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# TRANSPORTATION HISTORY AND TRB'S 75TH ANNIVERSARY

SEVENTY-FIFTH
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ANNIVERSARY

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## Contents

## Introduction

The Transportation Research Board celebrated its 75th Anniversary during 1995, and a number of special sessions and events commemorating the anniversary were held at the 75th Annual Meeting in January 1996. One of the special sessions, "Transportation's Rich History and Challenging Future," was sponsored by the TRB Executive Committee. Two papers were developed for the session, one on moving people and one on moving goods, to provide an historical perspective of the transportation changes that have taken place. The two authors, Lester A. Hoel and Joseph M. Sussman, are past chairmen of the TRB Executive Committee. Their papers present an interesting look back, as well as a thoughtful look ahead.

Another highlight of TRB's 75th Anniversary was the formation of a Transportation History Task Force. The task force will consider the appropriate role for TRB in preserving the experiences and lessons from the past. The task force is chaired by Alan E. Pisarski, Falls Church, Virginia, and its members include transportation historians from public and private agencies, museum curators, and others who have been actively involved in the historical aspects of transportation. Questions regarding the task force activities should be directed to Robert E. Spicher, Director, Technical Activities Division, Transportation Research Board.

# Historical Overview of U.S. Passenger Transportation

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For the first 1800 years after Christ and the thousands of years preceding that period, the means by which people traveled remained essentially the same. By land, travel was either on foot or by transport modes that were powered by animals or humans. Depending on the country, the motive power might have been horse, mule, camel, elephant or oxen. For travel by sea, boats were powered either by wind or humans. Whether by land or sea, the trip was usually slow, costly, and dangerous. The absence of non-animal power sources that could be "harnessed" to do the work needed to move people placed severe limitations on the time required to make a trip. It also constrained the capacity of vehicles used for travel, and limited the infrastructure that was provided to serve as roadways and terminals. It is no wonder that continents and nations remained relatively isolated and societies grew, flourished and declined without the knowledge of others living on the same planet.

In the 300 year span between the time that Columbus discovered the new world, in 1492, and the year that a new nation was born with a Constitution and Bill of Rights, passed in 1791, little had changed in the way Columbus traveled to America, from the manner in which Thomas Jefferson traveled to France.

In 1790, the year of the first census, 4 million people lived in the United States, most along the Atlantic seacoast in villages or on farms. Bad roads and poor communications kept communities isolated. For example, two stagecoaches and 12 horses carried all the traffic between New York City and Boston. It took almost a month for news of the Declaration of Independence to travel from Philadelphia to Charleston, South Carolina. In fact, the technology of urban and intercity passenger transport didn't look much different to Americans than it did to their ancestors until we reached the dawn of the 19th Century AD. Then, in a period of less than 200 years, this nation underwent changes in its transportation systems that were truly revolutionary, and the cataclysmic emergence of modern transportation was essential in changing world history.

Over the past 200 years, the evolution of a transportation mode typically has followed a sequence that included invention, demonstration, testing, evaluation, introduction into regular service, public acceptance, and ultimately the creation of totally new transportation services. The final stage typically influenced economic development, new land use patterns and the adaptation of life styles around the new mode. Improvements to the new mode were typically "incremental," essentially refinements on the basic characteristics of the existing technology. As other modes were introduced that had superior service qualities, the existing mode declined, losing market share, but not necessarily becoming extinct. The new mode would be accepted primarily because it was perceived by the public as providing an improvement in the level of service compared with existing travel options. If this condition was not met, there was little incentive for change, and any additional benefits of the new mode would likely never be realized.

While many so-called transportation "buffs" are fascinated with a particular mode and often remain strong advocates for their favorite technological fix, the traveling public has been more interested in the service characteristics themselves, which include travel time, cost, comfort, convenience, reliability, frequency, safety and security. Thus, to examine transportation history is to learn how the inventive genius, financial capability, and systems organization of the transportation industry in cooperation with state and federal government, combined to create

transportation networks that made possible new ways of travel for the American public.

It is helpful to view transportation within the context of the service it provides, including urban transportation, intercity travel by rail and highway, and international transportation. If we examine the history of transportation within this framework, then the changes that have occurred during the past 200 years in technology, networks and service can be linked to society's needs and the changing lifestyle of the nation.

Let us look at the transportation situation as it existed during the 19th century. At the dawn of the century, a significant change in transportation technology occurred. In 1769, James Watt a Scottish engineer patented a revolutionary steam engine design, and later formed a successful company that marketed the innovation for a variety of applications, including steamboats and railroads. Robert Fulton, a civil engineer and inventor, demonstrated the commercial feasibility of steamboat travel in the U.S. when on August 17, 1807, using a Watt engine, his new creation, often referred to as *Clermont*, but actually named, *North River Steamboat*, successfully traveled up the Hudson River from New York to Albany. In subsequent years, steamboat transportation flourished on major U.S. rivers and lakes providing passenger service to cities located on Long Island Sound, the Mississippi River, its tributaries, other rivers in the West, and the Great Lakes. To augment the river system, a system of canals were constructed for the purpose of connecting rivers and lakes and opening the west.

During the period between 1800 and 1850, approximately 4,000 miles of canals were built, which provided connections between various waterways in the northeastern portion of the U.S. Perhaps the most well known is the Erie Canal completed in 1825, which was 363 miles long and connected the Hudson River at Albany N.Y. to Lake Erie in Buffalo. This huge project spawned a new construction industry as well as the profession of Civil Engineering. Techniques and expertise developed in building the Erie Canal were used throughout the world in canal building projects in the 19th Century, such as the Suez Canal completed in 1869 and the Panama Canal, which was begun by the French in 1882, completed by the Americans, and opened for traffic in 1914. Canals shortened travel compared with other circuitous routes either by water or by horse and wagon, but travel times on canals were still limited by the speed of mules that were used to tow the boats. Furthermore, boats were delayed if the canal contained locks, and often fighting ensued between boat crews traveling in opposite directions as to who had first priority in traveling through. Often queues stretched for miles on both sides of the lock of a heavily traveled canal.

During the canal era a new mode was slowly emerging. The use of rails as a road surface enabled horses to pull heavier loads and by 1830, the Baltimore and Ohio Railroad became the first to offer this service. The introduction of steam power technology in England opened a new era of transportation and the "iron horse" soon replaced "Dobbin" as the source of motive power. Americans were slow to accept this new technology because they were committed to canals and the nation was blessed with extensive power resources from water. But steam railroads were gradually introduced, first by the South Carolina Canal and Railroad Company in the late 1820's, using a steam locomotive made in the U.S. named "Best Friend of Charleston," and then by the B&O which began to experiment with steam when it acquired the "Tom Thumb" in 1830. Incidentally, the story that Tom Thumb lost a race to a horse and carriage because a power belt slipped remains a transportation myth even today.

By 1850, railroads had proven that they could provide superior service characteristics of time, cost, and reliability when compared with either canals or turnpikes. Consequently, funds to build roads for horse-drawn carriages or further investments in canals began to be diverted and railroads became the dominant intercity passenger mode as Americans entered the 20th Century.

Having established that railroads were more competitive than canals or roads, the next stage was a massive construction effort of track laying, bridge building, and station construction throughout the nation. In 1887 alone almost 13,000 miles of track were laid, and by 1900 a railroad network of 260,000 miles stretched between the coasts and borders of the U.S. Now the railroads not only duplicated canal routes, but they opened vast territories of the West, a period in U.S. history that could not have occurred without this new and powerful technology. Thus, rail transport not only provided a competitive service that diminished the market share of an existing mode, but, because of its technological advantage, it could offer new services heretofore unavailable, thus influencing economic development and land use patterns.

The scenario described for the canal-railroad era is similar for other major transportation developments of the 20th Century, where truly remarkable changes in transportation have occurred, namely the emergence and dominance of automobile and highway transportation and the air transport industry. These new modes essentially replaced rail and bus for urban and intercity passenger transport, and ocean going steamships for international passenger travel.

The story of flight is exciting because it can be personalized with stories of inventors and heros whose actions truly shaped a new era in American transportation. Beginning with the Wright Brothers, who in 1903 proved that a self-powered heavier-than-air machine could fly, it was only 24 years later, in 1927, that a young pilot, Charles Lindbergh, would captivate the Nation by demonstrating the feasibility of transatlantic flight when he flew non-stop from New York to Paris in 33½ hours, a distance of more than 3,600 miles. A non-stop Pacific crossing, between Tokyo and the West coast, a distance of 4,883 miles, would first occur in 1931, but with much less fanfare — it pays to be first!

These events heralded the beginning of a new age in air travel, which was recognized for its military significance and then as the technology improved, as a carrier of domestic and international passengers. Air transport has a rich history, much of which has occurred during the lifetimes of many living today. It includes the pioneering period prior to World War I in which Europeans led in aircraft design and development, the use of airplanes in World War I for combat and reconnaissance, the postwar period which demonstrated the capabilities of air service for delivering mail and passengers, and the extensive use of air power in World War II.

By 1940, propeller-driven aircraft had reached the peak of its performance and although these planes were still in service in the 1950's, with the development of the first jet engine by a British designer, Frank Whittle in 1938, a new era in air transportation was soon to begin. In 1958, Boeing delivered the first American built commercial jet to Pan Am, and air speeds were suddenly increased from 360 to 570 miles per hour. Flight times coast to coast were reduced to less than 6 hours and international passenger travel was soon to shift from large ocean-going vessels to the new Boeing 747's introduced in 1970. Both domestic and international travel was to see a major shift from sea and rail to air transportation.

Just as our nation has been shaped by the intercity transportation systems which have been created in the past two centuries, so have its urban areas been influenced and molded by improvements in transportation services. Initially, water transportation played a key role and the location of urban places with access to harbors, rivers, lakes, and streams had higher potential than those land areas without easy access to water. Urban transportation has a significantly different function than does intercity transport, since it serves as an integral part of the infrastructure of the city itself and has impacts on land use and the quality of life. Expansion of city boundaries was made possible as travel speeds increased since the maximum time allotted for a journey to work trip has remained essentially constant. In addition to travel factors such as cost, time, and convenience, urban transport modes are favored if they are quiet, non-polluting and unobtrusive. Thus, it is no surprise that horse-drawn streetcars and carriages, which existed in cities by the 1830's, were soon replaced first by cable cars in the 1870's and later by electrically powered vehicles, which first appeared in the late 1880's. In addition to increased speed and lower costs, the reduction in animal pollution of the city streets with its odor and potential for causing illness and death, was considered to be a major improvement in the quality of city life. Early marketing of the automobile would also emphasize the non-polluting features of this new horseless carriage.

The introduction of the electric streetcar, later called the "trolley car," revolutionized urban transportation. Frank Sprague, who had worked with Thomas Edison at Menlo Park, is credited with creating this new mode, when in 1884 he created the Sprague Electric Railway and Motor Company and in 1888 electrified a 12-mile horsecar line in Richmond, Virginia, that demonstrated the use of electricity to propel a mass transit vehicle on rails. Sprague was not the inventor of the "electric street railway," but he was the first person to successfully assemble the various elements necessary for the system to function: an overhead wire to collect electricity, an improved control system to facilitate car operation, and a vibration-free suspension system for the motors.

The "streetcar" became the dominant mode of urban transportation for the next forty years, reaching a peak ridership in 1926 of 17.2 billion and connecting cities with interurban service. Thirty years after Sprague's demonstration in

Richmond, there were approximately 45,000 miles of street railway and 18,000 miles of interurban electric in the United States. The streetcar made possible the "starlike" pattern of cities and generated added traffic from amusement parks and residential communities located along and at the end of the lines. Large urban areas required greater capacity and speed than was possible by the electric streetcar, which was constrained by mixing and cross traffic. Thus was created the rail rapid transit systems, both elevated and underground. The first was opened in London in 1863 and later rail rapid service appeared in larger U.S. cities, New York, Chicago, Philadelphia, Boston, and Cleveland. After a hiatus of about 50 years a renewed interest in rapid rail transit was followed in the 1970's and 80's by the introduction of rapid transit systems in San Francisco, Washington D.C., Baltimore, Atlanta, Miami, and Buffalo.

When TRB's predecessor, the Highway Research Board (HRB) was formed in 1920, another mode of transportation was emerging, spawned by the inventiveness of people like Henry Ford, who developed and mass produced a motor car that could be purchased at a price most Americans could afford. In 1901 there were only 8,000 registered automobiles in the U.S. but by 1920, more people traveled by private automobile than by rail transportation. However, the nation's roads were not capable of servicing this new way of travel, in fact roads were of such poor quality that for many years the League of American Wheelmen, who represented bicycle interests, had themselves been lobbying for good roads. Thus, it fell to the states and the federal government to form a partnership and begin a program of highway development that would enable this "horseless carriage" to traverse the nation at will. In 1893 the Federal government had established the U.S. Office of Road Inquiry, within the Department of Agriculture, with an appropriation of $10,000. The office was charged with the task of investigating and disseminating information, but it wasn't until 1916 that the first Federal Aid Road Act was passed, which provided federal support for roads and gave State highway departments the authority to initiate projects, thus setting the stage for a long-term effort by states to organize, design and build a nation-wide highway system. The story of America's Highways was told in a book published by the Federal Highway Administration for the U.S. Bicentennial in 1976. This easy-to read volume traces the development of highway transportation in the U.S. from its origins to the active years of highway building that culminated with the now completed Interstate Highway system. The book also chronicles the influence of other modes on highways and describes the careers of those who led the effort.

One such man was Thomas McDonald, whose interest in highway engineering began as an undergraduate student with a thesis, written in 1904, on the highway needs of farmers and the force required to pull a wagon over different types of roads. His career began as an assistant professor of Civil Engineering at Iowa State, then Chief Engineer of the Iowa State Highway Commission, and in 1919 President Woodrow Wilson appointed him Chief of the Bureau of Public Roads, a post he held under seven Presidents until his retirement in 1953. McDonald's career spanned the building of millions of miles of hard surfaced roads in the U.S. and at the time of his death in 1957, the Interstate Era had just begun.

The highway research program, in which HRB would play an important role, involved the development of new theories and methods to be applied in planning, design, construction, operation, safety and maintenance. In 1956, Congress authorized the construction of a 42,500 mile system of Interstate and Defense Highways. The Interstate Highway System, now completed, has changed the face of this nation and has profoundly affected the reshaping of metropolitan areas and land use. It has also influenced the viability of passenger rail transportation and the centrality of urban public transportation.

By the time HRB had reached the 50 year mark, in 1970, air transportation had become a decisive force in both the domestic and international passenger transportation market. Now there were four modes — air, water, rail, and highway — that were well established. No longer would it be possible to consider one mode without understanding the impact on the others. In this climate, the concept of a new and expanded role emerged for the Highway Research Board, which was reconstituted as the Transportation Research Board in 1974.

What are the future research challenges for the TRB and the transportation community? We have seen profound changes in travel in the short span of two centuries when, for example, a trip between Philadelphia and Pittsburgh took 12 days by coach in 1800, 7 days by canal and rail in 1840, 8 hours by rail in 1910, 5 hours by auto in 1950, and 50 minutes by jet today.

In March 1995, the TRB and the National Science and Technology Council sponsored a Forum on Future Directions in Transportation

R&D. Research challenges in transportation for the 21st century were presented by industry, state and local government, stakeholders, and the research community. The research agenda proposed is in areas of, physical infrastructure, information infrastructure, next-generation vehicles and transportation system development.

Having placed transportation's rich history within the context of urban and international developments, speculation on its future would be the topic of a separate paper. Factors that will affect transportation include economic growth, demographics, energy availability, impacts on the environment, regulation, technology and communications. If the past is prologue then the future will be filled with change, challenge, and opportunity. If we do not know from where we have come, then how will we understand why we are here or where we are headed in the future.

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# Transportation's Rich History and Challenging Future — Moving Goods

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It is a great honor to have this opportunity on the 75th anniversary of the Transportation Research Board to discuss some aspects of the history of freight transportation in the U.S. and also to comment on what lessons we have learned from the past several centuries.

We all know that transportation is fundamental to economic development in any nation throughout the world. This is hardly a new idea. In a thin volume called "A Treatise on Railway Improvements" written by Richard Badnall, published in London in 1833, he says:

> "It is, I believe, universally acknowledged that in all countries, the rise to prosperity mainly depends on the convenience of conveyance from place to place. No nation can promote its real interest more effectively than by encouraging, in every possible way, the establishment of good roads, and rapid and convenient modes of traveling; for according to such convenience, will be the equity and price and the abundance of the supply of produce; the *real* value of land and other property and as before stated, the increase of wealth and comfort among all orders of society."

The above sentiments ring true around the world, but in the United States it is particularly relevant. We are a country large in extent, 3000 miles from coast to coast, 1500 miles from north to south. We have a substantial coastline on the Atlantic and Pacific Oceans and the Gulf of Mexico. The topography of this nation makes the development of transportation infrastructure a particular challenge. And the development of this infrastructure has quite clearly been central to our national development.

The history of the United States *is* the history of transportation system development over the last several centuries. Prof. John Hazard ties together the birth of our nation with transportation innovation when he notes that in the epochal year of 1776: 1) The Declaration of Independence was signed; 2) Adam Smith's "The Wealth of Nations," which focused on economic rationale favoring freedom of enterprise within and free trade without, was first published; and 3) The first successful steam engine, providing propulsion for both water and land transportation, was introduced by Bolton and Watt.

Given the time constraints we have, I can only touch upon some particular high points of our transportation history. For those of you with a scholarly interest in the subject, the best text I have found is called "Capturing the Horizon" by James E. Vance. This is a comprehensive treatise covering centuries of transportation development in an effective and clear way.

When Vance speaks of the early history of this country, he refers to the *mercantile model of settlement.* He notes that in the original thirteen colonies, trade was directed more towards Europe by each of the colonies rather than among the colonies themselves. Therefore, the emphasis was on development of port facilities that could accommodate the flow of goods in and out on the Atlantic coast. Infrastructure connecting the colonies was not emphasized in those pre-Revolutionary war years.

It was not until the early 19th century that attempts began to systematically coordinate among the states of the new United States of America for transportation purposes. The Congress, aware of what Vance calls the "unarticulated quality of American transportation" in that era recognized the importance of transportation initiatives for the growth of the new nation.

In 1807, the United States Senate asked the Secretary of the Treasury, Albert Gallatan, to prepare

> "a plan of the application of such means as are in the power of Congress to the purposes of opening roads and making canals, together with a statement of the undertakings of this nation, which is the object of public improvement be required and deserve the aid of government."

Gallatan's report was an important step, even a pioneering step, towards what eventually came to be a major and historically unprecedented investment in transportation infrastructure. His report recognized two fundamental issues in U.S. transportation development. First was the lack of capital for such enterprises, and second was the sheer geographical extent of the United States referred to earlier.

Gallatan's work gave important impetus to the development of what has variously been called the "National Road," "National Pike," the "United States Road" and the "Cumberland Road." Construction of this facility, which ultimately went from Cumberland, Maryland, to St. Louis, Missouri, began in 1811 and as has often been the case in our history, defense needs, in this particular case the War of 1812, drove the requirement that the country have good communication among its regions. This theme of transportation innovation through defense expenditures continues to the current day.

Further, the "National Road" can be characterized as intermodal in nature, as it often provided transportation between navigable rivers.

Maintenance of infrastructure was an issue even back at that time. Max Lay, from Australia, in his excellent book "Ways of the World: The History of Road Transportation," quotes a local commentator in 1827 as noting with regard to the "national road":

> "The stone surface was worn away almost as fast as it was built. The funds available for maintenance were not sufficient."

The question of public expenditure on roads was a serious issue in that period. The "National Road" was partially financed by a tax on government land sales. Some insisted that state-based finance of transportation infrastructure was important as a matter of "states' rights." However, much of the building was done by Army engineers, as the development of this infrastructure was seen as central to the national interest.

Other modes were important to the development of the U.S. The development of an extensive series of canals, including most notably the Erie Canal, completed in 1825, provided low cost freight transportation to the hinterland. The construction of a system of roads and turnpikes, often with private funds, together with innovations in vehicle technology, for example the Conestoga Wagon, which had its heyday from the mid-18th to the mid-19th century, helped tie the country together.

By the 1820s, we saw the first glimmerings of the massive railroad system that was to come. This was the beginning of infrastructure building, fueled by federal land grants to entrepreneurs who were interested in penetrating the U.S. hinterland with steel — wheel on steel — rail technology. This led eventually to the driving of the golden spike at Promatory, Utah, in 1869, linking up the nation with coast-to-coast rail infrastructure.

It is worth noting how the rail network has developed over this last century and a half. In 1840, the U.S. had about 3,000 miles of rail track. By 1860, one year before the beginning of the Civil War, we had 30,000 miles of rail track, a factor of 10 growth over that twenty-year period. We continued during that period with a substantial rate of growth. In 1880 there were 93,000 miles, a factor of about 3 in that twenty-year period. From 1880 to 1900 growth to 193,000 miles took place — a factor of 2 in that twenty years.

George Douglas in his "History of the U.S. Railroads: All Aboard — The Railway in American Life" notes that the

> "building of railroads into the wilderness never ceased to be a puzzlement to European visitors . . . Tiny hamlets were not reached by the railroad; the hamlets were dropped down from the railway cars themselves"

as the nation pursued its "Manifest Destiny" and a coast-to-coast rail system.

The rate of growth of the rail network slows up substantially as we jump ahead to 1920 — another twenty-year period. We do not yet have an important trucking industry in the United States; many roads are not paved; inland waterways were the prime competition to U.S. railroads; air freight was virtually non-existent, and the rail system had close to a monopoly in freight.

In 1916, "a cloud smaller than a man's hand on the horizon" appeared: the Federal Government allocated $74 million in grants for road construction — this was a critical step in building what came to be the extraordinary interstate system that the U.S. enjoys today. Further, in 1915, the Panama Canal opened, changing international patterns of trade quite substantially.

By 1920, the number of railroad miles in the U.S. was about 260,000 — a growth of about 25 percent since the turn of the century. This marked the high-water point of railroad network size as the over-capacity of the network became clear, as strong competition for freight traffic began to develop. By 1940 the system had shrunk to 230, 000 miles. In 1935, the Motor Carrier Act was signed. This legislation regulating the trucking industry foreshadowed a major period of competition between rail and truck.

We now go forward to 1960; we have been through World War II and the Korean War, and the rail network has shrunk to 217,000 miles. But in the next twenty years, as we move through 1980 — 16 years ago — the network has shrunk to 164,000 miles, a network equal in size to what we had in 1880 when the U.S. economy was a small fraction of its 1960 size — as the rail system was substantially rationalized. By 1990 the network was down to 120,000 miles — well below half the peak attained in 1920, and by 1992, the number fell further, to 113,000 miles.

The rationalization of the rail system, necessary for the financial survival of the industry, was expedited by several waves of railroad mergers as well as the abandonment of underutilized rights-of-way. Again, competition, and most particularly truck competition, was a fundamental impetus to the shrinkage of the railroads.

The railroads had a virtual monopoly on freight transportation through much of the early years of railroad history. Some of the commercial excesses by the railroads led to the formation of the Interstate Commerce Commission in 1887. Douglas writes of the cost of shipping from South Dakota to Chicago being greater than the cost of shipping from Chicago to Liverpool, England, as the railroads took substantial advantage of their monopoly position. Farmers formed the Granger movement to counter that monopolistic behavior.

The curtain came down on the Interstate Commerce Commission, or at least many of its functions, just several days ago on January 1, 1996, although it had been clear for many years that the monopoly powers of the railroad industry were no longer the defining factor in the relationship between the federal government and the railroad industry. The 1980 Staggers Act deregulating many aspects of the railroad industry has changed that business in a fundamental way, resulting in some of the best financial performance in its history.

Going back to the early years of railroad history, we note that railways were considered the major management innovators in the late 19th century. Prof. Alfred Chandler of Harvard University, in his books "Strategy and Structure" and "The Visible Hand," speaks of the management innovation introduced by these railroad organizations. They were, at that time, of unprecedented scale; they were geographically dispersed; they required management control for both business and safety reasons. The railroads provided a hierarchical system of management which served as a model for many industries in non-transportation areas for decades to come.

In the third decade of the 20th century, the rail industry carried about 85 percent of the freight ton-miles in the United States. In 1970, this number had been reduced to about 35 percent, as the trucking industry grew dramatically. Today, the U.S. railroad industry focuses on transportation of bulk low-value commodities (e.g., coal, grain) and intermodal trailers and containers. In the latter area, double-stack container trains, motivated by strong international freight flows on both the Atlantic and Pacific coasts, have made the railroads more productive and competitive for containerized traffic.

The major building of rail infrastructure in the 19th and early 20th century was mirrored by the construction of highways in the U.S., beginning in earnest in the 1920s. Highway construction was active in the 1920s through World War II. Many state highway departments, the bedrock of support of what is today TRB, were developed and shaped in that period. Construction slowed during the world conflict and resumed at an accelerated pace in the post-World War II era.

Legend has it that during the pre-World War II period, General (then Colonel) Eisenhower, in a tour of the United States, had the glimmerings of a national system of high-quality roads that would interconnect the country not unlike the visions that Secretary Gallatan had the early 19th century. In 1956, then President Eisenhower signed the Interstate Highway System into law, leading to a $130 billion public works program of unprecedented scale and impact. The

trucking industry came into full flower building upon this publicly provided infrastructure; the Interstate changed the shape of the U.S. freight transportation system, as well as its passenger system, forever. Trucks carried less than 1% of ton-miles in 1920. By the outbreak of World War II, they had a 10% share. By 1970, the ton-mile share was 25%, but their share of freight revenues was 75% as they focused on high-value goods for which service quality was important.

The trucking industry has become complex. It provides *truckload service* through very large companies like J. B. Hunt, as well as individual entrepreneurial owner/operators. Also, *less-than-truckload* service provided by Yellow Freight and a number of other major carriers and smaller regional and local carriers, have had a tremendous impact on the flow of goods around this country. Moving high-value freight building on the universality of a high-quality highway network has made the truckers an industry to be envied around the world in terms of the quality and quantity of service they provide; they are an important competitor (as well as a partner) to the railroad industry.

It is interesting to note that the railroad shift in the 20th century from general commodities carrier to a primarily bulk commodity and intermodal carrier, mirrors the same phenomena in the 19th century. At that time, the development of the railroad forced the then-general merchandise canal system into a position of hauling mainly bulk commodities as the railroad became the general merchandise carrier — the carrier of high-value goods. This parallels the current day interrelationship between the railroads and the truckers.

Intermodal partnerships have become the order of the day in our modern freight system. The fundamental challenge in intermodal transportation is using the inherent advantages of each modal partner. In this case, we combine the *universality* of the *highway truck network* and the *low-cost line-haul* attributes of the *rail network*. But if you cannot do an efficient transfer between the two modes, you dissipate those advantages. *Containerization* has been a major step forward in allowing that modal interchange to take place efficiently. The fact that containers are standard in size and transfer equipment, for example, high-performance cranes can deal effectively with containers, moving them readily from one mode to another, is fundamental to the idea of modern-day intermodal transportation.

Intermodalism goes hand in hand with another major development in our freight transportation system — the importance of international freight flows. The development of ports and supporting equipment on both the Atlantic and Pacific coast has been dramatic in recent years, as the U.S. has greatly expanded its international trade. A three-mode partnership between rail, truck and ocean shipping enables the growth of the international freight market.

It is interesting to think about the systemic nature of our national transportation system and how it relates to these international freight flows. In the early years of the Asian boom, when Japan and Korea were the primary manufacturers in Asia, the major freight flows took place from those countries to the West coast of the United States, for subsequent transportation to the midwest and beyond. In more recent years, as the manufacturing in Asia has shifted to Southeast Asia — countries like India, Thailand and others — the routing through the Suez Canal and across the Atlantic Ocean to the East Coast ports has become of substantial importance as well. So, we must recognize the continuing need to see the interrelationship on a systemic basis between what we are doing in our port development and what is going on in the international "geo-political" scene.

A brief comment on *air freight*. Air mail in the 1920s, an early example of air freight, helped fund the nascent airline industry. Currently, air freight and its growth is evidenced by acres of UPS and Federal Express airplanes sitting on the tarmac at many airports.

Air freight can hardly be characterized as the workhorse of the freight industry. It represents less than *1 percent* of the ton-miles that we currently carry. At the same time, it represents about *4 percent* of the U.S. freight revenue base. The high-value logistics links that are required for many industries are provided through the air freight system.

Let us now consider technology and its continuing as well as its historical role in our transportation system.

A delightful new book entitled "Longitude" by Dava Sobal describes the invention of the chronometer by John Harrison. This was necessary for calculating longitude at sea — a major technological advance that led to more reliable, safer flows of goods and people across the oceans. In 1714, the British Parliament offered $20,000 pounds (or about $12 million today) to anyone

who could calculate longitude at sea. This led to a major competition. Harrison's chronometer eventually carried the day — knowledge of time at the prime meridian was essential to the computation of longitude. The main competition for the prize was an astronomical method called "lunar distances" using the "Clock of Heaven," but ultimately the chronometer won out. There was a great deal of competition between these two major ideas in the 18th century — the chronometer and the "Clock of Heaven" — jealousy, intrigue, and fierce competition characterized the relationship between those two schools of thought.

Another innovation, which went hand-in-hand, in a sense, with the chronometer (which was calibrated on a voyage by Captain Cook in 1772) was the use of sauerkraut by the merchant fleet to avoid scurvy, a critical disease that seamen on long voyages contracted for lack of fresh fruits and vegetables. Cook imported sauerkraut from Germany: many British seamen said they would rather die than eat sauerkraut, and unfortunately, many of them did exactly that.

Another technological development of note is the pipeline and associated technologies invented by Samuel Van Sickle in 1856 to move oil, originally from western Pennsylvania. This reduced the transportation costs of oil by a factor of about 3 — from about $1.50 to $.50 a barrel.

The development of the internal combustion engine in the latter part of the 19th century revolutionized both passenger and freight transportation. The development of rubber-tired vehicles in the early 20th century also had an important impact. Certainly, the development of durable low-cost materials and more effective construction methods, many of these carried out by the states in these United States, enabled the development of our high-quality, high-capacity highway system.

As one moves forward to the modern era, we can introduce some of the newer technologies that are of importance to us; here we cite the "ITS-4" technologies from the "Intelligent Transportation Systems" world. These technologies deal with: first, the ability to *sense* the presence and identity of vehicles or shipments in real-time on the infrastructure through roadside devices or GPS; second, the ability to *communicate* (i.e., transmit) large amounts of information cheaper and more reliably; third, the ability to *process* large amounts of information through advanced information technology; and fourth, the ability to use this information properly and in real-time in order to achieve better transportation network operation. Here we refer to *algorithms* and *mathematical methods* used to develop strategies for network control.

The "ITS-4" have led to profound changes in our transportation system. We see more efficient urban highway networks with real-time control of flows and incident detection and removal. New technologies in areas like ITS' commercial vehicle operations (CVO) can result in productivity improvements through fleet management and safety improvements using in-vehicle equipment in the trucking industry. The idea of supply-chain management integrating the logistics chain of manufacturing organizations with the transportation system is enabled by these various technologies. We began with the rudimentary technology of electronic data interchange and have now gone well beyond that. Just-in-time (JIT) inventories that many of our manufacturing customers demand is also an important concept that has been enabled by the "ITS-4." The aforementioned intermodalism is dependent on the "ITS-4;" these technologies allow for more effective coordination between modes providing more efficient system performance and better customer service, and for what we call in-transit visibility: knowing where your shipment is at all times. The concept of the interaction of Vice President Gore's National Information Infrastructure (NII) and ITS gives us a new, imaginative way of thinking about the relationship between transportation and communications systems.

We advance technologically on other dimensions as well. We continue to innovate in materials technology; the Strategic Highway Research Program (SHRP) about which we have heard so much over this last decade is of fundamental importance in the highway field. The development of new lightweight durable materials for both vehicle and infrastructure have made our system more productive and cost-effective. The development of new mechanisms for propulsion — AC traction motors, for example — for use on the railroads, and advanced train control methods are also of fundamental importance.

The vehicle area has seen major technological advances in the maritime field. The development of "supertankers" for crude oil transport, and container ships that are specially designed for fast on and off loading, are important advances. New concepts like the "FastShip," a high-speed ship that can operate at 45 knots, are being developed. Innovations in trucking such as

efficient, more "environmentally friendly" power plants have had a positive impact.

In all, the partnership between transportation and technology has been a fruitful one, for operators and customers alike.

## Lessons

To close, let me mention a baker's dozen lessons that we can learn from the history of our freight transportation systems

First, history teaches us the *systemic* nature of transportation. We must consider, for example, the interactions between infrastructure and vehicles and interactions among various modes. We have learned that reductionism does not work as a method of analysis for complex transportation systems. Who could think of designing an urban transportation system without an effective understanding of land use, for example? Who could think about designing a transportation system or service without considering systemic issues such as the environmental and energy perspectives?

Second, *institutional* issues tend to be of a very *long-lived* nature in the transportation field. The excesses of the railroads and their monopoly position in 1887 and the formation of the Interstate Commerce Commission, were not totally redressed until over a century later. There are very long time constants in these institutional relationships. But they can and do change, and they are of critical importance, as witness the positive impact on railroads in recent years, as deregulation through the Staggers Act of 1980 changed the industry's market opportunities and cost structure significantly.

Third, *subsidies* of various sorts are a fact of life for all transportation modes. Our political system has reached the judgment that transportation is too important to be totally self-funded. The land grants to the railroads in the 19th century and the development of the Interstate in the 20th could both be viewed as important subsidies to particular modes. The paying of well-above-cost air rates by the federal government in the early 1920s for air mail movement could be viewed as an important subsidy in the development of the new airline industry. Subsidies will continue to play an important role in freight transportation.

Fourth, we must increasingly be concerned with the *customer orientation* in building our transportation systems and services. The needs of the customer and anticipating those needs are fundamental to success.

Fifth, closely related to the fourth, *competition* is essential for the provision of high-quality transportation. When we get into monopoly situations, both in freight and passenger, we tend to see degradation of service. Competition is at the heart of our economic system and is certainly a crucial element in providing the high-quality transportation service so important to our economy.

Sixth, history teaches us the need to *think big* in transportation. The transcontinental railroads, the Panama Canal, the Interstate system — these were all products of visionary minds. Conventional discounted cash-flow and benefit/cost analysis may not work well on major infrastructure programs that fundamentally change the way we provide transportation. These visionary projects must pass some test of rationality, but our conventional methodologies may not be sufficient to capture the richness and "step-function" changes induced by those kinds of programs.

Seventh, *technology* is a major driver of the transportation industry. With developments in propulsive power, advanced materials, and control systems, we can advance transportation systems efficiency and productivity substantially. The fields of information and communication have provided fundamental advances.

Eighth, we continually deal with *changing roles and relationships among our modes.* We have seen the railroads go from a position of monopoly, carrying all kinds of freight, to a primarily bulk and intermodal carrier. We saw the canal system go through a similar change. We now see partnerships between railroads and truckers that would have been hard to predict ten or fifteen years ago in that highly competitive marketplace. We see cycles of capacity in the various freight-carrying modes. The railroads went from a period of over-capacity to a more rationalized system in the current day. *Traffic World* reports that "truckers gladly close the door on a difficult 1995," characterizing the over-capacity of the industry as one of the problems that is holding down margins. We see continued capacity changes as management rationalizes the modes to achieve a balance of revenues and costs. As others have noted, "change is the only constant" in our industry.

Ninth is *internationalism*. The world will only become smaller, more international and more competitive. Our transportation system, and freight transportation systems in particular, must allow us to compete effectively by providing efficient transportation service domestically and effective gateways for international trade.

Tenth, *intermodalism* is a fundamental force in our business. The market — particularly the international market — demands it; technology enables it. Efficient freight movement requires intermodal capability and the continued effective operation of the intermodal system.

Eleventh, *public/private partnerships* for the provision of transportation infrastructure, vehicles, control systems, services, and research and development is the wave of the future. In the U.S., we are seeing a fundamental redefinition of the relationship between the public and private sector; we will need to think creatively about the public and private sector working together to provide the kinds of freight services we will need in the future.

Twelfth, transportation has *impact*, the economic impact and, indeed, the impact on all facets of the human condition by transportation systems is substantial. We have changed and can continue to literally change the world — we hope, for the better — through advances and investment in the transportation system.

Finally to complete our "baker's dozen," we must always be concerned with the education of the *new transportation professional*. Our profession is becoming more challenging with time, with transportation professionals needing to be knowledgeable with technology, systems and institutions in our increasingly complex world. A focus on education is required to develop the new generation of transportation professionals we will need to advance in the future.

In a sense, I have seen the future of transportation in my students; it is my special privilege to help educate them. Based on my observations of these students, the future of transportation will be as exciting and as innovative as its past; with those young people, I can assure you that transportation's future is in good hands.

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