrian Alternatives

Although bicycling and walking are two of the oldest forms of transportation, their role in the U.S. transportation system has changed significantly over the last 25 years. In the late 1970s, both were recognized as energy-efficient modes that could be used for shorter trips or in combination with other modes, such as mass transit, for longer trips. Given that a large part of harmful emissions are released within the first two minutes of starting cars, walking and bicycling on short trips were increasingly recognized as good for air quality. However, these transportation modes were sometimes overlooked when projects and programs were planned and implemented.

This began to change in the 1990s as a result of federal legislation such as ISTEA and TEA-21. Pedestrian and bicycle projects and programs must now be part of the planning process at the state and Metropolitan Planning Organization (MPO) levels. Increasingly, states have allocated additional funding for such projects.

The USDOT is supporting these forms of transportation by expanding funding and setting goals to increase their use and to make them safer. Goals call for doubling the percentage of trips made by bicycling and walking and for reducing the number of injuries and fatalities attributed to these activities by 10 percent.

Keys to the Future

Nitrogen oxide and unburned hydrocarbon emissions are projected to continue declining in response to more stringent regulations related to fuel quality and vehicle emissions, although an upturn, in response to increased travel, is still possible over the longer term.

Beyond 2010, further reductions in particulate matter might be available through more stringent emission standards and/or more stringent fuel-quality requirements. The groundwork has been laid so in the future, emissions of some hazardous air pollutants should decline significantly as fuel quality improves. The same types of changes that have enabled air-quality improvements, cleaner vehicles and fuels, and

"There's no doubt that clean-fuel vehicles are coming to the mass market. The billion dollar question is which one or ones will get there first and when?"

Mortimer Downey
Deputy Secretary of Transportation
Natural Gas Vehicle Coalition
Minneapolis, Minnesota
Oct. 5, 1999

cleaner industrial and electrical generation facilities likely will continue in response to technological improvements and ongoing regulation.

Through the Partnership for a New Generation of Vehicles (PNGV), government and industry are collaborating on developing prototype passenger vehicles that would achieve up to a tripling in fuel economy without increasing life-cycle cost and without compromising safety, performance, or convenience. Lightweight structural materials, hybrid electric power trains, and hydrogen fuel cells show promise toward meeting this goal. Such technologies also can significantly improve the efficiency of medium- and heavy-duty vehicles, a goal the federal government is pursuing through the Advanced Vehicle Technologies Program (AVP) and other incentives. AVP goals include tripling the fuel economy of transit buses and doubling that of freight trucks (see discussion in Chapter 6 Technology). If manufacturers are ultimately successful in marketing vehicles that meet AVP and PNGV goals, the long-term growth of emissions could be reduced significantly.

"The key (to reducing green-house gases) will be reducing the carbon intensity of our trans-portation sector, which can be done in three ways: by encouraging more efficient travel practices, by making transportation more fuel efficient, and by adopt-ing fuels that will emit less carbon."

Mortimer Downey
Deputy Secretary of Transportation
Washington, D.C.
Dec. 9, 1998

Air quality in the year 2025 will almost certainly be better than it is today. These improvements will probably be achieved in all sectors, but perhaps most significantly from mobile sources where the benefits of some regulations like those on heavy duty trucks and small engines are just starting to be realized. The improvements will be driven by the continuing importance the American people place on a healthy environment, which will result in increasingly stringent governmental and private sector attention to air quality. New technologies and fuels will be the mechanisms by which air quality gains are made. Electric hybrid vehicles, fuel cell engines, and new fuels—from reformulated petroleum products and entirely new sources like biomass—will be commonplace through widespread commercialization and "green marketing." Interestingly, these improvements will come despite ever increasing demand for travel. All travel modes will experience this increased demand as wealth, leisure time, and market globalization expand, but none so much as aviation. Yet despite these increases, extremely low and even zero-emitting engine-fuel combinations will represent a large part of what is now the complete set of internal combustion engines. Americans will have cost- and convenience-competitive choices in every class of engine. Such innovations will continue to be developed and introduced into the marketplace, completely offsetting any increases in emissions due to the volume of travel.

In the coming decades, the Marine Transportation System will provide environmentally sound transportation of people and goods, which can relieve congestion in other transportation modes, thereby reducing some unintended environmental impacts, including air pollution. Ferries increasingly will provide an environmentally sound alternative. The ferry system in New York and Washington State, for example, will continue to provide significant commuter links. The Puget Sound ferries, which today carry 23 million passengers per year, and the Alaska ferries will remain vital transportation links to homes and businesses.

Global Climate Change

In the last quarter century, the scientific evidence of human impacts on global climate patterns has mounted. It is now commonly recognized that the buildup of greenhouse gases in the atmosphere could cause increased average global temperatures; higher average sea levels that inundate some wetlands and low-lying coastal areas; more intense droughts, storms, and floods; extended growing seasons; and an expansion in the geographic range of insect-borne diseases such as malaria. Moreover, the emissions that contribute to the greenhouse effect remain in the atmosphere for much longer periods than do emissions affecting air quality. Most of the CO_2 released in 2000 through fossil fuel combustion will still be in the atmosphere at the beginning of the 22nd century.

Carbon dioxide is the dominant greenhouse gas emitted by transportation. It is produced in approximate proportion to the amount of petroleum used, and its production can only be reduced by burning less fossil fuel (i.e., through energy efficiency or use of alternative fuels). Transportation sources account for about 26 percent of greenhouse gas emissions, and transportation sector greenhouse gas emis-sions have increased by nearly 40 percent since 1975, in parallel with increases in transportation sector energy consumption (figure 5-28) [USDOE EIA 1999e]. Contributing factors include growth in travel; a significant market shift away from automobiles and toward trucks and sport utility vehicles (SUVs); and petroleum prices during the 1990s that, adjusted for inflation, were much lower than past levels.

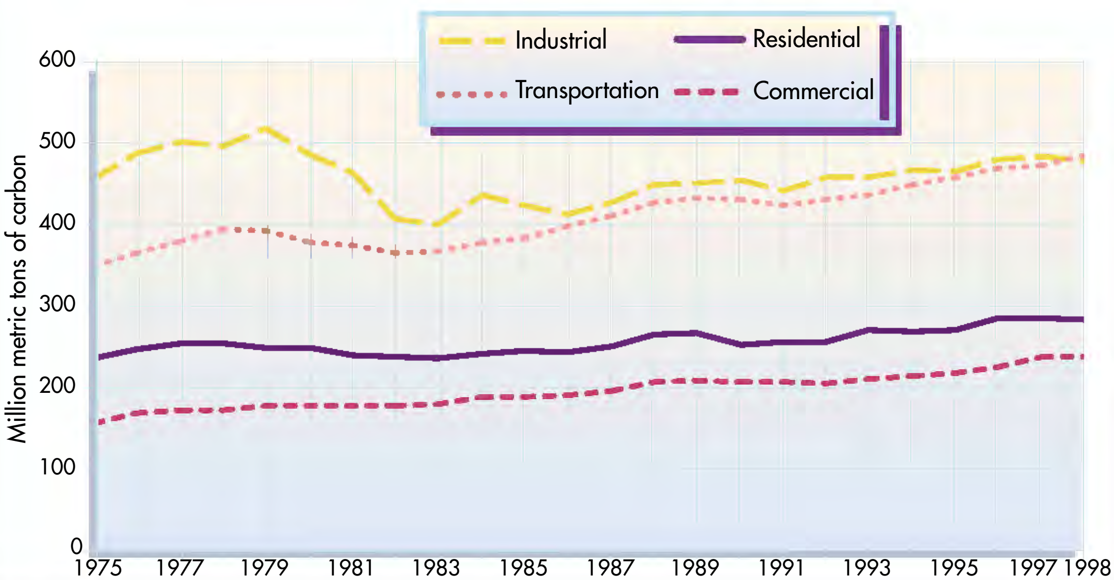
"Just last week, automakers unveiled cars that get 70 to 80 miles a gallon, the fruits of a unique research partnership between government and industry. And, before you know it, efficient production of biofuels will give us the equivalent of hundreds of miles from a gallon of gasoline."

President William J. Clinton
State of the Union Address
Jan. 27, 2000

Greenhouse gas emissions from private vehicles (cars and light trucks) increased by about 12 percent from 1990 to 1997 and accounted for about 70 percent of that period's overall growth in transportation greenhouse gas emissions. Emissions from other trucks and buses grew much faster—21 percent over the same period—accounting for most of the remaining overall growth. About 95 percent of these emissions were from medium- and heavy-duty trucks.

Figure 5-28

Carbon Dioxide Emissions by End-Use Sector: 1975-98
(Annual totals)

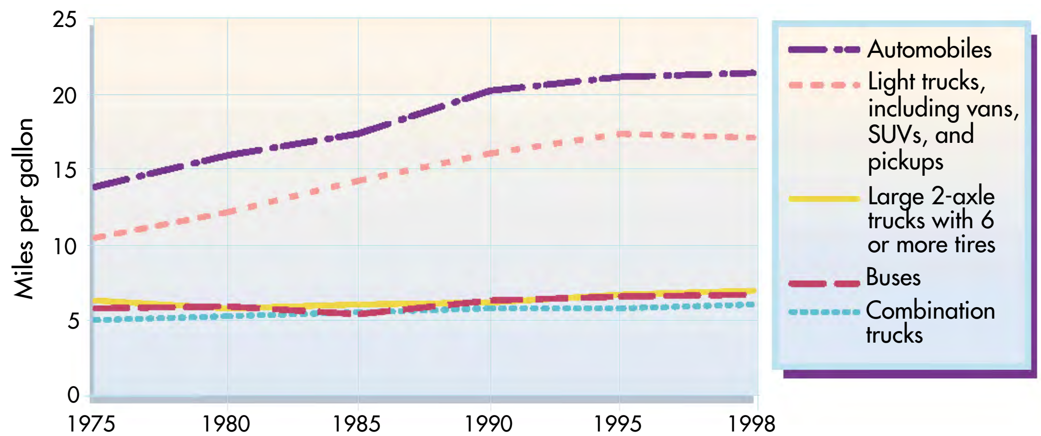


Source: U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States, 1998* (Washington, DC: 1999).

Because transportation greenhouse gas emissions are the direct result of fuel combustion, the nation's transportation-related energy trends and policies have had a major impact on the direction of levels of greenhouse gas emissions. A key energy policy step was passage of the Energy Policy and Conservation Act of 1975, which mandated Corporate Average Fuel Economy (CAFE) standards for each new car fleet. As a result, the average fuel economy of automobiles and light trucks increased by 54 percent and 63 percent, respectively, between 1975 and 1998 (figure 5-29). These measures were not adopted in response to climate change, but they have reduced the growth rate of CO_2 emissions. However, in the last few years, the growth in energy efficiency of automobiles and light trucks has slowed.

Figure 5-29

Average Fuel Economy of Highway Vehicles: 1975-98



Note: This figure shows results for the entire fleet of operating vehicles, not just new ones. It is derived from estimates of vehicle travel and total fuel consumed.
Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Annual issues).

As scientific recognition of the climate change problem grew in the 1980s, the public in the United States and elsewhere became increasingly interested in finding solutions. In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was negotiated in Rio de Janeiro to establish a framework for a global response to this problem. The ultimate pur-pose of the Convention is to stabilize atmospheric greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic interference with the climate system." A prominent feature was the nonbinding aim of returning to 1990 greenhouse gas emission levels by the year 2000 in developed countries. The United States was one of 184 (as of May 2000) countries that ratified the Rio accords; we did this in 1992.

The overall growth in transportation greenhouse gas emissions is indicative of the significant difficulties the United States, like many other developed countries, has experienced in making progress toward the voluntary goal under the Rio accords. Instead, transportation sector greenhouse gas emissions have grown since 1992 and are projected to grow significantly over the next 20 years.

In October 1997, President Clinton set out his goals for both international negotiations and domestic actions and proposed a shift from nonbinding aims to binding targets. He identified the nation's six climate change principles:

"The Kyoto Agreement is based on the simple idea that it will not be government bureaucrats or regulators, but free markets and free minds that will be our best bet to win the battle against global warming, while lifting the lives and the hopes of citizens around the world … I believe the American people can meet the challenge of global warming and end up with a better and stronger economy in the process."

Vice President Al Gore
Dec. 11, 1997

1. policies should be guided by science;
2. policies should rely on market-based, common-sense tools;
3. win-win solutions should be sought;
4. global participation is essential;
5. the United States will not adopt binding obligations without developing country participation; and
6. policies should be informed by common-sense economic reviews conducted every 5 years.

In December 1997, the third Conference of the Parties under the UNFCCC adopted the Kyoto Protocol, which has as its central feature a set of binding emission targets for developed nations. The specific limits vary from country to country, although those for the key industrial countries of the European Union, Japan, and the United States are similar: eight percent below 1990 levels for the European Union, seven percent for the United States, and six percent for Japan.

Box 5-9

Greenhouse Gases Governed by the Kyoto Protocol

Carbon dioxide (CO_2)
Methane (CH_4)
Nitrous oxide (N_2O)
Hydrofluorocarbons (HFCs)
Perfluorocarbons (PFCs)
Sulfur hexafluoride (SF_6)

The Protocol allows nations with targets to save money by meeting those targets as blocs, rather than on a country-by-country basis. The emissions targets are to be reached over five-year budget periods, the first of which will be 2008 to 2012. The emissions targets include six major greenhouse gases, and they may be offset through activities that absorb carbon, such as forestation.

Because climate change is a global problem, the Protocol provides flexibility in meeting emission reduction targets. It allows for emission trading so countries can purchase less expensive emission permits from countries that might reduce their emissions more easily. The Protocol addresses greenhouse gases from international aviation and marine transportation by requiring nations to work through the International Civil Aviation Organization and the International Maritime Organization.

In the United States, the Protocol becomes binding only with a two-thirds majority vote of the Senate. In addition, it will not enter into force until it is ratified by at least 55 countries, collectively accounting for 55 percent of developed countries' 1990 emissions. The Clinton-Gore Administration's proposed strategy for complying with a binding cap on domestic emissions in the Kyoto Protocol emphasizes reliance on domestic and international emissions trading. The United States signed the Kyoto Protocol, but the Clinton Administration stated it will not submit the Protocol to the U.S. Senate for its advice and consent until there is meaningful participation by developing countries.

"We have a chance to completely rewrite the transportation future of America, to dramatically reduce the one-third of our greenhouse gases that come out of transportation, and do it without some crippling regulation or some astronomical tax."

President William J. Clinton
U.S. Conference Of Mayors
Breakfast Reception
Jan. 28, 2000

Keys to the Future

An important way to limit future transportation greenhouse gas emissions is to increase reliance on fuels made from renewable resources. For example, Argonne National Laboratory has estimated that it is possible to achieve emission reductions of up to 25 percent by switching to corn-based ethanol fuels now; and, with wider use, a reduction of about 30 percent might be possible by 2005 [Wang et al. 1999]. However, because of issues such as cost and land availability, ethanol appears unlikely to displace more than 10 percent of gasoline consumption in the near future.

Other fuels show less promise at this time. Natural gas may provide modest greenhouse gas benefits, relative to gasoline, but can actually increase overall greenhouse gas emissions, relative to diesel fuel. When produced from renewable resources, hydrogen and electricity have the potential to virtually eliminate greenhouse gas emissions when they can be substituted for gasoline. However, the infrastructure does not exist to produce, distribute, or deliver hydrogen fuel on a widespread basis. Electric vehicles also are limited by infrastructure; and without breakthroughs in battery performance and cost, pure electric vehicles appear unlikely to significantly penetrate the market.

Although policies, such as purchasing requirements and tax incentives, have successfully increased the number of alternatively fueled vehicles and the use of alternative fuels, the transportation sector is still 95 percent dependent on petroleum. Moreover, despite the promise of these technologies and fuels, the cost and the pace of fleet turnover could limit their impact in the next 20 years. Five national energy laboratories recently projected that under favorable conditions, the combined effect of advanced vehicle technologies and alternative fuels could reduce transportation sector greenhouse gas emissions in 2015 by 25 percent relative to "business as usual" [ORNL et al. 1997]. This same analysis also projected that growth during that time could offset much of these reductions so that net emissions could remain at 1997 levels.

In the 1990s, domestic electric utilities gained considerable experience with emissions trading through the Clean Air Act sulfur dioxide permit-trading program. It is not yet clear whether or how the transportation sector might participate in an emissions trading program, although general concepts have been outlined; the USDOT's Center for Climate Changes and Environmental Forecasting is researching this issue.

Under one option, with *energy-source-based* emissions trading, refiners and refined product importers could be required to hold permits covering the projected emissions of transportation fuels sold by them for domestic use. Alternatively, under a *manufacturer-based* approach, transportation vehicle manufacturers and importers could be required to hold permits covering the projected future emissions of vehicles offered for sale. There are important policy, administrative, and technical differences among these and other potential approaches. Since reducing the transportation sector greenhouse gas emissions may be difficult, emissions trading among sectors and across countries might provide needed flexibility if a binding cap on overall domestic emissions is adopted.

Water Quality

The major direct source of water contamination from the transportation sector comes from oil and fuel leaks and spills, particularly from tankers, motor vehicles, and above- and below-ground fuel storage tanks. Oil spills from tankers can have major impacts on nearby ecosystems, aquatic species, wildlife, and birds, but the extent and severity of environmental contamination vary greatly with the location and size of the spill. Even a small amount of petroleum in the groundwater system can contaminate large quantities of water.

Runoff from roads, infrastructure construction, and the deterioration of discarded vehicles also have an impact on surface and groundwater quality. The amount and magnitude of highway runoff depend on traffic characteristics, maintenance activities, and climatic conditions, as well as the location of the road itself. For example, runoff from roads and parking lots has a higher than normal concentration of toxic metals, suspended solids, and hydrocarbons, which alter the composition of surface and groundwater. In northern regions, the application of road salts in winter is another concern. Increased sodium levels in water and surrounding soils can damage vegetation.

Moreover, transportation infrastructure may cause changes in the local water table and drainage patterns by increasing the share of rainwater that becomes runoff. This affects the soil moisture content of the area, which, in turn, may alter vegetation and wildlife. The construction of transportation facilities also may result in the destruction of wetlands. Wetlands are areas that are neither fully terrestrial nor fully aquatic. They range from the vast cypress swamps of the southern United States to shallow holes that retain water only a few weeks of the year. Wetlands can provide critical habitat for migratory waterfowl, control flooding, act as natural filters for drinking water, and provide recreation.

The largest threat to U.S. waterways remains petroleum in transport; of the 198 billion gallons spilled since 1975, 75 percent of it spilled during transportation. Nevertheless, oil spilled into U.S. waters in the 1990s has been much less than in the late 1970s and 1980s. From 1990 through 1998, the average annual amount of oil spilled was 2.6 million gallons, compared with 9.5 million in the 1980s, and 16.0 million from 1975 through 1979 [USDOT BTS 1999]. The improper disposal of used motor oil is a widespread source of groundwater and surface water contamination. According to EPA estimates, of the 714 million gallons of used motor oil collected annually in the early 1990s, 161 million gallons (23 percent) were disposed improperly [USEPA 1994].

Groundwater contamination often is caused by leaks from underground storage tanks, such as those found at local gasoline service stations, which have a history of leaking due to corrosion, overflows, and spills. Most underground storage tanks are used by the transportation sector. In response to legislation, EPA set up the Underground Storage Tank (UST) Program in the mid-1980s to remediate leaking tanks and establish regulations on leak detection and tank standards. Data reported to EPA by states, as of September 1998, show that the country has almost 900,000 active tanks, and that 1.2 million tanks have been closed and more than 300,000 cleanups initiated since 1990. There are 168,000 known releases not yet cleaned up [USEPA 1998].

Spills from aboveground storage tanks (ASTs) also are a source of groundwater contamination. ASTs at transportation facilities serve two primary functions: 1) to provide breakout storage or overflow relief at small pumping stations, and/or 2) to provide short-term storage at tank farms/distribution facilities. Spills from these facilities are often due to overfill, failure of tank bottoms, improper disposal of tank-bottom contaminants, and leakage from piping associated with tanks. A 1994 American Petroleum Institute (API) survey found improved spill prevention and reduced incidents of environmentally unsound disposal practices at refining, service station, and transportation facilities operated by API member companies [API 1994]. The survey did not yield information regarding incident frequencies or accidental release volumes.

Runoff from streets, parking lots, and airports is another source of water and groundwater contaminants. Motor vehicles are the primary source of pollutants, except during periods of snow and ice when deicing chemicals and abrasives predominate. Pollutants derive from, among others, tire and brake lining residue, gasoline, oil, grease, and hydraulic fluids. The nature and extent of damage nationally from highway runoff is still being studied. Aircraft deicing and ethylene or propylene glycol-based chemicals at airports are other sources of runoff contaminants. The total amount of aircraft deicing fluid (ADF) released by U.S. airports is uncertain and varies from year to year with weather, number of aircraft departures, and size and type of aircraft. EPA estimates that the United States released a total of about 28 million gallons of ADF per year to surface waters prior to 1990, when new practices for managing stormwater were implemented. Current discharges to surface waters are estimated to be 21 million gallons of ADF, with another 2 million gallons being discharged to publicly owned treatment works [USEPA 2000c].

The advent of increased environmental awareness and legislative action in the early 1970s paved the way for the preservation of wetlands and water quality. The Federal Water Pollution Control Act of 1972 and The Clean Water Act of 1977 significantly strengthened federal requirements. These laws clarified the intent of wetlands protection, strengthened the control of pollutant discharges from point sources, and eventually led to a national program to protect waters from pollutants introduced by stormwater runoff.

Additional Clean Water Act amendments in 1987 strengthened the stormwater program and instituted new measures, giving rise to greater areawide or watershed-based management approaches. Subsequent regulations were issued controlling the discharge of runoff from temporary construction sites and, in larger municipal areas, stormwater in general.

Mitigation for water quality impacts has always been an eligible activity on newly proposed transportation projects as part of the project development and the environmental review process established with NEPA. ISTEA and TEA-21 provided for and expanded funding for wetlands banking, environmental restoration, and pollution abatement. Environmental restoration returns the habitat, ecosystem, or landscape to a state as close as possible to its predisturbance condition and function. Since natural systems are diverse and dynamic, the process of recreating or duplicating their natural, or presettlement, state is virtually impossible. Therefore, the goal of the restoration is to reestablish the basic structure and function associated with recent predisturbance conditions. Pollution abatement includes the retrofit or reconstruction of stormwater treatment systems. In essence, a proposed restoration project will include analysis of the water quality impact from a previous highway project, in relation to a watershed plan for the area, and correct any past deficiencies in a stormwater treatment plan. These costs can be funded with federal highway dollars.

Since 1968, successive Presidents and Congresses have responded to the health and environmental threats posed by inadvertent releases of oil and hazardous substances by passing several major pieces of legislation. The Federal Water Pollution Control Act of 1972 is the principal federal statute protecting navigable waters and adjoining shorelines from pollution caused by oil and hazardous substance releases. Regulations based on this act detail specific requirements for pollution prevention and response measures. The EPA and U.S. Coast Guard (USCG) implement these provisions. EPA implements the legislation through a variety of regulations and programs, including the National Contingency Plan (NCP). The NCP (more properly known as the National Oil and Hazardous Substances Pollution Contingency Plan) was first developed in 1968 in response to 37 million gallons of oil spilled off the coast of England in 1967 from the Torrey Canyon oil tanker. To avoid the kinds of problems faced in this incident, officials developed a coordinated approach to cope with future incidents in U.S. waters. The 1968 plan provided the first comprehensive system of accident reporting and spill containment and cleanup. The NCP also established a response headquarters, a national reaction team, and regional reaction teams, which were precursors to the current National Response Team and Regional Response Teams.

Over the years, Congress has broadened the scope of the NCP. The Plan was revised in 1973 to include a framework for responding to hazardous substance spills, as well as oil discharges. Following the passage of Superfund legislation in 1980, the NCP was again broadened to cover emergency removal actions at hazardous waste sites on land. The latest revisions to the NCP were passed in 1994 to reflect the oil spill provisions of the Oil Pollution Act of 1990 (OPA-90), which was enacted largely in response to rising public concern following the Exxon Valdez spill in Alaska. OPA-90 required vessels and facilities that store and transport oil in bulk to develop response plans that ensure they have the equipment and manpower to respond to and mitigate a worst-case discharge. Additionally, it required the EPA and the USCG to develop stronger Regional and Area Contingency Plans concentrating on their area’s unique hazards and risks, including the planning for the potential use of alternate response technologies including dispersants and in-situ burning. As the beginning of a strong prevention initiative, OPA-90 enabled the USCG to initiate sweeping improvements to prevention, preparedness, and response. Using risk analysis and partnerships throughout the maritime community, over 42 regulatory projects were enacted. These changes have substantially reduced the risk of a pollution incident and have ensured increased vigilance by those transporting oil in our waterways.The Oil Pollution Act of 1990 also created the national Oil Spill Liability Trust Fund, providing up to $1 billion per incident for compensation if the spiller of the oil cannot be found or refuses to pay. In the latter case, the issue is settled in the courts.

The USCG's Port State Control (PSC) program ensures that foreign-flagged vessels calling at U.S. ports comply with the comprehensive safety standards of the International Maritime Organization. All foreign flag vessels have been subject to PSC exams to ensure that substandard vessels are identified and detained until safety deficiencies are corrected, thus reducing the risk of vessel casualties that may result in oil spills. This successful program resulted in a reduction of over 50 percent in the rate of such vessels discovered in U.S. ports between 1995 and 1999, and the downward trend is expected to continue as the quality of ships calling at U.S. ports continues to improve.

Hazardous liquid pipelines incurred an average of 200 incidents per year between 1988 and 1997 resulting in an average of 2 deaths, 16 injuries, $34 million in damages, and a net loss of 85,000 barrels of liquid per year. Outside damage and external corrosion were the primary cause of hazardous liquid pipeline incidents in 1997 [USDOT OPS 1998]. Natural gas transmission and distribution operators reported a 1988 to 1997 average of 215 incidents per year, resulting in 18 fatalities, 91 injuries, and $32 million in property damage. In 1997, the primary cause of natural gas pipeline incidents was the same as for hazardous liquid pipelines—damage from outside forces. For transmission pipelines alone, internal corrosion ranked second. At the conclusion of a 1996 liquid pipeline accident investigation, the National Transportation Safety Board recommended in late 1998 that the USDOT Office of Pipeline Safety make several changes to federal regulations to improve the pipeline industry's ability to prevent accidental releases caused by corrosion [USDOT OPS 1998]. In November 2000, the USDOT issued strong new requirements for large hazardous liquid pipeline operators to regularly inspect and promptly repair pipelines in populated and environmentally sensitive areas and to take systematic steps to detect and prevent leaks. Also the USDOT is taking steps to implement stronger pipeline safety standards, including improved enforcement, enhanced federal-state partnerships, increased public access to information, and more innovative technology. Together, these actions will help ensure that our oil and gas pipeline system is sound, our communities safe, and our environment protected.

Keys to the Future

Over the past 25 years, most water quality control efforts relied on broadly applied national programs that reduced pollution from individual sources, such as discharges from sewage treatment plants, industrial sites, and from polluted runoff. The result has been dramatic improvements in water quality throughout the nation. Today, there is a growing recognition that clean water strategies built on this foundation, but applied on a watershed scale, are the keys to the future. By 2025, universal application of consolidated and coordinated water resource management programs, coupled with dramatic advances in technology, will spell the end of water pollution as we know it today. The watershed approach in managing water resources and most other land-use issues will be applied uniformly throughout the nation. Such management will be commonplace in federal, state, tribal, and local governments and in private programs. There will be new collaborative efforts to restore watersheds that will involve all stakeholders, including transportation entities. Nonpoint source pollutant reduction programs will be highly successful in defining and treating water quality problems originating from diffuse sources.

Technology will match these management programs. Treatment facilities will be commonplace on highway facilities, such that no untreated roadway runoff having the potential to impact water quality will enter receiving waters. An abundance of inexpensive, yet highly effective, Best Management Practices will be available to highway designers to incorporate into road drainage system reconstruction and retrofit projects. Sources of pollution from roadways will also be controlled. The potential for water pollutant emissions will be a factor in the design of new vehicle propulsion systems, tires, lubricants, and structural components. Closed system lubrication will largely eliminate the oil and grease now common on roadway surfaces. Finally, the effectiveness of response to transportation-related water quality problems will dramatically improve. Spill response, crash clean-up, and other emergency actions will move from its infancy today to become a highly perfected, routine practice on future highways.

By 2025, many of today's challenges facing the nation's coastal-ocean interface will be a thing of the past. A strong risk-based network of regulations and partnerships to prevent spills from all sources coupled with an integrated planning and response capability from the local to the national level is a key to the future.

Noise Pollution

The transportation industry generates considerable noise pollution, which is defined as an intrusive, unwanted sound. Aircraft, trains, buses, automobiles, and other forms of transportation produce noise pollution that can lower the quality of life. Noise can be irritating or distracting and can disrupt sleep, all of which can be harmful to health. At extreme levels, or at high levels over a long period, noise can permanently harm hearing.

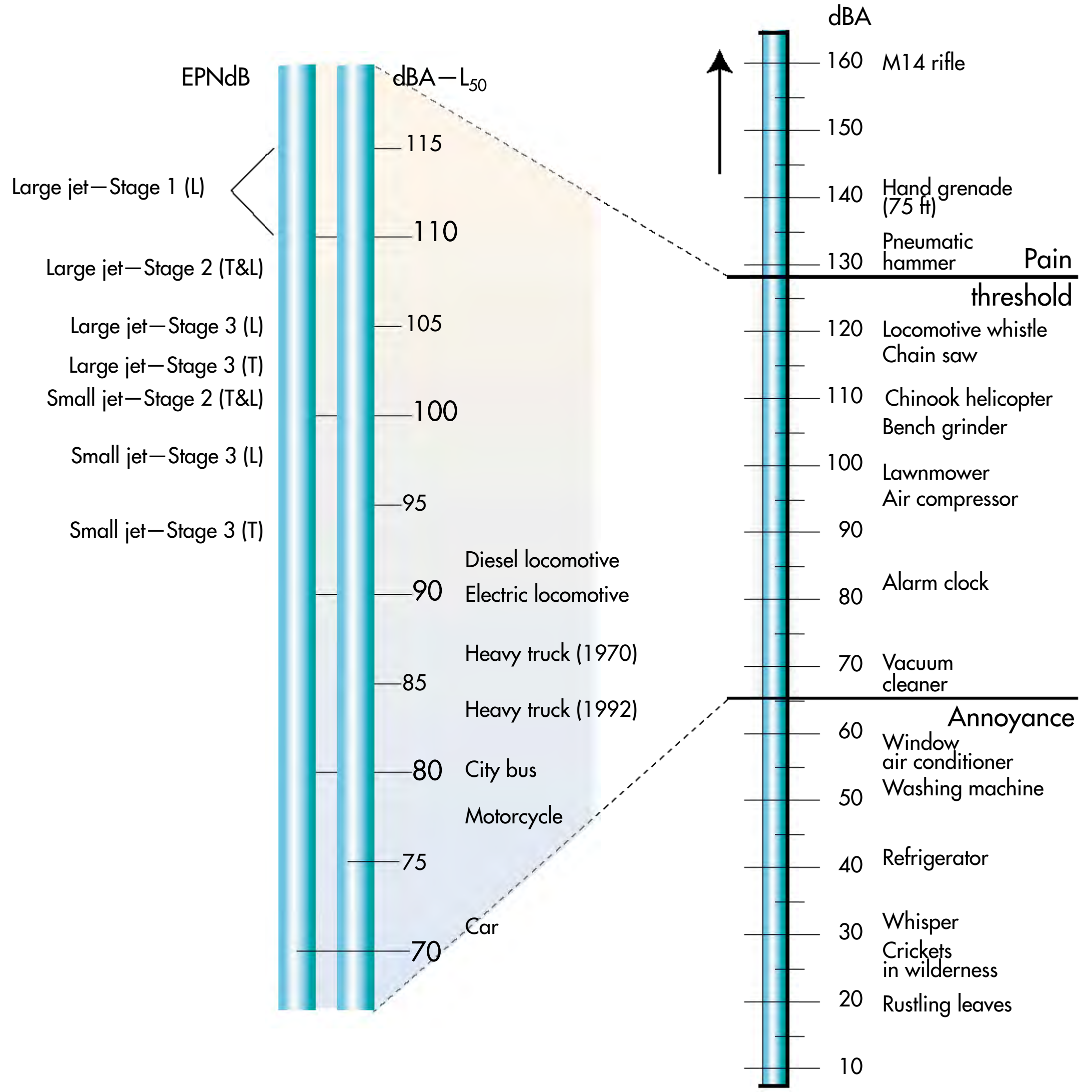
Sound is usually measured in decibels. The A-weighted scale, measuring the sound frequencies that humans can most easily hear, is the common reference point. As with the Richter Scale, which measures earthquakes, the measurements of decibels are nonlinear; a 10-decibel increase in sound on a scale of A-weighted decibels (dBA) represents a perceived doubling of sound. A vacuum cleaner operating 10 feet away is audible at 70 to 75 dBA. Noise becomes annoying at 65 dBA and painful at 128 dBA.

Noise is a purely local phenomenon, and its transmission is affected by both manmade structures and natural terrain. Therefore, because national or even regional measurements are nearly impossible, regulations are based on limiting the sources of noise pollution to safe levels. The federal Noise Control Act of 1972 authorizes the EPA to regulate transportation and other major sources of noise.

Selected vehicles are required to generate no more than certain levels of noise at prescribed distances. For example, trucks manufactured after 1988 are supposed to generate no more than 80 dBA. The limit for motorcycles varies from 70 to 80 dBA, depending on such factors as the year of manufacture. Locomotives built after 1979 must meet standards ranging from 70 to 90 dBA, depending on whether they are moving or stationary. Railcars moving at speeds above 45 miles per hour have a 93-dBA limit. Measurements are made 50 feet from the centerline of travel (figure 5-30) [USDOT FHWA 1994].

Figure 5-30

Transportation Noise Levels



Key: EPNdB = Effective Perceived Noise Level used to measure aircraft flyover noise during a specified 10-second interval. Included maximum audible sound level. Measurement is not comparable to A-weighted decibel scale.
dBA = A-weighted decibels (see text definition).
dBA—L_{50} = The sound level (measured in A-weighted decibels) exceeded by no more than 50 percent of the sample readings in the measurement time period. Peak sound level is not necessarily measured. Noise measured at a point 7.5 meters from highway vehicles and locomotives. Unless noted, highway vehicles are 1992 European models.
L = Landing noise over reference point 2,000 meters from runway threshold.
T = Takeoff noise over reference point 6,500 meters from start of takeoff roll.
Small jet = Commercial aircraft up to 100,000 lbs maximum takeoff weight.
Large jet = Up to 1,000,000 lbs maximum takeoff weight.
Stage 1 = Aircraft certified prior to 1969, before Federal Aviation Administration (FAA) noise regulations.
Stage 2 = Aircraft sound level needed to meet FAA 1969 noise regulations; now being phased out.
Stage 3 = Aircraft sound level needed to meet FAA's more stringent 1975 noise regulations.

Sources: Aircraft noise. adapted from 14 *Code of Federal Regulations*, Part 36, appendix C; Highway and railroad noise: P.M. Nelson, ed., *Transportation Noise Reference Book* (London, England: Butterworths, 1987) and T. Berge, Vehicle-Noise Emission Limits: Influence on Traffic Noise Levels Past and Future, *Noise Control Engineering Journal*, vol. 42, no. 2, March–April 1994; All other information adapted from Ann Arbor Science Publishers, Inc., *Environmental Impact Data Book* (Ann Arbor, MI: 1979).

A 1980s study estimated that 37 percent of Americans were exposed to noise levels exceeding 55 dBA from all sources; 10 percent were exposed to noise above 60 dBA; 7 percent were exposed to noise above 65 dBA; 2 percent were above 70 dBA; and 0.4 percent were above 75 dBA [OECD 1988].

Highway Noise: Highway noise is the most common form of transportation-related sound. The noise is produced by a combination of tires moving on pavement and the operation of engines, exhaust, and other vehicle systems. Traffic volume, vehicle speed, and vehicle mix are factors affecting the level of noise generated.

Highway noise can be mitigated through a variety of strategies, ranging from vehicle controls to highway design and land-use planning. Vehicle controls include quieter engines, engine sound enclosures, and improved mufflers. Proper vehicle maintenance, alone, can produce sound reductions in the 5 to 10 dBA range, and many localities enforce requirements restricting vehicle operating sounds to acceptable levels. Local agencies also sometimes employ various measures to prevent noise from affecting people, including limits on new development near roads, mandatory soundproofing, and the erection of noise barriers.

Highway design also is an effective countermeasure. Studies can determine a new roadway's potential impact on nearby communities. If the projected noise exceeds acceptable levels, alternative routes can be selected or other measures can be taken to construct the roadway in a manner that minimizes noise.

Finally, noise barriers—solid obstructions that separate roads from residences and other structures—can further reduce noise; reductions of 10 to 15 dBA are possible. Noise barriers also screen the view of roadways and can serve as a safety measure. For these reasons, their popularity as a solution to noise pollution has grown (table 5-6).

Table 5-6

Highway Noise Barrier Construction: 1970-98

	1970-79	1980-89	1990-98
Linear length (km)	281	925	1,397
Cost (millions $1998)	134	656	1,141

Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Traffic Noise Barrier Construction Trends* (Washington, DC: 2000).

Aviation Noise: Aircraft noise was a minor problem during aviation's first half-century, but the advent of commercial jetliners in the 1960s made it a much more serious issue. Although the noise from aircraft is not dangerous except in unusual or extreme circumstances, it can be disruptive to sleep and conversations.

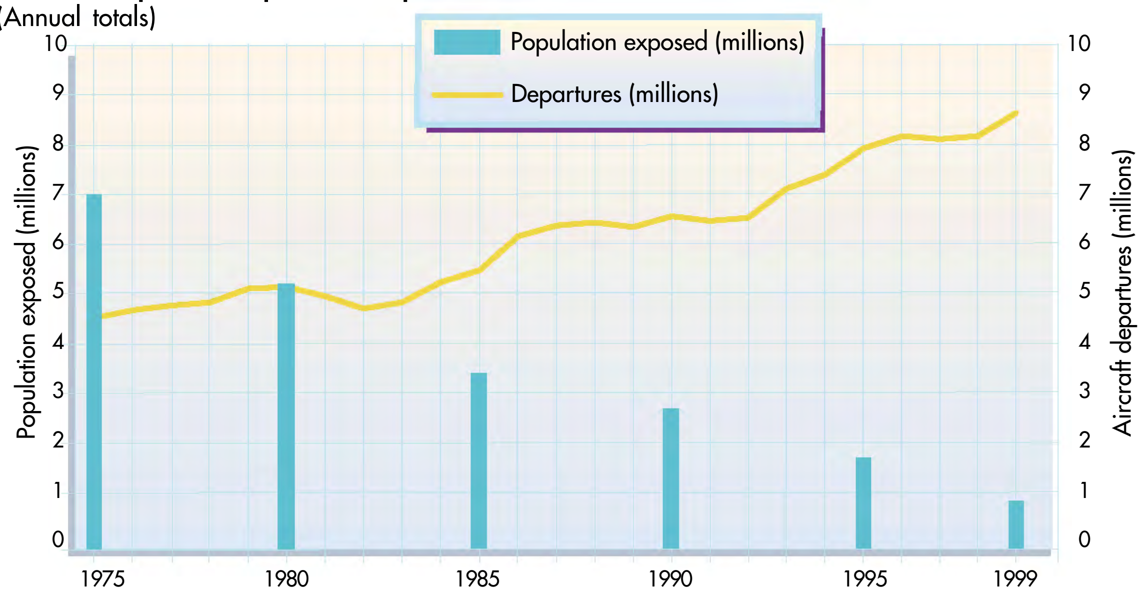
Amendments in 1968 to the Federal Aviation Act mandated standards and regulations for aircraft noise. The Federal Aviation Administration (FAA) adopted its first regulations the following year, establishing "Stage 2" standards for new turbojet and transport category aircraft. However, even in 1974, it was estimated that about seven million people were severely affected by aviation noise pollution. In 1976, the FAA required that existing planes be retrofitted to meet the Stage 2 standard.

Ensuing regulations have evolved to cover virtually all aircraft. These regulations have resulted in substantially lower noise levels for aircraft operating in the United States, as well as for the affected population (figure 5-31). Today, the average aircraft generates perceived loudness of about 25 dBA less than in the 1950s (a drop of about 80 percent in perceived loudness). Perceived loudness is a scale developed in the 1950s to measure the loudness of a jet aircraft by observers on the ground. The majority of these improvements resulted from the introduction of high-bypass-ratio engine designs.

Stage 3 aircraft were made mandatory by the 1990 Aircraft Noise and Capacity Act, which restricted noise levels to between 95 and 105 dBA (at a distance of 2,000 meters on landing approach and 6,500 meters on takeoff). All large aircraft operating within the United States had to meet Stage 3 requirements by the end of December 1999. This was accomplished, giving the United States the quietest aviation fleet in the history of the country. Many older, Stage 2 aircraft have been retrofitted with so called "hush kits" to bring them into regulatory compliance.

Figure 5-31

Estimated Population Exposed to Airport Noise Levels of DNL 65 dB or More: 1975-99
(Annual totals)



Sources: Exposure estimates: U.S. Department of Transportation (USDOT), Federal Aviation Administration (FAA), Office of Environment and Energy; Departures 1975-93: USDOT, FAA, *Statistical Handbook of Aviation (Washington, DC: Annual issues)*; Departures 1994-95: USDOT, Bureau of Transportation Statistics, *Airport Activity Statistics of Certificated Air Carriers: Twelve Months Ending December 31, 1995* (Washington, DC: 1996).

In January 2001, the International Civil Aviation Organization (ICAO) will meet to set international noise standards for the next several decades. This meeting will set the stage for future FAA actions. The Clinton-Gore Administration believes that the best way to achieve such noise reduction levels is to work through ICAO to establish a new Stage 4 standard and then implement that standard.

Keys to the Future

Highway traffic noise reduction is a shared responsibility. Thus, the Federal Highway Administration encourages state and local governments to practice compatible land-use planning and control in the vicinity of highways. Source control or control of noise emissions from the vehicles themselves is a joint responsibility of private industry and of federal, state, and local governments and will be an ongoing activity in the future. Noise abatement measures also will be considered and implemented if determined to be both reasonable and feasible. The construction of noise barriers will likely continue to be the most commonly used method. Future research efforts will strive to produce more cost-effective solutions and efficient allocation of resources to deal with the problems of highway traffic noise. Emphasis is anticipated in the areas of traffic noise prediction and abatement analysis.

The Federal Railroad Administration regulates noise based on standards developed by the Environmental Protection Agency. Operations in yards, particularly switching, is the primary source of railroad noise. By 2025, railroad traffic is expected to increase by nearly 75 percent;

and if we remain vigilant, we could stem the growth in railroad noise. As rail traffic increases and more people are exposed to railroad noise, pressure may grow to impose a more stringent train noise standard.

Because of the international nature of aviation, aircraft noise standards are established by the International Civil Aviation Organization (ICAO), a specialized agency of the United Nations. In 1991, ICAO's Committee on Aviation Environmental Protection, while retaining noise reduction at the source as the preferred option, agreed to pursue a "balanced approach" to noise. This approach would consist of reducing aircraft noise, developing procedures to make operations quieter, and land-use planning to minimize the number of homes and other incompatible uses near airports. Currently, airspace redesigns and remediation measures, such as land buyouts and residential insulation, play an important role in managing aircraft noise in the United States. Moreover, the U.S. Department of Transportation is currently working with NASA on developing even quieter airplanes, and is also working through the ICAO to establish and implement a new standard—Stage 4.

Solid Waste

Transportation generates a good deal of solid waste that is either recycled or ends up in landfills. Discarded vehicles and vehicle parts and abandoned infrastructure, such as pavement from highways or rail line materials, are the major elements of transportation-related solid waste. The maintenance of transportation infrastructure can also generate solid waste, the most notable of which is disposal of silt and other material dredged from ports and harbors.

Significant improvements have been made in dealing with these elements. Much of the material generated by scrapping automobiles is currently recycled. In 1994, nearly three-quarters of the 12.8 million tons of material generated from retired automobiles was recycled. The remainder (3.5 million tons) was placed in landfills [USDOT BTS 1999]. Between 1990 and 1998, the number of scrap tires stockpiled, landfilled, and dumped annually declined appreciably, while the annual number of scrap tires generated each year increased 10 percent. The number of tires used as fuel increased nearly fivefold, reaching more than 110 million. Nonfuel markets for processed and whole tires consumed 49 million scrap tires in 1998, three times the 1990 level. Export of scrap tires has increased more modestly since 1990, from 12 million tires in 1990 to 15 million in 1998 [USEPA 1991; Scrap Tire Management Council 1999].

The railroad industry also reuses and recycles much of its old infrastructure. Almost all rails removed from mainlines are reused on secondary lines, branch lines, or yard tracks. Other track materials such as fasteners, tie plates, spikes, and anchors are reused when possible, and components such as switch stands, joint bars, and switch plates are repaired and used or sold to short lines that need lower cost products. Materials that are not reusable are sold to brokers or directly to steel mills for recycling. Wooden ties are often repaired with a chemical plugging agent to fill holes, and are then reused. Those that cannot be reused are sold as landscape materials, parking bumpers, fence posts, and retaining walls or are sold to powerplants. Only the worst ties are placed in landfills. Like wooden ties, treated timber from bridges and other structures is either reused or disposed. Used concrete ties and most plastic rail-tie components are placed in landfills. Fine materials removed from ship ballasts that have been cleaned are occasionally reused on roads [Thompson & Morehead 1996].

Approximately 14 to 28 million cubic yards of contaminated material is dredged each year. This is estimated to be about 5 to 10 percent of all dredged material [NRC 1997]. Uncontaminated dredged material can be used for beach nourishment, wetland creation, and as caps for landfills, or it can be dumped in certain disposal sites in open waters. Contaminated material, on the other hand, may have to be treated to reduce its toxicity and managed using unique methods, increasing the costs of navigational dredging. Contaminants include heavy metals and other pollutants, such as dioxins and polychlorinated biphenyl (PCBs), that have been discharged into water and air. Contributing sources are industrial facilities within ports and upstream and nonpoint sources, such as transportation and agriculture. Contaminants reduce or injure fish and wildlife populations. Improper disposal of contaminated material can present costly environmental and human health risks.

Keys to the Future

Continued vigilance will be vital to reducing and reusing the many and varied types of solid waste generated by the transportation sector. Pressure to reduce and reuse solid waste will emanate from landfill capacity problems and NIMBY ("not in my back yard") sentiments, but also will be spurred on by technological innovations that reduce the amount of waste produced and which make recycling solid waste easier and more cost effective.

Land-Use and Habitat Effects of Transportation

The effects of transportation on land use and habitat include the impact of transportation on wetlands, the introduction of invasive species into ecosystems by transportation, and transportation and land-use interactions.

Wetlands: Since the early 1800s, the United States has lost or converted more than half of the wetlands that existed prior to European settlement. About 100 million acres of wetlands remain in the contiguous 48 states. Some states, such as California, Indiana, and Iowa, have lost more than 90 percent of their original wetlands. Much of this loss resulted from agriculture, urbanization, and infrastructure construction. In the 1960s and early 1970s, wetland loss was estimated at approximately 450,000 acres per year, primarily due to agricultural activities [USEPA 1996]. According to the U.S. Department of Agriculture resource inventories, the wetlands' rate of loss has, subsequently, declined to approximately 100,000 acres per year, not including those created or preserved through wetland restoration activities and programs, and now amounts to less than 50,000 acres per year. ISTEA and TEA-21 provided expanded funding for wetlands banking, which allows the mitigation of several or many projects at one location by combining funds to establish and manage larger wetlands complexes. This enhances wetlands functions and improves management while controlling costs.

Data on annual wetlands losses due to all transportation projects are not available, but those caused by federally funded highway construction have been available since 1996. Between 1,100 and 2,400 acres have been converted or lost annually since then (table 5-7). This represents less than 10 percent of the estimated total national loss or conversion and has been compensated at a rate of about 2.3 to 1, exceeding USDOT's performance standard of 1.5 to 1 [USDOT 1999]. In other words, wetlands are being replaced at more than twice the rate of loss in the federal-aid highway program.

Table 5-7

Wetlands Loss and Replacement for Federal-Aid Highways: 1996-99

	Acres impacted	Acres replaced	Recovery ratio	Target
1996	1,568	3,554	2.3:1	1.0:1
1997	1,699	4,484	2.6:1	1.0:1
1998	1,167	2,557	2.2:1	1.5:1
1999	2,354	5,409	2.3:1	1.5:1

Source: U.S. Department of Transportation, Federal Highway Administration, *Connecting America: 1999 Report to the Nation*, available at http://www.fhwa.dot.gov/reports/1999annual/, as of Sept. 25, 2000.

Invasive Species: Transportation influences water resources not only as a result of physical infrastructure, but also as a means by which species can be transferred between distinct ecosystems. One example of this type of problem is the zebra mussel. Zebra mussels are part of an environmental threat of invasions by non-indigenous species brought on, in part, by the increasing level of global commerce. Zebra mussels are thumbnail-sized freshwater mollusks that arrived in the United States through ship ballast water in 1986 and are projected to cause $5 billion in economic disruption to the Great Lakes region by the end of the year 2000. Since their discovery in Lake St. Clair in 1988, zebra mussels have spread throughout the Great Lakes; the Arkansas, Hudson, Illinois, Mississippi, Mohawk, Ohio, St. Lawrence, and Tennessee rivers; and other waters of southern Canada and the eastern United States. They also have been intercepted on boat trailers at four points in California.

"In its path, sprawl consumes thousands of acres of forests and farmland, woodlands and wetlands. It requires government to spend millions extra to build new schools, streets, and water and sewer lines. In its wake, sprawl leaves boarded up houses; vacant storefronts; closed businesses; abandoned, and often contaminated, industrial sites; and traffic congestion, stretching miles from urban centers."

Maryland Governor
Parris N. Glendening
A New Smart Growth Culture for Maryland

The mussels attach themselves to various surfaces, such as rocks, aquatic weeds, and industrial and residential water intake pipes. They rapidly form large reefs, reducing or blocking water flow through pipes used for municipal drinking water facilities, electric power generation, and industrial plants. By competing for the food and habitat of native species, the mussels can alter local aquatic ecosystems. They have also affected navigation, fishing, and the recreational use of beaches.

Earlier invaders, such as the lamprey and alewife, continue to affect Great Lakes fisheries. New England waters, such as Long Island Sound, are being invaded by new species on the average of one species every 36 months. The most common method of transport is via ballast water in oceangoing ships; although the organisms also can travel between lakes and rivers on boat hulls, on aquatic weeds caught in propellers, on boat trailers, and invisibly in bait buckets in their larval form. Other aquatic examples of species that have invaded U.S. ecosystems include:

- Asian clams, which filter the equivalent of the entire volume of northern San Francisco Bay more than once per day, severely disrupting the food chain;
- hydrilla, an aquatic plant that clogs waterways in 40 states and costs Florida $14 million per year to control; and
- purple loosestrife, another aquatic plant that has invaded 40 states, where it displaces native vegetation and disrupts ecosystems.

Urban Sprawl: Urban sprawl is a response to individual preferences and market signals. However, it also is the primary cause of numerous social and environmental problems, including the loss of farmland, forests, wetlands, and other natural habitats. Sprawl also is costly for government because the resulting development usually is served by new roads and single-occupant vehicles rather than more efficient transportation modes, such as mass transit, bicycling, or walking.

Sprawl is a complex, multidimensional phenomenon, with no easy solutions. There is no consensus about the severity and breadth of the problem because many of the contributing factors, such as single-family homes on large lots, low industrial and commercial structures, and abundant parking availability, are considered desirable.

Moreover, the role of transportation is not always clear. Partly this is a "chicken and the egg" question: does an extensive highway system lead to sprawl or do new highways handle the congestion created by growth? Some metropolitan areas, such as Phoenix and Milwaukee, have sprawled extensively without major highway systems. Others, such as Los Angeles, have extensive highway networks but have experienced little additional sprawl in recent years. Regardless, sprawl is inconsistent and does not occur across all metropolitan areas at the same rate.

Box 5-10

Characteristics of Sprawl

- Unlimited outward extension
- Low-density residential and commercial settlements
- Leapfrog development
- Fragmentation of powers over land use among many small localities
- Dominance of transportation by private automotive vehicles
- No centralized planning or control of land use
- Widespread strip commercial development
- Great fiscal disparities among localities
- Segregation of types of land use in different zones
- Primary reliance on the trickle-down or filtering process to provide housing to low-income households.

Source: Adapted from remarks by Anthony Downs at the University of Minnesota, Center for Transportation Studies, Transportation Research Conference, May 19, 1998, Minneapolis, MN.

The decentralization characteristic of urban sprawl is a phenomenon well entrenched in the American landscape. It was recognized as long ago as the 1920s. Researchers, at that time, identified causes of sprawl that are still applicable today: high urban property values, traffic congestion, inability to secure ample space, lack of choice locations, legal restrictions, and the desire to avoid urban problems.

"Investing in important mass transit projects...is key to rebuilding our cities and creating livable communities..." For hardworking Americans, who live in our metropolitan areas, the payoff is in a better quality of life."

Vice President Al Gore
Livable Communities Initiative
Press Release
Feb. 4, 2000

Keys to the Future

Wetlands: As the demand for wetlands mitigation increases, the costs of mitigation are expected to increase, even allowing for the increased efficiency of wetlands banking. Average mitigation costs for wetlands are expected to exceed the $20,000 per acre of mitigation provided in the immediate future and continue to increase as land values, performance demands, and technology costs increase.

The federal government also expects demands for compensatory mitigation to increase as regulatory agencies perceive continued threats and risks to existing wetlands and landscapes. This, combined with increases in the federal-aid highway program under TEA-21, is expected to result in slightly greater losses of wetlands due to additional construction, with even greater compensatory mitigation costs. The cost of compensatory mitigation in the federal-aid program is expected to exceed $100 million annually by 2010 if funding levels and construction programs continue at their current rate.

Invasive Species: The 1996 National Invasive Species Act is expected to help prevent contaminated ship ballast water from entering U.S. ports in the Great Lakes and across the country. As of July 1999, ships operating outside of U.S. waters must report their ballast water management practices to the USCG, which will enter the information into the National Ballast Water Information Clearinghouse database. The database will aid the USCG in identifying the patterns of ballast water management and delivery in U.S. waters. The USCG's ballast water program regulates discharges of ballast water in U.S. waters, while fostering the research and development of new technologies and management procedures that will greatly

Box 5-11

Clinton-Gore Livable Communities Initiative

Haphazard development patterns, disinvestment in older communities, and a deteriorating quality of life have led to concern about the livability of communities. Problems such as these, resulting from existing development patterns, have led many states and localities to adopt growth management laws over the past few decades.

Recently, these concerns have led to the "smart growth" or "livable communities" movement and the Clinton-Gore Administration's Livable Communities Initiative. The Livable Communities Initiative is aimed at broadening choices available to communities and empowering them to sustain prosperity and expand economic opportunity by strengthening local and regional economies, reclaiming brownfields, achieving a more favorable jobs-housing balance, and encouraging smart growth.

The initiative also seeks to enhance the quality of life by preserving open space; easing traffic congestion; securing safe streets; enhancing air and water quality; and ensuring that families have places and more time to walk, play, and relax with neighbors and friends. The initiative also hopes to build a stronger sense of community by creating community-centered schools, preserving local cultural heritage, and empowering individuals and communities with the information and tools they need to create the communities they desire. A whole range of initiatives has been developed in a variety of areas to accomplish this, including the Redevelopment of Abandoned Buildings Initiative, Regional Crime-Data Sharing, Community Transportation Choices, Land Acquisition Grants, and the Farmland Protection Program.

One way in which the U.S. Department of Transportation is supporting Livable Communities is by encouraging participation in transportation projects that include the use and redevelopment of contaminated "brownfield" sites when appropriate.

reduce the risks posed by shipping. Since invasive species are broadly recognized as a global problem requiring a global solution, there is a sense of optimism that the concerted efforts underway today to find technological solutions will be rewarded with significant breakthroughs soon. If we remain vigilant, by 2025, we will have developed environmentally sound methods to completely minimize the impacts of invasive species.

Urban Sprawl: Although urban sprawl is attributable to a series of factors, many have little relationship to transportation. Moreover, many of the factors contributing to sprawl are viewed as desirable by the public and, therefore, cannot be readily altered. However, factors such as home ownership and decreasing household size will change naturally over time, and their effects on sprawl will wane. It is likely that in the near future urban sprawl will be more a function of population growth; it is even conceivable that lower labor force participation rates, increasing household size, lower home ownership rates, and smaller lot sizes will contribute to more compact cities in the future. These offer promise toward declining rates of sprawl and need to be coordinated with new transportation initiatives to produce livable cities.

Box 5-12

Environmental Streamlining

Environmental streamlining refers to a new way of doing business to achieve both the timely completion of transportation projects and environmental protection. Enacted into law for highway and transit projects with the passage of TEA-21, environmental streamlining consists of cooperatively establishing and adhering to realistic project development schedules among government transportation and environmental agencies.

Because major transportation projects are affected by dozens of federal, state, and local environmental requirements administered by a multitude of agencies, such cooperation ensures that projects meet environmental standards without delay. Strategies include pilot efforts, process reinvention, alternative dispute resolution, and a focus on performance evaluation. Experience in implementing environmental streamlining may point to the need for revisions to transportation or environmental laws or regulations.

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chapter 6

Technology

"Just as in the 19th Century, when catalogs opened up retail markets and the railroads [transportation] made it happen, in the 21st Century, e-commerce will expand markets and again transportation will make it happen."

Ted Prince
Journal of Commerce
2025 Visioning Session, Atlanta, GA

"Technology will not reduce the need for travel, but change its nature and purpose and allow us to meet higher customer demands."

William W. Millar, President
American Public Transportation Association
2025 Visioning Session, Saint Louis, Missouri, June 13, 2000

"The PNGV showed us that partnerships work. We need to have more public-private partnerships on fuels, vehicle design, road design, mobility, transit, and intermodalism."

Curt Magleby
Ford Motor Co.
2025 Visioning Session, Mar. 29, 2000

chapter 6

Technology

Dramatic developments in advanced technologies have been the single greatest factor influencing changes in transportation during the past 25 years. In 1975, most of America's transportation infrastructure rested on technologies that were, in some cases, almost a century old. Since then, technology has quietly and thoroughly transformed the nation's transportation systems. We have harnessed the awesome power of technology to improve the safety, capacity, and efficiency of our transportation system. While vehicles and their guideways might appear relatively unchanged, internal changes are occurring rapidly. For example, in personal vehicles, microchips regulate engines; new technologies control the braking systems; and electronic tuning ensures cleaner engine burn. Additionally, vehicle components, materials, and systems are safer than they were 10 years ago. Flame-retardant materials have replaced flammable padding in cars, buses, trains, and airplanes; and a new generation of reinforced plastics has replaced conventional structural materials. Communication, information, and Global Positioning System (GPS)-based navigation are enabling efficient and safer travel. In aviation, aircrafts continue to become quieter, more efficient, and environmentally friendly; and tracking systems have revolutionized the freight industry.

Of the top 20 engineering breakthroughs of the 20th century, five were transportation related: the automobile, No. 2; the airplane, No. 3; the Interstate highway system, No. 11; space exploration, No. 12; and petroleum and gas technologies, No. 17 (electrification was No. 1).

National Academy of Engineering
National Engineers' Week 2000
February 2000

As infrastructure nears capacity, particularly in our urban areas, technology is helping to support continuing and growing demands. Advances in technologies for all modes—highways, transit, rail, air, maritime, and pipelines—promise to make our transportation system safer, more efficient, and environmentally friendly. Some of these technologies are described below.

- New information and communications systems have already transformed planning, design, development, maintenance, management, and control of our nation's transportation system. On our highways, video-monitored intersections and synchronized traffic lights are improving safety, capacity, and efficiency of urban and corridor travel. Positive Train Control systems have a similar potential to reduce collisions and improve efficiency by using the satellite-based GPS to monitor rail traffic. Travelers with computer terminals can conduct instant travel planning, reservations, ticketing, and rerouting through Internet connections for many kinds of trips and travel. Electronic tagging technology is used for diverse applications, such as automated toll collection on turnpikes and the automatic identification of freight train contents.

- Advanced material and structural technologies have led to new, environmentally safe, and corrosion-resistant materials with high structural strength (e.g., geosynthetics and fiber-reinforced composites) used in building safer vehicles. Other physical infrastructure improvements include durable recycled pavements and composite wrapping materials to reinforce older structures. New kinds of superconducting and magnetic materials may make high-speed ground transportation more attractive, and improved high-temperature alloys could lead to the development of hypersonic and orbital craft. The emergence of the field of nanotechnology (the building of devices and materials at the level of atoms and molecules) opens a new world of possible technology applications and lighter and stronger materials. For example, nanotechnology could allow for self-healing pavements, which would prevent cracks and other road damage.

- Energy, propulsion, and environmental engineering advances provide options to deliver improved transportation service that is less costly, more energy-efficient, and environmentally safe. A variety of new power plants for personal vehicles have entered operation on a test basis; hybrids that use gasoline-electric engines, and vehicles with alternative-fueled engines will have particularly broad impacts. The use of alternative fuels, such as natural gas, can reduce emissions of nitrogen oxides, energy costs, power plant maintenance costs, and dependence on foreign oil. Turbine-powered locomotives, now under development, are expected to accelerate implementation of high-speed rail corridor services throughout the country. New technology turbojet/turbofan, ramjet and scramjet (supersonic combustion ramjet), and linear aerospike engines could transform aviation during the next quarter century.

- Advanced simulation systems enable better evaluation of technological alternatives and allow more informed transportation investment decisionmaking.

- Improvements in information technology will facilitate timelines and improved data collection and dissemination.

Today's $300 billion telecommunications industry is becoming inextricably linked with the transportation system. Transportation moves people and products, while communications move data and ideas. The two systems provide a link and network for billions of users across the globe and reinforce each other's growth. GPS-aided in-car navigation and other satellite-based services serving multimodal transportation users become possible with real-time communication links to satellites. Geographic information systems will use real-time data from GPS to become a major resource for planners of future transportation systems.

The following sections provide a detailed description of past and future technological advances in GPS; Intelligent Transportation Systems (ITS); high-speed ground transportation; and railroad, aviation, and maritime system technologies.

Global Positioning Systems

GPS is a fully operational, worldwide, all-weather, satellite-based navigation system originally developed in the 1970s. The system has three parts: *the space segment*, *the user segment*, and *the control segment*. The space segment consists of 24 satellites, each in its own orbit, 11,000 nautical miles above the Earth; the user segment consists of receivers, which can be handheld or mounted in a car; and the control segment consists of ground stations (five, located around the world) that ensure the satellites are working properly [The Aerospace Corp. 1997]. GPS receivers receive these signals, measure the relative arrival times, and from these, compute the user's position. Using signals from at least four satellites, a GPS receiver can determine three-dimensional geographic coordinates. The United States provides free GPS service worldwide.

GPS began with the first satellite launch in 1978 and was completed by 1994 with the deployment of the 24th satellite, creating a virtual net of satellite coverage over the entire globe [The Aerospace Corp. 1997]. The Department of Defense (DOD) originally created GPS to provide

U.S. and Allied forces with accurate positioning information throughout the globe [Trimble 2000]. Allied forces successfully used GPS during Operation Desert Storm to carry out complex military maneuvers on land, sea, and in the air [The Aerospace Corp. 1997].

The commercial benefits of GPS became apparent in the early 1990s. Ground-based radio-navigation systems were limited in their use; high-frequency radio waves could provide accurate positioning but within a limited area; and lower frequency radio waves (AM radio) provided coverage over larger areas but provided inaccurate positioning. With increased global trade and development of complex logistics, the need for accurate global positioning became more apparent [The Aerospace Corp. 1997]. The GPS solved this problem by providing accurate worldwide satellite coverage, and today, the use of GPS in the civil/commercial sector has grown as the accuracy of positioning information has increased.

Until recently, for national security reasons, the DOD deliberately introduced error into the GPS signal for civilian and commercial uses. This practice, termed Selective Availability (SA), provided accuracy of GPS signals to only within 300 feet for civilian and commercial use [USDOC 2000].

In an effort to increase the reliability and accuracy of GPS and to encourage its peaceful civilian use, President Clinton issued a Presidential Decision Directive in March 1996, committing the United States to discontinue the use of SA by 2006. But, on recommendation by the Secretary of Defense, in coordination with the Departments of State, Transportation, and Commerce, the Director of Central Intelligence, and other Executive Branch departments and agencies, President Clinton announced the immediate discontinuation of SA on May 1st 2000, increasing the positioning accuracy of GPS to within 60 feet for civilian and commercial usage [USDOC 2000].

"The same technology that helped our troops succeed in Desert Storm will bring us safer air travel throughout the world, improved transportation on our roads and highways, and faster response to emergencies by rescue vehicles. And it will help America's industries lead the world."

President William J. Clinton
President Opens Door to Commercial GPS Markets; Move Could Add 100,000 New Jobs to Economy by Year 2000 (press release)
Mar. 29, 1996

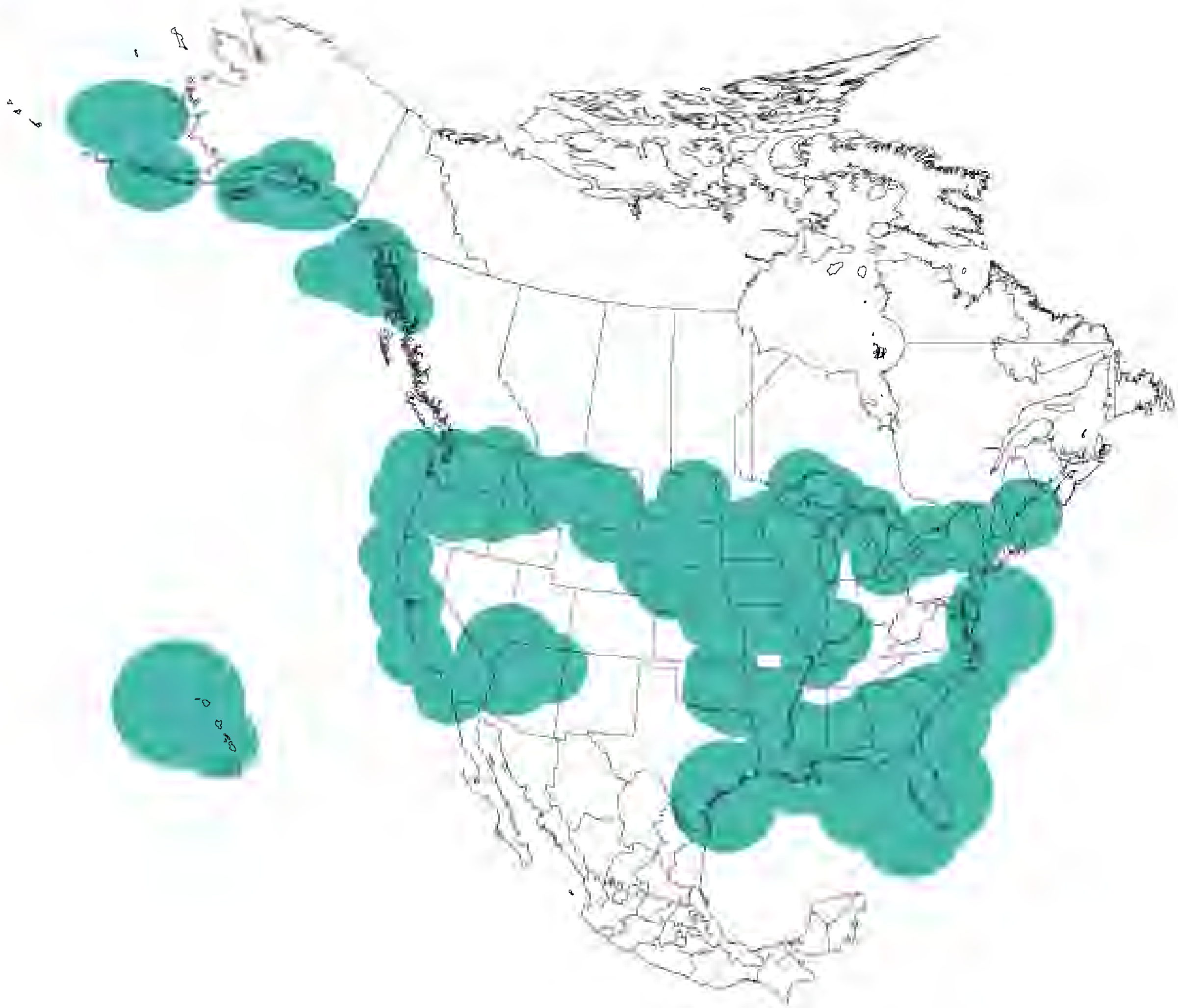
Differential GPS: To provide more reliable and accurate satellite navigation for civilian transportation, the U.S. Department of Transportation (USDOT) is implementing GPS "augmentations" based on a technique known as "Differential" GPS (DGPS). DGPS provides civilian and commercial users predictable accuracy of better than 10 meters (2 drms) in the coverage area and typically better than 1 meter within 150 km of the reference station [USDOC 2000] (figure 6-1).

A DGPS ground-based reference station continuously monitors GPS signals; and because the position of the reference station is precisely known, errors in satellite signals can be calculated and corrections broadcast to area users. The users' DGPS receivers apply the correction message to improve the accuracy of its own position. The DGPS broadcast may also include warnings to inform users when the system is unreliable for navigation. While it is highly accurate, DGPS relies on ground stations, which limits its geographic coverage over large expanses of water. However, this limitation has not prevented development of a variety of DGPS–based technologies for various transportation applications. Maritime DGPS sites incorporate NOAA's GPS Surface Observing Systems (GSOS) for measuring weather data and precipital water vapor measurements for forecasting. In addition, all sites have integrated NOAA's Continuously Operated Reference Station (CORS) equipment used for precise positioning and survey uses.

Automatic Vehicle Location (AVL) is a technology used for tracking vehicles; vessels; and mobile assets such as trailers, containers, and equipment. Each mobile unit has a GPS receiver that reports its position to the base station over a communications network, allowing

Figure 6-1

Nationwide Differential GPS Coverage as of November 2000



Source: U.S. Department of Transportation, Coast Guard Navigation Center, personal communication, October 2000.

the base station to monitor the entire fleet and manage mobile assets. This permits more reliable and timely logistics, more precise in-car satellite navigation, and more effective emergency responses (see also section on Intelligent Transportation Systems).

Satellite navigation also provides unprecedented accuracy and capabilities for mariners and maritime transportation managers. Underwater surveying, buoy placement, navigational hazard location, and mapping are increasingly being executed using satellite navigation signal data. Commercial fishing fleets use satellite navigation to locate optimum fishing locations and to track fish migrations. Quick access to accurate position, course, and speed information will save time and fuel by providing more efficient traffic routing.

Many railroad systems are comprised of long stretches of single track. Precise knowledge of a train's location is essential to prevent collisions, maintain smooth traffic flow, and minimize costly delays waiting for a track to clear. Satellite navigation provides a sound position-locating capability for rail traffic management systems, be it to manage the movement of cars and engines in switchyards or to ensure worker safety. Current technology also allows for fully automated train control through the use of DGPS capability, digital maps, and onboard inertial units.

Important applications of the GPS in aviation are under development and may be deployed in the near future. These are discussed under Keys to the Future. While we have described transportation-related uses of GPS above, there are many other civilian uses of GPS. GPS is being applied in the field of mapping and land surveys; construction of tunnels; location and dispatch of police, fire, and emergency medical services; wildlife management; and the use of GPS-equipped balloons to monitor air quality and holes in the ozone layer over polar regions.

Keys to the Future

The USDOT is carrying out three types of DGPS augmentations to meet the requirements of transportation—maritime, land, and aviation.

The *Nationwide Differential Global Positioning System (NDGPS)* is being implemented for surface transportation (maritime and land). Current coverage consists primarily of the USCG's Maritime DGPS Service, which is fully operational. More than 30 foreign countries also recognize the value of DGPS and have implemented surface DGPS services that conform to the USCG standard [USDOC 2000].

The Federal Aviation Administration (FAA) is implementing GPS augmentation systems for aviation. Together, the *Wide Area Augmentation System (WAAS)* and the *Local Area Augmentation System (LAAS)* will support all phases of flight. The Chicago metropolitan area's O'Hare International and Midway airports will be the initial testbeds for the LAAS. WAAS will provide guidance for en route flight, terminal, and approach operations. It sends differential correction and message reliability to aircraft via geostationary earth-orbit (GEO) satellites at the same frequency as the GPS, thus providing greater accuracy. LAAS will provide greater accuracy in all weather conditions for the more stringent approach and surface operations. The LAAS is intended to complement the WAAS; together they supply users with seamless, satellite-based navigation for all phases of flight and permit the full development of Free Flight (box 6-1) [USDOT 2000].

The USDOT, along with other federal government departments and agencies, including the DOD, is seeking to improve GPS services through a modernization program. Future GPS satellites will have three civilian signals: two frequencies will be protected for radio navigation, including aviation, and the third for nonaviation civilian uses. There also will be new military signals [USDOT 2000].

Box 6-1

Free Flight
Pilots today pick from a very limited set of routes and altitudes. But, with GPS navigation, a pilot is allowed Free Flight—the ability to select the safest and most fuel-efficient route. Through continuous tracking of a plane's position in relation to that of other planes, a Free Flight path can be changed manually or by computer to avoid extreme weather conditions or the possibility of collision with terrain or other aircraft. Tests have been conducted in the United States and over the central Pacific, and the results have been encouraging. Free Flight should be used by a significant portion of the world's airlines by 2010. Benefits of Free Flight include shorter flight times, cost savings, safer flights, lower energy use, and less pollution.

Sources: Trimble Navigation Limited, *All About GPS*, available at http://www.trimble.com/gps/index.htm, as of Aug. 18, 2000; U.S. Department of Transportation, Federal Aviation Administration, *Free Flight*, available at http://www.faa.gov/freeflight/ff-OV.htm, as of Aug. 10, 2000.

Box 6-2

Galileo—The European 'Satellite Navigation Initiative'
Galileo is an initiative of the European Union, in collaboration with the European Space Agency and the private sector, to provide a European civilian-controlled satellite navigation system. As of today, it is still in the planning stage with system design and development to be initiated on January 1, 2001, and deployment to be completed by the end of 2008. Galileo provides a European alternative to GPS and will seek to achieve interoperability with GPS for the benefit of the user community.

Galileo will operate on three levels. The global component will provide basic positioning services of the Galileo system worldwide. A regional component will fulfill a higher performance requirement on a regional basis especially on a European geographic level. The local component aims to increase the accuracy and integrity of the service over local areas, such as airports or harbors. The primary means for this is a local differential station, located in a fixed and well-known position, which can then calculate the local errors in the Galileo signals and broadcast the associated corrections to the users.

Source: Galileo Definition Phase Initial Results, available at www.galileo-pgm.org as of October 5, 2000.

This modernization should provide civilian and commercial users with both the accuracy of DGPS and worldwide coverage. The availability of multiple signals will make the modernized GPS more resistant to atmospheric interference. By 2015, civilian use of GPS is projected to achieve a positioning accuracy to within 15 feet, anywhere in the world [USDOT 2000].

Intelligent Transportation Systems

ITS represents the application of advanced technologies involving information processing, electronics and communication, and management strategies to improve our transportation system. Benefits associated with ITS include improved safety, increased system capacity, reduced travel times, and improved productivity. In short, ITS is using technology to make travel smarter.

ITS technologies can be divided into four functional areas—Metropolitan ITS, Rural ITS, Intelligent Vehicle Initiative (IVI), and Commercial Vehicles Operations (CVO). Each of these functional areas has a set of interlinked systems, which are discussed in this section.

"I want 75 of our largest metropolitan areas with a complete Intelligent Transportation Infrastructure in 10 years. And let us make a similar commitment to upgrading technology in 450 other communities, our rural roads, and Interstates, as the need warrants."

Federico Peña
Former Secretary of Transportation
Transportation Research Board
Jan. 10, 1996

The roots of ITS predate the establishment of a formal program by several decades. The world's first centralized traffic signal control system was installed in Toronto, Canada, in 1963. The first metered ramp was installed in Chicago on the Eisenhower Expressway in 1963. The Federal Highway Administration (FHWA) conducted research on an Electronic Route Guidance System (ERGS) in the late 1960s. These early efforts, however, were isolated and costly; although some, such as ERGS, were ahead of the times.

ITS in its current form emerged only in the late 1980s. Its growth and development were encouraged by several factors:

- The revolution in electronics and information technology generated dramatic performance/cost improvements in computer, sensor, and communications technologies.
- Concerns over traffic congestion, traffic safety, and air quality were growing.
- There was an increasing realization that new construction alone would not solve these problems.
- There was growing concern that European and Japanese ITS initiatives would reduce the competitiveness of the U.S. transportation industry.

Charlie Westerman/Chicago

In-vehicle navigation devices (most commonly found in rental and luxury cars) provide drivers with navigational assistance while en route to their destination

The most significant incentives in ITS development came from three sources: an ad hoc public-private-academic partnership called Mobility 2000, an independent study by the National Academy of Sciences, and a congressionally requested USDOT study. The recommendations of these groups resulted in the passage of the Intelligent Vehicle Highway System (IVHS) Act in 1991. The act called for a "national system of travel support technology, smoothly coordinated among modes and jurisdictions to promote safe, expeditious, and economical movement of goods and people." The federal focus was placed on research, development, and operational testing of ITS technologies and standards (box 6-3).

The Transportation Efficiency Act for the 21st Century (TEA-21), which President Clinton signed into law in 1998, recognized the maturity of many ITS-related technologies and broadened federal focus to place an equal importance on deployment. Similarly, state and local governments, as well as private industry, had begun deploying ITS.

Box 6-3

Standards Development

The USDOT-led creation of a national ITS architecture and the drafting of related standards are intended to lead to the development of open, interchangeable systems and components. This common architecture serves as a framework for regional ITS planning throughout the United States, and it has become a model for similar architecture development efforts now underway in Canada, the European Union, and Japan.

The growth in deployment is demonstrated through federal spending on ITS infrastructure, which totaled $1.3 billion from FY 1991 to FY 1997 [USGAO 1997]. These funds were primarily invested in Freeway Management Systems and Coordinated Traffic Signal Control Systems. ITS is being deployed across the country, and the rate of both public- and private-sector deployments appears to be increasing. Figure 6-2 shows the actual federal funding for ITS infrastructure from 1997 to 1999 and targeted funding through 2003 under TEA-21.

Between 1991 and 1999, ITS technologies, such as electronic toll collection and freeway monitoring systems, were increasingly deployed throughout the country. Figure 6-3 illustrates the deployment of ITS technologies among the 78 largest metropolitan areas with ITS deployments. Early testing, such as the TravTek test in Orlando, Florida, during 1991 and 1992, and ADVANCE in Chicago, Illinois, led to niche deployment of in-vehicle navigation systems. During this same period, the Internet became a global phenomenon, and civilian use of the GPS became available and affordable.

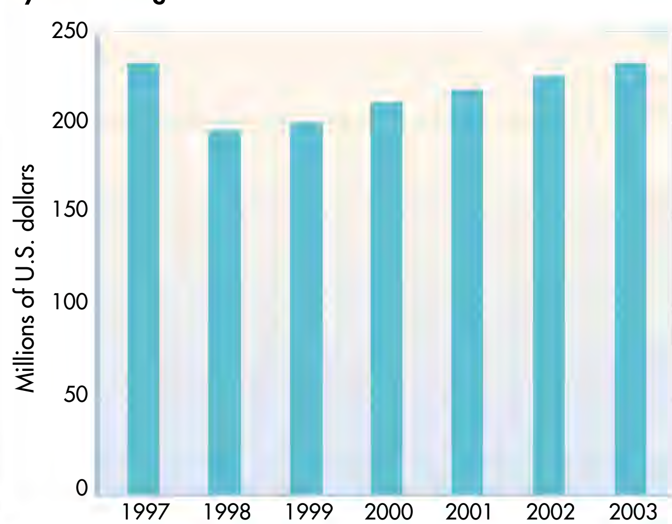
The following subsections discuss the first 10 years of ITS research, testing, and deployment, from 1991 through 2000.

Metropolitan ITS: Metropolitan ITS infrastructure is made up of nine major components, including Arterial Management Systems, Freeway Management Systems, Transit Management Systems, Incident Management Systems, Emergency Management, Electronic Toll Collection (ETC), Electronic Fare Payment, Highway-Rail Intersections, and Regional Multimodal Traveler Information. Table 6-1 shows these various components of Metropolitan ITS and their benefits.

Arterial Management Systems involve the use of roadside devices, communications equipment, and specialized software to improve traffic flow along local roads and arterials (non-freeway roadways). Primary focus is on traffic signal control to alleviate congestion; secondary emphasis is on signal pre-emption or prioritization for emergency and transit vehicles and intersection monitoring. The signal pre-emption technology, where a traffic signal turns to green as a transit bus approaches the intersection, can reduce travel times by up to 30 percent [Hagler Bailly 1999]. Figure 6-4 shows the number of metropolitan areas where different types of traffic signal control technologies are deployed.

Figure 6-2

Federal Funding for Intelligent Transportation Systems Program: 1997-2003



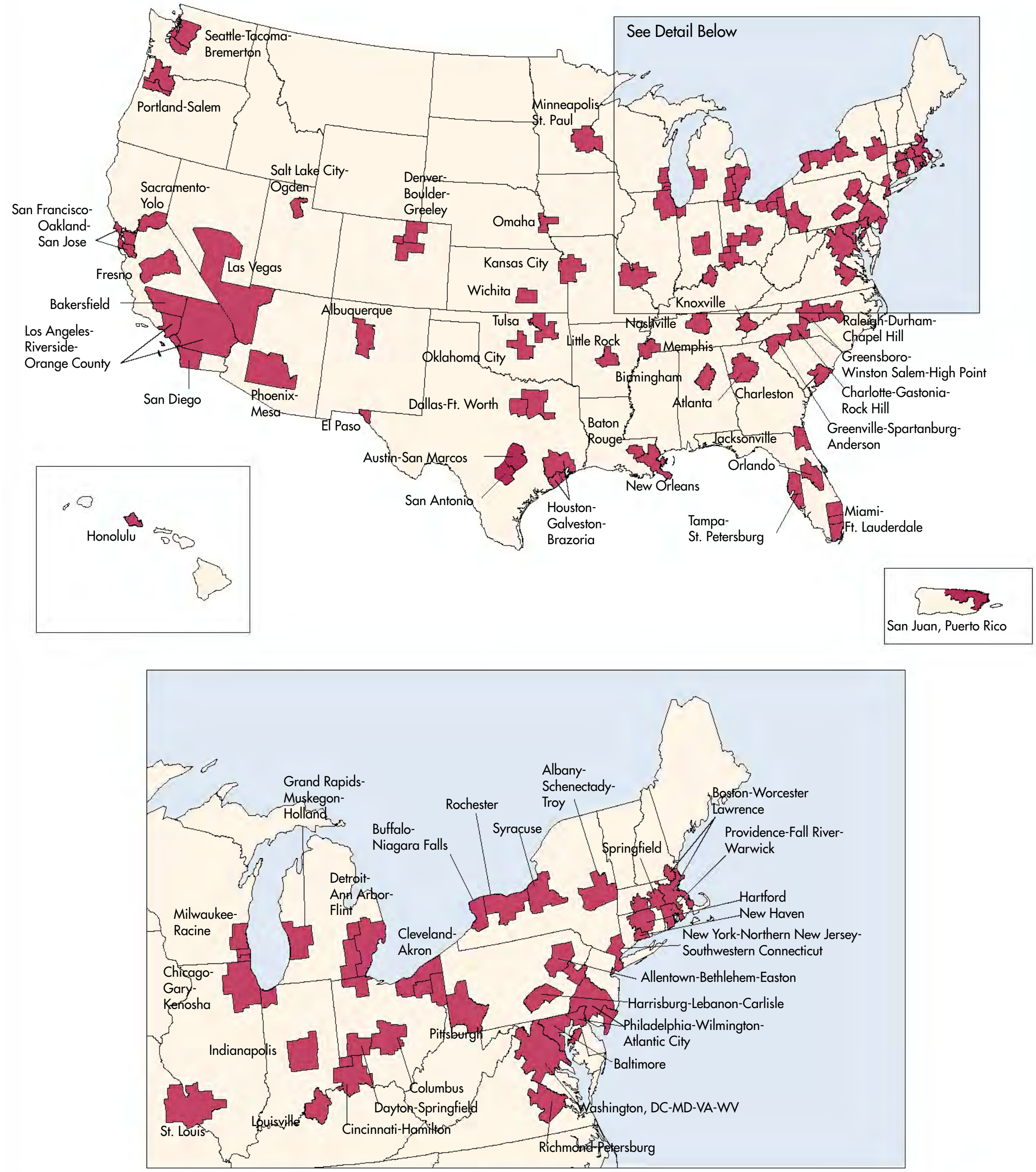
Note: 1997 data reflect funding from multiple sources. 1998 to 2003 data include ITS Research and Development funds and ITS Deployment funds.

Source: U.S. Department of Transportation, Federal Highway Administration, *TEA-21 Fact Sheet –Intelligent Transportation Systems Program* (Washington, DC: 1998).

Figure 6-36

The Largest 78 Metropolitan Areas with ITS Deployments: 1997

Projected Growth in E-Commerce (1997 to 2004)



Source: U.S. Department of Transportation, Federal Highway Administration, Joint Program Office for Intelligent Transportation Systems, *Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA: FY 1997 Results* (Washington, DC: 1999).

Table 6-1

Metropolitan Intelligent Transportation System Infrastructure Functions and Benefits

Infrastructure	Functions	Benefits Provided
Arterial management	Monitor arterial network traffic Implement range of adaptive control strategies Manage area-wide signal coordination	Safety, decreased travel times, increased capacity, fuel savings/lower emissions, customer satisfaction
Freeway management	Monitor freeway conditions Identify flow impediments Control ramp metering and lane control Control highway advisory radios	Safety, decreased travel times, increased capacity
Incident management	Incident detection Incident response/clearance	Safety, decreased travel times, fuel savings/lower emissions
Transit management	Monitor transit vehicle position Disseminate real-time schedules Provide computer-aided dispatch Provide vehicle condition monitoring	Safety, decreased travel times, lower costs, customer satisfaction
Electronic fare payment	Provide payment at station/stop or in-vehicle	Decreased travel times, customer satisfaction
Electronic toll collection	Provide payment at toll collection stop	Decreased travel times, increased capacity, lower costs
Emergency management	Monitor vehicle location Provide fleet management support	Decreased travel times, customer satisfaction
Highway-rail crossing management	Provide remote monitoring of highway-rail intersections	Safety
Regional multimodal traveler information	Provide information distribution on weather conditions	Lower costs, customer satisfaction, fuel savings/lower emissions

Source: A. Proper, *Intelligent Transportation Systems Benefits: 1999 Update*, prepared by Mitretek Systems for the Federal Highway Administration, U.S. Department of Transportation, 1999, available at www.its.gov/eval/itsbenefits.htminventory99b.pdf, as of Aug.18, 2000.

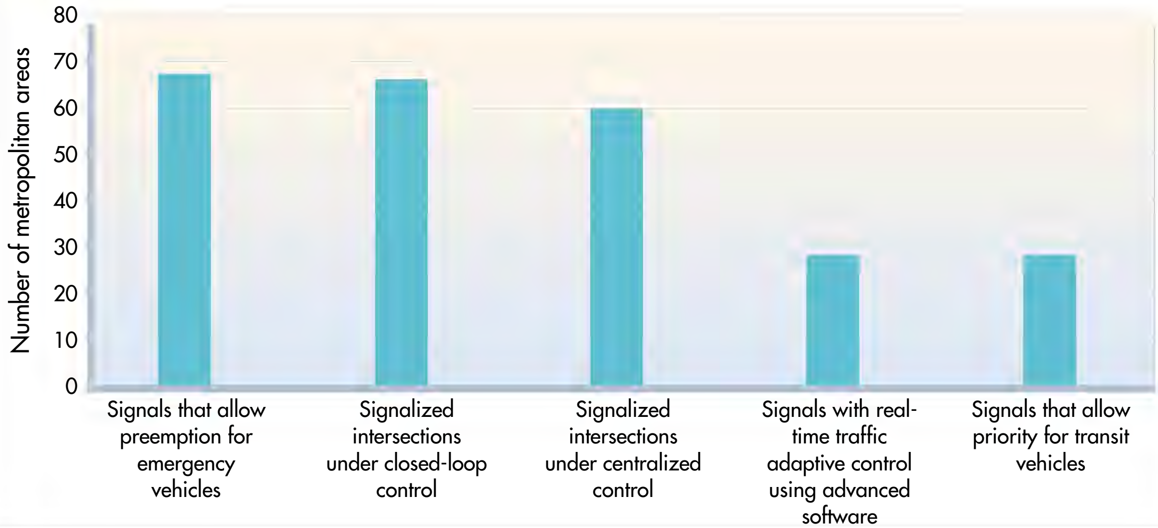
Freeway and Incident Management Systems include ramp metering programs, freeway surveillance systems, incident response systems, and information display or communications systems (e.g., variable message signs and highway advisory radio). Ramp meters are traffic signals on freeway entrance ramps that supply traffic to the freeway in a measured or regulated amount. The number of cities with ramp metering has remained fairly constant during the decade (22 of the largest 78 metropolitan areas employ ramp metering) (figure 6-5), but the number of ramps that are metered has increased. Surveillance systems, such as loop detectors and video cameras, became widely deployed on the freeways during the 1990s (figure 6-6). As the decade ended, a few localities also were beginning to provide video surveillance at major intersections to reduce the incidence of red-light running.

The acceptance of automated enforcement technology, while still controversial, has grown as the limited use of automated traffic signal enforcement has shown large benefits. For example, Fairfax City, Virginia, showed a 35 percent reduction in red-light running incidents after installing enforcement systems.

Transit Management Systems were deployed in the 1990s by many large and small transit agencies. Typical systems included AVL and Computer-Aided Dispatch (CAD) systems. These systems date back several decades, but in the 1990s, GPS became the primary location technology, due to its general reliability and decreasing cost. These systems delivered improved service reliability, improved operator visibility into problems, and enhanced security. A 1996 study found that 22 transit agencies had equipped 7,000 vehicles with AVL, and another 47 agencies were in the process of securing AVL systems. The passage of the Americans with Disabilities Act (ADA) also guaranteed increased demand for AVL and CAD

Figure 6-4

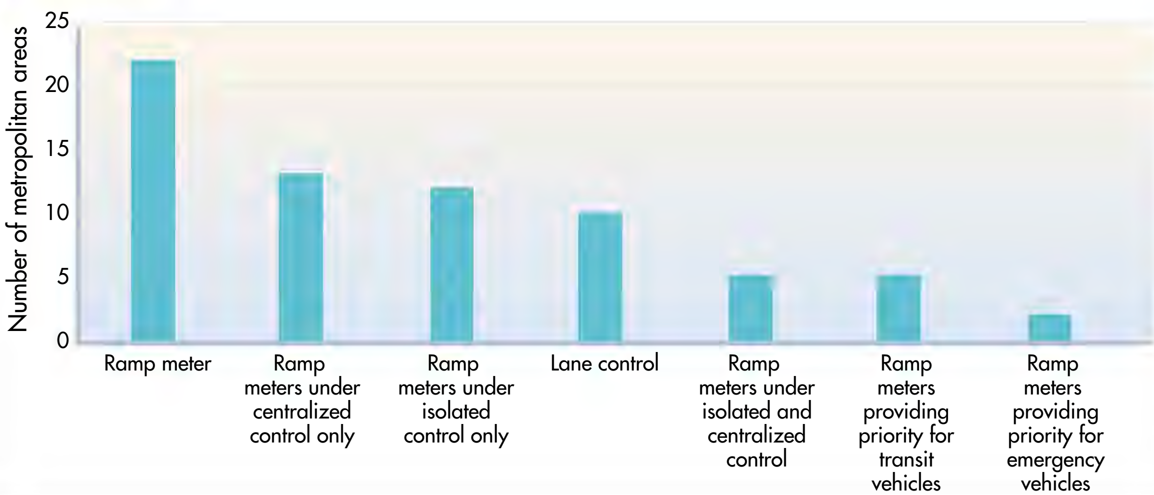
Deployment of Traffic Signal Control Technologies: 1997



Source: U.S. Department of Transportation, Federal Highway Administration, Joint Program Office for Intelligent Transportation Systems, *Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA, FY 1997 Results* (Washington, DC: 1998).

Figure 6-5

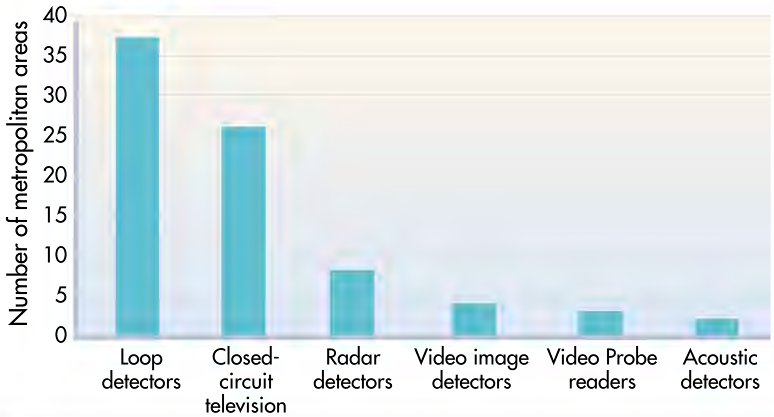
Deployment of Freeway Management Traffic Control Technologies: 1997



Source: U.S. Department of Transportation, Federal Highway Administration, Joint Program Office for Intelligent Transportation Systems, *Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA, FY 1997 Results* (Washington, DC: 1998).

Figure 6-6

Deployment of Freeway Surveillance Systems: 1997



Source: U.S. Department of Transportation, Federal Highway Administration, Joint Program Office for Intelligent Transportation Systems, *Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA, FY 1997 Results* (Washington, DC: 1998).

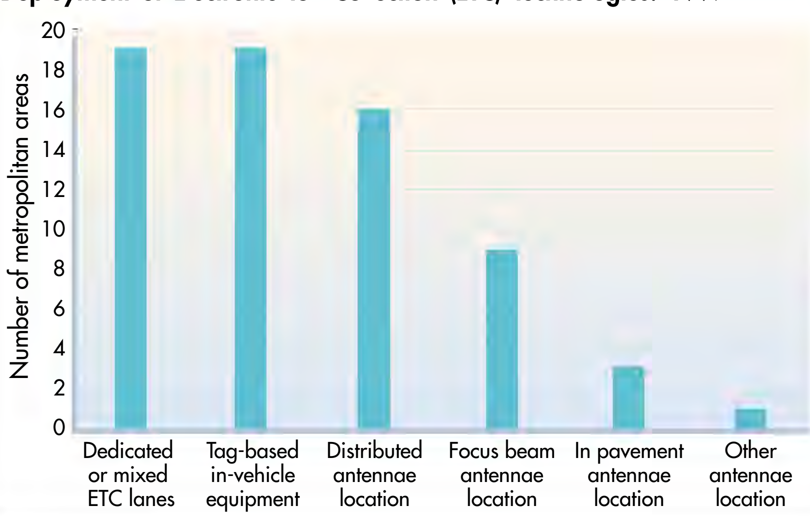
systems, as well as for communications, automatic stop annunciation, and other technologies [McGurrin 2000].

Electronic Toll Collection (ETC) deploys various communication and electronic technologies to support the automated collection of payment at toll plazas and other collection points. ETC is among the most successful ITS applications (figure 6-7). Since the first electronic toll system was installed in New Orleans in 1989, more than 100 facilities in 39 areas have installed ETC systems, and the number of vehicles equipped with radio frequency toll tags has grown to more than four million. The Oklahoma turnpike has estimated that the operating cost for an electronic toll lane is less than one-tenth that of a standard lane. The Triborough Bridge and Tunnel Authority found that the increased throughput of ETC lanes has shortened the evening congestion period by 90 minutes on the Verrazano Narrows Bridge [Shibata & French 1996].

Electronic Fare Payment systems were tested or deployed by a number of transit agencies during the 1990s. Although only a limited number of systems have been deployed, the rate of deployment is expected to increase because reliable and fast systems are now available. These systems reduce operating costs (due to reduced cash handling), can aid in passenger counting, and are convenient for passengers. This convenience is expected to increase as the

Figure 6-7

Deployment of Electronic Toll Collection (ETC) Technologies: 1997



Source: U.S. Department of Transportation, Federal Highway Administration, Joint Program Office for Intelligent Transportation Systems, *Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA: FY 1997 Results* (Washington, DC: 1998).

payment systems become integrated with other applications and one card can be used for many purposes.

Georgia Department of Transportation

Advanced Traffic Management Centers (TMCs), such as this one in Atlanta, Georgia, allow traffic engineers and operations personnel to proactively manage the freeway and arterial street systems while providing a comprehensive source of real-time traffic data for traveler information systems.

Regional Multimodal Traveler Information is being supplied by several transit agencies that have started using traveler information kiosks and Internet sites to provide schedules, expected arrival times, expected trip times, and route planning services to patrons. Also, several traffic management centers are providing current traffic conditions and expected travel times using similar approaches. These services allow users to make a more informed decision for trip departures, routes, and travel. They have been shown to increase transit usage and may help to reduce congestion when travelers choose to defer or postpone trips or select alternate routes.

Traveler information via the Internet went from nonexistent in 1990 to widespread deployment by 2000. Today, nearly every state provides highway construction and/or road closure information via the Internet (box 6-4). Thirty-five of the 75 largest cities make real-time freeway traffic information available [Gordon 1999].

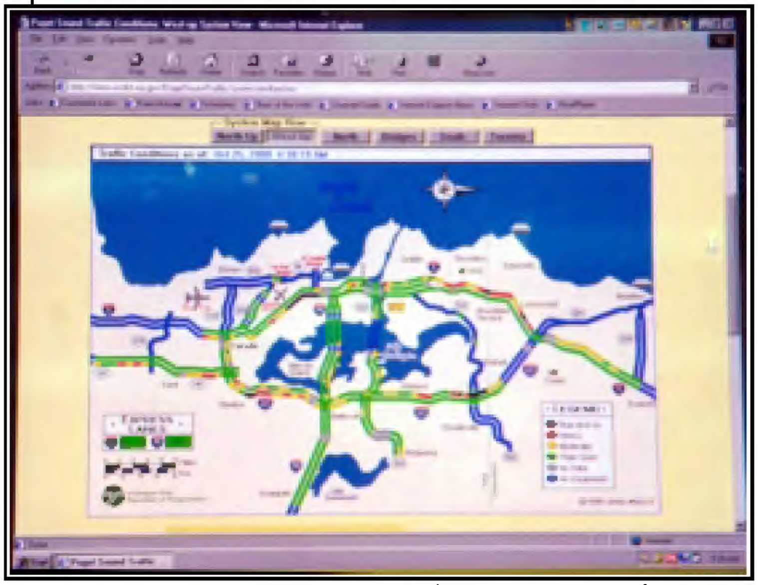
Box 6-4

ITS and the Internet

The Internet will play an increasingly important role in disseminating traveler information. Currently, the Internet is used primarily for semiautomated information exchange, in which people use a browser to pull information on traffic conditions and transit schedules from an automated server. The next major stage in the evolution of the Internet will be support for fully automated information exchange. This will be supported by the widespread availability of high-speed Internet access; low-cost, adequate security; and new standards. These trends will increase the utility of Internet-based real-time and predictive traffic information, both between agencies and consumers, with benefits also provided to commercial vehicle operations, fleet management, and intermodal freight tracking.

Rural ITS: Rural travelers need the same basic ITS services required by urban travelers, but the priorities are different. These priorities and needs reflect the conditions in rural localities: generally longer local travel distances; lower traffic volumes; longer emergency response times; sparse and patchy telecommunications infrastructure; and a dispersed system with high unit costs for service delivery, operations, and maintenance.

As a result, there is an emphasis on *weather and road condition information* for all rural highway users and on the use of *automatic vehicle location* and computer-aided *dispatch systems* for rural transit and paratransit services. Automated collision notification and mayday services are already operational in some areas. Improving traveler information in National Parks also is an important initiative under Rural ITS. Table 6-2 shows the major components of Rural ITS and their benefits.



Washington State Department of Transportation

State and local departments of transportation make use of the Internet to provide real-time traveler information to the public. Dynamic Web pages are linked to advanced traffic management systems to display real-time travel speed, incident and road construction information.

Intelligent Vehicle Initiative: Following the successful testing in 1997 at San Diego, California, the federal Automated Highway System program became the Intelligent Vehicle Initiative, with a focus on implementable, near-term safety improvements. Automated highway research, such as the California Department of Transportation-supported research into fully automated vehicle operation, continued at a lower level. Three important sets of technologies under this initiative are discussed below.

In-Vehicle Navigation and Dynamic Route Guidance (using real-time traffic information) can provide turn-by-turn instructions to guide travelers to their destinations and support travel-related services (gas stations, hotels, and parking). Within a few years, navigation systems will be able to incorporate data on traffic conditions in real-time and adapt the preferred route accordingly. This system may incorporate the use of GPS antennas and receivers, Liquid Crystal Display (LCD) panels, Compact Disk-Read Only Memory/Digital Video Disk (CD-ROM/DVD) players, communications hardware, driver interface units, map databases, and route optimization programs. These technologies have established a niche in the rental car market and in some higher-end car models, but their use is spreading with the increasing accuracy and falling costs of component technologies [Proper 1999].

Table 6-2

Rural ITS Infrastructure Functions and Benefits

Infrastructure	Functions	Benefits Provided
Travel safety and security	Hazardous conditions information Surveillance	Safety, customer satisfaction
Emergency services	Incident notification mobilization and response	Safety
Tourism and travel information	Route selection, navigation, and services information	Customer satisfaction
Operation and maintenance	Traffic management	Decreased travel times, lower costs
Public travel and mobility services	Transit accessibility Dispatch and routing Ride sharing and matching	Fuel, savings/lower emissions, customer satisfaction

Source: U.S. Department of Transportation, Federal Highway Administration, Joint Program Office for Intelligent Transportation Systems, *Measuring ITS Deployment and Integration,* Version 2 (Washington, DC: January 1999).

Collision Avoidance and Warning Systems are expected to improve highway safety by reducing the number of crashes. Collision avoidance includes several user services, such as Intelligent Cruise Control, Rear-End Crash Avoidance, and Road Departure Avoidance. Each of these is described in detail in Chapter 3 under Highway Safety.

Mayday and Security Systems combine wireless communications and positioning information to enhance driver/passenger safety. The Mayday System enables the driver (or vehicle) to notify emergency services immediately in the event of an accident. As an added feature, travelers can contact roadside assistance, request navigation assistance, and track a stolen vehicle. Typical systems consist of in-vehicle hardware and a monthly service charge. Applicable hardware includes GPS antennas and receivers and communications hardware [Hagler Bailly 2000].

Commercial Vehicle Operations (CVO): The ITS/CVO initiative is expected to improve administrative efficiency, highway data collection, and safety, and also reduce operating costs of commercial vehicles. Currently, ITS/CVO covers three areas of state motor vehicle regulations. These are discussed below.

Electronic Screening can result in reduced congestion at weigh and inspection stations by allowing safe and legal carriers to bypass without stopping. Roadside electronic screening allows authorities to concentrate on greater percentages of potentially unsafe vehicles.

Safety Information Exchange Programs will assist in improving the safe operation of commercial vehicles. These programs will provide inspectors with better access to safety information, increasing the number of unsafe commercial drivers and vehicles removed from the highway. On-board monitoring of cargo can alert drivers and carriers of potential unsafe load conditions.

Credentials Administration will support in-house administrative functions and can provide savings to state and administrative agencies. Electronic credentialing can improve the time required for states to approve operating permits. Data warehouses can facilitate the exchange of credentials data between agencies and states.

Keys to the Future

By 2010, high quality, real-time travel information will be generally available for urban and heavily used Interstate routes, usually via wireless receivers. By 2025, real-time transportation management will be a reality, with highways and transit not just monitored, but proactively managed. For example, traffic control strategies will be closely coordinated to prevent alternative routes from becoming congested after a primary route becomes congested.

By 2025, improved sensors, sophisticated algorithms, and more powerful computers will yield systems that greatly improve driver situational awareness, vehicle controllability, and crashworthiness, as well as sense driver incapacitation due to fatigue, alcohol, drugs, or any other cause. Voice recognition for various functions will minimize problems caused by driver inattention resulting from distraction or other factors. Full integration of these systems into vehicle design, coupled with external inputs regarding weather, road conditions, intentions, or status of nearby vehicles, and other safety advisories, will extend the dramatic decline in fatality and injury rates that began in the early 1970s.

Open standards-based traffic management equipment now in development will support interoperability, which will promote new entrants and encourage development of new technologies. Today's cluster of intelligent transportation vehicles and travel planning and information services will be integrated in new vehicles with smart driver-operator technologies, in-car sensors, on-board emission management systems, and links to wayside information infrastructure. Advanced multispectral sensors, distributed microprocessors, communications, tracking technologies, and traffic information displays in urban traffic management centers will improve safety, enable more efficient use of limited infrastructure capacity, relieve congestion, and lessen the environmental impacts of transportation. Travelers will benefit from integrated trip planning, scheduling, and routing options—the result of in-car navigation and information systems that are linked directly into the vehicle's electronics systems to provide maps, weather data, traffic conditions, and alternative routes.

With the improvements made possible by ITS deployment, the passenger automobile probably will continue to dominate transportation in the United States. However, the passenger car will go through some marked changes over the next 20 to 30 years. More fuel-efficient gasoline powered cars will be joined by hybrid diesel-electric vehicles, alternatively fueled vehicles, and fuel cell powered vehicles. The market for automobiles may partition, based on trip lengths and purposes. Electric cars and station cars, powered by advanced or conventional electric batteries, as well as solar-powered and people-powered personal vehicles, will assist commuters to perform local errands or economically reach transit system suburban collection terminals. These will complement larger vehicles, which will be used for longer trips, or when additional carrying capacity is needed. Both types of vehicles should be lighter and safer than current autos, as vehicle structures use more new plastics and composite materials.

Application of improved understanding of human performance and behavior, vehicle crashworthiness, and biomechanics, coupled with the structural improvements noted above, will help mitigate crash impacts substantially. However, most of the systems to improve safety will be introduced as equipment on new vehicles. The integration of new systems on a fleetwide basis may take 10 to 20 years from initial introduction of the technology. The average age of vehicles in the fleet is increasing, as more solid construction and reduced needs for maintenance permit consumers to retain their vehicles longer. Overall safety statistics will improve, but may not fully reflect the benefits of new crash avoidance/mitigation techniques at once.

Personal commuting and family pleasure travel will have many more real-time travel planning, scheduling, and routing options, due to intelligent recreational vehicles, advanced public transportation systems, and automated highway systems. The safety of personal travel and commercial vehicle operations will be ensured by advanced incident management and onboard collision avoidance radars, as well as intelligent cruise control. Speech recognition software will allow drivers to make vehicles comply by asking for the change. In-car navigation and information systems will be commonplace, integrated directly at all times and in all weather, and small video cameras may substitute for items like rearview mirrors. Intelligent driver trainers and simulators will be used to prepare and test for driver licensing and sobriety testing, as well as for safety recertification.

For intercity trips, there should also be fully automated highways, allowing high-speed auto travel with minimal driver intervention on selected routes. These may be separate highways, or lanes on existing/expanded highways reserved for vehicles with the appropriate high-speed control packages. The intelligent infrastructure for these highways will be compatible with, and possibly integrated into, multimodal traffic control systems directing aviation and maritime movements.

Public transportation systems will provide widely available, inexpensive alternatives to the personal vehicle for shorter trips. The recent emphasis on "smart growth" and "livable communities" will promote new human-scale developments that are designed to be served by local circulation and transit systems. Shuttle services will link these complexes with intercity modes for longer trips among clusters of development.

Computer dispatched paratransit vehicles serving the suburbs and elderly and disabled passengers will integrate with, and share HOV lanes with, advanced technology urban and intercity transit buses in more densely developed areas. Specialized and public transit services will reach into rural and lower-density areas, linking their carless residents to urban services. Many of these options will be powered using alternative fuels or use fuel cells.

The transit systems will profit from the technologies of the intelligent transportation infrastructure, with safety and performance improvements in bus vehicle maneuvering, merge collision avoidance, forward collision avoidance, and docking. Automatic vehicle location systems will be commonplace, with positions monitored from metropolitan scale traffic management centers. Real-time information on actual bus positions and schedules should be readily available to potential riders. With an increasing number of elderly riders, these systems will exemplify the "human centered design" concept.

High-Speed Ground Transportation

High-speed, ground transportation is a self-guided intercity passenger transportation mode that is time-competitive with air and/or auto for trips of 100 to 500 miles. This form of transportation has been a prevalent phenomenon outside of the United States, with the French National Railways' TGV, Germany's ICE train, and Japan's Shinkansen train having long been leaders in high-speed ground transportation.

From the mid-1950s to the mid-1970s, intercity passenger trains lost more than three-fourths of their traffic base; high-speed services such as the multiple fast schedules between Chicago and the Twin Cities disappeared, and much of the passenger infrastructure deteriorated or was scrapped. Amtrak, which was created in 1971, was establishing itself from the passenger services, equipment, and facilities it had inherited from its predecessor railroad companies.

In 1975, corridor-type passenger service with top speeds of 90 miles per hour (mph) or greater existed on the Northeast Corridor main line, on two Northeast Corridor extensions, and on former Santa Fe Railway trackage in Southern California. However, no federal funding was available or proposed for high-speed rail corridors beyond the Northeast Corridor main line.

Under the High-Speed Ground Transportation Act of 1965, a partnership between the federal government and the Penn Central Transportation Company had created two major demonstrations of incremental high-speed rail technology later operated by Amtrak:

1. Metroliners, which offered schedules of three hours between New York City and Washington over old tracks and other fixed facilities; and

2. Turbotrains, which provided a somewhat improved service between New York and Boston over the antiquated former New Haven Railroad.

In 1975, the Northeast Corridor main line was about to receive what amounted to nearly $3.3 billion (by the end of 1980s) in federal fixed-facility investments to implement the recommendations of the Northeast Corridor Transportation Project for improved high-speed rail service between Washington, New York, Boston, and intermediate points [USDOT FRA 2000b].

High-speed service also was offered on two analogous routes in the 100- to 150-mile range, each linking a state capital with the state's largest city. The first ran over 104 miles of former Pennsylvania Railroad trackage between Philadelphia and Harrisburg, Pennsylvania. The second covered 145 miles of former New York Central Railroad trackage between New York City and Albany, New York. A third line in California, Santa Fe's 129-mile Surf Line, provided 90-mph service between Los Angeles and San Diego [USDOT FRA 2000b].

The federally funded Northeast Corridor Project provided the Washington–New York–Boston main line with a largely new infrastructure. The project realigned curves; upgraded track structure, including concrete ties; installed a new train control system with centralized traffic and electrification control; renovated stations; built new equipment shops; eliminated most highway grade crossings; and installed a new electrification system between New Haven and Boston, permitting fully electrified operation along the Boston–Washington right-of-way.

Amtrak

The Acela train, capable of reaching speeds of 150 mph, will provide an unprecedented high quality of service within the Northeast Corridor.

The original Metroliners and Turbotrains have been replaced by a new generation of locomotive-hauled trains. A third generation of Acela luxury equipment is in service on the Northeast Corridor. Reliable daily operation achieves 150-mph top speeds [USDOT FRA 2000b].

Progress also occurred on the two high-speed extensions of the Northeast Corridor. In the 1990s, New York State, Amtrak, the localities, and the federal government invested nearly $300 million in upgrading and re-equipping the Albany to New York portion of the Empire Corridor.

California, meanwhile, made significant investments in the Los Angeles to San Diego Surf Line as part of a program in the 1990s to upgrade and re-equip its entire Amtrak network, including lines linking Southern California, the Central Valley, the Bay Area, and Sacramento. About two-thirds of this $2 billion investment was state financing; the rest came from Amtrak, the localities, the freight railroads, and various federal sources. California plans a $300 million additional investment early in the 2000s [USDOT FRA 2000b].

Today, high-speed ground transportation options fall into three groups: accelerated rail service over existing railroads (Incremental High-Speed Rail [HSR]), new high-speed rail systems (New HSR); and magnetic levitation (Maglev), in order of increasing performance capabilities and initial cost (box 6-5).

The 1998 TEA-21 transportation legislation authorized a Magnetic Levitation Transportation Technology Deployment Program with $55 million for high-speed Maglev construction planning and up to $950 million authorized for construction of a single Maglev project [USDOT FHWA 1998]. In 1999, the federal government initiated a competition to select the best Maglev project for the purpose of demonstrating the use of Maglev technology, with selection slated for 2001 and design and construction for 2002 [USDOT FRA 2000a].

Incremental HSR has shown significant evolution since 1975 and is poised for still more expansion in the 21st century. In the 1990s, sizable federal commitments were made for HSR development outside the Northeast Corridor main line. The transportation reauthorization bills of 1991 and 1998 had established and expanded a program to federally designate high-speed corridors (figure 6-8). Among the corridors that had applied for designations and future funding as high-speed corridors as of early 2000 were lines between Chicago and Cleveland; Cleveland, Columbus, and Cincinnati, Ohio; and Boston, Massachusetts, and Portland, Maine.

Box 6-5

Types of High-Speed Ground Transportation

Incremental HSR consists of upgraded intercity rail passenger service on existing railroad rights-of-way, most of which belong to the freight railroads. Incremental HSR options may have top speeds ranging from 90 to 150 mph and may be electrified (powered by electricity distributed to locomotives through overhead wires) or non-electrified (powered by on-board generators).

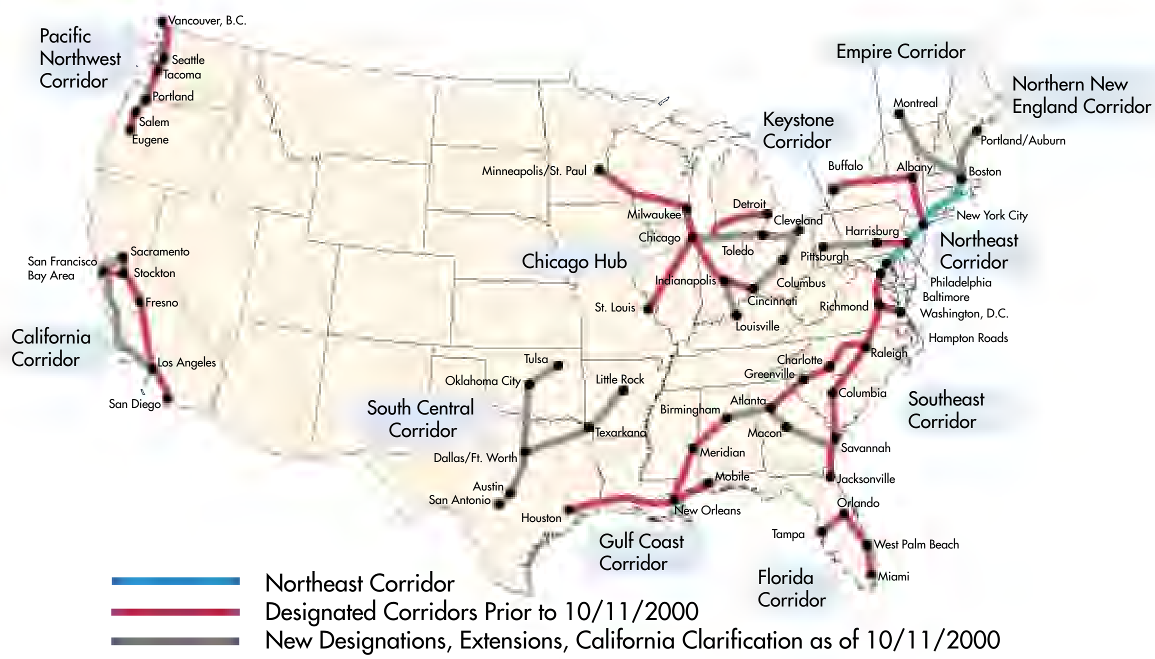
New HSR represents advanced steel-wheel-on-rail passenger systems on largely new rights-of-way. Through a combination of electrification and other advanced components, expeditious alignments, and state-of-the-art rolling stock, new HSR can attain maximum practical operating speeds on the order of 200 mph. However, because the trains are still able to operate on existing track, new HSR can combine new lines with existing approaches to urban terminals. The ability to operate over existing rights-of-way at their prevailing speeds, as well as on new routes, means that service can be extended beyond the New HSR line to other cities.

Maglev is an advanced transport technology in which magnetic forces lift, propel, and guide a vehicle over a specially designed guideway. Using state-of-the-art electric power and control systems, this configuration eliminates the need for wheels and many other mechanical parts, thereby minimizing resistance and permitting excellent acceleration, with cruising speeds on the order of 300 mph or more. This high performance would enable Maglev to provide air-competitive trip times at longer trip distances than other high-speed ground transportation options.

Source: U.S. Department of Transportation, Federal Railroad Administration, *High Speed Ground Transportation for America* (Washington, DC: September 1997).

Figure 6-8

Designated High-Speed Rail Corridors: 2000



Source: U.S. Department of Transportation, Federal Railroad Administration, personal communication, October 2000.

The 1990s also saw a renaissance of technology development for HSR. This Next-Generation High-Speed Rail Development Program addressed specific subsystems for enhancing the safety and affordability of HSR. These systems included:

- turbine-powered high-speed locomotives,
- radio-based positive train control,
- new cost-effective grade crossing solutions, and
- better riding, lower cost track and structures.

Keys to the Future

If state and Amtrak interest in high-speed rail continues to grow, then corridors in many regions of the nation could provide significant high-speed train service by 2025. In particular, by 2025, all of today's designated corridors would have Amtrak service at 90 mph or better. These corridors will bring high-speed rail service to 150 million people living in metropolitan areas, nearly 75 percent of the metropolitan population. There could also be other lines, such as the additional Chicago Hub lines under consideration by the Midwestern consortium, parts of the Texas Triangle, or one or more of the lines for which designation applications were pending as of December 31, 1999.

To the extent that high-speed rail takes hold, the public would obtain benefits from airport and highway congestion reduction and from reduced air pollution. The extent of these benefits for a group of eight illustrative corridors is analyzed in a federal report, *High-Speed Ground Transportation for America* [USDOT FRA 1997].

By 2025, the next generation HSR technologies will mature to support reliable, cost-effective systems with superb service quality:

- nonelectrified corridors working at 125 to 150 mph,
- train control in place nationwide for productivity and safety,
- virtually all crossings eliminated on rail routes with significant traffic, and
- infrastructure delivering superb ride quality at low cost.

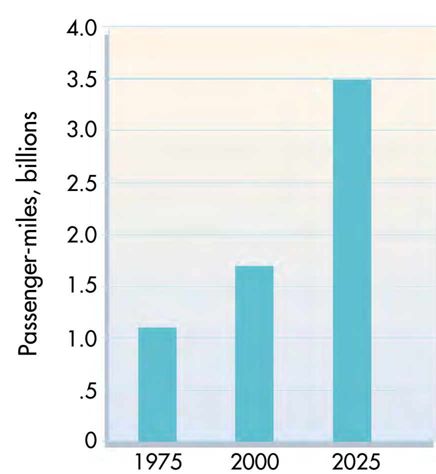
HSR's inherent advantages, particularly its connectivity with commuter rail and urban transit systems, could be fully realized, offering seamless transportation to a growing clientele.

HSR investments can yield significant benefits in terms of transportation production. For example, in the Northeast Corridor, traffic growth estimates project that high-speed rail will generate 3.5 billion passenger-miles annually by 2025, up from about 1.1 billion in 1975 and 1.7 billion in 2000 (figure 6-9). The *High-Speed Ground Transportation for America* report shows the expected growth in annual passenger-miles for typical corridors outside the Northeast Corridor main line (figure 6-10).

The first Maglev project in the United States could be operating in revenue service by 2010 if funds are appropriated. Beginning with a short demonstration, it could point to longer intercity systems in very high-density corridors. In fact, the *High Speed Ground*

Figure 6-96

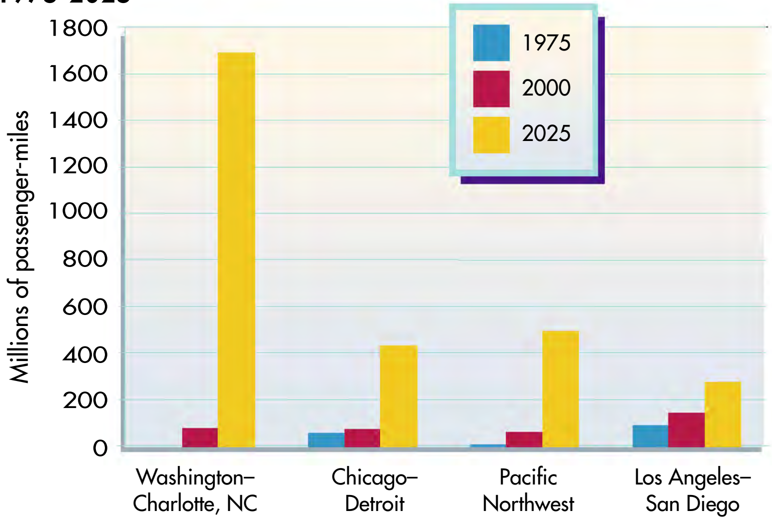
Projected Growth in Passenger-Miles in the Northeast Corridor: 1975-2025



Source: U.S. Department of Transportation, Federal Railroad Administration, *High-Speed Ground Transportation for America* (Washington, DC: 1997).

Figure 6-10

Projected Growth in Passenger-Miles Outside the Northeast Corridor: 1975-2025



Source: U.S. Department of Transportation, Federal Railroad Administration, *High-Speed Ground Transportation for America* (Washington, DC: 1997).

Transportation for America report found that Maglev could have the potential to bring about public-private implementation partnerships in the nation's two highest density corridors: the Northeast Corridor and California. Maglev could capture two-fifths of the existing airline market in California and generate almost six billion passenger-miles by 2025. In the Northeast Corridor, Maglev could capture about two-fifths of the remaining air market in the Northeast Corridor—about half the New York-Washington air/rail traffic currently uses Amtrak—and would generate about five billion passenger-miles per year in 2025.

It also is possible that Maglev would induce a heavy volume of completely new traffic, given the unusually short travel times it would permit between the major Northeast Corridor cities. By offering a new level of ground transportation service, a 300-mile-per-hour Maglev system in a major corridor would divert significant traffic from existing airports and highways. This would result in reduced congestion delays and emissions and would also reduce the need to expand air and highway facilities.

Railroad System Technologies

Over the last quarter century, the traffic on our railroad system has continued to increase, both for passenger travel and freight movement. However, the extent of the rail system has not changed substantially, which has led to congestion on the system and caused safety-related concerns. Use of advanced communication, information, and navigation technologies can help enhance efficiency, capacity, and safety of the existing railroad system.

Typical railroad locomotives produced in 1975 were 3,600 horsepower diesel-electrics with direct current (DC) traction motors [USDOT FRA 2000c]. Continuous welded rail was just entering into widespread application, and wooden ties were used under all trackage. The typical freight car had a 70-ton carrying capacity, although 100-ton cars had just been introduced; all freight cars were made of steel. Unit trains were operated on only a limited number of routes. Only about one-third of the track network was signalized, and microwave radio communications systems had been installed primarily on the western railroads [USDOT FRA 2000c]. Improved understanding of train-track interactions was just emerging, and typical, state-of-the-art rail safety technology entailed improved visibility of locomotives and audible horn signals at intersections.

More than half of the nation's intercity passenger service had been discontinued four years earlier. Amtrak, successor to the private railroads for intercity passenger service, was purchasing locomotives that could be readily put into freight service when passenger train service ended. Self-propelled, electric Metroliner cars were in use on the Northeast Corridor, and a few Turbotrains were in service for medium-speed runs on a few passenger corridors, but these required excessive maintenance.

Today, typical locomotives produced are 6,000 horsepower diesel-electrics with alternating current (AC) traction motors. The typical freight car has a 125-ton carrying capacity, and larger cars are being considered; many of the new freight cars have aluminum car bodies. Continuous welded rail is in place on virtually all mainlines, and concrete ties have been installed on the heaviest density lines. Additionally, half of the rail network is now signalized. Unit trains carry nearly half of the freight revenue ton-miles.

Amtrak has invested in new, high-speed trainsets that are capable of providing 150-mph service on the Northeast Corridor between Washington and Boston [USDOT FRA 2000c]. A number of states, including California, Illinois, Michigan, New York, North Carolina, Ohio, Oregon, Virginia, Washington, and Wisconsin are establishing high-speed passenger corridors on existing rail lines. States also are increasingly pursuing the development of new high-speed corridor services to reduce congestion on highways and at airports. The result is a greater combination of freight and passenger trains on common tracks, raising new safety concerns.

A key solution for many of these issues is digital communication technologies. The USDOT and the railroad industry are examining ways to develop Intelligent Railroad Systems that would incorporate the newest digital communications technologies into train control, braking systems, grade crossings, and defect detection (box 6-6). The new communications-based train control systems are a key element in making the railroad system safer and new intercity passenger services both safe and economically viable. New electronic sensors and transmission systems will help railroads achieve the long sought-after goal of advanced detection of hazardous conditions in equipment and track.

Box 6-6

Intelligent Railroad System Technologies

Nationwide Differential Global Positioning System (NDGPS), an augmentation of the GPS, provides one-to-two-meter positioning accuracy to receivers. NDGPS receivers will be placed on locomotives and maintenance-of-way vehicles, and their locations will be transmitted back to control centers over a digital data link communications network. NDGPS is now operational for more than 80 percent of the continental United States and is scheduled to be fully operational in 2004.

Positive Train Control (PTC) systems are integrated command, control, communications, and information systems for controlling train movements with safety, precision, and efficiency. PTC systems bring together digital data link communications networks, continuous and accurate positioning systems such as NDGPS, on-board computers on locomotives and maintenance-of-way equipment, in-cab displays, throttle-brake interfaces on locomotives, wayside interface units at switches and wayside detectors, and control center computers and displays. PTC systems will improve rail safety by significantly reducing the probability of collisions between trains, casualties to roadway workers, damage to equipment, and overspeed accidents.

(continued on next page)

Box 6-6 continued

Intelligent Railroad System Technologies

Electronically controlled pneumatic (ECP) brakes use an electronic signal along an on-train communications network to initiate brake applications and releases and, thereby, permit the simultaneous application of all brakes on a train, substantially shortening braking distance. They are an advance over current train braking systems that use air to both power the brakes and initiate brake applications and releases. As with PTC, this technology already exists, but is not yet widely deployed.

Automatic Equipment Identification tags have been installed on all U.S. and Canadian freight cars and locomotives since 1995. Electronically reading these tags enables railroads to know the precise location of every locomotive, car, and shipment at all times.

Wayside equipment sensors can identify defects that can occur on passing trains so they can be stopped for necessary repairs. Among the defects that can be detected by wayside sensors are overheated bearings and wheels, deteriorating bearings, cracked wheels, derailed wheels, and excessively high and wide loads.

Locomotive internal health monitoring systems consist of sensors mounted on locomotive engines; electrical, air, and exhaust systems; and fuel tanks. These sensors communicate over the digital link network to permit real-time monitoring of locomotive performance at control centers and maintenance facilities.

Car onboard commodity component sensors can monitor the status of the commodities being carried and identify a number of car defects. This information can be transmitted over the ECP brake communications channel and digital link to train crews, control centers, and maintenance facilities.

Intelligent grade crossings use information gleaned from PTC systems to provide information on train presence and arrival times to motorists and information on a vehicle stalled in the middle of a grade crossing to railroad control centers. This information could dramatically reduce grade crossing collisions nationwide.

Intelligent weather systems, combining a network of local weather sensors and instrumentation with forecast data, will alert train control centers and crews of hazardous weather and the potential for dangers such as flooding, track washouts, or avalanches.

Tactical traffic planners produce plans showing when trains should arrive at each point on a rail line, where they should meet and pass, and which trains should take sidings. These plans complement the activities of PTC systems.

Strategic traffic planners serve as the highest-level real-time control system in the PTC control hierarchy, analyzing schedule and performance data to maximize safety and efficiency.

Freight car reservation and scheduling systems allow customers to reserve freight car capacity and routing, allowing railroads to better schedule their cars. These systems, similar to airline reservation systems, reduce shipping of empty cars, and reduce delays to loads and empties at intermediate yards. They also reduce fleet size requirements and improve asset utilization.

Source: U.S. Department of Transportation, Federal Railroad Administration, Working Paper on Railroad System Technology, draft, Washington, DC. March 2000; personal communication, Federal Railroad Administration, Office of Railroad Development, October 2000.

Aviation Technology

The U.S. National Airspace System (NAS) is the largest, busiest, most complex, and most technologically advanced aviation operation in the world (box 6-7). The FAA provides the NAS infrastructure to support all air operations within the United States and certain ocean regions. FAA responsibility extends from air traffic control (ATC) to aviation safety and security and international coordination.

Box 6-7

What is NAS?
The National Airspace System (NAS) is a complex collection of facilities, systems, equipment, procedures, and airports. It includes more than 18,770 airports, 21 air route traffic control centers, 194 terminal radar approach control (TRACON) facilities, more than 467 airport traffic control towers, 76 flight service stations, and approximately 4,533 air navigation facilities. More than 34,000 pieces of maintainable equipment, including radars, communications switches, ground-based navigation aids, computer displays, and radios are used in NAS operations. NAS operates nonstop, 24 hours a day, 365 days a year.

Source: U.S. Department of Transportation, Federal Aviation Administration, *FAA Administrator Fact Book* (Washington, DC: December 1999).

U.S. commercial aviation has been growing rapidly over the last quarter century and is projected to grow even faster during the next 25 years. To accommodate this growth and to enhance current safety and efficiency levels, the FAA is engaged in a comprehensive program to modernize the ATC system. This includes replacing radar surveillance systems; modernizing voice communication systems; and introducing enhanced automation aids, data links, and improved weather systems.

In addition to ATC modernization (which will safely and efficiently move the increasing air traffic and reduce congestion in the skies), new aircraft technologies are under development that will allow better use of existing infrastructure capacity.

During the 1970s, the ATC infrastructure needed to handle this growth in demand also needed modernization. At that time, the ATC system was a combination of equipment, techniques, procedures, and skills that had evolved over the previous four decades. On one hand, it was the safest, most efficient ATC system in the world. On the other hand, it was very expensive to operate and maintain; expansion capability was limited at major airports; and adaptability to evolutionary change was constrained.

By 1973, the NAS "En Route Stage A" Phase One modernization had been completed. This was a decade-long program to automate and computerize the nation's en route air traffic control system for commercial aviation. All 21 air route traffic control centers in the United States gained the capability to automatically collect and distribute information about each aircraft's course and altitude to all of the sector controllers along its flight path.

General aviation and military pilots still had to file flight plans at flight service stations and military operations offices, but computers would then handle the centers' "bookkeeping functions" of assigning and printing out controller flight strips. The new computers also had the ability to record and distribute any changes registered in aircraft flight plans en route. Eventually, the system was tied in with the new Automated Radar Terminal Systems being installed at major airports. In 1975, phase two of the En Route Stage A automation program provided controllers at the 21 air route traffic control centers with new radar displays, which provided vital flight information, such as altitude and speed, on the screen.

During the last 25 years, the federal government has made impressive strides in its technology planning methodology and approaches. It has encouraged NAS users (airlines, pilots, U.S.

military, and general aviation) to become part of the planning process to ensure needed system improvements are identified early.

In 1981, the federal government released the first *National Airspace System Plan*, which resulted from an intensive 10-month study of NAS needs. The plan described a comprehensive approach for modernizing and improving ATC and airway facilities services through 2000. In parallel, the federal government completed the *National Airspace Review* in collaboration with industry. This study of the operational uses of the nation's airspace included ATC procedures, flight regulations, and the airspace environment.

The NAS plan addressed the problems of how best to accommodate the increasing demands for aviation services while constraining costs, recasting the required technical framework, and replacing aging facilities. It delineated specific improvements to facilities and equipment and described needed research and development to support NAS. Particular emphasis focused on terminal and en route air traffic control, flight service stations and weather services, ground-to-air services, and interfacility communications, as well as auxiliary services.

In 1991, the annual *Capital Investment Plan* was introduced to replace the *National Airspace System Plan.* The *Capital Investment Plan* incorporated *National Airspace System Plan* projects, more than 86 percent of which had been completed or were in field implementation by that time. It also added new projects that were identified as mission-critical. Essentially, the CIP recognized that NAS modernization was not a one-time upgrade of the NAS, as some had interpreted the NAS Plan, but rather a phased implementation with a continuing set of capital investments needed to maintain and sustain NAS performance in an evolutionary way (which administrator Garvey termed as "Build a little, test a little.") to meet the continued growth of aviation and the changing aviation business environment.

"It took 45 years to reach a world fleet of 13,000 jets. That number should double in the next 16 years. In the 12 years from 1970 to 1982, the number of passengers carried by airlines around the world doubled to 750 million. Sixteen years later, in 1998, that number doubled again to over 1.5 billion passengers…more than the population of China. And by 2016, when The Boeing Company will be 100 years old, traffic will double again to three billion. Both airports and the Air Traffic Management system must contend with significant fleet and passenger growth in the years ahead."

Philip M. Condit
Chairman and Chief Executive Officer
The Boeing Company
Aviation in the 21st Century: Beyond Open Skies Ministerial
Chicago, IL Dec. 7, 1999

Despite the growth in air traffic, only one major new airport has been built in the past 25 years: Denver International Airport, which opened in 1994. The expansion of existing airports has been slowed by a variety of concerns, ranging from cost, to limited space, to noise and other environmental considerations. To better use existing capacity, the federal government has sponsored an aggressive investment program to carry out the *Capital Investment Plan* and modernize the ATC system. As a result, major technological improvements have taken place in NAS functional areas: communications, navigation, surveillance, weather information, automation, and facilities and associated systems. The advancements made in each of these functional areas are discussed below.

Communications: In 1975, the NAS was characterized by vacuum-tube-type electronic equipment that frequently failed and was costly to maintain. In ATC communications, leased point-to-point lines for interfacility communications were the rule. These lines were costly and provided little flexibility. For air-to-ground communications, multiple, overlapping radio sites and archaic switching systems in ATC facilities impeded controllers' ability to serve system needs. Box 6-8 shows some important communication technologies implemented in the last 25 years.

Box 6-8

Communication Technologies

- **Interim Voice Response System:** This system, installed in 24 cities by 1985, made weather information available to pilots using a touch-tone telephone.

- **Consolidated Notices to Airmen (NOTAM) System:** Activated in 1986, the Consolidated NOTAM System collects, processes, and distributes messages to aviators throughout the United States and abroad.

- **Voice Switching and Control System/Enhanced Terminal Voice Switch:** These systems replaced older, electromechanical communications systems. They provide controllers with faster, more reliable, and more economical computer-controlled communications with aircraft and other ATC facilities.

- **Aeronautical Data Link (ADL):** Data link is intended to establish an alternative link between pilots and controllers to relieve voice congestion and some of the problems introduced by sole reliance on voice communications. The first phase of Aeronautical Data Link is Tower Data Link Services (TDLS). Fifty-seven airports/terminals have been completed and operational with TDLS as of 1997.

Source: U.S. Department of Transportation, Federal Aviation Administration, *Blue Print for NAS Modernization* (Washington, DC: January 1999).

Navigation: The NAS relies on a system of ground-based navigational aids. These aids cannot provide complete area navigation throughout United States at low altitudes. While the long-term solution is a complete conversion to satellite-based navigation with greater reliance on GPS, there have been many interim capital investments to sustain performance. The current aviation navigation system is comprised of more than 4,000 ground-based systems whose signals are used by aircraft avionics for en route navigation and landing guidance. Despite the large number of ground systems, navigation signals do not cover all airports and airspace. Some navigation technologies are described in box 6-9.

Box 6-9

Navigation Technologies

- **Loran-C:** The USCG-operated Loran-C navigation system was adapted for civil aviation use in 1986. Loran-C became a supplementary system for aviation, and the "mid-continent gap" in navigation was closed in 1991 through construction of several new stations.

- **Very High Frequency (VHF) Omni-Directional Radio Range:** The first of a new generation of navigational aids was commissioned in 1982 to replace vacuum tubes with more reliable solid-state equipment. By 1985, 950 sites had been upgraded. Today, this technology remains the backbone of the nation's aviation navigation system, pending transition to GPS-based navigation.

- **Precision Approach Path Indicator:** Adopted internationally in 1982 to replace the older Visual Approach Slope Indicator, the Precision Approach Path Indicator gave pilots an indication of the extent of their deviation from the intended glide path, rather than merely warning that they were too high or too low. By 1997, 237 systems were installed at international runways at U.S. airports.

Source: U.S. Department of Transportation, Federal Aviation Administration, *Blue Print for NAS Modernization* (Washington, DC: January 1999).

Surveillance: Surveillance systems provide positional data of aircraft in U.S. airspace, on the airport surface, and over the ocean. These are important to prevent mid-air collisions and for safe aircraft operations. In 1975, NAS surveillance was based on a mixture of primary ("independent") radars and secondary ("dependent") radars, called ATC radar beacons, in the en route and terminal areas of the United States. In many areas (e.g., oceanic, remote, low altitudes, and airport surfaces), there was no surveillance coverage. The *National Airspace System Plan* envisioned that a new, secondary radar system would interrogate aircraft transponders on an individual basis, paving the way for automatic data link air-ground communications on the same system. This system, known as "Mode-S," has not yet been fully implemented. Some surveillance technologies are described in box 6-10.

Box 6-10

Surveillance Technologies

- **Mode-C Intruder Capability:** In 1973, the federal government required aircraft flying in designated areas to carry an improved radar beacon transponder with automatic altitude reporting capability, as well as the ability to transmit identity codes. This rule was designed to reduce the potential for mid-air collisions.

- **Mode-C Conflict Alert:** In 1978, the federal government installed conflict alert capability at selected facilities to give controllers early warning of potential mid-air collisions.

- **Precision Runway Monitor:** In 1989, the federal government began testing a new Precision Runway Monitor radar that increased the frequency with which aircraft movements were updated on air traffic controllers' screens, thereby improving their accuracy and ability to prevent collisions. Three systems were operational by 1999, and two remaining systems are due for completion in 2001.

- **Mode-S Radar:** First tested in 1991, Mode-S production systems have been implemented in 144 locations across the country. They provide the foundation for the next generation Monopulse beacon radars, which provide aircraft position information faster than the older radar beacon systems.

Source: U.S. Department of Transportation, Federal Aviation Administration, *Blue Print for NAS Modernization* (Washington, DC: January 1999).

Weather: Weather is a critical aspect of aviation safety, responsible for 65 percent of all delays and 40 percent of all crashes. Over the last 25 years, the federal government has made breakthroughs to achieve significant improvements in weather-related technology.

Perhaps the greatest weather-related progress has been made in reducing the threat of windshear—which is a sudden and dramatic shift in wind speed and direction. Its most dangerous manifestation is in the phenomenon of "micro-bursts." Micro-bursts occur when severe thunderstorms induce a rapid, downward movement of air that can destabilize aircraft, especially when they are in their final descent to an airport. The Terminal Doppler Weather Radar program and the Low-Level Wind Shear Alert System have been very effective in helping pilots and controllers maneuver around trouble spots. Combined with pilot training and on-board windshear detectors, these technologies have reduced the threat from windshear. Some of the weather information technologies are described in box 6-11.

Automation Systems: The NAS is a very large and complex command-and-control system. In this system, information from the diverse sensor systems (surveillance, navigation, and weather) are routed to air traffic control facilities by a robust communications system. In the facilities, automation systems analyze, process, and display this sensor data to controllers, who then work with pilots and others to establish and maintain a smooth, safe, and efficient air transportation flow throughout the NAS. Thus, automation systems are crucial to system effectiveness, and they have been a major focus of investment during the past 25 years. Automation technologies are described in box 6-12.

Box 6-11

Weather Information Technologies

- **Terminal Doppler Weather Radar:** The Doppler effect permits an object's or air masses' speed and direction to be determined. Based on studies conducted in 1983 and 1984, the Terminal Doppler Weather Radar program was designed to produce warnings on dangerous windshear micro-bursts at airports. First operational in 1994, Terminal Doppler Weather Radar was deployed at 43 sites nationwide by 1999.

- **Low-Level Wind Shear Alert System:** First operational in 1978, and expanded to 110 airports, the Low-Level Wind Shear Alert System detects wind changes associated with wind shear by means of multiple sensors that measure wind speed and direction at several locations around the airport. It assists in safe landing and takeoff operations.

- **Next-Generation Weather Radar:** Using the Doppler effect, Next-Generation Weather Radar can "see" inside storms and measure the velocity and direction of wind-driven precipitation. The entire system of 158 Next-Generation Weather Radars was completed between 1994 and 1999.

Source: U.S. Department of Transportation, Federal Aviation Administration, *Blue Print for NAS Modernization* (Washington, DC: January 1999).

Box 6-12

Automation Technologies

- **ARTS IIIA Upgrades:** Beginning in 1976, ARTS III radar installations were upgraded to an ARTS IIIA configuration to provide radar tracking of aircraft not equipped with transponders. Completed by 1985, this system enables automatic reporting of aircraft identity and altitude. An upgraded ARTS IIIE system with greater capacity is now being installed.

- **Minimum Safe Altitude Warning:** First commissioned in 1976, the Minimum Safe Altitude Warning system was an add-on computer feature that could warn controllers of unsafe conditions by automatically monitoring aircraft altitudes and comparing them to terrain maps stored in the computer's memory.

- **ARTS II Systems:** Designed for airports that did not warrant the more costly and highly automated ARTS III, the ARTS II, installed at 120 smaller airports beginning in 1978, enabled full tracking of transponder-equipped aircraft.

- **Display System Replacement:** Begun in 1996 and completed in 2000, Display System Replacement provides new, automated workstations and color displays for controllers at all en route centers.

- **Standard Terminal Automation Replacement System (STARS):** Begun in 1996 after termination of the Advanced Automation System, STARS includes new computers, displays, and software for air traffic control facilities. The first deliveries of partial, new operational systems began in 1999.

Source: U.S. Department of Transportation, Federal Aviation Administration, *Blue Print for NAS Modernization* (Washington, DC: January 1999).

Facilities: In 1975, there were many individual ATC facilities with large overhead costs. Consolidation of ATC services in large metropolitan areas can generate significant safety, operational, and economic advantages. The first Consolidated/Large TRACON Facility was located in the New York City area, where it serves several major airports. Consolidation also has been completed in Southern California and is being undertaken in several metropolitan areas across the country.

The National Air Traffic Control System Command Center was established at Washington, D.C., in 1970. Periodic upgrades, such as Aircraft Situation Display (1987), Monitor Alert

USDOT, FAA

Using the Enhanced Traffic Management System (ETMS), air traffic controllers are able to monitor incoming and outgoing flights. The picture shows an ETMS screen display for four airports in the Northeast region (JFK, Philadelphia, Pittsburgh, and Boston Airports) with identities of various aircraft in the air space at a particular time.

(1987), and the Enhanced Traffic Management System (1990), have permitted greater ability to exercise real-time traffic flow management strategies in congested traffic conditions, especially during major storms.

Keys to the Future

America's aviation industry is entering the 21st century with projected increases in business, recreation, and personal travel. U.S. airlines project they will carry twice as many passengers within the next 15-20 years as they do today [USDOT FAA 2000]. This increase will not only be at large metropolitan airports, since the growth of regional jet service also will increase traffic at smaller airports. To manage this increased load on the NAS, the ATC system and supporting services require coordinated, long-term technology modernization (box 6-13).

To ensure that ATC services meet increased demand and a changing environment, the federal government joined with the aviation community to develop a NAS modernization plan that identifies the capabilities needed by the NAS users and service providers in order to provide more efficient operations. This plan addresses the need for modernizing, deploying, and inserting new technologies into the NAS and improving services and capabilities during the first quarter of this century. The plan focuses on several key areas, which are discussed in the following paragraphs.

Box 6-13

Future Aviation Technologies

In his speech during the *Aviation in the 21st Century: Beyond Open Skies Ministerial* conference, Chicago, Illinois, on December 6, 1999, NASA Administrator, Daniel S. Goldin outlined many new technological developments that will allow aviation systems to meet today's needs and address future concerns. Among those concerns are safety, noise, air quality, and congestion at airports and in the skies. The technologies include:

- runway Independent Aircraft, which are "capable of takeoff and landing on whatever ground is available – independent of size and direction" and may reduce the need for additional runways;
- Final Approach Spacing Tool (FAST) and a wake vortex sensing and prediction system that can improve the number of safe takeoffs and landings;
- semi-buoyant airplanes capable of carrying large loads of cargo;
- development of self-diagnosing and self-repairing airplanes that could lessen the occurrence of repair oversights;
- development of planes that are equipped with embedded sensors for full-time and real-time situation awareness and are able to compensate for pilot stress and fatigue which can reduce pilot error;
- model-based reasoning and neural networks that will analyze abnormalities to help accurately diagnose problems that may occur during flight;
- development of artificial vision—an integrated system of advanced sensors, digital terrain databases, accurate geo-positioning, and digital processing that will provide a clear three-dimensional picture of terrain, obstacles, runway, and traffic, and can help pilots avoid a number of flight hazards; and
- full-scale annular combustors for jet engines that can improve air quality and reduce noise, which could increase the public's acceptance of airports in their neighborhoods;

Source: Excerpts from speech by Daniel S. Goldin, Administrator, National Aeronautics and Space Administration, Aviation in the 21st Century: Beyond Open Skies Ministerial Conference, Chicago, Illinois, December 1999.

Communications: Communications quality and reliability can be improved through integrated digital communications. This modernization requires replacement of outdated hardware, better use of the available VHF spectrum, and integration of systems into a seamless network using digital technology. During the transition, the federal government plans to continue to support analog communications.

For the past 20 years, demands on VHF spectrum for air traffic services have grown by an average of four percent per year, saturating the available spectrum in many locations. Transition to digital radios will effectively increase the capacity of each VHF frequency, by at least a factor of two.

Controller-pilot data link communications (CPDLC) will introduce data exchange between controllers and pilots to reduce voice-channel congestion. Data link is also expected to reduce the opportunity for missed communications or misinterpretations of the messages. Transition to data link communications will occur gradually as new applications are tested prior to national deployment and as users equip with the necessary avionics. CPDLC initially will provide two-way exchange of air traffic control messages, such as transfer of communications and altimeter settings that are currently conveyed by voice. Voice communications will continue to be available. Oceanic and en route use of data link will precede the use of data link in terminal airspace. Current airport data link operations, called pre-departure clearance, will continue to expand.

Navigation: GPS-based services can provide increased accuracy, operational safety, and airport coverage. Over the next 10 years, the navigation system is expected to use satellite-based services, augmented by ground monitoring stations, to provide navigation signal coverage throughout the NAS. Reliance on ground-based navigation aids is expected to decline as satellite navigation provides equivalent or better levels of service.

The transition to satellite-based navigation would depend on implementation of WAAS and LAAS, as described previously in the GPS section.

Surveillance: The NAS modernization plan calls for evolution from current primary and secondary radar systems to digital radar and automatic dependent surveillance. This change is designed to improve and extend surveillance coverage and provide the necessary flexibility for Free Flight. The FAA will continue to use primary and secondary surveillance radars to detect and track aircraft in en route and terminal airspace.

Surveillance in the future NAS will provide coverage in nonradar areas and include aircraft-to-aircraft surveillance capabilities for greater situational awareness and safety. An automatic dependent surveillance-addressable system (ADS-A) will provide surveillance of intercontinental flights in oceanic airspace. Once installed in the aircraft and on the ground, these capabilities and accompanying procedures will increase aviation safety and efficiencies while reducing procedural separation distances, thereby enhancing the airport capacity.

A new avionics capability, automatic dependent surveillance-broadcast (ADS-B), may be introduced that will provide higher capability surveillance services compared to today's radar-based surveillance.

Weather: NAS modernization includes improved methods for collecting, processing, and transmitting weather information during all phases of flight. The key to reducing weather-related incidents is to improve pilot decisionmaking by providing timely weather information. Service providers and users will simultaneously receive depictions of hazardous weather to improve their understanding of weather conditions.

Modernization of aviation weather forecasting systems will replace present-day separate, standalone systems with ones that are fully integrated into the NAS. The focus is on two key capabilities:

1. improved processing/display—systems critical to this capability are the Integrated Terminal Weather System and Weather and Radar Processor, both of which will be installed by 2002, and

2. improved sensors/data sources—featuring the Next Generation Weather Radar, Terminal Doppler Weather Radar, and ground- and aircraft-based sensors.

"Every airplane in the system can know exactly where it is located and know the location of every other airplane. Every airport will have every runway effectively equipped with precision approach since there will be a universal satellite system rather than individual runway guidance systems. Every airport system could increase capacity without additional runways."

Philip M. Condit
Chairman and Chief Executive Officer
The Boeing Company
Aviation in the 21st Century: Beyond Open Skies Ministerial
Chicago, IL
Dec. 7, 1999

Avionics: Avionics is the use of satellite-based navigation and digital communications to improve safety and efficiency. It will evolve to take advantage of the benefits found in the new communications-, navigation-, and surveillance-related technologies planned in NAS modernization. With the new avionics, users will have access to many enhanced services that will help them fly more safely and efficiently. The pace of modernization will be benefits-driven and dependent on users equipping the aircraft with these new avionics.

Free Flight Phase I: Free Flight Phase I, to be introduced by 2002, uses advanced airborne and ground based technologies and new procedures to permit the use of optimum tactical separation between planes, enabling more planes to fly and to take more efficient, more direct routes. An important objective of Free Flight Phase 1 is to mitigate NAS modernization risks by deploying operational tools at a limited number of sites to evaluate performance, training procedures, human factor requirements and solutions, and safety issues. Users and service providers will have the opportunity to assess system performance, operational benefits and acceptability, and safely before further deployment. With positive results, each Free Flight Phase 1 tool will be fully developed, integrated, and deployed to suitable locations. To date, Free Flight Phase 1 has been a complete success. Free Flight Phase 2 will build upon the success of Phase 1 and will alleviate congestion over a wider geographic area. The Phase 2 timeline extends from October 2000 through December 2005.

Departures/Arrivals (Optimizing Aircraft Sequencing): Arriving and departing aircraft are sequenced in and out of the airport by air traffic controllers at the terminal radar approach control facilities. Providing controllers with tools for sequencing and spacing aircraft more precisely can ensure a steady flow of aircraft, particularly during peak periods. The objective is to reduce variability in services and optimize use of airspace and available runways. Focused on increasing airport capacity, terminal modernization will evolve through the installation of improved automation systems to provide technology and procedural enhancements.

With new capabilities inherent in advanced navigation and surveillance technology, departure and arrival procedures will change to reduce or eliminate speed and altitude restrictions and to allow aircraft to use a greater portion of the airspace around airports.

A new generation of advanced aircraft, using lighter and stronger materials and new propulsion concepts will replace today's aging commercial and general aviation air fleet. They will take advantage of the enhanced navigation, communication, and air traffic control system described previously.

Travelers will be able to make expanded use of small aircraft and small airports for business and personal intercity transportation, especially in lower density areas. NASA is working on the Small Aircraft Transportation System (SATS) initiative, which is intended to provide, by 2022, a system that will enable doorstep-to-destination travel at four times the speed of highways to 90 percent of the nation's suburban, rural, and remote communities. It includes expanding the number of public-use airports that are equipped for near all-weather operational support of SATS aircraft. SATS aircraft will encompass new avionics, airframe, engine, and pilot training technologies. These new technologies will create new features and capabilities that will significantly improve affordability, safety, and ease of use over today's aircraft.

The next generation of commercial aircraft will be safer, quieter, and environmentally compatible, as well as more efficient and customized to market niches (e.g., low fare, business, and tourist). Super-jumbo, wide-body jets may carry 800 passengers on routes serving the Pacific basin or major shuttle corridors, relieving air traffic congestion, yet accommodating growing global tourism demand. Such large airliners will be cleaner, quieter, and more fuel-efficient, but will also bring added challenges in security, baggage handling, and traffic management around airports they operate from.

Airport complexes (Reagan National, Washington Dulles, and Baltimore-Washington International; Newark; NY La Guardia, NY JFK International, and Islip/Mac Arthur; Manchester, NH; Boston, MA; and Providence, RI) serving heavily developed areas should continue to proliferate, with associated ground access problems as traffic levels rise. Inter-airport ground shuttles, Maglev systems, short-range air links, and better integrated intercity services may be used to lessen these pressures. These multimodal linkages, combined with improved weather forecasting and user-oriented ticketing systems, may reduce overall travel delays, and provide alternatives for travelers whose journeys are interrupted by adverse flight conditions.

Environmentally friendly supersonic and hypersonic aircraft with advanced noise and sonic boom reduction technologies will transport passengers and high value cargo more quickly. Tiltrotors, quiet helicopters, and other vertical take-off and landing (VTOL) agile small and light aircraft will rapidly carry and deliver intercity business travelers to the downtown to relieve airports, or to suburban destinations, replacing some corporate jets. These aircraft will incorporate "fly-by-light" technology and artificial cockpit vision (which fuses radar, infrared imaging, and video) for all-weather, 3-D situational awareness and the safety that comes with it.

In addition, tomorrow's aerospace transportation system must integrate the requirements of the emerging space transportation industry. Low-cost, user-friendly commercial space access is the key to the future of global telecommunications, safe navigation for all types of transportation vehicles, and operations of both civil and military transportation services. Current activities made possible by orbital platforms will become more inexpensive and expand: massive transmissions of voice communications and data will occur in real time, monitoring of changing weather and other conditions at the surface of the earth will improve; positioning and navigation services will become more accessible; and fleet management and parcel tracking will be facilitated. Commercial exploitation of space will continue with expanding telecommunications, new remote sensing applications, and medical complexes in orbit. There may be the first signs of a premium fare space and tourism industry. The presence of a permanent space station or lunar base should accelerate these trends.

Manned traffic into low earth orbits should increase substantially. The X-33/Venture Star and X-34 should lead to single-stage-to-orbit shuttles, which carry payloads directly into space, return to earth, and then are quickly recycled for their next mission. Low-cost, versatile launch vehicles, associated spaceports, and payload integration infrastructure will make the continued growth possible. Currently in testing are commercial launch vehicles with controlled re-entry characteristics to allow their re-use, and air-launched orbital vehicles which function as air-breathing space planes. In addition to orbital missions, these new classes of aerospace vehicles operating sub-orbitally could provide access to anywhere in the world in less than two hours to transport premium-fare passengers and high-priority freight.

Maritime Technology

Major technological advances have occurred in the 1990s in vessel propulsion, navigation, positioning, charting, and traffic management. Studies have been conducted to investigate the feasibility of using fuel cells to provide shipboard electric power. Charting advances include the use of aerial photography to accurately annotate areas, such as the national shoreline, and the use of electronic devices and software to replace paper charts. Vessel traffic management systems route and monitor vessel traffic efficiently and safely through ports and other areas. Electronic navigation aids use satellites to provide real-time position information to mariners and to improve the safety of life and property. Following a century of major technological advances, today's challenge is to make these technologies compatible across many media and among the various modes of transport. Significant technological efforts will continue to be needed to reduce the introduction of aquatic nuisance species and to mitigate the effects of cruise ship discharges of sewage and wastewater.

Navigation Aids: Navigation aids can be grouped into two categories: short- and long-range. In the past, primary navigation was based on short-range aid, which included buoys and lighthouses, daymarkers, foghorns, and fog signals. Focus was on improvements in construction and maintenance of existing navigation aid technology. Lightships—unmanned small vessels equipped with lights—were still in operation, but were phased out in the early 1980s. Long-range navigation systems (LORAN) relying on a grid of low-frequency radio waves transmitted from ground-based stations located around the world provided accuracy within one quarter mile for both civil and military air, land, and marine users until the mid-1990s. Today, the satellite-based GPS provides reliable accuracy to within a few meters. A variety of electronic aids, ranging from direction-indicating beacons to satellites, have been used in radionavigation. The Radionavigation Aids Program, which manages and operates federal maritime radio aids, provides continuous all-weather navigation capability.

Application of new technologies to navigation and marking systems can improve overall mission performance by providing alternative, customized cues that allow users to navigate in a wider range of environmental conditions and situations. In the long term, if such a system could meet stringent reliability and availability standards, it could be argued that the physical hardware infrastructure could be eliminated, and the support fleet and personnel could then be deployed to other critical missions, providing improved resource allocation.

Navigation Charts: A chart is a working document used by the mariner both as a roadmap and worksheet, and is essential for safe navigation. In conjunction with supplemental navigational aids, it is used to lay out courses and navigate ships by the shortest and safest route. Federal law requires all ships in excess of 1,600 gross tons to have and use current editions of Navigational Charts or Coast Pilots produced by the National Oceanic and Atmospheric Agency's (NOAA) Office of Coast Survey. Environmental groups, academia, and coastal zone planners also use charts and hydrographic surveys.

By the middle of the 19th century, the Office of Coast Survey was using photography to shrink and enlarge a chart's scale and had developed a process that allowed engravers to make an infinite number of copper printing plates from a single engraved master. The 20th century brought the development of technology to find the waters' depth in an attempt to identify obstacles before ships encountered them.

For the 21st century, NOAA is implementing its new Electronic Navigational Charts, which can meet demands for greater protection of life, property, and the environment, as well as significantly improve the efficiency of maritime commerce. Using sources ranging from the USCG's weekly Notice to Mariners to letters from companies describing cables laid and channels dredged, NOAA cartographers have equipped each electronic chart with embedded information about hundreds of navigational aids, obstacles, and landmarks. By the end of 2000, NOAA expects to have 90 Electronic Navigational Charts in circulation, focusing on 15 to 20 critical ports on the east and west coasts of the United States [Gugliotta 2000].

Vessel Traffic Management: In 1972, Congress passed the Ports and Waterways Safety Act. This act authorizes the USCG to establish, operate, and maintain vessel traffic services for ports, harbors, and other waters subject to congested vessel traffic. The USCG operates the Vessel Traffic Service in nine major U.S. ports and, since 1994, has shared responsibilities with the State of California at the Port of Los Angeles-Long Beach [USDOT BTS, MARAD, and USCG 1999]. In 1975, Vessel Traffic Service was mainly nonelectronic and relied heavily on the skill of the mariner and on vessel construction. Today's radar, closed-circuit television, radiotelephone, or a combination of these devices, provides surveillance of critical areas.

The methods used to gather and distribute vessel traffic and marine safety information need improvement. New approaches are necessary to improve the timeliness of information, increase overall distribution capacity and quality, and conform to the operation of modern navigation systems. Fully automated approaches to information distribution can improve safety, while reducing implementation and operating costs and reducing the communications congestion on the VHF marine frequencies. The methods, technologies, and standards that can support full automation of a modern vessel traffic management information service need to be developed, tested, and demonstrated under a variety of marine conditions. They also need to be evaluated with respect to their sensitivity and responsiveness to the operational needs of the marine community.

As part of the Vessel Traffic Management, an Automated Identification System has been developed. It includes nine shipboard broadcast transponder systems, operating in the VHF maritime band, capable of sending identification, position, heading, ship length, beam, draught, and hazardous cargo information to ships and to shore. The system is designed to reduce the number of vessel incidents in ports and busy waterways by providing ships with up-to-the-minute data on traffic conditions on the water. It also is capable of handling more than 2,000 reports per minute and updates as often as every two seconds [USDOT BTS, MARAD, and USCG 1999].

Vessel Propulsion: The 20^{th} century saw the demise of sailing ships, the rise and fall of steamships, and the rise of diesel engines. Scientific advances in hull design, the use of bilge keels, and the adoption of improved ballasting techniques produced more stable vessels. Not only did new hull designs reduce roll, but diesel engines also kept the vessels headed into the wind for even greater stability. However, they were not necessarily environmentally friendly. Research and development regarding vessel propulsion designs were focused on energy efficiency. Today studies are being conducted to develop fuel cell-based propulsion systems. These demonstrate the feasibility of reforming marine diesel to generate electric power using current fuel cell technology. Due to their higher efficiency, fuel cells can generate power using 25-30 percent less fuel than existing marine diesels or gas turbines [USCG 1999]. While it appears technically feasible to implement such technology, the future development of these systems for shipboard use remains an issue.

Initial U.S. Navy and USCG studies showed that existing land-based fuel cell systems need to be made lighter, more compact, and resistant to salt, air and high shock environments before they are suitable for marine use. Fuel cell developers are reluctant to devote resources to meeting these unique shipboard requirements until they are persuaded that a sufficient marine market exists. Federal agencies, such as the U.S. Navy, USCG, and Maritime Administration, are contributing to this effort. Fuel cells are thermally efficient, have low vibration and noise levels, and produce low exhaust emissions.

Vessel Construction and Cargo Handling: During the 1970s, intermodal shipping was a new concept. Examples of new generation ships were barge carriers (lighter aboard ship and SEABEE systems), liquid natural gas tankers, and containerships. Fast containerships had capacities of approximately 3,000 20-foot equivalent units (TEUs) and traveled at speeds between 25 and 36 knots.

Today's container vessels have cargo capacity up to about 7,000 TEUs and travel at speeds of 18 to 25 knots [Cargo Systems 1999]. Future container vessel capacity of 13,000 TEUs is being considered. In order to handle the expected increase in container vessels and their cargo capacity, port terminals will need to expand and increase productivity of intermodal services. Sophisticated gate systems are being installed in ports to expedite truck movements into and out of terminals. The maritime industry is increasingly integrating electronic tools, such as the Internet, and e-commerce is developing in the industry to better coordinate cargo bookings and freight management.

Maritime safety continues to be a high priority as high-speed or "fast ferries" (ferries with speeds of at least 25 knots) carry more passengers in the United States every year and as the number of bigger and faster personal watercraft is increasing.

Positioning: Highly accurate and affordable GPS make real-time position information available worldwide. Just as early navigators needed charts and astronomical almanacs to derive their position using a sextant and chronometer, GPS and other modern systems operate in concert with high-precision digital charts.

The DGPS was developed by the USCG and provides coastal coverage of the continental United States, the Great Lakes, Puerto Rico, portions of Alaska and Hawaii, and portions of the Mississippi River Basin.

The National Geodetic Survey (NGS), an office of NOAA's National Ocean Service, manages and coordinates a nationwide network of continuously operating reference stations (CORS) that provides GPS carrier phase and code range measurements in support of three-dimensional positioning activities throughout the United States and its territories. Some of these stations also provide meteorological data.

As of 2000, CORS data were available from 191 stations [Weston 2000]. A complete NGS CORS network is not anticipated before 2004, when other CORS-compatible networks such as the USDOT-sponsored NDGPS network become fully operational. The remainder of the stations incorporated into the NGS CORS network will be operated by a large number of different cooperating organizations to support diverse applications. Non-USDOT organizations currently contributing sites to the NGS CORS network include several federal, state, and local agencies, as well as academia and private industry.

Keys to the Future

Over the next 25 years, innovative technologies and new operational concepts will revolutionize the maritime industry and make it safer and more productive. These include developing and implementing computer-assisted vessel and cargo tracking systems; advanced navigation aids; remote pollution-monitoring; and other ship and landside, including port and intermodal system. Effective use of these technologies will be critical to taking full advantage of the potential of faster ships and more efficient ports now being developed to serve growing global trade. Leveraging emerging technologies will also be critical to ensuring U.S. global competitiveness. Overall, maritime operations will come to resemble a well-coordinated and managed enterprise, akin to aviation, rather than the traditional image of autonomous ships acting independently on the judgment and intuition of only their captains.

These improvements in operational concepts will enable the system to deal with a much broader range of maritime vehicles and services. Ferry service will probably become more prevalent, to compensate for reduced land available in highly developed areas. High-speed hydrofoils, catamarans, SWATH (small water area twin-hull) ships and hovercraft will operate as high-speed ferries in the coastal mega-cities that will have evolved from today's east and west coast urban complexes.

Intelligent vessel traffic services, coupled with differential GPS navigation, electronic charts, and related vessel improvements, will greatly improve the safety and efficiency of the marine transportation system. Marine security information will be readily available to vessel operators, integrated into the displays of data from which control decisions are made. Ocean-going vessels will be responsible for a large proportion of international movement of bulk commodities, but intelligent control technologies, improved weather forecasting, and higher vessel speeds will have increased the safety of these operations while simultaneously improving their productivity. As required by the Oil Pollution Act of 1990, only double-hulled tankers will be in service in U.S. waters.

The growth of global tourism will lead to more cruise ships of all sizes, linked to plains and trains through multimodal port terminals. These vessels will carry international and U.S. vacationers across the oceans and major inland waterways. Some forecast particular growth in very large ocean liners, carrying several thousand passengers. Advanced super-high speed "techno-superliners"—the next generation 50-100 knot passenger ships—will be operating both as long-distance coastal and ocean-crossing carriers. These vessel technologies applied to tomorrow's container ships, tankers, and bulk carriers, will help deal with greatly increased world trade volume by improving the speed of delivery of water cargo. Mega-float offshore airports and intermodal terminal ports will be coupled with high-speed sea ferries to solve the airport capacity constraints and better serve the U.S. and world coastal mega-city hubs. Larger and larger cruise ships may evolve into self-propelled floating resort "cities," which can migrate based on changing weather and climate conditions.

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chapter 7

National Security

"In the future, we envision that our transportation system will remain ready to exceed our national security requirements in three critical areas: military—to assure access and defense mobilization; economic—to ensure economic viability; and public security and safety—to exceed the citizen's expectations by maximizing security, enhancing public protection, and controlling illegal drug trafficking."

Vision of the National Security Roundtable
2025 Visioning Session, Aug. 3, 2000

"Our safety programs protect us from accidental harm; our national security programs protect us from deliberate harm."

Mortimer Downey
Deputy Secretary, U.S. Department of Transportation
Feb. 7, 2000

chapter 7

National Security

Transportation is inextricably linked to the security of our nation and its citizens. Supporting our armed forces and minimizing the transportation system's vulnerability to intentional disruption, damage, or exploitation are crucial elements of the U.S. Department of Transportation's (USDOT's) national security objective. Keeping the nation's transportation system operating efficiently to support national defense requirements and to assist in disaster response and recovery efforts, without interrupting the flow of people and goods, is expected to be a major focus over the next 25 years.

During the last quarter century, U.S. armed forces have shifted from just anticipating a possible global conflict with a dangerous and powerful adversary to being prepared for rapid deployment in localized military and humanitarian efforts as well. At the same time, the U.S. national security leadership has decided to station fewer permanent U.S. troops in foreign countries, increasing reliance on reserve forces. This new role for the military creates different demands on our transportation system.

The collapse of the Soviet Union and the Warsaw Pact transformed the world by eliminating the Soviet conventional war threat to Europe and dramatically reducing the strategic nuclear threat to the United States. However, regional instability, drug trafficking, international terrorism, information warfare, and the random use of weapons of mass destruction emerged as principal threats to our national security.

Since the end of the Cold War, many regions of the world have suffered violent intrastate or ethnic conflicts that have undermined regional stability. Pursuant to our interests and those of the international community, the United States has selectively responded to these complex emergencies with diplomatic, humanitarian, economic, and, sometimes, military responses. The chosen action reflects a careful balance of maximizing security while facilitating commerce.

"We have pursued a concerted national and international strategy against terrorism on three fronts: first, beyond our borders, by working more closely than ever with our friends and allies; second, here at home, by giving law enforcement the most powerful counterterrorism tools available; and, third, in our airports and airplanes by increasing aviation security."

President William J. Clinton
George Washington University
Aug. 5, 1996

The Department conducts a wide range of peacetime engagements with foreign democracies, in support of U.S. foreign policy, to help those nations build the security and transportation infrastuctures critical to their survival. The agencies of the Department provide support through cooperative assistance to help nations establish or improve critical infrastructure elements such as radionavigation, command and control, disaster response, maintenance, search and rescue, and law enforcement.

Homeland security is an element of national security. While the domain of national security is global, the domain of homeland security is primarily limited to our exclusive economic zone inward to the United States and its territories. Homeland security protects our homeland and citizens against an array of national security threats; it comprises three principal components—homeland defense, border protection, and sovereignty preservation.

The nation's ability to meet the security challenges of the 21st century depends heavily on the flexibility, responsiveness, and capabilities of our transportation infrastructure. To that end, the USDOT has developed the following goals:

1. reduce the vulnerability of the transportation system and its users to crime and terrorism,
2. increase the capability of the transportation system to meet the national defense needs,
3. reduce the flow of illegal drugs entering the United States,
4. reduce illegal incursions into our sovereign territory,
5. reduce the flow of illegal migrants entering the United States,
6. increase support for United States interests in promoting regional stability, and
7. reduce transportation-related dependence on foreign fuel supplies.

Force Deployment

The ability to maintain strong, capable forces throughout the world, backed by flexible, strategic, deployable forces, makes the United States a major stabilizing factor in international affairs. Transportation helps provide vital strategic mobility of materials and forces in times of national emergency.

One of the first military actions undertaken in a conflict is force deployment or "projection"—moving troops and equipment. Force projection relies on three components: sealift, airlift, and ground transportation. The importance of the key transportation role was demonstrated during Operation Desert Shield/Desert Storm (1990-1991). The United States mobilized and shipped hundreds of thousands of troops and their supporting weapons, equipment, and supplies to the Persian Gulf in a matter of months, and then returned these personnel and cargo to their home bases. The USDOT mobilized and coordinated the public and private transportation resources and systems necessary to accomplish this feat in the time required to make the operation a success [A. Strauss-Weider, Inc. 1999]. Vital, small-scale support also was needed for peacekeeping activities in Bosnia, Kosovo, Haiti, and Somalia, as well as for U.S. troops engaged in regional armed conflicts in Grenada and Panama.

The U.S. Coast Guard (USCG) facilitates the safe, efficient, and secure maritime embarkation of troops and equipment here at home. Overseas, U.S. Coast Guard Port Security Units (PSUs) support military operations worldwide by providing waterborne and limited land-based protection for shipping and critical port facilities within the waters of a port or harbor. In times of conflict, PSUs conduct operations in conjunction with Harbor Defense Commands, Mobile Inshore Undersea Warfare Units, Explosive Ordnance Disposal detachments and other U.S. or coalition rear area forces.

Sealift

The ability of the United States to respond unilaterally to military emergencies requires adequate U.S.-controlled maritime shipping capacity [USDOT MARAD 1999]. Since the end of the Cold War, increased globalization and consolidation of maritime shipping companies have reduced the number of U.S.-flagged commercial carriers. Nevertheless, nearly 80 percent of the military cargo transported during the Persian Gulf conflict was carried on U.S.-flag ships [USDOT MARAD 1998]. More than 30 percent of the cargo carried on U.S.-flag ships was transported aboard commercial vessels as a part of normal operations or under time-charter to the Department of Defense (DOD) without disruption to regular commercial service [USDOT MARAD 1998].

Table 7-1

Maritime Security Program (MSP) Participants

Participants	Vessels
American Ship Management, LLC	9 container ships
Central Gulf Lines, Inc.	3 roll-on/roll-off vessels
Crowley Maritime Corp.	3 container roll-on/roll-off vessels
Farrell Lines, Inc.	3 container ships
First American Bulk Carrier Corp.	2 container ships
First Ocean Bulk Carriers Corp., I, II, & III	3 container ships
Maersk Line, Ltd.	4 container ships
OSG Car Carriers, Inc.	1 roll-on/roll-off vessel
Sea-Land Service, Inc.	15 container ships
Waterman Steamship Corp.	4 Lighter aboard ship (LASH) (barge-carrying ship)
Total	**47 vessels**

Source: U.S. Department of Transportation, Maritime Administration, Office of Sealift Support, personal communication (Washington, DC: March 1999).

There are several programs and acts that help the United States maintain a U.S.-flag merchant fleet capable of supporting economic and national security in times of political or economic turmoil:

The Maritime Security Program (MSP) provides annual funding for nearly 50 vessels, owned by private operators, to provide emergency sealift and related services to DOD. Table 7-1 shows the current breakdown of MSP participants.

The Voluntary Intermodal Sealift Agreement (VISA) is an emergency preparedness pro-gram that makes commercial transportation systems available to DOD during war or other national emergencies (table 7-2).

The National Defense Reserve Fleet (NDRF) supports DOD during national emergencies and consists of U.S. vessels strategically docked throughout the United States. The number of ships in the NDRF has declined since 1975 (figure 7-1) and today comprises 257 ships [USDOT MARAD 2000a], 90 of which are Ready Reserve Force (RRF) ships [USDOT MARAD 2000b].

The RRF ships provide crucial sealift support during armed conflicts and humanitarian efforts, and can be tendered to the Navy's Military Sealift Command in 4, 5, 10, 20, or 30 days, depending on their location and assigned readiness priority [Hart 1999]. High-priority RRF vessels, those with four- or five-day status, are located at outport berths near military loading facilities and have civilian maintenance crews to assure the fastest possible

Table 7-2

Voluntary Intermodal Sealift Agreement (Fiscal year 1999 participants)

Alaska Cargo Transport, Inc.
American Auto Carriers, Inc.
American Automar, Inc.
American President Lines, Ltd.
American Ship Management, LLC*
Central Gulf Lines, Inc.*
Crowley American Transport, Inc.*
Crowley Maritime Services
Dixie Fuels II, Ltd.
Double Eagle Marine
Farrell Lines, Inc.*
First American Bulk Carrier Corp.*
Foss Maritime Company
Lyndon
Lykes Lines Ltd., LLC
Maersk Line, Ltd.*
Matson Navigation Company, Inc.
Maybank Shipping Company, Inc.
McAllister Towing & Transportation
Moby Marine Corp.
NPR, Inc.
OSG Car Carriers, Inc.*
Osprey Shipholding Corporation, LLC
Resolve Towing & Salvage, Inc.
Sea-Land Service, Inc.
Seacor Marine International, Inc.
Sealift, Inc.
Smith Maritime
Totem Ocean Trailer Express, Inc.
Trailer Bridge, Inc.
Trico Marine Operators, Inc.
Troika International, Ltd.
Van Ommeren Shipping (USA), LLC
Waterman Steamship Corp.*
Weeks Marine, Inc.

* Denotes Maritime Security Program operators.

Source: U.S. Department of Transportation, Maritime Administration, Office of Sealift Support, personal communication (Washington, DC: March 1999).

Figure 7-1

National Defense Reserve Fleet: 1975-99

Source: U.S. Department of Transportation, Maritime Administration, *Marad '99* (Washington, DC: May 2000).

Figure 7-2

National Port Readiness Network: 2000

Source: U.S. Department of Transportation, Maritime Administration, available at http://www.marad.dot.gov/nprn/index.html, as of July 2000.

activation. Fourteen U.S. commercial ports are designated by DOD as strategically important for the movement of military equipment and supplies (figure 7-2). As outlined in USDOT/DOD Memorandum of Agreement on Port Readiness, a number of agencies are involved in the operation of militarized ports and port facilities during war or national crises. Included among these are the USCG (e.g. harbor defense, port security, port safety and vessel traffic management), DOD's Transportation Command (Military Sealift Command and Military Traffic Management Command), the Army Corps of Engineers (channel maintenance and wreck removal) and the Maritime Administration (contractual arrangements). Local Port Readiness Committees, chaired by USCG Captains of the Port, provide effective coordination at the executive level.

To increase the size of our U.S.-flag fleet, the President's National Shipbuilding Initiative (NSI) is being implemented through the Maritime Guarantee (Title XI) program. Under the NSI, the Title XI program was expanded to include financing for exporting vessels constructed in U.S. shipyards and modernizing U.S. shipyard facilities.

As mentioned in Chapter 4, the number of U.S.-flag ships has been declining, and the nation's shipbuilding capacity has fallen. National security considerations might require increasing the number of U.S.-flag ships of the dry bulk fleet, increasing jobs for U.S. merchant mariners, and increasing the percentage of U.S. foreign commerce carried on U.S.-flag vessels in order to maintain the economic viability of our U.S. merchant fleet as well as its availability for national security use.

Airlift

Airlift is both the means of delivery and the sustainable lifeline for troops until sea lines of communication can be established. A significant part of the nation's mobility resource is the Civil Reserve Air Fleet (CRAF)—aviation's equivalent of the MSP. Selected aircraft from commercial U.S. airlines are contracted to CRAF to support DOD emergency airlift requirements should airlift needs exceed military aircraft capabilities. The CRAF has three main segments: international airlift, national airlift, and aeromedical evacuation. The international segment is divided into long- and short-range sections, and the national segment into domestic and Alaskan sections.

To belong to CRAF, commercial airlines contract to activate their aircraft, as needed, to support CRAF segments. To provide incentives for civil carriers to commit aircraft to the CRAF program, Air Mobility Command (AMC) awards peacetime airlift contracts to civilian airlines that offer aircraft to the CRAF. The International Airlift Services contract is the largest of these. For fiscal year 1999, the guaranteed portion of the contract is $345 million, and AMC estimated that throughout fiscal year 1999, it would also award more than $362 million in nonguaranteed business. Carriers also must commit and maintain at least four complete crews for each aircraft [USAF 1999]. As of October 1, 1998, 35 carriers and 657 aircraft were enrolled in CRAF (table 7-3).

Table 7-3

Members of the Civil Reserve Air Fleet (CRAF)

Long-Range International
Air Transport International
American International Airways
American Airlines
American Trans Air
Arrow Air
Continental Airlines
Delta Airlines
DHL Airways
Emery Worldwide
Evergreen International
Federal Express Airlines
Fine Airlines
North American Airlines
Northwest Airlines
Polar Air Cargo
Sun Country Airlines
Tower Air
Trans Continental Airlines
United Airlines
United Parcel Service
World Airways
Short-Range International
Alaska Airlines
American Trans Air
DHL Airways
Evergreen International
Express One
Miami Air International
Sun Country Airlines
Sun World
US Airways Shuttle
Aeromedical Evacuation
Delta Airlines
US Airways
Domestic
America West Express
Reno Air
Southwest Airlines
Alaskan
Northern Air Cargo
Reeve Aleutian
Lynden Air Cargo

Source: U.S. Department of the Air Force website, USAF Fact Sheet, May 1999.

Ground Transportation

The nation's rail and highway systems play critical roles in the movement of military equipment and personnel during peacetime and, particularly, in wartime. When a contingency arises, huge amounts of military equipment and personnel are moved expeditiously from various continental U.S. (CONUS)-based military installations to various seaports and airports. Most of this equipment is convoyed over U.S. highways.

The Strategic Highway Network (STRAHNET) system of public highways forms a key component of U.S. strategic defense policy, providing access, continuity, and emergency transport of personnel and equipment in times of peace and war. The 61,000-mile system comprises about 45,400 miles of Interstate and defense highways and 15,600 miles of other important public highways.

STRAHNET is complemented by about 1,700 miles of STRAHNET Connectors—additional highway routes linking more than 200 important military installations and ports to the network. These routes are typically used when moving personnel and equipment during mobilization or deployment and generally terminate at the port boundary or installation gate. It is these routes where infrastructure deficiencies are most likely to occur because connector roads tend to be secondary facilities. Therefore, STRAHNET Connectors are a subject of continuous scrutiny and emphasis for the transportation community.

"The National Highway System is essential to our ability to move equipment and personnel in support of contingencies or peace-keeping efforts anywhere in the world."

Lt. Gen. Kenneth R. Wykle, USA,
Deputy Commander in Chief, U.S. Transportation Command,
Mar. 2, 1997

Together, STRAHNET and STRAHNET Connectors define the minimum public highway network needed to support defense emergencies. Because of national security importance, the Intermodal Surface Transportation Efficiency Act of 1991 and the National Highway System Designation Act of 1995 provided for inclusion of STRAHNET and important STRAHNET Connectors in the 161,000-mile National Highway System (NHS). Federal oversight ensures optimum maintenance levels for the NHS and assures that roads can support emergency deployment. With DOD's current emphasis on CONUS-based military units, the NHS will play an increasingly important role in future deployment scenarios.

In today's environment, the most important STRAHNET and Connector routes support the movement of Army and Marine Corps troops and equipment between the Power Projection Platforms (PPPs) and embarkation seaports. The majority of the Army and Marine Corps units will ultimately mobilize and deploy from PPP sites (figure 7-3).

The Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) administers the Highways for National Defense Program on behalf of the U.S. Transportation Command. MTMCTEA works with the Federal Highway Administration (FHWA) to identify important defense highways and ensure that the infrastructure is able to support a defense emergency. Current initiatives involve documenting the condition and needs of PPP deployment routes.

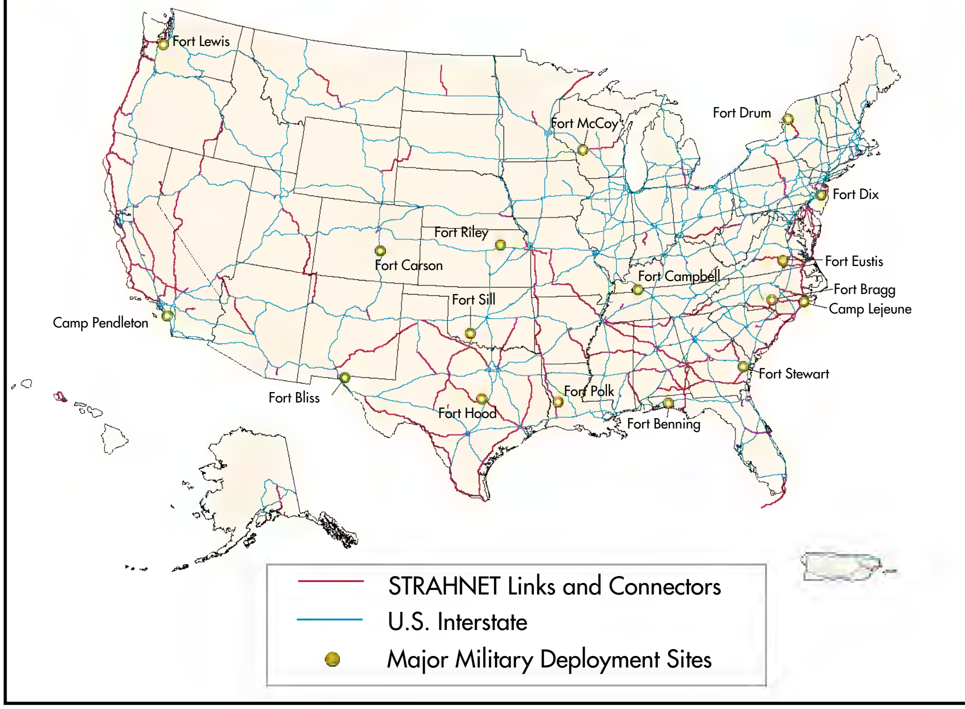
Over the next few decades, the demand for personal travel and goods movement is expected to increase significantly. This increase in travel demand could impact defense mobility because of conflicts between military traffic and the demand for movement of people and goods. These conflicts be reduced, however, by the use of Intelligent Transportation System (ITS) technologies for communicating real-time information to users that will provide deployment officials with route guidance. The ITS system will use the existing highway and rail databases, be Internet accessible, capable of using video logs and remote sensing satellite imagery, and provide real-time information on traffic conditions, road closures, construction, and weather. The military will evolve into highly mobile, light, lethal forces that will reduce the current bridge, tunnel, and roadway structural requirements for tanks and other heavy equipment.

Vulnerability

One of USDOT's national security strategic goals is to reduce the vulnerability and consequences of intentional harm to the entire transportation system and its users. Such vulnerability exists in every country's transportation infrastructure. In the last quarter century, there have been intentional harmful attacks against every transportation mode in the United States,

Figure 7-3

The Strategic Highway Network (STRAHNET) and Major Military Deployment Sites: 2000



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, National Transportation Atlas Database, 2000; and military deployment sites information available at http://www.msrad.dot.gov/nprn/index.html, as of July 2000.

especially against the aviation system during the 1970s and 1980s. The visibility of aviation operations as symbols of national pride, the high loss of life that results from such incidents, and instantaneous worldwide media coverage makes aviation systems a favorite target of terrorists. The complex nature of protecting aviation from such attacks is discussed in the Threats to Aviation Security section of this chapter. The following section, Threats to Infrastructure Security, provides a discussion of all other transportation modes.

Threats to Infrastructure Security

To respond effectively, transportation security officials strive to identify threats and determine the vulnerability of transportation systems and to deter attacks through effective security enhancements.

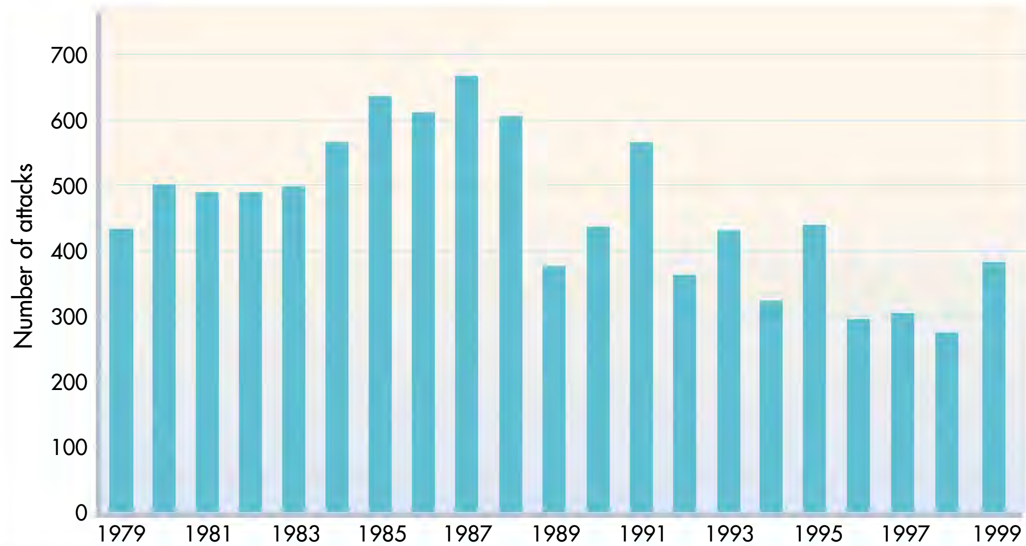
The number of international terrorism incidents peaked in the mid-1980s (figure 7-4), led by a shift in terrorist tactics from hijackings to vehicle bombings, assassinations, and kidnappings in the Middle East, Europe, and Latin America.

During the mid-1980s, terrorism continued to pose a worldwide threat, and the U.S. government upgraded its antiterrorist organizations and resources. Although worldwide terrorist attacks declined during the 1990s, the number of casualties remained high. Locations of the attacks showed some marked trends (figures 7-5 and 7-6), which reveals that North America had the fewest terrorist attacks during this period.

By the early 1990s, terrorist threats and incidents shifted to transportation targets. Tokyo subway passengers were poisoned by a release of sarin nerve gas, allegedly by a religious cult; and there were violent attacks against transit passengers, vehicles, and systems in several parts of the world.

Figure 7-4

Worldwide International Terrorist Attacks: 1979-99



Source: U.S. Department of State, *Patterns of Global Terrorism 1998* (Washington, DC: 1999), appendix C.

Figure 7-5

Worldwide Casualties Due to International Terrorism: 1993-98
(Annual totals)

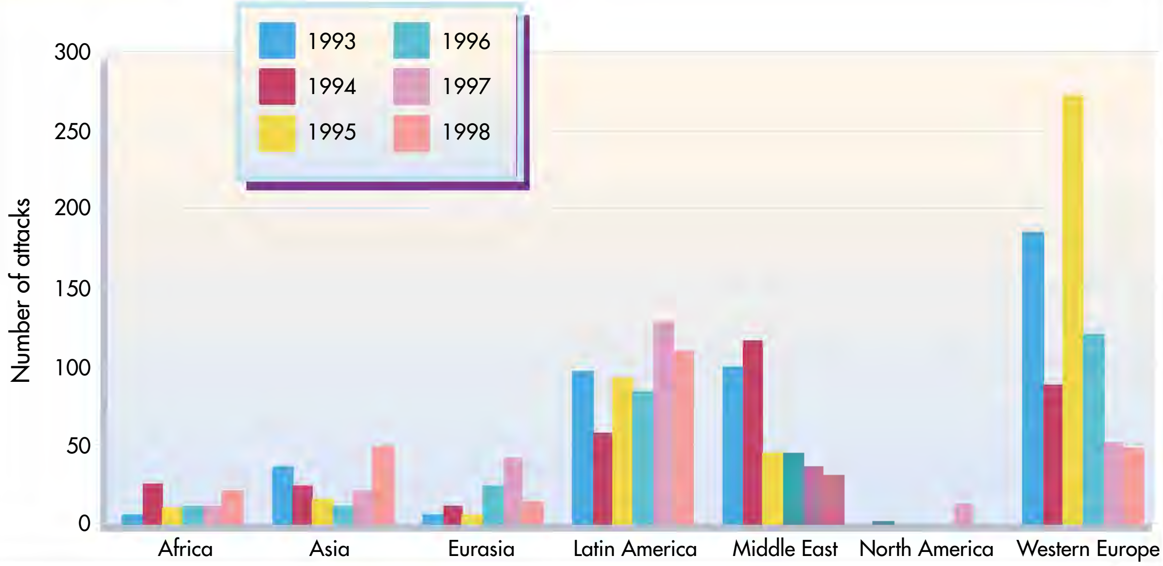
Source: U.S. Department of State, *Patterns of Global Terrorism 1998* (Washington, DC: 1999), appendix C.

According to the Federal Bureau of Investigation (FBI), in the 1990s, U.S. terrorist incidents (actual, suspected, and prevented) varied from a low of one in 1994 to a high of 25 in 1997 (figure 7-7). The types of incidents and culprits varied during these years. In the early 1990s, bombings and arson predominated. By the late 1990s, letter bombs and large-scale vehicle bombs became the major concern, particularly following the Oklahoma City incident in 1995. Antigovernment organizations and "hate" groups were increasingly linked to these events.

Worldwide, transportation and transportation infrastructure are increasingly becoming targets of violent attacks by both terrorist and criminal elements. In 1998, there were 1,033 violent incidents against transportation worldwide, which was an increase of nearly 20 percent over the previous year and an increase of 107 percent since 1995 [USDOT OST OIS 1999]. Figure 7-8 shows worldwide violent attacks, by mode, in 1998, while figure 7-9 shows worldwide violent attacks against transportation, by region, for that same year. Many of these attacks against transportation were intended to cause mass casualties [USDOT OST OIS 1999].

Figure 7-6

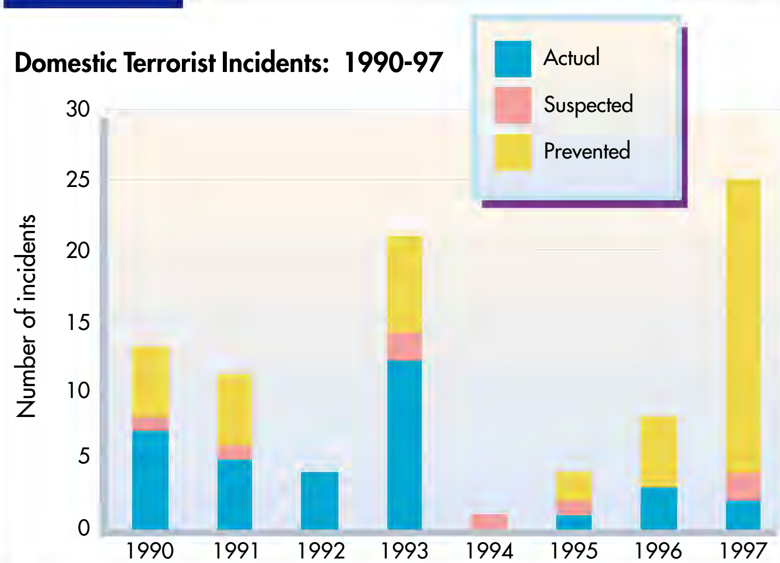
Worldwide International Terrorist Attacks by Region and Year: 1993-98



Source: U.S. Department of State, *Patterns of Global Terrorism 1998* (Washington, DC: 1999), appendix C.

Figure 7-7

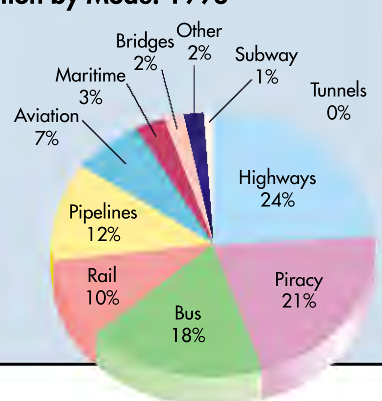
Domestic Terrorist Incidents: 1990-97



Source: Federal Bureau of Investigation, *Terrorism in the United States–1997* (Washington, DC: 2000), p. 3.

Figure 7-8

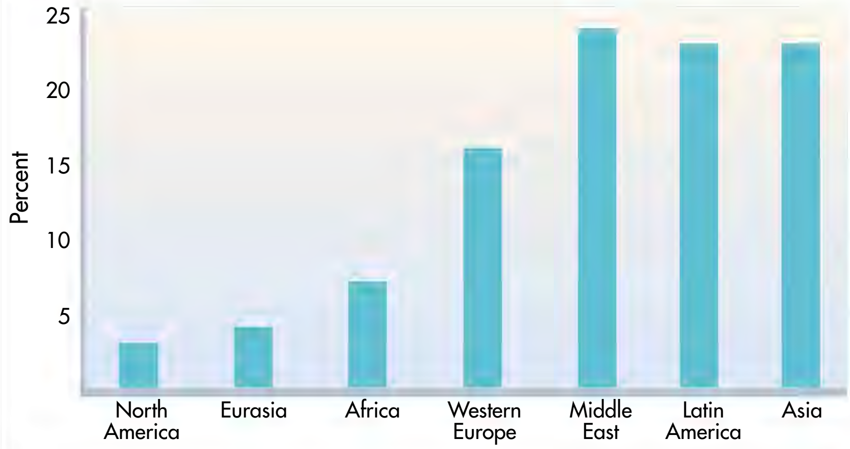
Worldwide Violent Acts Against Transportation by Mode: 1998



Source: U.S. Department of Transportation, Office of Intelligence and Security, *Worldwide Terrorist and Violent Criminal Attacks Against Transportation 1998* (Washington, DC: 1999), p. 4.

Figure 7-9

Terrorist Attacks Against Transportation by World Region: 1998



Source: U.S. Department of Transportation, Office of Intelligence and Security, *Worldwide Terrorist and Violent Criminal Attacks Against Transportation 1998* (Washington, DC: 1999), p. 17.

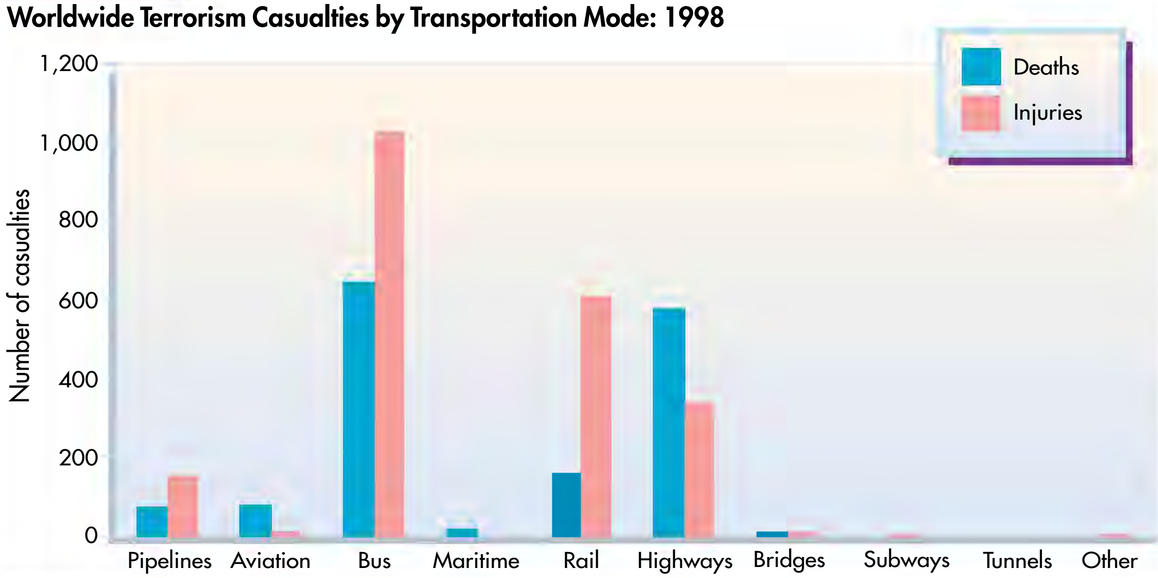
Figure 7-10 shows the number of deaths and injuries caused by terrorist and other violent attacks by mode worldwide. Nearly every attack on trains, buses, and public transit caused multiple casualties; bus passengers incurred the greatest number of casualties.

In North America, there were 27 violent acts against transportation reported in 1998; none involved international terrorists. Eleven of the incidents were against rail, including sabotage and derailment, attempted bombings, bomb threats, and one case of an incendiary device placed on railroad tracks. The remaining incidents included three bus hijackings; two planned or threatened attacks against bridges; three attacks against aviation; two pipeline bombings; and six maritime incidents that involved piracy, threats against cruise lines, bombing, and civil disobedience. Overall, five casualties were reported [USDOT OST OIS 1999].

Maritime piracy attacks worldwide rose 50 percent between 1998 and 1999, and they continue to be centered in Southeast Asian waters [Parker 2000], where the Straits of Singapore are the most heavily trafficked maritime crossroads in the world [DOT OIS OST 1999] (figure 7-11).

Figure 7-10

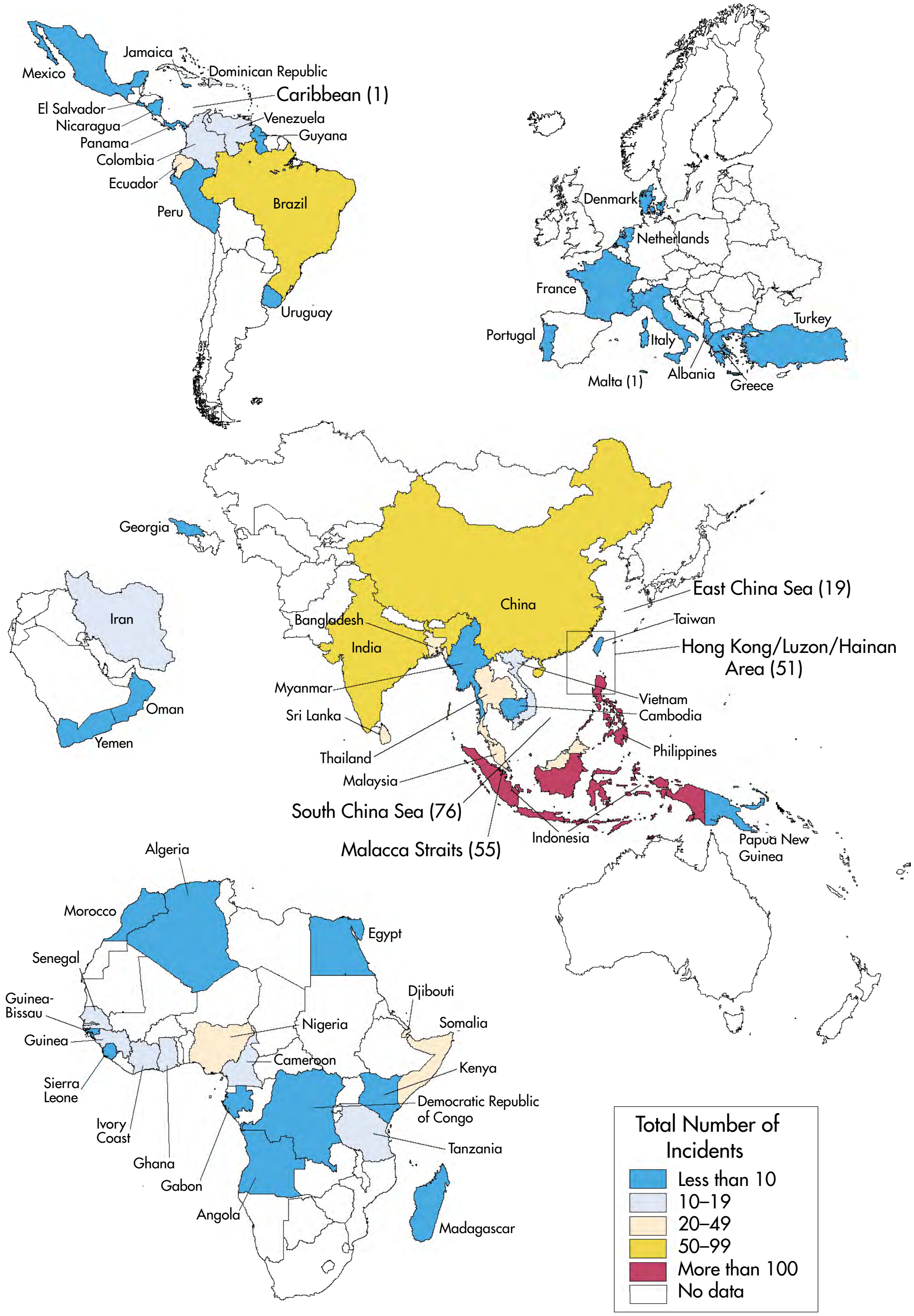
Worldwide Terrorism Casualties by Transportation Mode: 1998



Source: U.S. Department of Transportation, Office of Intelligence and Security, *Worldwide Terrorist and Violent Criminal Attacks Against Transportation 1998* (Washington, DC: 1999).

Figure 7-11

Worldwide Incidents of Piracy: Cumulative 1991 through 1999

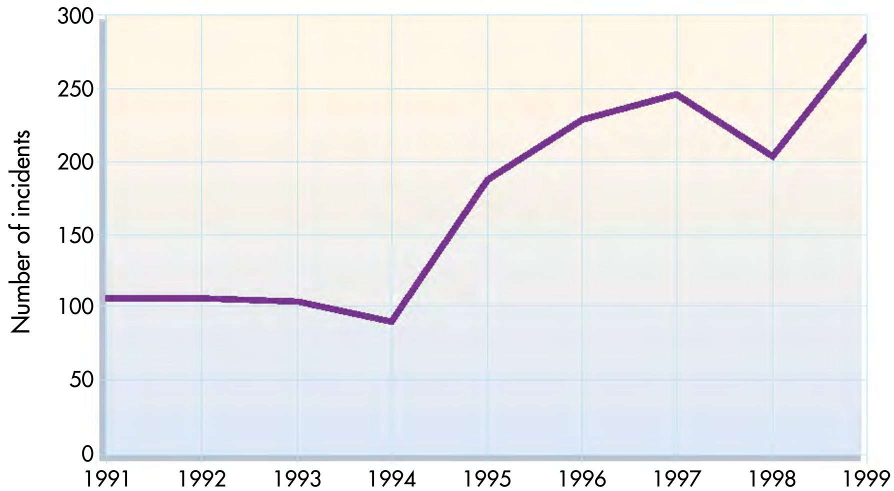


Note: Incidents took place in the territorial waters of respective countries.
Source: U.S. Department of Transportation, Maritime Administration, personal communication, May 2000.

These acts of piracy accounted for 20 percent of all transportation incidents. There were 209 reported acts of piracy/sea robbery committed against merchant shipping interests worldwide during 1998 (figure 7-12). Eighty-eight people were killed in these piracy incidents, an increase of more than 450 percent from 1997. There is no evidence to suggest that vessels of a specific flag were targeted in any given region, but 21 U.S.-flag vessels have been attacked over the last five years [USDOT OST OIS 1999]. The majority of these attacks took place at night while vessels were at anchor.

Figure 7-12

Maritime Piracy Incidents: 1991-99
(Annual totals)



Source: International Chamber of Commerce, International Maritime Bureau, Maritime Piracy Annual Report, available at http://www.iccwbo/ccs/menu_imb_piracy.asp, as of October 2000.

There were 122 attacks worldwide against pipelines in 1998, a 15 percent increase from 1997. Eighty of these incidents were international terrorist attacks, and all but five of the attacks were bombings. Seventy-four people were killed in these attacks [USDOT OST OIS 1999]. Pipelines are regarded as easy targets because they often traverse many miles of isolated territory virtually unprotected.

In 1998, highway infrastructure was the most frequently attacked transportation target worldwide. There were 242 such attacks in 1998, in which 579 people were killed. Eleven of these incidents were terrorist attacks. Additionally, there were 22 attacks against bridges and 4 attacks against tunnels in 1998. One bridge incident was an international terrorist attack [USDOT OST OIS 1999].

The increasing reliance of the transportation system on sophisticated electronic information and communications systems in day-to-day operations is a cause for concern due to the possibility of cyber-based disruptions of key support services. Examples of these services include the extensive and growing use of Electronic Data Interchange (EDI) and the Internet to conduct business, air traffic control as part of the National Airspace System (NAS), extensive use and dependence on the Global Positioning System (GPS) for navigation functions, the rapidly expanding use of Intelligent Transportation Systems (ITS), the railroad signal system, and the use of Internet-Based Supervisory Control And Data Acquisition (SCADA) systems to control modern pipeline operations. All of these contribute to a more efficient transportation system, but at the same time, these developing technologies make our transportation system vulnerable to cyber attack.

Box 7-1

The Y2K Challenge

The Y2K problem (as it is popularly known), caused by the practice of two-digit coding of years in computer databases, could have caused serious problems in some of the transportation's mission critical systems (e.g., the FAA's air traffic control system and the USCG's search-and-rescue and GPS services). A four-year, $400 million effort by the USDOT prevented serious disruptions to transportation services as we turned the century and the millennium.

During the late 1990s, the security of the nation's transportatio system, the potential countermeasures, and the need for improvements were catalysts for the creation of the President's Commission on Critical Infrastructure Protection. This Commission was formed to review the physical and electronic, or cyber, vulnerabilities of transportation, as well as other vulnerable areas of the nation's critical infrastructure sectors.

The Commission recommended education and awareness programs, research and development (R&D), improved threat assessment capabilities and information sharing, and a national structure to determine who would carry out these activities and how they would be coordinated. In transportation, the Commission was particularly concerned about two potential vulnerabilities—satellite-based GPS, particularly if it becomes the sole source for radionavigation for aircraft landings, and the NAS, including Federal Aviation Administration (FAA) air traffic control facilities.

In May 1998, President Clinton issued two Presidential Decision Directives (PDDs): Combating Terrorism [Clinton 1998a] and Protecting America's Critical Infrastructure [Clinton 1998b]. The President formalized the role of the National Coordinator for Security, Infrastructure Protection, and Counterterrorism as a senior position in the National Security Council (NSC). New interagency organizations—the Critical Infrastructure Assurance Office, the National Infrastructure Protection Center, and the National Infrastructure Assurance Council—were established to oversee the implementation of the President's Commission recommendations. At the same time, DOD designated National Guard units in 10 states to create teams to train and assist state and local "first responder" agencies in chemical and biological incidents within the United States.

PDD 63 established the need for a new private-public sector partnership to combine the resources of both the transportation industry and the federal government to identify new threats and vulnerabilities emerging from the growing information-based global economy. The USDOT has the lead in working with the transportation industry sector coordinator in establishing this partnership and ensuring U.S. critical infrastructures are protected for the nation's security and economic well-being.

In June 1999, the President's National Security Telecommunications Advisory Committee, in the *Transportation Information Infrastructure Risk Assessment Report*, recommended steps to increase awareness and information about the cyber threat to the transportation system and its information resources [NSTAC 1999]. The panel contended that the continued implementation of new technologies made the potential impact of disruptions to transportation systems even more significant than in the past and proposed expanding R&D into countermeasures. Collectively with the nation's defense agencies, the USDOT intends to protect our transportation system by identifying threats, determining the extent of vulnerability to which the system is exposed, and using effective security enhancements to deter attacks.

In August 2000, President Clinton released the report of the Interagency Commission on Crime and Security in U.S. Seaports. The Commission's report identifies threats to our seaports and recommends a number of measures aimed at reducing the vulnerability of maritime commerce and the Marine Transportation System infrastructure that supports it. Hearings in the Senate were held in October 2000 to discuss recommendations of the report and how best to meet these challenges. The USCG unveiled the concept of Maritime Domain Awareness to help meet several of the report's key recommendations.

Keys to the Future

Terrorism is a growing threat against transportation and transportation infrastructures in the United States and throughout the world:

- Today's terrorist groups are fluid and multinational.
- Growing international support networks enhance the ability of extremists to operate in the United States.
- The rise of extremism is threatening stability in the Middle East and elsewhere in the world.
- The breakup of the Soviet Union and the Warsaw Pact has unexpectedly contributed to global instability through increased ethnic strife.
- Cults, such as the Japanese Aum Shin Rikyo, pose a growing threat.

The World Trade Center bombing in New York, on February 26, 1993, and the Oklahoma City bombing of the Alfred P. Murrah Federal Building, on April 19, 1995, stunned the U.S. public. These incidents make it clear that symbols of the United States and those of its trade and commerce are just as vulnerable to terrorist targets as similar targets in other countries worldwide.

Our transportation system has not escaped the attention of terrorists, as underscored by the 1993 planned bombings of the Lincoln and Holland tunnels and the George Washington bridge in New York City by the same individuals who bombed the World Trade Center. Overseas, a series of sarin gas attacks in the Tokyo subway system by the Aum Shin Rikyo religious cult in March 1995 marked the first large-scale use of chemical agents as a weapon of mass destruction against a civilian transportation target.

Technology has added to the terrorist threat. Since the breakup of the Soviet Union, sophisticated arms and weapons systems are available to terrorists at competitive prices, and there is an increasing likelihood that terrorists may try to use weapons of mass destruction/disruption (chemical, biological radiological, and information warfare).

Confronting and preventing this new class of threats before reaching our land, maritime, aerospace, and cybernetic borders are not simple tasks. They require a balance between security imperatives and the need for a fast and efficient U.S. transportation system, a key contributor to the country's overall economic prosperity. The Secretary of Transportation has laid out a blue print that meets these new global threats head on. The *Marine Transportation System Report* provides direction for how we will meet our national security obligations.

The USCG has developed a concept called Maritime Domain Awareness (MDA). MDA is effective knowledge of all activities and elements that threaten the safety, security, or environment of the United States or its citizens. The USCG is unique in that it is the only federal agency that operates in both military and law enforcement environments, providing ties to the national foreign intelligence community (e.g., NSA, CIA, ONI) and domestic law enforcement databases (e.g., Customs, FBI). This capability, when linked from the Intelligence Coordination Center to other federal enforcement agencies and with USCG stations, aircraft, and cutters, will provide actionable information that will significantly improve our ability to address threats before they reach our borders.

Threats to Aviation Security

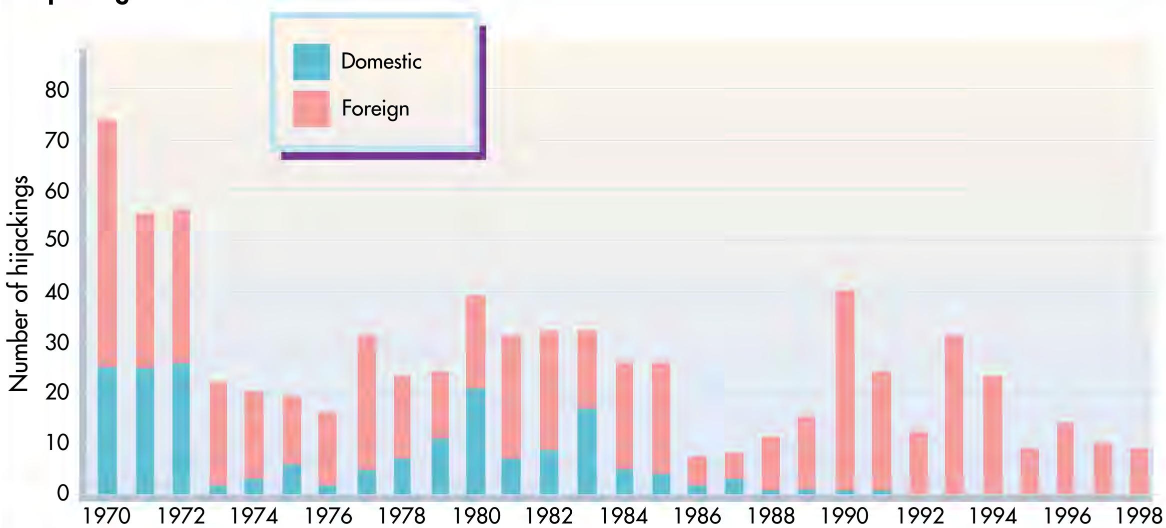
The emergence of globalization resulted in the worldwide spread of business affiliations, customers, suppliers, subsidiaries, and manufacturing sites. More passengers, both business and leisure, are taking advantage of air travel. This growth in air travel, coupled with potential increased threat, has created concern for the safety and security of travelers.

Worldwide, incidents of unlawful interference with civil aviation, primarily hijacking and sabotage, have decreased since the 1970s (figure 7-13), while the number of flights, enplanements, and passenger-miles flown by scheduled air carriers has increased.

With hijackings becoming an all too frequent occurrence in the late 1960s and early 1970s, air carriers voluntarily cooperated with the federal government on measures to counter the threat. Providing security is now treated by air carriers and airports as a cost of doing business.

Figure 7-13

Hijackings Worldwide: 1970-98



Source: U.S. Department of Transportation, Federal Aviation Administration, *Criminal Acts Against Civil Aviation–1998*, available at http://cas.faa.gov/crimacts/index.html, as of September 18, 2000.

While in the United States there were 142 domestic hijackings between 1961 and 1972 and 8 explosions aboard commercial aircraft between 1955 and 1976 [Harris 2000], only the September 1976 hijacking at LaGuardia Airport was clearly linked to terrorism.

Throughout the 1970s and into the 1980s, the United States and the world aviation community took action to stop hijacking attempts using a broad range of strategies, including:

- more effective passenger and baggage screening,
- imposition of contingency or extraordinary security measures in special circumstances,
- worldwide use of X-ray and metal detection equipment,
- in-depth assessments of U.S. and foreign airport and air carrier security,
- establishment of the U.S. Federal Air Marshal Program,
- tightened control of access to aircraft and security-sensitive areas,
- more R&D of explosives detection and other security technologies,
- improved analysis of intelligence on terrorist activities, and
- improved technical assistance and training for operators and personnel.

In addition to these strategies, the FAA is considering legislation to improve personnel selection criteria and training standards for aviation security (box 7-2).

Box 7-2

Aviation Security Training

Proper deployment of highly sophisticated screening devices requires employment of trained operators capable of following procedures and making appropriate decisions. However, this need is compromised by high turnover rates for screeners due to low wages and a tight labor market.

The FAA's proposed "Certification of Screening Companies" rulemaking offers the public an opportunity to comment on selection criteria and training standards and to seek ideas for improving aviation security training. Proposals have been made for the FAA to mandate 80 hours of intensive classroom/laboratory training and 40 hours of on-the-job training before performance certification for all airline security screening personnel.

Currently, the FAA and airlines are deploying elements of the Screener Proficiency Evaluation and Reporting System (SPEARS), a major FAA effort to improve training and monitor screener effectiveness. SPEARS has computer-based training modules, which are effective and efficient methods for training screeners. These have been installed at 17 major airports.

The other SPEARS component, Threat Image Projection (TIP), is a system whereby artificial images of improvised explosives devices and other threat objects are presented to the screener during the performance of normal duties as if objects actually were in baggage. The screener's decisions are tabulated and recorded to furnish real-time feedback for effectiveness monitoring and as a training tool. Approximately 300 TIP systems are being deployed to the 19 busiest airports.

In addition, the FAA provides formal training through airport security seminars for law enforcement officers and airport personnel. Aviation security special agents also provide one or two hours of instruction in airline training courses. Similar participation occurs in industry association-sponsored schools and conferences.

Source: White House Commission On Aviation Safety and Security, *The DOT Status Report*, available at http://www.dot.gov/affairs/whcsec3.htm, as of July 26, 2000.

The vast majority of criminal and terrorist acts against civil aviation during the 1980s took place overseas [Simon 1994]. The bombing of Pan Am Flight 103 over Lockerbie, Scotland, during a flight from Frankfurt in December 1988, stimulated the most significant changes in aviation security since the early 1970s. The Lockerbie disaster turned the world's focus toward finding and developing new technologies to detect concealed explosives in passenger baggage.

In 1990, the Aviation Security Improvement Act strengthened the role of the federal government in civil aviation security. The Act instructed the FAA to fund the development of Explosives Detection Systems (EDSs), establish EDS certification standards, and test and certify potential EDSs for eventual deployment. Since 1990, both the Office of the Secretary of Transportation and the FAA have upgraded those organizations that handle aviation security. Both are headed by senior executives who report directly to the Secretary or the FAA Administrator.

The U.S. aviation system has been on heightened security status since 1995, and security measures overseas have been adjusted numerous times since then. The decision to increase security in 1995 was based on information provided by federal law enforcement and intelligence agencies, combined with an analysis of the state of affairs at the time.

On July 25, 1996, after the loss of TWA Flight 800, President Clinton established the White House Commission on Aviation Safety and Security, chaired by Vice President Gore, and directed that preflight security inspections be conducted on all overseas international flights. The Commission recommended the following procedures:

Improve baggage checking and checkpoint screening by deploying advanced security technologies.

- Require certification of security screening companies and improve personnel.
- Strengthen security through consortia and partnerships with airport, airline, and law enforcement personnel.
- Perform unannounced, realistic operational tests of security systems.
- Require enhanced controls on access and movement in secure areas of airports.

Air carriers bear the primary responsibility for applying security measures to passengers, service and flight crews, baggage, and cargo. Airports, run by state or local government authorities, are responsible for maintaining a secure ground environment and for providing law enforcement support for implementation of airline and airport security measures. All major air carriers assume operations costs for installed EDSs and other technologies, and pay maintenance costs to cover service performed after warranties have expired and following initial maintenance periods. About 100 companies conduct screening at airports in the United States [65 *Federal Register* 559], with at least 16 different companies, including two air carriers, conducting screening at the 19 busiest airports [USDOT FAA 1998].

The FAA has purchased and deployed advanced security technologies, including more than 100 EDS devices for checked baggage screening and more than 570 explosives trace detection devices for use at screening checkpoints at more than 90 U.S. airports [Flynn 2000]. Voluntary security consortia have been established at 170 airports. Here government agencies and airline industry representatives assess and discuss security and work together to eliminate vulnerabilities. Interagency efforts to assess and mitigate potential threats posed by chemical and biological weapons and surface-to-air missiles actively continue.

Keys to the Future

The U.S. government works with the International Civil Aviation Organization (ICAO) to strengthen international security standards. The FAA is pursuing R&D in aviation security to provide the technologies and tools necessary to cope with new threats and improve existing countermeasures. Hardening standards are being studied for new aircraft, and a transition to hardened containers to prevent catastrophic damage from explosive devices is underway. Human factors research is being emphasized to aid in identifying threats, interacting with advanced technology, and determining hiring qualifications and specialized training requirements [Flynn 1999].

Historically, explosives and other improvised explosive devices, as well as weapons concealed on individuals, accounted for a high percentage of all civil aviation security incidents. Consequently, the FAA is working to improve the detection of explosive devices concealed in carry-on bags and to do so economically, without introducing significant operational delays. Conventional metal detectors are generally considered effective for weapons detection, although other detection means may be required.

Research to reliably detect explosive components and weapons carried by people continues to be emphasized. The FAA's R&D program conducts a systematic assessment of checkpoint security devices and techniques. Based on these assessments, a checkpoint security screening model will be developed to create a checkpoint architecture for the future. This architecture will address the mandates of both security and operations and will form the basis for testing prototype configurations in airports [Roder 1999].

Following the recommendations of the White House Commission on Aviation Safety and Security, the federal government resumed a practice not used since the height of the hijacking threat in the mid-1970s—the government purchase of security equipment for use by private-sector air carriers to screen passengers and baggage prior to boarding. The FAA plans, in the near term, to continue purchasing EDSs and other advanced security technologies for expedited deployment as part of an overall effort to improve security [Tucker 2000].

In the coming years, the FAA also plans to deploy an increasing number of EDSs and explosives trace detection devices at a steady rate. It also plans to replace every checkpoint X-ray device in the country with models that feature Threat Image Protection (TIP). The number of explosives detection canine teams subsidized and certified by the FAA rose from 87 teams at 26 airports in 1996 to 174 teams at 39 airports in 1999. The FAA has canine teams at all major airports, and growth in this program is expected to continue [Flynn 2000].

The destruction of Pan Am Flight 103 in 1988, the French airline Union de Transport Aeriens (UTA) Flight 772 in 1989, and the hijacking of Indian Airlines Flight 814 in 1999 are reminders that aviation security is an international concern (box 7-3). There is a need for improved security through better screening equipment operated by carefully selected and well-trained and tested screening personnel [Flynn 1999]. Additionally, R&D can improve explosives and weapons detection, technology integration, aircraft hardening, and aviation security human factors.

Ensuring effective screening of ever-increasing numbers of passengers, baggage, and cargo on more flights without restricting movement remains the greatest challenge for the future. To overcome this challenge, U.S. airlines must continue to work together and embrace improved aviation security as part of their mission to provide better service to their customers and a safer environment for all passengers [Garvey 1999].

Box 7-3

Attacks on Aviation System

June 14, 1985: Trans World Airlines (TWA) Flight 847 from Athens, Greece, was hijacked. The hijacking lasted 17 days before the terrorists released the aircraft and its remaining hostages in Beirut, Lebanon.

June 23, 1985: Air India Flight 182 from Toronto and Montreal to India crashed at sea after an explosion in the front cargo hold, probably caused by a bomb. All 329 passengers were killed, including 22 U.S. citizens. The same day at Tokyo's Narita Airport, a checked bag being transferred from a Canadian Pacific to an Air India flight exploded, killing two baggage handlers and injuring others.

November 23, 1985: An EgyptAir flight was hijacked enroute from Athens to Cairo and diverted to Malta. An Egyptian commando unit stormed the plane after several passengers were shot, including three Americans, because Malta authorities failed to meet hijacker demands. A total of 59 of 96 passengers died in the fire and gun battle.

December 27, 1985: Simultaneous attacks occurred at two European airports in open terminal areas. Sixteen people were killed and 74 wounded at Rome's Leonardo da Vinci International Airport, including 5 Americans; 3 persons were killed and 45 wounded at Vienna's Schwechat International Airport.

April 2, 1986: A bomb placed onboard TWA Flight 840 detonated enroute from Rome, Italy. Four passengers were killed, but the aircraft made a safe landing in Athens, Greece.

May 30, 1986: The FBI and Canadian authorities uncovered a terrorist conspiracy to bomb an Air India jet departing from JFK International Airport. Five individuals were charged with sabotage; two were convicted and sentenced to life imprisonment.

(continued on next page)

Box 7-3 continued

September 5, 1986: Terrorists assaulted Pan Am Flight 73 in Karachi, Pakistan, as the aircraft waited to depart. After 17 hours of negotiations, the aircraft's auxiliary power unit failed. Anticipating an attack by security forces, the terrorists opened fire on the massed passengers, killing 22 persons and injuring 125 others before security forces could intercede.

November 29, 1987: A bomb on Korean Airlines Flight 858 detonated over the Indian Ocean. All 115 persons onboard were killed.

April 5, 1988: Kuwait Airways Flight 422 was hijacked enroute from Bangkok, Thailand. The hijackers left the aircraft 15 days later in Algiers, Algeria, after the Kuwait government refused to release prisoners in exchange for hostages. The hijackers had killed two Kuwaiti passengers to emphasize their demands.

December 21, 1988: Pan Am Flight 103 was destroyed in flight by a bomb placed in checked baggage. All 243 passengers and 16 crew on board, plus 11 people on the ground at Lockerbie, Scotland, were killed. Subsequent inspection of the reconstructed aircraft determined that a device consisting of plastic explosives inside a tape cassette player was concealed in checked luggage.

September 19, 1989: Union de Transport Aeriens (UTA) Flight 772 was destroyed by a bomb over Chad, 9 months after the Pan Am 103 explosion over Lockerbie. All 171 persons on board were killed, including 7 Americans.

November 11, 1989: A bomb placed in the cabin area onboard Avianca Flight 203 detonated over Colombia, destroying the aircraft in flight. One hundred seven passengers and crew were killed.

Attacks on Aviation System

July 19, 1994: An Alas Chiricanas Airline plane exploded in flight over Panama, killing all 21 people on board, including three U.S. citizens.

December 11, 1994: On Philippine Flight 434, a bomb detonated enroute to Tokyo from Cebu. One passenger was killed.

December 24, 1994: While on the ground at Houari Boumedienne International Airport, Algeria, Air France Flight 8969 was commandeered by four terrorists armed with automatic weapons, hand grenades, and other explosives. The hijackers killed three passengers. French counterterrorism forces stormed the aircraft at Marseille Marignane Airport; all four hijackers were killed.

In addition to these incidents, individual acts of revenge or criminal activity are noted below.

December 7, 1987: Pacific Southwest Airlines Flight 1771 crashed after a recently terminated airline employee boarded the Los Angeles-San Francisco flight with a handgun, shot one passenger (his former supervisor), the flight crew, flight attendant, and presumably himself. All 38 passengers and five crew on board were killed.

May 7, 1995: A man armed with a semiautomatic rifle attempted to enter a secure area through a door in the baggage claim area at Minneapolis/St. Paul International Airport. Unable to gain access, the gunman proceeded through the terminal firing his weapon. He exited the terminal to a public driveway, exchanged fire with responding police officers, and was shot three times before being apprehended. Flying debris injured three people, none seriously. The gunman never gained access to secure areas of the airport.

Source: U.S. Department of Transportation, Federal Aviation Administration, *FAA Historical Chronology — 1926 to 1996*, available at www.faa.gov/newsroom.htm, as of October 24, 2000.

Threats to Maritime Security

Our National Security roles go beyond military operations to include activities such as drug interdiction. The United States has aggressively battled drug control since the 1930s when the Federal Bureau of Narcotics was established. Nevertheless, the U.S. population today is becoming the world's largest illegal drug consumer.

Although U.S. citizens and government officials have been concerned about illicit drug consumption for many decades, the United States did not begin focusing significant attention on the problem until the late 1960s. The sharp increase in illicit drug use in the United States during that decade prompted the government to adopt a policy that remained relatively consistent for more than 20 years. Starting with "Operation Intercept," the U.S. government began a rigorous inspection program along the U.S.-Mexican border in 1969.

Historically, U.S. policymakers have assumed that a key part of the overall strategy to reduce domestic illicit drug consumption is to reduce the supply of drugs entering the United States from international locations. There has been some success with this strategy. For example, changes in opium production methods in Turkey, from opium gum to poppy straw concentrate, made illicit production of opium poppy and heroin more controllable. This technological change and subsequent enforcement actions by the Turkish and U.S. governments reduced imports of opium into the United States in the early 1970s. A U.S.-supported aerial campaign in Mexico in the late 1970s also was successful, significantly reducing the illegal import of marijuana into the United States.

Throughout the 1980s, the "war on drugs" focused on stopping illegal drugs at the source. Latin American governments were strongly pressured by the United States to intensify their drug control efforts. By the late 1980s, most cocaine entering the United States was flown directly from the producing countries of South America into northern Mexico, where the cargo was transported by truck across the border. However, in response to joint U.S.-Mexican drug interdiction efforts in northern Mexico, traffickers began to adjust their routes and moved their operations and staging areas to southern Mexico and neighboring Central American countries.

The U.S. military was enlisted in drug control efforts during the 1980s by a sequence of laws that gradually expanded the military's role in this effort. In 1988, Congress gave the military the ability to engage in drug control activities by authorizing them to search, seize, and arrest outside the land area of the United States.

Today, the U.S. Coast Guard (see box 7-4) focuses on interdicting illegal drugs by using a "layered" defense, attempting to interdict illegal drugs in their departure zones, in the transit zones in the Pacific Ocean and Caribbean Sea, and in the arrival zone in the United States. To do this, they use a variety of surface and air assets.

In 2000, the USCG seized 132,919 pounds of cocaine with an estimated street value of $4.4 billion—the equivalent of about 600 million individual doses. In response to President Clinton's National Drug Control Strategy, the USCG developed new techniques and operations aimed at stopping illegal drug suppliers, while other agencies worked on reducing U.S. demand for the smugglers' products. The 2000 seizures marked the most successful year in this effort [USDOT USCG 1999].

Box 7-4

U.S. Coast Guard

Located within the USDOT, the U.S. Coast Guard (USCG) is the lead federal agency for maritime drug interdiction and shares lead responsibility for air interdiction with the U.S. Customs Service. As one of the five U.S. armed services, the USCG is a full partner with its DOD counterparts and operates as a specialized service with the Navy in times of conflict. USCG has five operating goals: safety, protection of natural resources, mobility, maritime security, and national defense.

Source: U.S. Coast Guard, *Lifesavers and Guardians of the Sea*, Coast Guard Overview Briefing, December 1999, available at www.uscg.mil, as of July 24, 2000.

The USCG has enforced immigration laws, as directed by the President and Congress, virtually since the birth of the United States. The USCG's introduction to immigration enforcement came with the passage of antislavery legislation in the late eighteenth and early nineteenth centuries. As the federal government's only means of enforcing laws on the waters surrounding the nation, the Revenue Cutter Service, forerunner of the USCG, was charged with enforcing the nation's antislavery laws. The service's responsibilities increased as Congress passed immigration restrictions, primarily concerning Chinese immigration, in the mid-nineteenth century.

The mission first gained high visibility during the first mass migration emergency the United States faced in 1980 when approximately 124,000 undocumented Cuban migrants entered the United States by sea in what became know as the Muriel Boatlift. The hazards of illegal maritime migration were highlighted in 1981 when the bodies of 30 Haitian migrants washed ashore in Florida. These events led to Presidential Proclamation 4865, which suspended the entry of undocumented migrants to the United States from the high seas.

Between 1991 and 1995, there was a dramatic increase in the number of undocumented migrants interdicted by the USCG. During this period, over 120,000 migrants from 23 countries were interdicted, primarily from Cuba and Haiti. In 1992, Executive Order 12807 directed the USCG to interdict migrants at sea and return them to their country of origin or departure.

In 1994, the USCG was involved in its largest peacetime operation since the Vietnam War, responding to two mass migrations at the same time—first from Haiti, then from Cuba. Over 63,000 migrants were rescued, mostly from overloaded and unseaworthy watercraft, and prevented from illegally entering the United States. Illegal migration continues today, but the primary mode has changed from inner tubes, rafts, and overloaded boats to smugglers using fast-boats. This practice can be just as dangerous as rafting, however, as illustrated by the deaths of numerous migrants in 1998-2000 when overloaded vessels overturned.

The USCG has protected U.S. natural resources since the 19th century, starting with seals that were considered a major economic resource in Alaska for their furs and continuing today with protected marine resources and fisheries. Since the passage of the Fisheries Conservation and Management Act in 1976, which extended the U.S. Exclusive Economic Zone to 200 nautical miles, guarding American sovereignty over the richest fishing grounds in the world has been a primary USCG mission.

Keys to the Future

The National Drug Control Strategy recognizes the need to reduce demand for illicit drugs in the United States, calling for a 25 percent reduction by 2002 and a 50 percent reduction by 2007 [White House 1999]. Reaching the goal will require continued cooperation between U.S. government agencies, including the detection and monitoring resources of the DOD. International cooperation, especially between the United States and the nations and territories of

Latin America and the Carribean Basin, will be pivotal for further strides in reducing drug flow.

Drug traffickers and migrant smugglers move quickly and adapt new smuggling routes and methods in reaction to law enforcement presence. Recent record cocaine seizures in the eastern Pacific indicate that drug traffickers are increasingly targeting southern California and the southwest border. Cooperative efforts involve sharing intelligence information with, and providing guidance to, other nations to disrupt the activities of criminal drug and migrant smuggling organizations and to interdict illegal drugs and migrants in source and transit countries. The USCG provides assistance to other nations to develop multimission maritime organizations. This assistance includes organizational management, resource development, training, and standardization of procedures and interoperability capabilities that enhance international cooperation. The DOD provides extensive detection and monitoring capabilities to facilitate interdiction operations involving U.S. agencies and their foreign counterparts.

To successfully reduce the supply of illegal drugs and the flow of illegal migrants into the United States, cooperative diplomatic efforts also will be needed. International law provides that, with few exceptions, boarding and searching a foreign vessel in international waters requires consent of the flag state. When vessels or aircraft are used for trafficking, they often move quickly from one national jurisdiction to another. Unless prior consent exists to stop, board, and search such vessels or aircraft, U.S. and other law enforcement authorities can easily be frustrated in their efforts to interdict traffickers crossing multiple jurisdictional lines.

The United States is party to 21 bilateral maritime counterdrug agreements, 12 international fisheries enforcement agreements, and 1 migrant repatriation agreement. Several additional agreements are under negotiation to provide a more effective web of cooperation.

To modernize its fleet, the USCG has initiated a Deepwater Capability Replacement Project [USDOT USCG 2000], a comprehensive approach to designing and obtaining its next fleet of ships, aircraft, and communications systems. Technology improvements also will be a key part of the battle against drugs. These include night vision goggles, forward-looking infrared systems, improved radar, faster boats, increased fixed-wing assets, and drug detection devices. The ability to monitor maritime activity covertly is an essential part of reducing the flow of illegal drugs and migrants and deterring unauthorized fishing.

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appendix A

List of Figures and Tables

appendix B

Acronyms and Initialisms

3PL	Third-party logistics
4PLs	Fourth-party logistics companies
AC	Alternating Current
ACC	Adaptive Cruise Control
ADA	Americans with Disabilities Act
ADF	aircraft deicing fluid
ADS-A	automatic dependent surveillance-addressable system
ADS-B	automatic dependent surveillance-broadcast
AIADA	American International Automobile Dealers Association
AIADA	American Imported Automobile Dealers Association
AIR-21	Aviation Investment and Reform Act for the 21st Century
AM radio	lower frequency radio waves
API	American Petroleum Institute
ASRS	Aviation Safety Reporting System
ASTs	aboveground storage tanks
ATC	Air Traffic Control
ATO	Air Traffic Organization
AVL	Automatic Vehicle Location
AVP	Advanced Vehicle Technologies Program
B2B	business-to-business
B2C	business-to-consumer
BAC	Blood Alcohol Concentration
BART	Bay Area Rapid Transit
BBC	British Broadcasting Corporation
Bbl	barrel
Big LEO	special handheld telephone
BTS	Bureau of Transportation Statistics
Btu	British Thermal Unit
$C0_2$	Carbon dioxide
CAB	Civil Aeronautics Board
CAD	Computer-Aided Dispatch
CAFÉ	Corporate Average Fuel Economy
CD-ROM/DVD	Compact Disk-Read Only Memory/Digital Video Disk
CDL	Commercial Driver's License
CDS	Crashworthiness Data System
CFIT	controlled flight into terrain
CH_4	Methane
CNG	Compressed Natural Gas
CO	Carbon Monoxide
COMSTAC	Commercial Space Transportation Advisory Committee
CONUS	Continental U.S.
COO	Chief Operating Officer
CORS	Continuously operating reference stations
CPDLC	Controller-Pilot Data Link Communications

CRAF	Civil Reserve Air Fleet
CVO	Commercial Vehicles Operations
DBA	Decibels
DC	Direct Current
DFDRs	Digital flight data recorders
DGPS	Differential GPS
DOD	Department of Defense
DOJ	Department of Justice
DVD	Digital Video Disk
ECP	Electronically Controlled Pneumatic
EDI	Electronic Data Interchange
EDSs	Explosives Detection Systems
EMS	Emergency Medical Services
EPA	Environmental Protection Agency
ERGS	Electronic Route Guidance System
ETC	Electronic Toll Collection
EU	European Union
FAA	Federal Aviation Administration
FARS	Fatal Accident Reporting System
FAST	Final Approach Spacing Tool
FBI	Federal Bureau of Investigation
FedEx	Federal Express
FHWA	Federal Highway Administration
FMC	Federal Maritime Commission
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GAIN	Global Aviation Information Network
GAMA	General Aviation Manufacturers Association
GARA	General Aviation Revitalization Act
GDP	Gross Domestic Product
GEO	Geostationary Earth Orbit
GES	General Estimates System
GMDSS	Global Maritime Distress and Safety System
GNP	Gross National Product
GPRA	Government Performance and Results Act of 1993
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GWP	Gross World Product
HFCs	Hydrofluorocarbons
HOV	High occupancy vehicle
HTF	Highway Trust Fund
HSIS	Highway Safety Information System
HSR	Incremental High-Speed Rail
IASA	International Aviation Safety Assessment
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICC	Interstate Commerce Commission
IHS	Interstate Highway System
IMO	International Maritime Organization
ISTEA	Intermodal Surface Transportation Efficiency Act
ITS	Intelligent Transportation Systems
IVHS	Intelligent Vehicle Highway System
IVI	Intelligent Vehicle Initiative
LAAS	Local Area Augmentation System

LCD	Liquid Crystal Display
LEO	Low Earth Orbit
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LTL	Less Than Truckload
LTVs	Light trucks and vans
Maglev	Magnetic levitation
MARAD	Maritime Administration
MERCOSUR	Southern Common Market
mmbd	Million barrels of oil per day
mph	Miles per hour
MPO	Metropolitan Planning Organization
MSP	Maritime Security Program
MTMCTEA	Military Traffic Management Command Transportation Engineering Agency
MTS	Marine Transportation System
N_2O	Nitrous Oxide
NAFTA	North American Free Trade Agreement
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NHS	National Highway System
NCP	National Contingency Plan
NDGPS	Nationwide Differential Global Positioning System
NDRF	National Defense Reserve Fleet
NEPA	National Environmental Policy Act
New HSR	new high-speed rail systems
NGS	National Geodetic Survey
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
NIMBY	not in my back yard
NMMA	National Marine Manufacturers Association
NMSL	National Maximum Speed Limit
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Agency's
NOTAM	Notices to Airmen
NO_x	nitrogen oxide
NPTS	Nationwide Personal Transportation Survey
NS	Norfolk Southern
NSC	National Security Council
NSI	National Shipbuilding Initiative
NTSB	National Transportation Safety Board
NUMMI	New United Motor Manufacturing, Inc.
O_3	ozone
OPEC	Organization of Petroleum Exporting Countries
OSRA	Ocean Shipping Reform Act
OTRBs	over-the-road buses
PanAm	Pan American
Pb	lead
PCBs	polychlorinated biphenyl
PDDs	Presidential Decision Directives
PFCs	Perfluorocarbons
PM_{10}	particulate matter less than 10 microns
PNGV	U.S. Partnership for a New Generation of Vehicles
ppm	parts per million

PPPs	Power Projection Platforms
PTC	Positive Train Control
PTP	Prevention Through People
R&D	research and development
RNAV	Area Navigation
RPM	Revenue Passenger Miles
RRF	Ready Reserve Force
RRIF	Railroad Rehabilitation and Improvement Financing
RSPA	Research and Special Programs Administration
RTMs	revenue ton-miles
SA	Selective Availability
SAFER	Special Aviation Fire and Explosion Reduction
SCADA	Supervisory Control And Data Acquisition
SEABEE	Construction Battalion (CB)-this acronym is a Phonetic reference to the CB member of this Navy Unit.
SF_6	Sulfur Hexafluoride
SIPs	Safety Integration Plans
SIPs	State Implementation Plans
SO_2	sulfur dioxide
SPEARS	Screener Proficiency Evaluation and Reporting System
STARS	Standard Terminal Automation Replacement System
STB	Surface Transportation Board
STRAHNET	Strategic Highway Network
SUVs	sport utility vehicles
TCAS	Traffic Alert Collision Avoidance System
TDM	Transportation Demand Management
TDLS	Tower Data Link Services
TEA-21	Transportation Efficiency Act for the 21st Century
TEU	20-foot equivalent unit
TIFIA	Transportation Infrastructure Finance and Innovation Act of 1998
TIP	Threat Image Projection
Title XI	Maritime Guarantee
TL	Truckload
TRACON	Terminal Radar Approach Control
TTI	Texas Transportation Institute
TWA	Trans World Airlines
TWA	Trans World Airlines
UNFCCC	United Nations Framework Convention on Climate Change
UPS	United Parcel Service
USCG	U.S. Coast Guard
USDOC	U.S. Department of Commerce
USDOT	U.S. Department of Transportation
USGS	U.S. Geological Survey
USPS	U.S. Postal Service
UST	Underground Storage Tank
UTA	Union de Transport Aeriens
VHF	Very High Frequency
VISA	Voluntary Intermodal Sealift Agreement
VLCCs	very large crude carriers
VMT	vehicle-miles traveled
VOCs	volatile organic compounds
VSL	variable speed limit
WAAS	Wide Area Augmentation System
WRDA	Water Resources Development Act

appendix C

Glossary

Air control facility: A station that provides air traffic control service to aircraft operating on an IFR (instrument flight rule) flight plan within controlled airspace and principally during the en route phase of flight.

Aircraft sequencing: Automation technology that helps air traffic controllers maximize runway space by managing aircraft arrival and departure rates.

Airlift: Both the means of delivery and the sustainable lifeline for troops by air until sea lines of communication can be established.

Alternative fuels: Methanol, denatured ethanol, and other alcohols, separately or in mixtures of 85 percent by volume or more (or other percentage not less than 70 as determined by Department of Energy rule) with gasoline or other fuels. Compressed Natural Gas (CNG), Liquefied Natural Gas (LNG), Liquefied Petroleum Gas (LPG), hydrogen, coal-derived liquid fuels, fuels other than alcohols derived from biological materials, electricity, or any other fuel determined to be substantially not petroleum.

Anthropogenic interference: Of, relating to, or resulting from the influence of human beings on nature.

Arterial (highway): A major highway, primarily for through traffic, usually on a continuous route.

Avionics: Aviation communications, navigation, flight controls, and displays.

A-weighted scale: Scale that measures those sound frequencies humans can most easily hear. Measurements of decibels are nonlinear; a 10-decibel increase in sound on a scale of A-weighted decibels (dBA) represents a perceived doubling of sound. A vacuum cleaner operating 10 feet away is audible at 70 to 75 dBA. Noise becomes annoying at 65 dBA and painful at 128 dBA.

Ballast (rail): Cinders, crushed rock, or gravel placed on the roadbed to hold track ties in place and to promote uniform drainage.

Ballast (sea): Heavy substances loaded by a vessel to improve stability. Seawater ballast is commonly loaded in most vessels in ballast tanks.

Barge carriers: Ships designed to carry either barges or containers exclusively, or some variable number of barges and containers simultaneously. Currently, this class includes two types of vessels, the LASH and the SEABEE.

Barge: A nonmotorized water vessel, usually flat-bottomed and towed or pushed by a tugboat or pushboat.

Beam: The width of a ship. Also called breadth.

Berth: A place in which a vessel is moored or secured.

Bilateral Agreement: A concurrence reached between two states.

Bilge keel: One of a pair of longitudinal plates that, like fins, project from the sides of a ship or boat and run parallel to the center keel. They are intended to check rolling. On large ships the outward projections of the bilge keels may be slight; on small yachts they may be comparatively deep.

Bill of lading: A document by which the master of a ship acknowledges having received in good order and condition (or the reverse) certain specified goods. A bill of landing specifies the name of the master, the port and destination of the ship, the goods, the consignee, and the rate of the freight.

Biometric identification systems: Identification systems involving voice recognition, handprint, and face scans.

Blind spot: Areas around a commercial vehicle that are not visible to the driver either through the windshield, side windows, or mirrors.

Break bulk: The process of assimilating many small shipments into one large shipment at a central point so that economies of scale may be achieved; to commence discharge of cargo.

Breakbulk vessel: A cargo ship that carries a variety of products of nonuniform sizes, often bound on pallets to facilitate loading and unloading.

Brownfield sites: Abandoned, idled, or underused industrial and commercial facilities/sites where expansion or redevelopment is complicated by real or perceived environmental contamination. They can be in urban, suburban, or rural areas. The Environmental Protection Agency's Brownfields initiative helps communities mitigate potential health risks and restore the economic viability of such areas or properties.

Bulk Carrier: Vessels designed to carry dry-bulk cargo such as grain, fertilizers, and ore.

Cabotage: The carriage of goods or passengers for remuneration taken on at one point and discharged at another point within the territory of the country.

Car capacity: Load limitation, by volume or weight, of a rail freight car.

Carload: A shipment of not less than 10,000 pounds of one commodity from one consignor to another.

Circumferential commuting pattern: Commuting between suburban areas on the fringe of a city.

Civil Reserve Air Fleet: Provides a significant part of the nation's mobility resource. Selected aircraft from commercial U.S. airlines are contracted to support Department of Defense emergency airlift requirements should airlift needs exceed military aircraft capabilities.

Class I railroads: A railroad with an annual gross operating revenue in excess of $250 million (1991 dollars).

Collector (highway): In rural areas, highway routes serving intra-county rather than statewide travel. In urban areas, roads providing direct access to neighborhoods as well as to arterials.

Commuter air carrier: A small certificated air taxi operator performing at least five round trips per week between two or more points according to published flight schedules that specify times, days of the week, and points between such flights.

Commuter rail (transit): Urban passenger train service for short-distance travel between a central city and adjacent suburb. Does not include rapid-rail transit or light-rail service.

Compact car: An automobile industry designation applied to cars with a wheelbase between 100 and 104 inches.

Container: A rectangular box used to transport freight by ship, rail, and highway. International shipping containers are 20 or 40 feet long, conform to International Standards Organization standards, and are designed to fit in ships' holds. Off the ship, containers are transported on public roads on a container chassis towed by a tractor. Domestic containers, up to 53 feet long and of lighter construction, are designed for rail and highway use only.

Corporate Average Fuel Economy (CAFE): Originally established by Congress for new automobiles, and later for light trucks. CAFE standards require automobile manufacturers to produce vehicle fleets with a composite sales-weighted fuel economy that meets or exceeds the CAFE standards in a given year. For every vehicle that does not meet the standard, a fine is paid for every one-tenth of a mpg below the standard.

Culvert: A sewer or drain running under a road, railroad tracks, or an embankment.

Daymarker: An unlighted shore aid to navigation, either diamond, square, or triangle shaped.

DC traction motor: The motive power of the train is provided by a motor powered by direct current through overhead electrified wires.

Deadweight: The number of tons (metric or long) of cargo, stores, and bunker fuel that a vessel can transport. It is the difference between the number of tons of water a vessel displaces "light" and the number of tons it displaces when submerged to the "load line."

Dependence ratio: The ratio of household members who are not of working age (either under 16 or over 65) to those of working age. This results in more persons living in households in which they are responsible for supporting only themselves as opposed to supporting dependents (i.e., children or aging parents).

Doppler effect: The apparent difference between the frequency at which sound or light waves leave a source and that at which they reach an observer, caused by relative motion of the observer and the wave source.

Doublestack rail services: Intermodal service characterized by shipping containers stacked two-high on railcars.

Dredge: The act of cleaning, deepening, or widening harbors and waterways with a machine equipped with a scooping or suction device. This equipment is also called a dredge.

Dry bulk: Cargo such as grain, fertilizers, and ore.

Dry-cargo ships: Large flat-bottomed, nonself-propelled vessels used to transport dry bulk materials such as coal and ore.

Dynamic routing: In demand-response transportation systems, the process of constantly modifying vehicle routes to accommodate service requests received after vehicles begin operations, as distinguished from predetermined routes assigned to a vehicle.

Enplanement: The total number of passengers boarding an aircraft and the total revenue tons of freight and mail loaded on an aircraft.

Environmental impact statement: A document required of federal agencies by the National Environmental Policy Act for major projects or legislative proposals significantly affecting the environment. The statement describes the positive and negative effects of the undertaking and cites alternative actions.

Environmental streamlining: The development and implementation of an environmental review process for highway and transit projects that coordinates the regulations of all agencies affected by the project. One element of the streamlining process is concurrent review, another is a review slated for completion within a cooperatively determined time period.

Ex-urban: Rural location on the fringes of a suburban area having residents who commute to work in urban areas.

Final approach spacing tools: The use of aircraft descent performance characteristics, position/track data, user preferences, and controller inputs to generate a recommended arrival/landing sequence for each plane.

Fixed-wing turbine aircraft: An aircraft with an internal-combustion engine to turn a turbine.

Flag of convenience: Sometimes referred to as flag of necessity; denotes registration of a ship to a nation, other than the nation of the vessel's owner, that offers favorable tax structures, regulations, and other incentives.

Force deployment: The moving of military units outside the borders of a state.

Foreign flag air carrier: A foreign air carrier that makes stops within the borders of the United States.

Free flight phase 1: To be introduced by 2002, will use advanced airborne and ground-based technologies and new procedures to gain optimum tactical separation between planes, enabling more planes to fly and to take more efficient, more direct routes.

Free flight: a system using advanced technologies and procedures that give air crews more freedom to select flight paths, speeds, and altitudes that are the most direct or otherwise satisfy operational requirements.

Fuel cell: A device that produces electrical energy directly from the controlled electrochemical oxidation of the fuel. It does not contain an intermediate heat cycle, as do most other electrical generation techniques.

Gauge (rail): The distance measured between the inside edges of the running rails.

GDP (gross domestic product): Total market value of goods and services produced by a nation's economy during a specific period of time (usually a year), plus the income accruing to a nation's residents from investments abroad, minus the income earned in the domestic economy accruing to non-nationals located abroad (*see* GNP (gross national product)).

Geostationary orbit: Any orbit at an altitude of 23,000 miles above the equator traveling at a velocity and in a direction that keeps pace with the Earth's rotation, making it appear to be stationery in the sky (*see* Geosynchronous).

Geosynchronous orbit: Any orbit that has a rotational period equal to that of the Earth's rotational period and which may or may not be positioned over the equator. Geosynchronous orbits inclined to the equator pass over the same points of the Earth at the same time each day. Geosynchronous orbits over the equator appear to be stationary (*see* Geostationary).

GNP (gross national product): Total market value of the final goods and services produced by a nation's economy during a specific period of time (usually a year), computed before allowance is made for the depreciation or consumption of capital used in the process of production (*see* GDP).

GWP (gross world product): Aggregate value of all final goods and services produced worldwide in a given year.

Hazardous material (Hazmat): A substance or material that has been determined to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

Heavy rail (transit): An electric railway with the capacity for a heavy volume of traffic and characterized by exclusive rights-of-way, multicar trains, high speed and rapid acceleration, sophisticated signaling, and high platform loading. Also known as subway, elevated (railway), or metropolitan railway (metro).

High-occupancy vehicle lanes: Exclusive road or traffic lane limited to buses, vanpools, carpools, and emergency vehicles.

High-occupancy vehicle: A vehicle that can carry at least two passengers, for example, a car, bus, or van.

Highway Trust Fund (HTF): The source of funding for programs described in a particular Act. The HTF under the Transportation Equity Act for the 21st Century is composed of the Highway Account, which funds highway and intermodal programs, and the Mass Transit Account. Federal motor fuel taxes are the major source of income into the HTF.

Highway-rail grade crossings: A location where one or more railroad tracks cross a public highway, road, or street or a private roadway at grade, including sidewalks and pathways at, or associated with, the crossing.

Household-trip: One or more household members traveling together.

Hub: A central location to which traffic from many cities is directed and from which traffic is fed to other areas

Hull loss: Serious damage or destruction to an aircraft due to an accident.

Hybrid vehicle: A vehicle powered by both an internal combustion engine and an electric motor. The emission levels of hybrid vehicles are lower than vehicles powered solely by an internal combustion engine.

Hydrographic survey: Surveying of underwater features.

Intercity rail system: Transportation provided by Amtrak.

Intermodal: Pertaining to transportation using a combination of two or more land, sea, or air systems.

Joint Aviation Authorities: An associated body of the European Civil Aviation Conference representing the civil aviation regulatory authorities of a number of European states who have agreed to cooperate in developing and implementing common safety regulatory standards and procedures. This cooperation is intended to provide high and consistent standards of safety and a "level playing field" for competition in Europe. Much emphasis is also placed on harmonizing JAA regulations with those of the United States.
The JAA Membership is based on signing the "JAA Arrangements" document originally signed by the then current member States in Cyprus in 1990.

Just-in-time: The principle of production and inventory control in which goods arrive when needed for production or use.

Lean-burn gasoline: Lean combustion engines were designed to enhance fuel efficiency without sacrificing power or drivability. All engines burn a mixture of air and fuel, but a lean-burn engine has a higher air-to-fuel ratio than conventional engines. This can mean significant savings in petrol, and thus in emissions like CO_2.

Lighter aboard ship: An ocean ship that carries barges. These barges are loaded with cargo, often at a variety of locations, towed to the ocean ship, sometimes referred to as the mother ship, and lifted or, in some cases, floated on board. After the ocean crossing, the barges are off-loaded and towed to their various destinations. This type of ship eliminates the need for specialized port equipment.

Lightships: Navigation aids consisting of unmanned small vessels equipped with lights. Phased out in the early 1980s.

Line haul: The management of freight transported between cities, usually more than 1,000 miles apart.

Liner: A cargo-carrying ship that is operated between specified ports on a regular basis for an advertised price, versus a chartered ship that operates for single deliveries to a variety of ports.

Liner trade: The passage of ships between designated ports on a fixed schedule and at published rates.

Livable Communities Initiative: Aimed at broadening choices available to communities and empowering them to sustain prosperity and expand economic opportunity by strengthening local and regional economies, reclaiming brownfields, achieving a more favorable jobs to housing balance, and encouraging smart growth.

Loop detector: An inductive loop of insulated wire, usually embedded in a roadbed, that detects metal objects that cross its path. Used to control such devices as traffic lights, toll collection systems, and motorized gates and doors.

Load factor: Percentage of cargo or passengers carried in relation to total capacity, for example, 4,000 tons carried on a vessel of 10,000 ton capacity has a load factor of 40 percent.

Loran: An electronic navigational system by which hyperbolic lines of position are determined by measuring the difference in the time of reception of synchronized pulse signals from two fixed transmitters. Loran A operates in the 1,750-1,950 kHz frequency band. Loran C and D operate in the 100-110 kHz frequency band.

Maintenance-of-way equipment (rail): Machinery and rolling stock used to keep track and roadbed in good operating condition.

Manifest: A listing or invoice-of-charge for a particular shipment of goods and material.

Micro-bursts (air): A small downburst with outbursts of damaging winds extending 2.5 miles or less. In spite of its small horizontal scale, an intense microburst could induce wind speeds as high as 150 knots.

Multilateral agreement: Agreement reached between more than two states and to which all signatories are bound, example the World Trade Organization. Compare with Plurilateral.

Multimodal: See intermodal.

Narrowbody aircraft: A commercial passenger jet having a single aisle and maximum of three seats on each side of the aisle. Narrowbody aircraft include B727, B737, B757, DC9, MD80, MD90, and A320.

Oil sands: Deposit of loose sand or partially consolidated sandstone that is saturated with highly viscous bitumen. Oil recovered from tar sands is commonly referred to as synthetic crude and is a potentially significant form of fossil fuel.

Oil shale: Any sedimentary rock containing solid organic material that yields hydrocarbons, along with a variety of solid products, when subjected to pyrolysis—a treatment that consists of heating the rock to about 500ºC.

Omega system: An area navigation (RNAV) system designed for long-range navigation based on ground-based electronic navigational aid signals.

On-demand air taxi: Use of an aircraft operating under Federal Aviation Regulations, Part 135, passenger and cargo operations, including charter and excluding commuter air carrier.

Over-the-road bus: A bus characterized by an elevated passenger deck located over a baggage compartment, more commonly known as an intercity bus or motorcoach.
Paratransit: Comparable transportation service required by the American Disabilities Act for individuals with disabilities who are unable to use fixed-route transportation systems.

Park-and-ride: An access mode to transit in which patrons drive private automobiles or ride bicycles to a transit station, stop, or carpool/vanpool waiting area and park the vehicle in the area provided for the purpose. They then ride the transit system or take a car or vanpool to their destination.

Particulates: Carbon particles formed by partial oxidation and reduction of the hydrocarbon fuel. In the transportation sector, particulates are emitted mainly from diesel engines.

Pavement loops: Electronic devices installed beneath the surface of a road that can detect the passing of a car. Based on the frequency of passing cars, traffic flow can be monitored and controlled using computer-based traffic control systems. See loop detector.

Pedalcyclists: A person on a vehicle powered solely by pedals.

Person trip: Trip by one person using any mode of transportation. For example, four people traveling together in one auto equal four person trips.

Plurilateral agreement: Treaty between more than two states reached within the auspices of a "multilateral agreement." However, not all multilateral signatories are bound to the plurilateral agreement unless they have specifically committed themselves to it.

Positive train controls (PTC): The application of digital data communications, automatic positioning systems, wayside interface units (to communicate with switches and wayside detectors), on-board and control center computers, and other advanced display, sensor, and control technologies to manage and control railroad operations. PTC can help reduce the probability of collisions between trains, collisions between trains and maintenance-of-way crews, and overspeed accidents. PTC systems can also improve the efficiency of railroad operations by reducing some train over-the-road delays, increasing running time reliability, increasing track capacity, and improving asset utilization.

Power Projection Platforms (PPP): U.S. military bases from which armed forces are moved to seaports for military deployment.

Radial commuting pattern: Commuting from suburban areas on the fringes of a city towards its center or core.

Ramjet: An air-breathing jet engine that operates with no major moving parts. It relies on the craft's forward motion to draw in air and on a specially shaped intake passage to compress the air for combustion. Ramjets work best at speeds of Mach 2 (twice the speed of sound) and higher.

Ramp metering programs: Control devices on entrance ramps that regulate the amount of traffic entering a freeway.

Regenerative brakes: A system wherein much of the braking and deceleration energy is recouped and returned to the battery to increase overall efficiency rather than being wasted as heat.

Revenue passenger miles: One passenger carried one mile generates one passenger-mile.

Revenue ton-miles: One ton of revenue cargo (including all baggage) transported one mile.
Right of establishment: The right of airlines to create or purchase subsidiary airlines within a foreign nation.

Right-of-way: 1. The track, roadbed, and property alongside which is owned by the railroad. 2. The land acquired for and devoted to highway transportation.

Roll on/roll off vessel (water): Ships that are especially designed to carry wheeled containers or other wheeled cargo, and use the roll on/roll off method for loading and unloading.

Route sequencing (air): Process by which an air-traffic controller issues instructions to pilots on the proper flight headings, altitudes, and speeds to maintain separation from other aircraft and ensure safe and efficient order of arrivals, departures, and en route traffic.

Sealift: U.S.-controlled maritime or aviation shipping capacity used in times of military emergencies.

Seat-miles: The aircraft-miles flown between airports multiplied by the number of seats available on that flight for revenue passenger use. Seventy-five passengers flying 300 miles would equal 22,500 seat miles.

Smart growth: A concept intended to promote the quality of life in existing urban areas, limit urban sprawl, and promote a sense of community. Policies stemming from smart growth include the restoration of center cities and older suburbs, investment in transit and pedestrian forms of transportation, a greater mix of housing, commercial, and retail uses and the preservation of open space and many other environmental amenities.

Smart pigs: Devices that travel inside a pipe and are able to detect corrosion, metal loss, and mechanical gouges or dents.

Stages 2 and 3 aircraft: Under Federal Aviation Regulation Part 36, aircraft sound levels are categorized by stages. Stage 2 is the aircraft sound level needed to meet FAA 1969 noise regulations. Examples of Stage 2 aircraft include the B-727-200 and the DC 9. Stage 2 regulations are being phased out. Stage 3 refers to aircraft sound levels needed to meet FAA's more stringent 1975 noise regulations. Examples include the B-737-300, the B-757, the MD-80, and the A-310. Stage 3 aircraft noise levels range from 95 to 105 dBA.

Station cars: Electric vehicles driven to and from mass transit stations by transit riders. Typically, they are battery-powered, two-seat vehicles designed to transport transit users who cannot reach their final destinations by walking. They are intended to provide an option that could encourage transit use by those who otherwise would be compelled to drive their own vehicles.

Steel wheel (rail): The cast or forged steel wheel that rolls on the rail, carries the weight, and provides guidance for rail vehicles. The wheels are semipermanently mounted in pairs on steel axles and are designed with flanges and a tapered treat to provide for operation on track of a specific gauge. The wheel also serves as a brake drum on cars with on-tread brakes.

Supersonic combustion ramjet (scramjet): An air-breathing engine designed for speeds beyond Mach 6, which mixes fuel into air flowing through it at supersonic speeds, used in hypersonic aircraft.

Supply chain: A set of three or more organizations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer.

Supply chain management: The systematic, strategic coordination of traditional business functions within a particular company and across businesses within the supply chain for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.

Tanker: An oceangoing ship designed to haul liquid bulk cargo in world trade.

Tier II: Environmental Protection Agency (EPA) regulations that cover motor vehicles and the fuels they use. These standards require a reduction in tailpipe emissions and lower sulfur content. These regulations specify acceptable ranges for some fuel qualities (e.g., volatility, sulfur content). In areas of the country with severe ozone problems, EPA requires the use of gasoline that has been reformulated to meet a predicted level of emissions performance, based on a range of fuel characteristics.

Tractor: Truck designed primarily to pull a semitrailer by means of a fifth wheel mounted over the rear axels. Sometimes called a truck-tractor or highway tractor to differentiate it from a farm tractor.

Tractor-trailer: Tractor and semitrailer combination

Traffic calming techniques: Road design strategies to reduce vehicle speeds and volumes. Traffic calming projects can range from a few minor changes to neighborhood streets to major rebuilding of a street network. Impacts range from moderate speed reductions on residential streets to arterial design changes.

Traffic signal control system: A system that controls traffic flow by adjusting and coordinating traffic signals at intersections. The system can also monitor traffic conditions with vehicle detectors and cameras. These functions allow a traffic management agency to service traffic demand, share traffic status with other agencies and with the traveling public, and operate and maintain the traffic signal control system.

Trestle: A wooden bridge-like structure usually having all supporting members below the railway tracks.

Trip chaining: The incorporation of multiple stops in one trip, instead of several individual trips, thus reducing fuel consumption.

Trust funds: Accounts that are specifically designated by law to carry out specific purposes and programs. They are usually financed with earmarked tax collections.

Turbojet/turbofan: Jet engine in which a turbine-driven compressor draws in and compresses air, forcing it into a combustion chamber into which fuel is injected. Ignition causes the gases to expand and to rush first through the turbine and then through a nozzle at the rear. Forward thrust is generated as a reaction to the rearward momentum of the exhaust gases. During the 1960s, the turbofan, a modification of the turbojet, came into common use. The turbofan moves a much greater mass of air than the simple turbojet, providing advantages in power and economy.

Twenty-Foot Equivalent Unit (TEU): A measure of container's carrying capacity determined by calculating the length of that container divided by 20. A 48 ft container equals 2.4 TEU.

Two-way end-of-train device: Provides an additional measure of safety to a train's braking system, particularly on steep grades, by enabling locomotive engineers to apply an emergency brake from both ends of the train.

U.S. flag carrier or American flag carrier (air): A class of air carriers holding a Certificate of Public Convenience and Necessity issued by the Department of Transportation, approved by the President, authorizing scheduled operations over specified routes between the United States (and/or its territories) and one or more foreign countries.

Unit train: A train with a specified number of railcars that remains as a unit for a designated destination or until a change in routing is made.

Unlinked passenger trips: The number of passengers who board public transportation vehicles. A passenger is counted each time he/she boards a vehicle even though he/she may be on the same journey from origin to destination.

Vehicle-miles of travel (VMT): A unit of measurement of vehicle travel made by a private vehicle, such as an automobile, van, pickup truck, or motorcycle. Each mile traveled is counted as one vehicle-mile regardless of the number of persons in the vehicle.

Vehicle occupancy: The number of persons, including driver and passenger(s) in a vehicle. Nationwide Personal Transportation Survey occupancy rates are generally calculated as person-miles divided by vehicle-miles.

Vessel feeder services: Cargo to/from regional ports are transferred to/from a central hub port for a long-haul ocean voyage.

Vessel sharing agreement: An agreement between ocean common carriers whereby a carrier or carriers agree(s) to provide vessel capacity for the use of another carrier or carriers in exchange for compensation or services.

Volatile organic compounds: Gases released into the air from certain solids or liquids such as gasoline, solvents, and paint thinner. They include a variety of chemicals that can have both short-term and long-term health effects as well as contribute to global warming.

Voluntary security consortia: Cooperative group established at 170 airports that brings together government agencies and airline industry representatives to assess and discuss security issues and work together to eliminate vulnerabilities.

Wake turbulence: Every aircraft in flight generates a wake of turbulent air. The disturbance created by the wake is caused by a pair of counter rotating vortices trailing from the wingtips of the aircraft. The vortices from large aircraft pose problems to encountering aircraft. and if encountered at close range, can damage aircraft components and equipment and cause deaths or injuries.

Watersheds: Area from which all precipitation flows to a single stream or set of streams.

Waybill: Freight car handling order identifying the shipper, receiver, routing, and contents of the car.

Weigh-in motion: The process of measuring the dynamic tire forces of a moving vehicle and estimating the corresponding tire loads of the static vehicle. Weigh-in-motion technology provides highway planners and designers with traffic volume and classification data by time of day and day of week.

Wet lease: An arrangement for renting an aircraft under which the owner provides, for example, crews, ground support equipment, and fuel.

Wetlands: Areas that are neither fully terrestrial nor fully aquatic. They range from the vast cypress swamps of the southern United States to shallow holes that retain water only a few weeks of the year. Wetlands can provide critical habitat for migratory waterfowl, control flooding, act as natural filters for drinking water, and provide recreation.

Widebody aircraft: A commercial passenger jet having a twin aisle, able to hold a greater number of passengers than narrowbody aircraft. Examples include Boeing's 747, 777 and Airbus's A310.

Windshear: A sudden and dramatic shift in wind speed and direction.