Future Technologies: Implications for U.S. Transportation

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When asked about the future, I'm reminded of Winston Churchill's definition of what it takes to be a leader: "First, to be able to predict with unfailing accuracy what is going to happen. And second, to be able to explain later why it didn't happen that way."

As we explore the future of transportation technology, it is vital to recognize up front that no matter how well informed we are on this vital subject, we will probably be way off base in our predictions.

In 1893, for example, at the Columbian Exposition in Chicago, 74 of the most prominent men in America were asked to predict what the world would be like in 100 years. Even though a German automobile was on display at the exposition, not one person predicted that the automobile would be common in the future. In fact, Treasury Secretary Charles Foster predicted with absolute certainty that the fastest form of transportation in 1993 would be the steam locomotive.

History repeated itself in 1927, when Congress commissioned a blue-ribbon panel, chaired by Herbert Hoover and composed of 300 scientists and business and political leaders, to predict what transportation would be like a more modest 50 years into the future. Not one of the 300 predicted the development of a national highway system or the possibility of commercial aviation.

Transportation in its many forms has played a critical role in the development of the U.S. life-style. Transportation is key to the evolution of North America as the prime economic power of the 20th century. It is the well-being of the citizenry and the boosting of the economy that make transportation decisions so important. One of the outstanding attributes of the U.S. business system, compared with business systems in other parts of the world, is the ability to move goods efficiently. Our transportation system is one of the key ingredients in the U.S. economic juggernaut, and it is critical to future growth and continued prosperity.

If you accept this premise, then the old adage "history repeats itself" is something from which we can learn. A review of the development of transportation in the United States will provide some perspective on how we might look at the future.

Transportation Development

The evolution of the automobile started in Europe in the 1870s. During the late 1800s automobiles were curiosities and toys for the wealthy. Virtually all transportation, both personal and business, involved horse power, in a literal sense. A typical downtown street had a predominance of horse-drawn carriages and wagons.

It must have been extremely difficult to extrapolate from this situation to a vision of future transportation. Simple extrapolation would have predicted massive gridlock of horse-drawn carriages, with very little room to expand. The gridlock would have been accompanied by a major "emissions" problem.

At any time in history, people probably would have come to similarly false conclusions. Extrapolating the prevailing transportation system would have led to an image of unacceptable regulatory solutions. What actually happened, of course, was that periodic and distinct transitions in transportation occurred, which prevented unacceptable outcomes and yielded a system more efficient from an economic standpoint and more acceptable from a personal standpoint. These transitions were successful because they let people do what they wanted; the transitions were market driven.

The image of the pioneers crossing the country as they sought to open up the West is a familiar one. You need only be an observer of Hollywood westerns to know that the laborious transportation on which pioneers relied was replaced by the steam locomotive. Once the railroad system spanned the nation, people could more easily travel greater distances, which opened up new areas for business development. Nonetheless, during this time, most people stayed close to home, and there was little movement to different job locations. Because transportation in this period was based on the railroad system, all economic and personal predictions about the future of transportation also were based on railroad use.

The next step in transportation was introduced by Henry Ford, with his invention of the production line. This invention changed the whole equation relative to the economics of movement and allowed evolution of a flexible transportation system unimagined by the horse-and-buggy and railroad stalwarts.

International business, which also stimulates domestic growth, depends on the intercontinental transportation of goods. Exports and imports necessitate the movement of goods across oceans. In the early 1800s the only available means for moving goods was sailing ships. Although the number of sailing ships was significant, the amount of cargo per ship was limited because of the restrictive sizes of shipyards. The movement of substantial amounts of goods between continents was both inefficient and relatively expensive.

Just as railroads, which replaced covered wagons, improved transportation, Fulton's invention of the steamship led to a quantum improvement in the intercontinental movement of commercial products. Steamships also provided personal travel, but clearly their greater impact was that they allowed the United States to export, and import, products on a much larger scale.

Another quantum leap occurred later with the introduction of containerization, which allowed both overland and sea transport of large volumes of goods in standardized packaging. Containerization produced an efficiency that could not have been achieved from the previous method of goods movement.

The American public's love affair with the automobile led to its becoming the preferred mode of personal transportation. Until the advent of air fleets, the automobile displaced the railroad for both local and long-distance personal movement. This occurred not only because of the relatively low cost of personal automobiles and gasoline, but also because of the flexibility and independence offered by the automobile, which is unmatched by any other form of transportation. The preference for the automobile is dominant even in the face of many daunting obstacles, and some defend its use as a God-given right. In looking at technologies of the future, it is important to consider the extraordinary significance of independent transportation.

The evolution of aircraft mirrors the evolution of the automobile, but taking place 50 years later. Early aircraft were restricted in size and were expensive. Changing technology

facilitated increased efficiency and size, which generated an air fleet that allows movement of large numbers of people and goods over long distances at a reasonable cost. The United States has the most efficient and inexpensive air traffic infrastructure in the world. The rapid expansion and affordability of the air transportation system would never have been foreseen in the early days of the flying machine.

The development of our present air transportation system has enabled society to prosper. The continued improvement of the U.S. standard of living during the past century can be attributed mainly to our extremely efficient transportation system, which makes our commercial development the envy of the world. Likewise, our personal freedom of movement is unmatched anywhere else, both in terms of flexibility and cost.

Problems Generated by Transportation

Transportation developments have generated some major problems. One of the more obvious is automobile gridlock in major cities, as evidenced by rush hour in Los Angeles, which is frequently publicized on television news programs. Former U.S. Transportation Secretary Andrew Card, Jr., said that he considers gridlock the single largest force behind the relative decline of the U.S. economy.

We are faced with significant problems in surface and air transportation, and extrapolating these problems to find solutions indicates an impossible situation in both cases. One solution is to make better use of our current systems, but this may be impossible without regulatory restrictions. Americans like freedom of choice and economic viability; therefore, solutions that impose restrictions on personal choice are not popular. The right choices will be market driven—they will let people do what they want to do. Further, what must be realized is that as problems increase in seriousness in a free-market culture, they tend to inspire solutions.

A Look Ahead

What potential advances might create a new transition in transportation, taking into consideration the need to maintain the advantages of the current system while resolving the major issues? I do not pretend to have the answers, but I do know that there is a large role for individual creativity and collective research. As I sifted through possible scenarios searching for future transportation trends, I came upon digital electronics over and over again. Digital electronics has infiltrated our lives in many ways—telecommunications, personal computers, and compact discs, for example—and it will likely play an important role in mitigating our transportation problems.

Every day 108 million Americans drive to work. Of all workers, 73 percent drive alone, 13 percent carpool, and only 5 percent use public transportation. If congestion causes these 108 million drivers to be just 10 minutes late, it costs the economy $26 billion a year. And this is just lost time—it does not count the wasted fuel or the impact of more air pollution.

The Texas Department of Transportation studied congestion trends in 50 urban areas of the United States. Between 1986 and 1991, 35 of the 50 areas had at least a 15 percent growth in traffic delays, 11 areas had at least a 50 percent growth, and both Sacramento and Salt Lake City had a 100 percent growth. None of the urban areas showed a decrease in traffic delays.

The emergence of distributed computing and the exceptional power of modern processors suggest a role for what we at Ford call "virtual collocation." The backbone for virtual collocation is an integrated services digital network (ISDN). Ford is probably the first company in the world to use an ISDN across national borders. Our designers use virtual collocation to link our design studios in Michigan, California, Italy, England, Germany, and Japan, allowing our best people to work together as if they were in the same location. This

idea is particularly important because we have assigned leadership for various car and truck programs to offices in different parts of the world.

For example, Ford of Europe uses its ISDN to simultaneously engineer small and mid-size cars. Interior design is done in England; the exterior, engine, and chassis in Germany; and testing and development in Belgium. There are no more paper drawings—masters are now created using computer-aided design tools. Ford's suppliers are on the network, too.

As interesting as these applications are, we must note that they are done on stand-alone systems, custom designed for Ford's specific needs. If virtual collocation is to be a realistic alternative for business, we need continued technical and operations research to achieve a standard, broad-band, real-time communication infrastructure backbone that can support high volumes of complex data traveling across national borders.

Eventually the electronic virtual office will connect people in every part of the world by a web of networks and intelligent, integrated computing and communication devices. Workers throughout the world will operate as if they are located at company headquarters. These workers will not necessarily have to travel to their work sites—they might telecommute. Telecommuting is coming into its own. Right now there are about 7 million telecommuters—people who work at least part of the time off company premises. Personal computers, cellular phones, and fax machines are their tools, as they are for 24 million people who run businesses from their homes and 9 million people who work at home after their workday has ended at the office.

The home office trend began to take off in 1990 when Congress passed the Clean Air Act Amendments, which require companies with more than 100 employees in nonattainment areas to reduce the number of workers commuting by car. Carpools and vanpools are nice, but it is actually cheaper to have employees telecommute, using a home computer to do the work they would normally do in the office.

American homes are ripe for telecommuting, with more than one-third containing at least one computer. About half these homes have a modem, 23 percent have a fax machine, and 14 percent have a copier. A telephone answering machine is found in 78 percent of American homes.

Some people take telecommuting to the extreme. One mutual fund analyst for Chicago-based Morningstar does her work from a home office in Los Alamos, N.Mex. She interviews fund managers by phone, prepares her reports on a personal computer, and sends them via electronic mail to an editor in Chicago; the edited copy is returned to her via a fax machine.

Telecommuters use several unconnected appliances—a personal computer, fax machine, modem, cellular phone, and so forth. To be truly effective, future telecommuters will need smaller, lighter, and cheaper integrated devices. We need additional research into component and systems miniaturization; compact, long-lasting, and highly portable energy sources; and improved displays.

If we cannot convince people to work at home, perhaps we can convince them to use other transportation modes. If we asked 500 commuters in New York City their opinions, 80 percent would describe rush-hour driving as either "unpleasant" or a "nightmare," 50 percent would consider moving to another city to escape the commute, and more than half would rather go to the dentist than use public transportation. These perceptions suggest that solutions for increasing use of public transportation must be market driven instead of regulated.

Intermodal solutions usually mean a broadly available, urban public transit system, much like the Washington-area Metro or the Houston Metro. Unfortunately, there is no public transit system in the world that breaks even; therefore, a consistent level of government subsidies must be available for these systems to operate. As indicated by market research, many people are less than enthusiastic about using public transit unless there are sufficient incentives, such as low fares, or ponderous disincentives, such as a shortage of parking spaces.

One important key to public intermodal success is that up-to-date information on schedules, routes, and fares for the different transit modes be widely available to potential users. Such information should be available at their homes and offices, in their cars, on buses and

trains, and in public areas, such as building lobbies. The information must be reliable. To be really useful, the information should relate to a specific customer's intermodal needs. This means further research into data selection techniques, probably involving artificial intelligence, as well as research into broad, parallel, processor-supported communication networks.

Intermodal solutions, however, are becoming more popular with goods shippers. Almost one in three shippers has turned from trucks-only to intermodal movements for part of its transportation needs. Most users say intermodal services improved from 1989 to 1992, according to the latest data. Higher trucking costs and rail service improvements are the principal drivers behind the intermodal switch.

Of course, no discussion on applying digital electronics to solve transportation problems would be complete without including intelligent transportation systems (ITS). A study underwritten by the American Academy of Arts and Sciences, *Avoiding the Collision of Cities and Cars,* recommended, among other things, that ITS be deployed to (*a*) direct vehicles around congested areas, (*b*) enhance night vision, (*c*) alert drivers to impending collisions, and (*d*) collect road tolls (*1*).

There are at least 250 organizations experimenting with advanced technologies that could be applied to highway networks as well as to the cars and trucks that use them. These technologies include transponders for tracking commercial vehicles, satellite-linked vehicle navigation systems, and radar systems to keep vehicles from colliding with one another. The auto companies and the National Highway Traffic Safety Administration are particularly interested in the last item because, with 50 percent of highway deaths being unavoidable once a collision begins, preventing crashes is very important.

Consumers are likely to accept ITS products the same way they accept other new automotive features. During the early phases, purchasers will represent about 1 percent of the population aged 25 to 49 with household incomes of $60,000 or more. This is typical of another recent electronics feature, the cellular telephone. It is likely that ITS applications will become similarly popular once their value is perceived and increasing volumes reduce their prices to a mass-market level.

ITS research priorities include improved "smart" sensors, including some preprocessing that can be part of integrated smart systems; low-cost, low-cube data processors running faster than 100 MHz; low-cost displays incorporating shared architecture; and a standard communication backbone architecture.

The possibilities for future transportation technologies are virtually endless. In addition to congestion, technologies must be developed to address the related problems of lost productivity, increased petroleum use, increased air pollution, and risks to safety. We know we are in for a paradigm shift—1995 looks too much like 1895, except it is cars and nitrogen oxides instead of carriages and manure—but the problems of congestion, accidents, and lost time sound much the same.

Digital electronics likely will be one key element of the solution. It is too early to tell what the solutions might be—virtual collocation, telecommuting, intermodalism, ITS, or combinations of these. One thing is clear, though. No matter what we predict, no matter what we plan, we can be sure that the future will not follow our best-laid plans. But we need to execute the planning process. As General Eisenhower said, "Planning is everything, the plan is nothing."

Reference

1. *Avoiding the Collision of Cities and Cars.* American Academy of Arts and Sciences, Chicago, Ill., 1993, 72 pp.

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