

Highway Investment for Competitive Economies

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It is a cliché to say that we live in a changing world. However, there is little question that some of the most dramatic changes in the economic structure of the world have occurred during the past decade. The key word in this statement is “world.” Never before have financial markets in all parts of the world been linked by near instantaneous communications that allow 24-hr financial transactions or enable manufacturing industries to develop strategies for making and selling products on the basis of which country is best suited to make which parts of the product and where the final markets are located. Trade and economic security issues have begun to surface as key negotiating points among nations. And large trading blocs are forming to take advantage of the efficiencies and productivity enhancements that accompany cooperative ventures.

In this new economic environment, the nations that will prosper in the coming decades will be those having (a) a skilled and educated labor force that can produce the products of tomorrow, (b) an efficient national transportation system over which these products can reach far-flung markets, and (c) an advanced communication network that connects corporate decision making to the balance of the world.

This paper examines the important role of highways, and a continuing investment in highways, in keeping the U.S. economy competitive in this world market. In particular, the recently passed Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) has placed greater weight on freight movement and access to transshipment points in national, state, and local transportation planning and decision making. Within the context of ISTEA, and reflecting the changes in the world economic structure just mentioned, it appears appropriate to ask how the United States should view its National Highway System (NHS), in particular, with comparison to other such systems.

What are the changing transportation needs of our society that must be considered as our nation enters the post-Interstate era of transportation planning and investment? What trade-offs exist between enhancements in motor carrier productivity and system capacity? What other trade-offs exist between these enhancements and the concomitant impacts on the quality of the environment and energy consumption? Finally, how do all of these concerns reflect what we as a nation should do to ensure that a vital part of our economic survival—the mobility of people and goods—remains an asset instead of a liability?

This paper addresses these concerns by identifying five key issues that must be faced by the nation’s transportation system designers. Each issue is accompanied by background com-

ments, inputs, and some discussion. Some options are merely straw-man alternatives because posing realistic alternatives is a bigger job than can be undertaken here. The issues are important ones, however, and this paper attempts to begin the public dialogue.

SHIFTING PRODUCTION CHARACTERISTICS OF CHANGING ECONOMIC STRUCTURE

Global Production Systems

Business needs three things to survive: goods or services to sell, reliable sources of resource supply for these goods, and markets in which to sell. Because there are economies of scale in both producing and distributing many products, the market place in which a given producer attempts to compete has become increasingly larger and more competitive. In this context, "large" is measured in terms of the buying power of the market. Large population centers, for example, attract the interest of producers, leading to their "inclusion" into the market system of that particular producer. The market domain of many producers is becoming the entire world.

The world is rapidly evolving into three major aggregations: Europe, North America, and Asia. The makeup and size of the countries within each group is shown in Figure 1. In each case, the major partners are in various stages of forming closer economic unions that will have dramatic effects on world trade and on the relative competitiveness of the economies of individual countries. These economic organizations will have at their core an examination of how to make transportation between producers and consumers as seamless as possible.

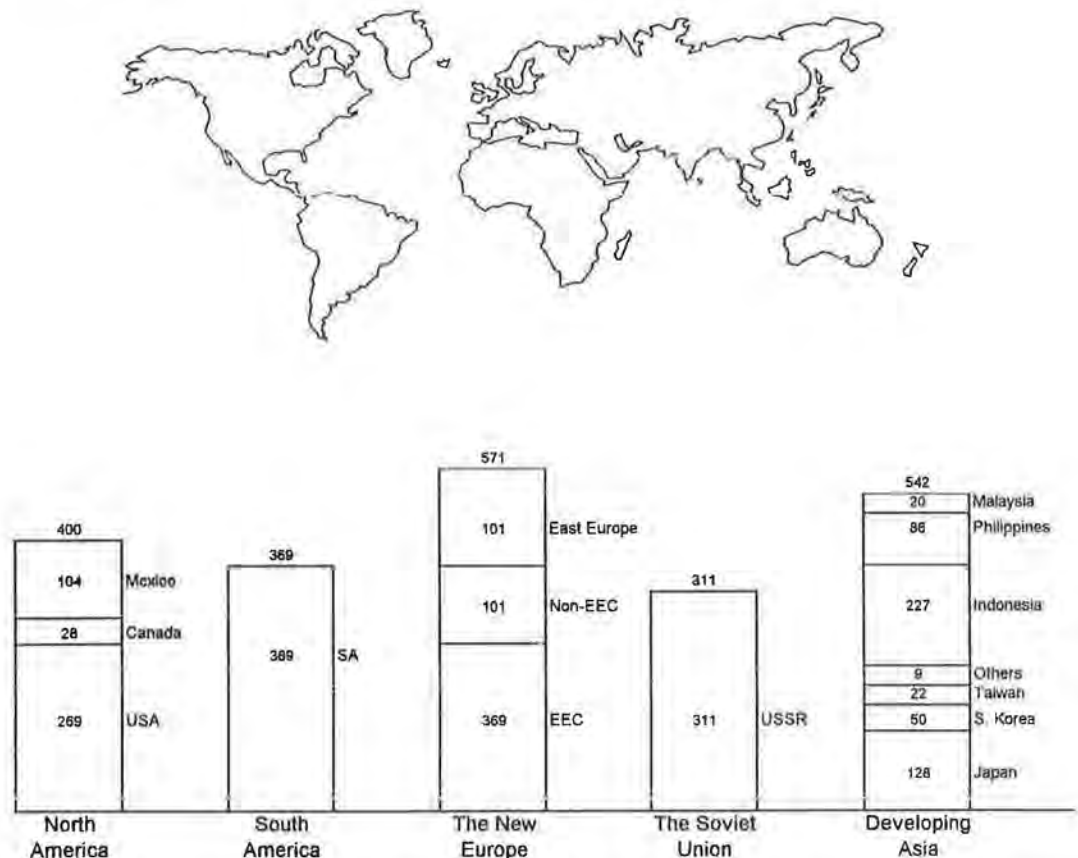


FIGURE 1 Major trading groups (source: World Bank projections).

Europe, currently stymied in its efforts to form the European Economic Community (EEC), now has a whole new set of potential partners in the countries of Eastern Europe. Not only can this set of new partners furnish the productive, low-cost labor needed to increase the pace of industrial growth, but it also provides a potentially larger market in which to sell goods and services. The question facing Germany as it integrates its East German provinces is the availability of investment capital. The countries of the former Soviet Union, now on the periphery of this newly consolidating economic giant, will serve as an additional market for European industries. It will probably be several years before the impact of the former Eastern Bloc nations on the European economic structure will be known. However, it appears likely that these three potential trading partners will have a very influential role to play in the next several decades. Interestingly, one of the first large investments made by Western European nations in the Eastern European nations has been in transportation infrastructure. Clearly, the Europeans are viewing transportation links as a key to the economic vitality that they hope to enjoy.

Japan stands in much the same position relative to the emerging nations of Asia as Germany does to the new European Community. South Korea, Taiwan, Singapore, Hong Kong, Thailand, and Malaysia are all part of this group, and Indonesia and the Philippines are now being included. China and India, though more tentative partners, function relative to this industrial concentration somewhat like Russia and the other former Soviet countries do to Europe. However, with their massive market, China and India appear to be ideal partners for the type of trade associations that will probably develop in this part of the world. It is interesting to note that Japan has been investing in this region for many years. The percentage of Japan's exports that goes to Asia is now equal to the percentage that goes to the United States, once its predominant trading partner. Because of the physical characteristics of this part of the world, however, the primary transportation interest in this economic association is waterborne and air transportation (this ignores the tremendous rail and highway potential of China). It is no accident that the largest increase in passenger air transportation in the world is expected in Asia, or that some of the most modern airports being constructed anywhere in the world are found here (e.g., Hong Kong).

The United States, Canada, and Mexico form the third major trading bloc in the world, the North American Economic Community. With the signing of the North American Free Trade Agreement (NAFTA), these three countries will, in essence, function as a single economic community. The countries of Central and South America are the western hemisphere's equivalent of the outlying countries to the trade regions identified earlier. North American manufacturing systems have been developing among these three countries for decades, and many U.S.-based industries have had manufacturing plants in Mexico for years. Canada has been the major importer and exporter of goods to the United States for more than 100 years. Given the very long borders shared by the United States with its neighbors, transportation issues will certainly rank high among the programs and challenges to be faced now that NAFTA has been signed.

Of course, many imponderables could change the trade patterns that flow out of this picture. The General Agreements on Tariffs and Trade, or GATT, is only part of the current set of unresolved issues. Although it is not clear whether NAFTA will change the existing patterns of trade, it is clear that foreign trade between the United States and other countries will continue to grow at very high rates. As a consequence, both domestic and international transportation capabilities will play an increasing role in our nation's economic affairs.

Change in Product Mix

The past two decades have seen a tremendous proliferation of both products and product lines being produced by American companies. For many goods, the consumer can buy from even a range of quality in craftsmanship. Many items, of course, are designed to work as components of, or in conjunction with, other items. As a consequence of this large increase in products, model numbers or stock keeping units (SKUs) have grown at an ever-increasing pace.

To keep companies from being swamped with unwanted inventory, automated inventory control processes have been developed in both the manufacturing and retail industries. Point-of-sale computers identify the products that customers are buying and adjust the manufacturing and distribution process accordingly. Companies also focus on ways to miniaturize the product, to improve the packaging to reduce transport cost, and in some cases to design the product to be shipped as "in-process" components, which are then completed to customer specifications only after they reach the local market.

Recently, many products have become lighter, more expensive, more carefully packaged, and, using lighter and tougher materials, more transportable. Finished goods and components account for a larger portion of the transportation budget of the country, whereas raw materials used to account for the greatest percentage.

Drive for Quality

One key to success in business is the provision of goods and services that meet a given standard of quality, which is perhaps the surest way to differentiate a product and thereby increase its demand. The drive for quality is clearly a hallmark of the 1990s: every company would like to have its goods or services recognized as products of high quality.

Quality is measured in a number of dimensions, including consistent performance, customer-sensitive design, endurance, beauty, safety and stability, and dependable prices. One reason that customers develop loyalty to a brand is that they know what they will get and approximately what price that they will pay. For retail industries, quality also implies a broad range of choices, ready availability of product, and consistent service. For service industries, and for transportation in particular, high-quality service means that equipment is available to provide service when the shipper wants to ship and it must be prepared to go where the shipper wants the product delivered. For goods transportation, the logistics system must guarantee the delivery of the shipment on time, at the consignor's location, with absolute reliability.

The link between quality and transportation reliability is a key issue that relates this transportation characteristic to effective and efficient highway systems. Congestion on the highway system or major bottlenecks as goods reach transshipment points are usually characterized by high levels of unstable traffic and unpredictable delays. It is clear that finding a way to increase the reliability of service provided by transportation systems is one of the most important objectives of future investment in the system.

Elimination of Inventory

Long thought by managers as essential to running an efficient business, inventory is now viewed as part of the production process that is best characterized as "the smaller the better." Large inventories represent an inefficient use of resources and production time. Many companies are now trying to eliminate inventory wherever they can find it: materials on order, in-process goods, defective goods, finished goods, goods trapped in the distribution system, goods in transit, and goods on store shelves in excess quantities.

Distributors face increasing pressures to be more efficient. Companies such as Wal-Mart, K-Mart, Toys-R-Us, the Gap, the Limited, Safeway, Whirlpool, and a host of other "new wave" distributors of consumer products have organized themselves to purchase, assemble, and distribute goods very profitably. They have all learned how to reduce inventory tied up in their distribution system to an absolute minimum. Part of the secret is the use of mixing warehouses to stage the delivery of products to retail outlets. Another technique is to use the shelf space in each store as the only inventory carried and to combine low shelf inventory with frequent replenishment of only what is sold. This is facilitated by updating the inventory using computerized cash registers at the point of sale to automatically trigger selection, picking, and loading of the truck with exactly the amount of product that replenishes supply. Then, armed with the knowledge of what is selling and where, managers can adjust purchasing to fit the

marketplace. The strategy of these distribution companies is to minimize inventory at every stage in the process without sacrificing service. They view it as increasing inventory "turns," and increasing the number of inventory turns is one of the ways in which the nation's profitability can be improved.

Changes in Regional Distribution Systems

The process of expanding the retailing operation in order to realize economies of scale and to increase inventory turns has been under way for years. A major step took place as a consequence of the rise of the personal automobile. One might call it the automobile revolution. After World War II, families, mobilized by their new cars, could live in the suburbs and shop over comparatively long distances. Chain-operated supermarkets replaced single-proprietor corner grocers. With an automobile-based society, each supermarket draws from a tributary area established by convenient driving distances in an automobile (5 to 10 mi) rather than by possible walking distance from the store (less than 1 mi). Shopping malls sprang up, offering virtually the same line of products available in the city's downtown, and with less bother and expense for parking. Larger stores, drawing from a larger market area, funnel more goods through each store, increasing the turnover of merchandise, reducing inventory, and contributing to higher profits.

Society is now engaged in a second distribution revolution. This one is based on the principle of the mixing warehouse. The new model of efficient distribution establishes regional distribution centers where goods are shipped direct from the manufacturer in full truckload or carload lots to a mixing and store replenishment warehouse. Truckloads of mixed products are distributed very often from these increasingly large regional centers. Many companies are now redesigning their distribution systems to cope with the proliferation of products and the increased demand for service quality (both of which could result in an increase in the amount of inventory carried) and the need to reduce inventory (to lower the cost of inventory carrying charges).

This second distribution revolution is well under way, but it has accelerated during the last decade. The most often cited example is Wal-Mart's well-planned purchasing and distribution philosophy, designed to capitalize in every possible method of lowering inventory and increasing turns. Wal-Mart is not the only successful innovator. The new wave distribution companies described earlier all draw from the same basic strategy. One sure way to reduce inventory in the system while maintaining an adequate buffer of safety stock is to consolidate the inventory of several local warehouses into a single regional warehouse. Fluctuation in the demand of each of the outlying local warehouses is smoothed by combining several "use" streams into a single larger stream, with fluctuations that are smaller, percentage-wise, that they would be at individual local facilities. The reduction in the amount of safety stock in the system as a whole is $1/n$, where n is the number of warehouses eliminated. Consequently, replacing 25 warehouses with 1 reduces the amount of safety stock inventory to 20 percent of that required to protect the original 25 warehouses with safety stock held in each individually.

The key to making this strategy work is frequent, on-time transportation. Transport from the factory to the mixing warehouse must be just in time. If goods arrive early, they will crowd the mixing warehouse and add to inventory carrying costs. Likewise, replenishment of stocks in the store must be both frequent and timely if store buffer stocks are to be kept low. This means that store delivery by truck must be well-organized and located close enough to be able to handle emergencies. For daily deliveries of fast-moving inventories, this distance from a regional distribution center to the stores it serves should probably be less than 50 mi (see Figure 2). This distance appears to be the rule of thumb followed by food stores and other retail distributors of highly perishable products. For nonperishable goods moving more slowly, the distance from the regional distribution center can be greater. The distance that can be reached in a day of driving with return to the home base on the same driver shift is 200 to 250 mi, which will allow drivers to be domiciled at the distribution center and will not require them to "overnight" on the road. This both lowers costs and facilitates the recruitment of high-quality drivers.

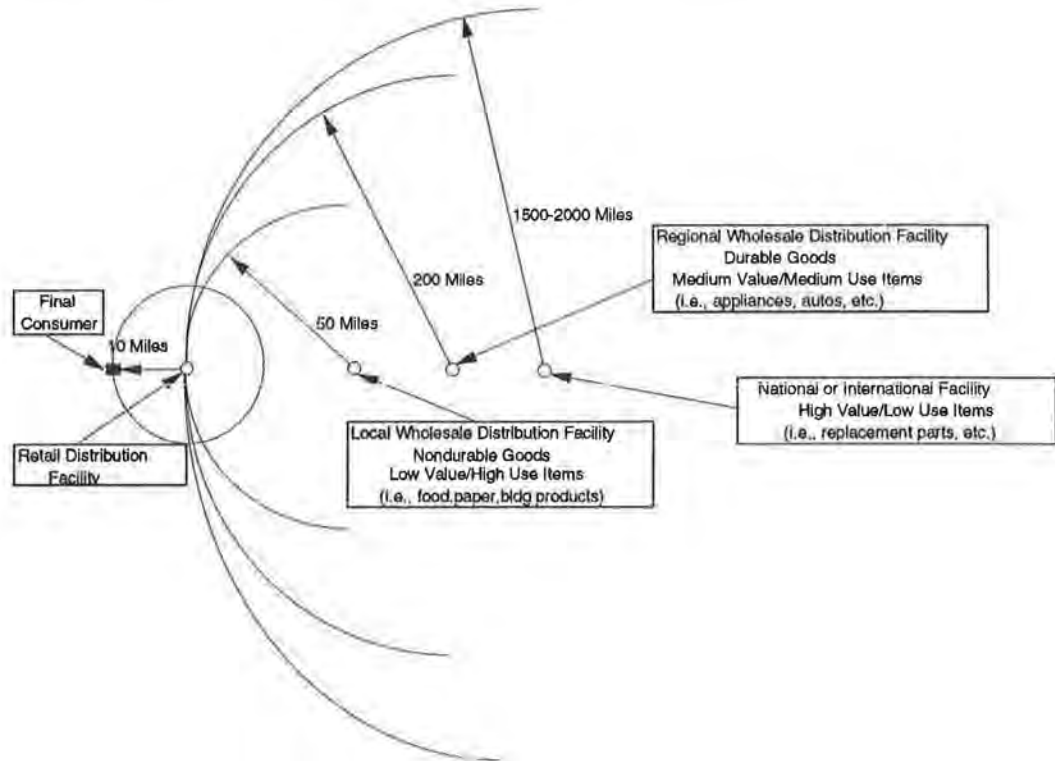


FIGURE 2 Spatial relationships between levels.

Eastern Pennsylvania, for example, is particularly well located as a distribution point for the Mid-Atlantic region. A population of 17 million resides within 100 mi of Harrisburg. A 200-mi circle will serve 44 million people (see Figure 3 and Table 1). The personal consumption expenditures of 44 million people are an astounding \$515 billion/year. Food products alone account for \$36.4 billion. This is 1,492 truckloads of food that must be delivered each day. For all personal consumption products delivered to this large population, 7,511 truckloads of products must be delivered each day. Major distribution centers are developing in other sections of the country: Columbus, Memphis, and Atlanta come immediately to mind. Retailers are all looking for the ideal site for locating new, larger distribution centers. These new regional distribution centers will need the central location, the road system, the vacant land, and the skilled labor force required to function as distribution facilities for the year 2000.

It appears likely, therefore, that the smaller stores and local warehouses served by strategically located mixing warehouses that have characterized the U.S. economic structure for years will continue to be replaced by more efficient retail operations as regional wholesale distribution centers. How far along the nation is in this transition is hard to say—a guess is 30 percent. If so, another 70 percent of retail operations will be forced to modernize and update their existing facilities, eliminating inefficient, small, local warehouses and replacing them with larger and more efficient operations. These distribution centers will use modern inventory control procedures, computer-directed stock picking, loading of trucks, and routing of loads to the retail stores. Computer-linked trucks will allow real-time control of shipments. Specialized transportation teams will perform the store delivery and, in some cases, install equipment.

Public-Private Responsibilities

Transportation has been a service that falls in both the public and private sectors. Over the history of the United States, however, the primary responsibility for providing this service has

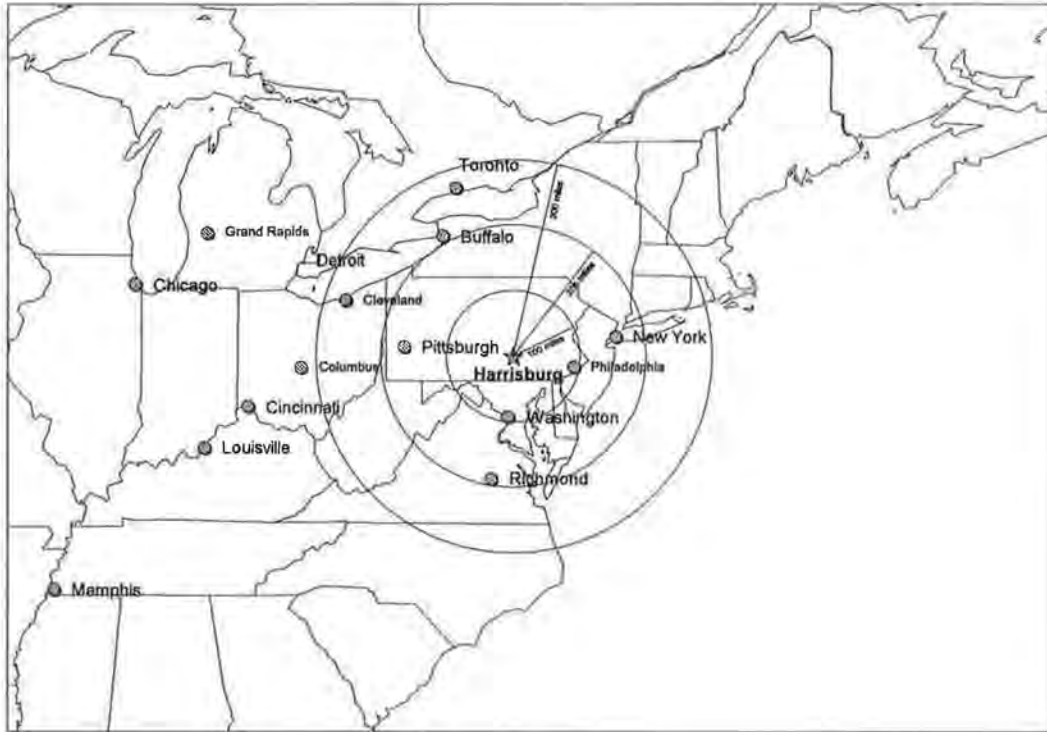


FIGURE 3 Distribution centers in Pennsylvania.

swung back and forth between sectors. Now the pendulum appears to be in the middle. ISTE has created a new era of public-private interaction in transportation decision making and planning. At a recent TRB conference on intermodalism, participants concluded that strong public-private sector relationships among the many actors involved in transportation planning and decision making will truly benefit all those who desire an effective and efficient transportation system. A relationship does not necessarily mean that a partnership is required or, for that

TABLE 1 Markets for Pennsylvania-Based Distribution Centers (13)

	Radius from Harrisburg		
	100 mile	200 mile	300 mile
Population	17 mil	44 mil	66 mil
Personal Consumption	\$205 bil	\$515 bil	\$685 bil
Food Products	\$14.5 bil	\$36.4 bil	\$48.4 bil
Truckloads of Food/Day	595/day	1492/day	1983/day
Apparel	\$4.8 bil	\$12.2 bil	\$16.2 bil
Truckloads of Apparel/Day	40/day	100/day	133/day
Paper products	\$.9 bil	\$2.2 bil	\$3 bil
Truckloads of Paper Products	73/day	184/day	244/day
Motor Vehicles	\$7.9 bil	\$19.7 bil	\$26.2 bil
Motor Vehicles by Truck	75	188	249
Truckloads All Products/day	2997/day	7511/day	9985/day

matter, desired. A partnership should not begin until an agreement on a clearly defined and understandable set of values and commitments can be consummated. Thus, to develop partnerships, there will be an initial period that will require an investment of time in communication and education to decide whether a partnership makes sense. On the basis of this understanding of the process, however, the conference concluded that there would be benefits associated with intermodal partnerships.

The rules of the game have been changing dramatically over the past several years. Regulatory policies are being relaxed for most modes. The use of private-sector toll roads is growing. Given the importance of efficient transportation infrastructure to the well-being of the nation, both the public and private sectors have a stake in making sure that such infrastructure is provided.

Issue 1

Should the United States have as a fundamental goal of its national transportation policy the provision of a national transportation infrastructure that will achieve the economical movement of freight through the United States?

Options

- The federally aided transportation infrastructure in the United States is planned and designed to achieve several policy objectives, including enhancing mobility while preserving environmental quality. This diversity of focus of national transportation policy should continue with the efficiency of freight movement included as one of many goals for transportation improvements.

- The "I" in ISTEA stands for "intermodal." This benchmark legislation for the first time acknowledges the important role that freight movement has in the economic well-being of the nation. The United States should establish a policy toward transportation investments that will enhance the efficiency of freight movements.

- Given the world market in which the U.S. economy is now competing, the United States should provide targeted investments for those facilities (e.g., ports and airports) that serve as critical links to the world market.

Recommendations

The movement of freight throughout the nation is a critical factor today, and will become even more important, in defining the ability of the United States to compete internationally. It is probably too expensive to provide a separate freight delivery system, yet both manufacturing and distribution/retail companies cannot continue to realize economies associated with new approaches to logistics without some guarantee of service reliability incorporated into the transportation system. The United States should aggressively pursue a national transportation policy that has as one major focus the efficient movement of freight and goods.

IMPLICATIONS FOR TRANSPORTATION SYSTEM REQUIREMENTS

The previous paragraphs provided some characteristics of the changing production process and world economic order that will affect how the United States will survive economically. These can be described as changes in

- Production process and desired product characteristics,
- Locations of economic activities,
- Structure of industrial sector,

- Competitive nature of a world market, and
- Importance of service sector.

Role of National Highway System

As has been suggested, the ability of the transportation system to handle the movement of people and goods in an efficient and effective manner is critical for the United States to enhance domestic economic vitality and for U.S. industries to prosper in the future world economic order. There is strong evidence that the NHS in particular is a critical component of national economic productivity. In a recent report, FHWA provided the following conclusions regarding the relationship between highway investment and productivity:

While the magnitude of the relationship between highway investment and economic productivity may have been overstated by some economists, national production function estimates do signify the existence of this linkage. Studies suggest that a decline in public capital is responsible for almost half the decline in U.S. productivity. . . . Arguments that public capital does not contribute to the productivity decline are not realistic. The public contribution to provide production of goods and services has been largely and conveniently ignored because economic analysis techniques are oriented to private enterprise. . . .

The majority of state-level studies indicate that public capital has a small, positive effect on private output and productivity, and that the decline in public capital is a factor in the decline in productivity. . . . When investment in highways is identified as a separate component of public capital, it often yields the strongest effect on productivity of the public capital variables (1).

In addition, the National Transportation Strategic Planning Study concluded in 1990 that the industries likely to be expanding over the next decades will be extensive users of transportation and that speed and reliability of service will continue to be major determinants of the demand for transportation services. The report states that an effective transportation system is critical to the continued economic health of the nation (2).

Clearly, the changing industrial process and world economic order will have a profound impact on transportation, just as transportation will have a profound impact on the ability of the United States to compete in the changing world. From a market perspective the demand for transportation will be for speed, reliability, security, and flexibility (i.e., ability to change rapidly to changing technologies and market trends). This means that highway investments aimed at enhancing economic productivity and competitiveness should have several characteristics that will help meet economic competitiveness requirements.

Perhaps the most important characteristic is that the NHS needs to be just that, a *national system* of highways that is designed and operated to allow for efficient movement of goods and people. The system needs to connect major economic activity centers and, in the context of a world market, provide efficient connections to locations of import and export activities. The system should be designed to allow for the safe movement of goods (C. M. Walton's presentation "Highways for Efficient and Safe Goods Distribution"), efficient movement (see paper by Zogby in this Proceedings), and provide reliable and quality performance to those who use it. Of course, the Interstate highway system provides the backbone of such a system, and the ISTEA-required designation of the NHS takes the next step. However, as will be discussed, certain characteristics of such a system designation, and ways in which investment priorities are set, should be considered if the system is truly to serve as a foundation for the economic well-being of the nation.

The importance of such a system of "economic" highways has not gone unnoticed by others. In Europe, for example, the Trans-European North-South Motorway System is under development; it will consist of 10 000 km of roadway connecting Poland to Italy and Greece. Other corridors from Sweden to Italy and from France to Morocco are being examined. The European nations have agreed to develop an "E-Road" system of Interstate-type highways that are designed to have consistent geometric and operating standards that will provide for fast and

reliable cross-continental travel. In addition, several more trailer-on-flatcar tunnels through the Alps are being planned to expedite freight movement along the north-south European axis.

The Mexican government is especially interested in the improvements of highway links to the United States. Only 8.5 percent of the primary roads in Mexico are more than two lanes, and in most cases even these are far inferior in geometry and safety design to U.S. Interstates. And severe congestion and safety problems exist at border points. The Canadian national government, with the cooperation of the provincial governments, is planning to establish designated highways for transnational movement of goods and people.

Importance of NHS to Success of NAFTA

Perhaps the most important recent economic and trade opportunity that will affect the U.S. market, and thus the transportation system, is NAFTA. The impact of NAFTA on the United States, Canada, and Mexico could be significant. For example, roughly 65 percent of all U.S. industrial exports to Mexico will be eligible for duty-free treatment within 5 years after enactment. Within 3 years, all parties may make cross-border deliveries, and within 6 years, trucks will have access to all of the United States and Mexico.

However, as noted by the California Department of Transportation in a discussion paper on NAFTA, "the benefits of NAFTA will be only as good as the transportation facilities available and the efficiency of border clearances provided by the three countries" (3). For the most part, NAFTA leaves infrastructure decisions to each nation and to each border state. This will be a particularly important issue for the border state highway systems in that the preferred form of goods movement across both borders in the foreseeable future will be by truck.

Issue 2

Given the importance of a NHS to the economy of the United States and its trading partners in NAFTA, how can we be assured that the designed system achieves objectives associated with the movement of freight throughout the United States?

Options

- The federally mandated NHS should be established with national objectives in mind, similar to the interstate transportation and defense objectives that were established for the Interstate highway program. The movement of freight should be one of the most important national objectives in the definition of a NHS.
- Travel corridors serving likely NAFTA import and export routes should receive primary emphasis in early NHS designation, with special investments targeted to these corridors.
- The approach currently being followed for NHS designation, primary responsibility resting with the states, should continue, with some guidance provided for consideration of freight movement.

Recommendations

All of the options presented must be adopted, at least in part. An NHS must in fact be an international system, connecting the producing and consuming areas of each region and the major interchange points in the transportation system across the entire continent. The coverage should be seamless, without discontinuities caused by differences in standards and designation of facilities. The system must pay particular attention to freight moving at the national, international, and regional levels. It must also embrace policies that will promote smooth functioning of the freight system at the local level in concert with local passenger movement. All of this must be done within the constraints that exist on funding, sovereignty, and operating responsibilities. Thus the designation of the system must be coordinated between governments,

with the federal government taking a leadership position, providing guidance in system designation where national concerns are paramount.

Interstate transportation and access to the world market are clearly to be considered national concerns. What is needed are reliable funding sources and quantitative measures for priority ranking the flow of investment and operating capital and directing it into the parts of the system most important to the country's aggregate economic performance. Setting out a quantitative process for designating priorities is a larger job than can be undertaken in this paper, but it is fundamental to the success of the planning process.

ISTEA REQUIREMENTS THAT AFFECT TRANSPORTATION AND ECONOMIC CONSIDERATIONS

In the United States, ISTEA has provided an impetus to examining the nation's highway system in the light of concerns similar to those just discussed. First and foremost, ISTEA has placed great emphasis on the true intermodal nature of transportation by calling for the development of a National Intermodal Transportation System. The system is to move people and goods efficiently and achieve broad national goals; it is expected to be the centerpiece of the economic survival of the United States in the 21st century. States and metropolitan planning organizations (MPOs) are directed to prepare plans and investment programs that meet a variety of requirements. For MPOs, ISTEA provided 15 factors to be considered in the development of these plans and programs, including the consideration of improved border crossings and access to ports, airports, intermodal transportation facilities, and major freight distribution routes, and methods to enhance the efficient movement of freight. Similar requirements exist for state departments of transportation, which must consider "methods to enhance the efficient movement of commercial vehicles." In addition, the MPOs and state departments of transportation are required to develop management systems that will provide important information on the transportation investment decisions made across the nation. In particular, the congestion management and intermodal management systems will be directly related to the concerns of freight movement. ISTEA is then a strong foundation for establishing a planning and programming process that actively considers efficient movement of freight within metropolitan areas and across states.

Designation of NHS

Perhaps the most important requirement of ISTEA as it relates to this discussion was the requirement for Congressional approval in 1995 for the NHS, a system of 155,000+ mi of principal arteries serving major cities, border crossings, ports, airports, and other transportation facilities. The NHS funding provided by Congress can be used only for the construction and operational improvements of NHS roads, for adjacent facilities that improve service on the NHS roads themselves, and for some other assorted activities. Road access to ports, airports, and intermodal terminals is eligible for these funds and is considered by many as a Congressional priority. To a large extent, the designation of the NHS is the activity of the state departments of transportation, with guidance from FHWA.

This process has not been without some controversy. Some states such as California have argued that specific criteria such as access roads to federal lands (e.g., parks, military bases), access to ports and airports, and Interstate road designation should be used as criteria for designating the NHS. This argument is based primarily on the desire to have consistent designations from one state to another, so that similar types of facilities are designated in all of the states. The counterapproach to the criteria-driven process is to allow the states to designate the roads for the NHS as they see them fitting into their own states' road network and providing for federal review after the proposed plans are submitted.

It is not the purpose of this paper to take a side in these different approaches. The NHS that would be designated with either approach would be very familiar and, certainly from the

perspective of freight movement, most likely identical. However, the intent of ISTEA seems clear. The NHS should enhance intermodal movement of goods and people, and national economic concerns should be considered in NHS investment. Therefore, the development of the NHS and the subsequent review should be linked directly to the economic opportunities provided by this system. Several criteria for such an influence in NHS designation include, but are not limited to, the following:

- Access points to ports;
- Access points to airports;
- Access points to border crossings;
- Access points to intermodal terminals;
- Roads linking major economic regions to export transshipment locations;
- Interstate-type roads with high-speed, high-capacity characteristics;
- Bypasses of major congestion locations;
- Access links to major warehousing locations; and
- Roads that can handle certain sizes of trucks.

Setting of Performance Levels on System

Of greater importance, however, than designating these elements of the NHS is setting the performance levels. One could argue that ISTEA has institutionalized a new approach to planning, one based primarily on establishing system performance targets or goals. For example, an FHWA-sponsored working group that gathered in 1991 to discuss the concept of a congestion management system developed the following definition of such a system: "A congestion management system is the continuous activity of considering and implementing actions that enhance mobility and reduce congestion on designated systems or in targeted areas, appropriate to the magnitude and scope of desired system performance" (4).

Two aspects of this definition relate nicely to the topic of this proceedings. First, targeted systems or areas are those corridors and facilities that will be important to a national transportation system. State and local officials can also identify subareas where severe congestion levels occur that should be targeted for special attention. Second, performance measures, defined by state and local officials, should be the basis for determining progress in achieving performance objectives. These performance measures should measure the extent, severity, and duration of congestion and the reliability of system performance. Although most participants at the FHWA workshop did not believe that national performance standards should be set for specific types of facilities, such as Interstate highways, others thought that such standards were the only way to preserve the integrity of nationally important facilities. Generally, it was believed that the performance measures should be considered targets, with perhaps some "desirable" minimum targets for certain facilities.

Another meeting, this time focused on intermodal transportation issues, again raised the issue of performance-based planning (6). The basic elements of an intermodal management system were recommended to include

- Inventory of modal and intermodal elements including institutions, markets, operations, and physical plants;
- Identification of an intermodal system that becomes the focus of the intermodal management system;
- Use of performance measures that will allow some sense of how the system is doing over time and where problems exist;
- Identification of strategies and actions that will improve intermodal transportation efficiency and effectiveness, including non-investment options such as pricing, regulatory changes, and so forth;
- Analysis and evaluation of these strategies and actions from the perspective of intermodal concerns (e.g., economic value to system users, cost, improvement to system interconnectivity);

- Establishing priorities among strategies and actions within the context of the overall planning effort; and
- Mechanisms for including users and providers in this process (e.g., advisory groups).

Once again, the concept of system performance was an important characteristic of the planning process that informed investment decisions. Because the focus of the intermodal management system included both freight and passenger transportation, the recommended performance measures were much broader than those discussed for the congestion management system. Several system performance measures were identified:

- Level of service,
- Trip time,
- Quality of travel,
- Cost of travel,
- Safety,
- Reliability,
- Convenience,
- Amount of capacity,
- Energy use or efficiency,
- Environmental impact,
- Flexibility in accommodating new intermodal services, and
- Opportunity for expansion of intermodal capabilities.

Establishing Minimum Levels of Performance

If the NHS is to provide the type of safe, reliable, and efficient service required to compete in a world market, it seems reasonable to expect that this system should achieve some minimum level of performance. This means that roads of economic significance should be expected to achieve certain target levels, similar to the existing national goal of achieving air quality standards in nonattainment areas. For those areas not able to reach these standards, the states and metropolitan areas need to show a program of action that will lead to eventual attainment. So too for national "economic" highways, it would be proposed that such designated roads must meet certain levels of performance and that, if the levels were not already attained, states and MPOs would need to show the steps necessary to achieve them.

The model for this approach can already be found in many states. In Pennsylvania, for example, the Pennsylvania Department of Transportation many years ago developed a commercial and economic highway network that was designed to handle the major truck improvements (e.g., bridge reconstruction) that were fed into the investment priority-setting process for the state. In this way, the road system considered most important for the economic vitality of the state received priority treatment. This is similar to what is being proposed here. This process could also be easily implemented through the management systems now being developed by every state and MPO in the nation.

With regard to international trade routes and systems, the performance and geometric criteria needed to enhance the efficiency of trade transportation could be incorporated into the decision-making process. Of course, the first step in this process is designating these trade routes. This step is already under way by Congress and FHWA. FHWA is currently undertaking an International Trade Corridor and Facilities Study that will include a comprehensive network analysis; the identification of international trade corridors; the identification of border crossings, major ports, major highways, and other transportation modes within the corridor; the coordination and identification of trade corridors and facilities on both sides of borders; and an assessment of the potential contributions of advanced technology applications. A report to Congress is expected in June 1993 on these issues. This much-needed effort will go a long way toward taking the initial steps that are required to relate road networks to national economic competitiveness. However, these steps provide no insight into how transportation investments

should be ranked to provide for acceptable level of service in these corridors as suggested. This is the next important step in the process of relating the future road network to national economic competitiveness.

The NHS is used for moving both people and goods. And as has been pointed out in other papers in this proceedings, the different types of vehicles using a highway result in certain design requirements and thus varying costs. The national productivity enhancements from highway investment mentioned earlier and, in particular, the highway investment needed to respond to non-facility productivity improvements coming from the freight industry (e.g., truck size), require that trade-offs be made. These trade-offs not only occur between what can be achieved by the motor carrier industry if certain investments are made by public agencies, but also relate to longer-term trade-offs in public policy objectives associated with environmental quality and energy consumption.

Issue 3

Can the NHS be designated and performance measures established to ensure that it functions as required?

Options

- A broad set of criteria for designating the system and establishing performance measures that will apply across the entire system should be developed.
- Economic criteria for designating the system and establishing performance measures that vary according to the economics of the situation should also be developed.
- The federal government should set minimum levels of performance for NHS routes that are considered highways of economic significance.

Recommendations

The criteria used to designate the NHS and to establish performance measures must have some consistency if they are to produce the proper effect. At the same time, they should have an underlying economic rationale. It is not necessary, for example, to maintain the high operational standards in rural areas that are necessary in heavily congested urban areas. Minimum standards of operating performance should be established for highways on the basis of their economic significance. The federal government should either provide strong guidance on such minimum standards or require that they be maintained.

TRADE-OFFS BETWEEN MOTOR CARRIER PRODUCTIVITY AND SYSTEM CAPACITY

Shipper Requirements for More Productive Operations

Given that transportation is considered nothing more than a part of the production process, shippers are interested in the most cost efficient transportation of the product and of the elements that go into producing the product. This is always a trade-off between price, quality, and service capacity. The successful supplier is one that can provide the product to the buyer in the quantities needed, at the location specified, in the most cost effective package overall when measured in total costs to the receiver (including ordering, transport, storage, capital carrying, stockout, and emergency shipment costs, to name only a few).

In transportation, this trade-off has become sharper as shippers have discovered the crucial importance of reducing inventory while increasingly designing their entire distribution systems to capitalize on truckload or carload purchases of a particular product from a single supplier to regional mixing centers. This means that reduced transportation costs can occur if greater

volume is transported from one distribution location to another. Once there, goods are then delivered to stores on a very frequent basis. This process as a whole depends on reliable supply direct from the original source and frequent, highly reliable transportation service at every point in the distribution process.

An excellent example of how shippers' demands for reliable and secure transportation resulted in a revolution in freight transport is the container. From a simple, converted tanker, carrying 58 trailer vans in 1956 to the now enormous container trade throughout the world, the reaction of shippers to this innovative form of freight transportation has revolutionized goods transport. Such service has caused realignment and regrouping of carriers on major trade routes, has generated more competitive vessel design, has led to innovative ocean vessel operations, and most important to the shipper has produced many new routing and pricing alternatives (6).

Carrier Responses to Shipper Needs

Carriers have chosen to respond to shipper needs with a variety of new services. The most visible is just-in-time delivery, which delivers the quantity of inputs required for the day's production at exactly the moment it is needed. But this is only one example of how carriers have been responding to market demands. Shippers need to know that equipment is available to meet their frequently variable needs, and carriers have entered strategic alliances with shippers to ensure the flexibility that they need in their operations. Indeed, some carriers have entered alliances with what had been considered their traditional competitors to guarantee the existence of sufficient capacity. More and more shippers are selecting a set of "core" carriers to provide all of their transportation needs instead of dealing with hundreds of carriers on a day-to-day basis. Creative pricing, including multiple independent factor rates and long-term contracts, are also a part of this carrier response to rapidly changing shipper needs.

Truckers have increased their productivity through the use of more and larger trailers. The Surface Transportation Efficiency Act of 1982 (STAA 92) prohibited state restrictions on the use of less than 48-ft, 102-in. semitrailers and 28-ft doubles in all 50 states. This action allowed a 13 percent increase in carrying capacity for those products that could use the higher cube semitrailers. For LTL carriers that switched to doubles, it was a 33 percent increase in productivity over the old 45-ft trailers that had been the standard. These productivity increases fueled the desire of truckers to use even larger trailers. The STAA legislation did not preclude the use of longer semitrailers, and the 48-ft standard has now almost been replaced by the 53-ft trailer, and the interior height and width of the equipment has been augmented by the use of low radial tires and improved plate trailer design. Truckload carriers wanted turnpike doubles to be allowed on the Interstate system, whereas LTL carriers preferred to be allowed to use triple 28s. These longer combination vehicles (LCVs) were the subject of intense debate in the legislative maneuvering before the passage of ISTEA, but their use was deferred until after Congress could receive a report concerning their impacts on the highway system.

At the same time that truckers were achieving efficiency gains by using larger equipment, railroads were busy doing the same. Since 1983 railroads have developed double-stack intermodal service, which carries two containers for less than the previous cost of one, and what appear to be dramatically more efficient RoadRailers, which provide for the movement of highway trailers without the cost and time delays or the loading and unloading involved in trailer- and container-on-flatcar operations. Double-stack service, which was motivated by the need to deliver maritime containers traveling in international trade to inland destinations, has now spread to the carriage of domestic containers. Double-stack containers have been designed with the same carrying capacity as 53-ft-high cube highway trailers, and truckload carriers have indicated that they are interested in entering long-term arrangements with the railroads to provide this service. Maritime carriers—which pioneered containerization and the science of loading, unloading, consolidating containers into loads, and deconsolidating them for sorting and delivery—are now addressing the full-scale automation of this process.

Obstacles to Carrier Response to Shipper Needs

Many barriers are associated with effective carrier response to market demands, from institutional constraints to geometric design of existing facilities. This paper will focus on the highway system, assuming that the important constraints not related to the highway system will be covered by the other papers in the proceedings.

As noted, the major shipper needs relate to fast, reliable, and flexible transportation. This means that the highway component of the transportation system must provide this type of service. The principal barrier to the continued growth and development of America's transportation system is the mounting congestion in the operation of the system. Urban highway congestion is perhaps the most important source of inefficiency in the current goods movement system, and it is growing in a way that threatens the performance of the transportation system as a whole. (The congestion in New York City and its surroundings, for example, has led long-haul truckload trucks to impose a surcharge of \$200/load on movements into or out of New York City and Long Island.) Pickup and delivery of goods is handled almost exclusively by truck. Trucks perform consolidation and deconsolidation for the rest of the system. Whether the move will travel by air, water, or rail, the pickup and delivery segment of the trip is by truck, the exception being bulk liquids such as those handled by pipelines or bulk dry goods typically handled by rail or barge. Ways must be found to improve the pickup and delivery function performed by trucking without getting tangled in the daily commuting patterns of the population; suggestions include truck-only roadways, urban bypasses, and integrated multimodal terminals.

Trade-Offs Between Vehicle Configuration and Cost of Highway System

One of the possible productivity improvements in the existing delivery system is to increase the carrying capacity of individual vehicles. Over time this nation has allowed increases in truck size, and the pressure to continue this growth continues. LCVs are advocated by some as the answer to increasing the nation's productivity. Others see them as a threat to safety and as a degradation of the driving environment on our highways. Engineers view them as being detrimental to maintaining the structural integrity of the highway network. Those responsible for highway finance and economics see these larger vehicles as a tremendous cost burden because of the changed design standards of the system.

The types of impacts for different vehicle configurations depend heavily on the context within which the vehicles are permitted. For purposes of this paper, a distinction will be made between impacts per truck unit that are associated with the individual use of a vehicle and the aggregate impacts that are really a function of the systemwide context of such use. At the individual unit level, several studies have examined the probable impacts of larger trucks on the condition and performance of the system. A study of the impacts of LCVs on pavement costs performed by the Urban Institute concluded that pavement damage would be reduced if LCVs were allowed on a nationwide network (7). This is possible because the heavier load is spread over a longer vehicle with more axles, allowing the same tonnage to move in fewer vehicles. Axle loadings remain limited by Bridge Formula B, however, so that the cost savings in reduced pavement deterioration are solely the consequence of having fewer trucks run over the surface. The study estimated that if LCVs were allowed on a national basis, the pavement savings could range from \$15 million to \$65 million depending on the amount of diversion from conventional vehicles to LCVs. Significant amounts of freight were estimated to shift.

Studies of Turner trucks published by TRB found pavement cost savings for combination trucks using twin trailers (34 ft each) that are only slightly longer than those currently in operation (8). The study recommended, however, that a maximum of 15,000 lb be allowed on a single axle and 25,000 lb on a tandem axle, compared with the current federal limits of 20,000 and 34,000 lb, respectively.

The cost of replacing deficient bridges on the Interstate system and major primary highways has been estimated in at least three recent studies. These are the Turner truck study (7),

the Urban Institute study (8), and the University of Texas study (9). Results of the studies differ substantially. The Turner truck Study concluded that increased bridge costs associated with authorizing the use of vehicles that exceed the current 80,000-lb gross weight cap but that are less damaging than triples or turnpike doubles, would have replacement costs of \$6.3 billion. The Urban Institute study estimates increased bridge costs of \$429 million/year. This translates into a discounted present value of about \$6 billion at an interest rate of 7 percent and an unlimited life. As was pointed out by this study, every bridge on the Interstate and major rural primary systems carries higher weights than proposed for LCVs every day under current special permit provisions. State transportation agencies schedule bridge replacements every year; many are scheduled as soon as the money becomes available. Therefore, this study concluded that the annual bridge costs associated with LCV use are not insurmountable.

The University of Texas study used a somewhat different methodology, employing the inventory rating of each bridge, a safer limit (55 percent allowable stress) than the operating rating (75 percent allowable stress) used in the Turner and Urban Institute studies. The result is a replacement cost of \$12.5 billion. In addition, the Texas study points out that the cost of travel delay, additional cost of fuel, and the like during reconstruction and replacement of the rural bridges amounts to another \$8.8 billion. If these replacements are extended into the urban Interstate and primary highways, the total is even higher.

The difference in the costs estimated by each of these studies results largely from the assumptions underlying each study. The Turner truck study used lower axle limits and a smaller vehicle than the other studies; the Urban Institute and University of Texas studies based their findings on different engineering safety factors and assumed different sets of implementation costs. One might view them as the range of possible costs given the uncertainty in the system. Both have some validity.

This brief discussion shows some of the key issues that need to be discussed when developing a national system of economic highways. Unfortunately, very few studies have been undertaken that provide both the scope to address these very complex issues and the level of detail required to resolve them successfully. The productivity gains to the nation of implementing an LCV system and the costs that will be incurred for designating such a system of highways and making it safe for operation have not yet been adequately addressed. Both the General Accounting Office and FHWA are conducting studies in the context of the NHS designation. It is hoped that these studies will examine the trade-offs of investment with enhanced economic competitiveness.

Issue 4

How should the United States invest in transportation so that the overall productivity of the economic and transportation systems is enhanced?

Options

- To ensure that the highway system remains a strong asset to the United States economy, it should be designed and operated as a stand-alone system.
- A new form of multimodal and intermodal planning and policy analysis must be adopted in all transportation investment decisions to help select the most efficient and effective transportation investments regardless of mode.
- With limited resources, the best approach is to center highway investment on a stand-alone system but focus intermodal planning and investment decision making at those elements in the transportation system that are the transfer or terminal points.

Recommendations

The state and regional planning process must recognize that the transportation system is just that, a system, consisting of many different elements and providing services to many different

users. Innovation in freight movement requires that highway investment be examined from a more holistic perspective. The rise of containerization, for example, makes it possible to substitute rail capacity for intercity highway capacity in many of the nation's long-haul freight movements. LCVs and their impact on the functioning of the entire transportation system must be considered explicitly. At the same time, operational improvements (which might mean capacity expansion) are needed in many urban areas so that freight movement can occur reliably. First and foremost, the planners and operators of the nation's highway systems should understand the importance of freight movement to their regions and states and consider the consequences to their economies if transportation system performance deteriorates to a level at which they are no longer competitive.

TRADE-OFFS BETWEEN HEAVY TRUCKS AND ENVIRONMENTAL AND ENERGY CONCERNS

Highway Capacity and Congestion

The operating characteristics of larger trucks can have a sizable impact on the flow of traffic when these vehicles are introduced into the traffic stream. Some of these impacts include speed, highway capacity and level of service, passing, splash and spray, aerodynamic buffeting, merging and lane changing, and off-freeway operation. It should be noted that safety engineers and finance experts debate the exact nature of these effects. In particular, the implications of these impacts need to be weighed against the positive benefits that might accrue from enhanced productivity. Each is examined briefly in this paper.

Because of its higher gross weight and lower horsepower per unit of weight, an LCV typically has lower acceleration and slower speed on grades than conventional vehicles. Both features could be improved by adding higher horsepower if it is sufficient to achieve maximum allowable speeds on level roadways, albeit at the expense of acceleration.

Passing or being passed by an LCV is what motorists appear to dislike the most about longer vehicles. An automobile traveling 5 mph faster than an LCV requires 494 additional ft to pass a 110-ft-long LCV than is required to pass a 65-ft conventional tractor semitrailer. This is only 6.12 sec, but on a two-lane highway the exposure to a head-on collision with oncoming traffic makes it a nerve-racking experience.

The problems of passing are even greater during inclement weather because of splash and spray. Splash and spray are generated when a vehicle's tires throw drops of water onto the underside of the vehicle where they break up into smaller particles that then escape from the rear of the vehicle as spray or mist.

Merging and lane changing will be more difficult with LCVs than with conventional vehicles. A number of the factors mentioned earlier contribute to the difficulty. These include the slower acceleration, reduced handling ability, need for a longer space in which to perform the maneuver, and the difficulty in passing.

Finally, if larger trucks are authorized for use on a nationwide network that includes all or most of the Interstate system, there will be a diversion of traffic from other means of transport. Some rail movement will be diverted. Much of the long-haul truck traffic will be diverted from semitrailers and twins to these larger vehicles.

Energy and Air Quality Issues

Understanding the energy and air quality impacts of heavy trucks is complicated by the wide variety of combinations of trucks and rail services that can be provided. Piggyback service, for example, provides benefits in both categories for longer haul trips.

For long-haul movements, rail is more energy-efficient and causes less air pollution. Our figures show that fuel use per ton mile by rail is only 45 percent that by truck; however, this figure needs to be reduced by the circuitry that is typical of rail and by the inefficiencies

experienced by rail in urban pickup and delivery (10). Consequently, diversion from rail to truck would appear to use more energy and result in more pollution. However, diversion from semitrailer truck to larger trucks reduces fuel use. Efficient carriers using larger trucks would use only 57 percent of the fuel previously required to transport the same freight by a conventional tractor-semi-trailer (11). There could be a net savings in fuel use depending on the diversion results. Because effluent from the burning of fuel is roughly proportional to the amount of fuel used, the air pollution impacts of LCVs will probably parallel those of fuel use.

It should be noted that several state transportation agencies have been working with trucking associations to develop guidelines for truck operations that go toward alleviating some of these issues. For example, some western states have developed a *Guide for Uniform Laws and Regulations Governing Truck Size and Weights Among WASHTO States* (12), which has seen some success at dealing with these issues.

Issue 5

Are the investment requirements occasioned by larger trucks worth the price?

Options

- LCV triples could be allowed to use a designated system of highways, but not turnpike doubles.
- Both triples and big doubles could use a designated system of highways.
- LCVs could be prohibited except where they are already allowed by grandfather rights.

Recommendations

The full "price" to the economy and the rest of the nation's transport system for allowing LCVs to use a designated system of highway is not yet known. With improved safety precautions, such as antilock brakes, double drawbar dollies, and rigorous operating standards, there is little reason to forbid triples on a designated system of highways that avoid urban areas. The price looks like it will be small.

By contrast, turnpike doubles are hard to accommodate on the existing Interstate network without substantial rebuilding of interchanges to accommodate their large turning radii and the construction of marshaling yards for consolidating and deconsolidating the trailers so that they will not have to travel on regular roads and streets. The funds that would need to be spent on such accommodations might be better spent on operational improvements to urban highway systems. Bypasses and truck-only roads should be considered to facilitate the movement of freight in urban areas.

CONCLUSIONS

This paper has examined the changing characteristics of the world market and the subsequent impacts on the U.S. transportation system. There is little question that the market forces of the new economic order will force major changes in the way freight moves in this country. These changes will be especially dramatic in the motor carrier industry. ISTEA provides some unique opportunities for dealing with these new challenges. The requirements for a nationally designated highway system and for states and MPOs to consider freight movements in their planning as well suggests that the national freight system should be linked to the types of highway investment strategies that will ensure a safe, reliable, and stable transportation service. There is a need to have consistent performance measures across the nation to allow this designated highway system to function as it is supposed to. In addition, the federal government in concert with state governments should target international trade corridors that are considered strategic transportation assets to the nation's economy and provide greater priorities for

investments in these corridors. Finally, the link between our nation's economic productivity and the role of freight movement requires greater scrutiny.

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