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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