of Seattle. The six agencies directly affected by the project have been in disagreement over the configuration and number of lanes since the late 1960's. The project has been in litigation since 1972 and enjoined by the courts from further right-of-way acquisition or construction since 1973.

Following completion in early 1976 of additional hearings ordered by the courts, it was apparent the disagreement among the agencies still prevailed. The department concluded that we needed the services of a professional mediator to try to resolve the differences and reach a common agreement.

Through the efforts of a local mediator that was sponsored through Ford Foundation and Rockefeller Foundation grants, we were able to reach accord with all of the involved agencies on a design configuration for the facility. A memorandum agreement has been entered into by the affected agencies that not only identifies the design configuration for I-90 but also obligates the agencies to work toward solving other transportation problems throughout the area.

With the agreement, the final environmental impact statement has been rewritten and submitted to the Federal Highway Administration and to the Department of Transportation for approval. Our plan calls for returning to the courts to demonstrate satisfaction of their requirements later this year and hopefully have the injunction lifted so that the project can proceed. Research relating to the effectiveness of formal mediation processes to resolve highway problems may be of interest to many states.

In summary, I suggest that we need to continue research to identify new and imaginative fields in all areas associated with transportation. In part, however, I feel we should be monitoring the effectiveness of what we are doing, what we have done, and what we are required to do. I believe that all agencies should be willing to honestly evaluate that research and be willing to change existing rules and regulations if it would result in more efficiency as well as being responsive to the nation's needs. The findings of the research, I am sure, also would be useful to those who are responsible for establishing the law of the land and whom I feel also are willing to evaluate its effectiveness and to respond to changes as may be needed.

TRANSPORTATION PROBLEMS AND RESEARCH NEEDS IN THE RURAL SECTOR

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The objective of this paper is to present a series of recommendations regarding research needs on social, economic, and environmental problems in rural transportation. To substantiate the need for the suggested research some background is presented describing the evolution of the rural transportation system and itemizing some of the present serious problem areas in the system.

The Evolution of the Rural Transportation System

Our rural transportation system has evolved in several stages which are distinguished by competition between the different modes of transportation. It also should be recognized that the development of our economy has been greatly influenced by the progressive development of the transportation system.

The Turnpike Era. At the time of the founding of the country, 200 years ago, the inland transportation system mainly consisted of a few north-south trails, suitable for horse and rider. Freight was principally moved on water, and the population was concentrated near ports along the Atlantic seaboard.

With the advent of the Conestoga wagon (around 1750), a means of land transportation became available, and the development of "Turnpikes" commenced, constructed both by the states and by private companies. The first involvement of the federal government in road building was authorized in the Ohio Statehood Act of 1802. It is interesting to note that three years ensued between the authorization of funds by Congress and the beginning of the route location studies. Planning continued for eight years and then the Cumberland Road was constructed for a distance of about 130 miles in less than four years, being completed at Wheeling on the Ohio River in 1818. It is not recorded how many pages the Environmental Impact Statement ran, but this pattern of "planning a road to exhaustion" has been carried over in federal-aid projects to this day.

The Water Transport Era. The invention of the steam engine permitted the development of steam-powered boats in the early 1800's. Soon thereafter a major effort was concentrated on the construction of waterways and canals, and by the 1820's the cost of water transport was less than half that of wagon transport.

The Rail Transport Era. Shortly after the middle of the 19th century railroads began to displace water transport as the most economical and hence most attractive mode. For example, tonnage on the New York State canals peaked in 1880 and began a decline which was not reversed until the 1920's.

As the mileage of railroad track began to mushroom in the last third of the 19th century, every city and rural hamlet wanted to be located on a rail line. Financial incentives stimulated frantic and excessive rail building which continued into the early 20th century.

The Highway Era. Throughout the period of development of water and rail transport in the 19th century, roads continued to be built. The road system grew from a few thousand miles of trails and turnpikes in 1800, to about 2 million miles in 1890, slightly more than half of the present road mileage.

The roads served mainly as feeders to the rail and waterways systems. Little or no attention was given to their engineering or maintenance, and as a result their trafficability was highly seasonal. Farm products could be moved to the railhead for shipment to market only at certain times of the year.

In 1893 Congress mandated rural free delivery of mail, contingent on the availability of improved roads. In 1895 Congress established the Office of Road Inquiry, which has evolved into the present Federal Highway Administration. By the turn of the century, the advent of the automobile and the truck had created further pressure for improved roads.

In 1905 there were 77,000 automobiles registered and 1,400 trucks. By 1916 those numbers had grown to 3,400,000 and 250,000, respectively. And in 1916 Congress passed the first Federal-aid Highway Act, for the purpose of financing post roads to facilitate rural mail delivery and to "get the farmer out of the mud." The highway era was well on its way.

Summation. It can be seen from the preceding brief review that the rural transportation system has evolved as the consequence of improvements in technology. This has resulted in an uncoordinated, multimodal transportation network in which one mode or another is overbuilt in some regions of the country. Responsiblity for regulation of this system

lies with a multitude of agencies, and they suffer from the lack of a single, national policy framework, within which decisions could be made in a systematic manner.

It should be clear, however, that economic forces (transportation costs) have had a significant influence in the system evolution. If a governmental regulating agency had taken a protectionist stance toward waterways in the mid-nineteenth century, the railroads and highway systems might never have developed to provide lower cost freight transport. Thus we must be cautious today in approaching policy development and system regulation. We must find out how to improve the efficient operation of the transport system, without merely maintaining the status quo.

Problem Areas in Rural Transportation

The importance of the rural transportation system to our nation's economy is illustrated by the fact that the single bright spot on our international balance of payments ledger since 1970 occurred in 1973, the year of the big Soviet grain deal. An examination of the statistics for 1973 and the previous year shows that all but two percent of the favorable trade balance can be explained by an increase in agricultural exports.

It is clear that our nation's financial health depends heavily on exporting agricultural commodities. And people in other countries are increasingly relying on us for food. But the Soviet grain deal also showed us that our transportation system, particularly our railroads and waterways, were not prepared to move significantly increased quantities of farm products from the farm to port for international shipment. Grain was backed up on sidings and in silos for more than a year in that particular instance.

Railroads. As noted previously, during the late 19th and early 20th century the railroad companies greatly overbuilt their trackage, extending service to rural areas through many miles of spurs and feeder lines. This overbuilding was especially prevalent in the northeastern and midwestern parts of the country.

The year 1916, when there were 254,000 miles of line-haul track in the U. S., marked the peak of railroad mileage in this country. A steady decline in mileage has ensued, such that by 1973 the total was reduced by nearly 20 percent, to 201,000 miles. Bankruptcies of the major northeastern rail companies resulted in federal reorganization into the Consolidated Rail Corporation (Conrail), but the trend toward retrenchment has continued. In 1972 the U. S. Department of Transportation recommended the abandonment of an additional 78,000 miles of track, nearly 40 percent of the present system.

Since 1920 the Interstate Commerce Commission (ICC) has been charged with the responsibility of evaluating applications for abandonment of railroad trackage. There have been many of these applications, and most of them have been approved. For example, from 1960 to 1973 the ICC received 1,937 applications to abandon a total of nearly 31,000 miles of track, the overwhelming majority of these requests were granted, about 100 were dismissed without decision, and only 47 were denied. In the last five years, there has been a significant increase in the number of applications received each year, affecting nearly every state in the nation, but primarily concentrated in the cornbelt and the northeast.

The question arises regarding what happens to the farms and rural businesses such as granaries and fertilizer dealers which lose their rail service. Recent research reported by the Federal Railroad Administration, by the U. S. Department of Agriculture-Economic Research Service, and by Iowa State University indicates that farmers would shift to truck transportation, with a trend toward larger capacity(and thus heavier) vehicles and more frequent trips. Some researchers have found that the transportation costs for farm goods would increase, while others have predicted that the increases in revenue from truck taxes would not be sufficient to pay for the increased highway maintenance costs generated by the additional truck travel.

While the ICC should want to strive to improve the economic efficiency of the rail transportation system, it should be cognizant of the fact that rail abandonments have impacts beyond the balance sheet of the rail company involved. Improved procedures need to be developed for the evaluation of rail abandonment applications which will specifically take into consideration the ability of other modes to absorb the traffice. In particular, as we shall see in the following paragraphs, such improved procedures need to be able to evaluate the structural adequacy of highways and bridges.

Highways. Of the 3.8 million miles of highways and streets in the United States, only about 630,000 miles are in urban areas; the remaining 3.2 million miles (84 percent) are rural. With about three-fourths of our population located in urban areas, some people might argue that there is a disproportionate distribution of highway and street mileage. Nevertheless, in 1973, 43 percent of all passenger travel and 58 percent of all truck travel was reported by the Federal Highway Administration to occur on the rural transportation system. About one-fourth of the rural travel was on local (or feeder) roads, and three-fourths was on main rural roads.

But what of the condition of the rural highway system? Despite our concerted efforts during the past 50 years to "get the farmer out of the mud," 23 percent of the rural highway system remains unpaved (only about 4 percent of our urban mileage is unpaved). Another 59 percent of the rural mileage is categorized by the Federal Highway Administration as being of "low load-bearing capacity." The vast majority of these roads are under county and township jurisdiction and are mainly located in the midwest and the west. Nevertheless, overall approximately 82 percent of the rural highway system could be described as being structurally deficient. These are the roads which serve the quarter of our population that is rural, and which carry about half of our total motor vehicle travel each year.

In most rural areas there is a striking difference between the design standards and the structural adequacy of the main arterial highway system, as compared to the local feeder road system. The higher standards for the arterial system are usually justified in terms of the greater traffic volumes that are served. But in recent years there has been considerable public pressure for improving local feeder road standards. Governmental and quasi-governmental (AASHTO) regulations have moved in the direction of higher standards.

Responsiblity for the feeder road system usually rests with local government such as the counties, townships, etc. These governments often face problems in raising revenue because of their small tax base. There always is a trade off between spending larger sums of money initially for better quality highway construction with resultant lower maintenance costs. Many of the present inadequacies of the rural highway system are due to the fact that the local governments cannot financially or politically take the necessary steps to appreciably improve the situation. The importance of rural transportation to

our national economy suggests that we need to revise our present policies to encourage federal/state/local cooperation in solving the rural highway dilemma.

Bridges. The final results on the nationwide survey of the condition of our 563,000 highway bridges are not yet published. But at the present time we do know that on the federal-aid systems alone, there are almost 40,000 bridges that are either structurally deficient or functionally obsolete. In a 1971 study of bridges, the Federal Highway Administration reported that about one-fourth of the inadequate bridges were located on the federal-aid highway system, and the remaining three-fourths were on state and local systems. Thus when the final count is in, we might expect to find more than 150,000 inadequate bridges, and all evidence indicates that far more than half of these will be on the rural highway system. Using the analogy that a chain is no stronger than its weakest link, the presence of so many inadequate bridges and weak pavements on the rural highway system gains tremendous significance, especially with regard to its ability to absorb heavier and more frequent farm-to-market freight movements due to railroad abandonments.

Research Needs in the Rural Transportation Sector

What then does all this mean in terms of research needs in the rural transportation sector? By means of conclusion some suggestions are offered.

1. Optimal Use of the Present Transportation System. In most areas of the country it must be conceded that we presently have an adequate or even an excessive multimodal transportation system. We need to develop improved procedures for modeling the existing system, with a view to answering the question of how we can optimize the utilization of the system. Perhaps the most logical criterion for optimization would be to minimize the cost of moving goods to and from the farm.

Such an optimization will require multimodal coordination at a level far beyond present capabilities. Studies need to be continued which will investigate the incentives and disincentives to transportation due to current governmental regulatory policies, subsidies, etc. Because of intermodal competition and other problems, communication between different modes of transportation and with organized labor involved in transportation, is presently inadequate and shows no signs of immediate improvement. Resistance to the increased use of containerization in the movement of freight is an example of this problem. Research needs to point the way to improvements in this situation.

2. Optimizing the Extent of the Transportation System. This area differs from the preceding one in that it does not accept at the onset the idea that we must live with the present transportation system.

Procedures need to be developed which will enable the identification of regions which have too much (or too little) transportation. For example, how can we decide whether or not there are too many roads in a rural area? If there are too many roads, which ones should be eliminated? Is there a factual basis from which such decisions can be made, or must the decisions finally be made in a political environment?

3. Optimizing the Organization of the Transportation System. It can easily be conceded that excessive redundancy in the transportation system is an economic waste. In the private sector techniques need to be developed which will permit the identification of an optimal balance in terms of number of firms, modes, size of facility, etc., to maintain a competitive but not wasteful transportation system. Certainly there is no single balance point which can be struck here, and the challenge lies in encouraging a free economy without excessive governmental regulation and yet also without economic waste.

In the public sector regulation can be implemented more easily, but politics often create barriers to change. Techniques need to be developed which will enable us to identify where economies of scale could be realized. For example, many of the older states, particularly those in the northeast and midwest, have township highway organizations as well as counties, cities, villages, etc. On the other hand, the southern and western states have many fewer governmental units responsible for streets and highways. How can we determine what benefits (or costs) might accrue if the number of governmental units in a region were to be reduced? What cultural or political questions would need to be addressed in those regions of the country where the concept of local (small and close to the people) government is highly regarded? It is often said that bigger is not necessarily better, but how can we assess this quantitatively? Could improved intergovernmental coordination obviate the need to abolish governmental units? Where and how do these possibilities exist?

4. Optimum Land Use. How can we identify the "best use" to which abandoned transportation facilities (either highways or railroads) can be put? To what extent is this affected by regional attitudes? For example, perhaps in some parts of the country local opinion would hold that an abandoned right-of-way should be made into a bikeway, whereas elsewhere it would be deemed preferable to return the land to crops, or some other use.

We should reexamine the old shibboleth that "improved transportation reduces the cost of farm goods." In certain suburban areas, for example, the construction of a high-speed, controlled-access road will intensify the demand to convert agricultural land to housing. Where local policies require that such land be taxed for its "highest use," the cost of farm goods must necessarily go up, as the direct consequence of the improved transportation. How can we better predict such consequences?

5. Standards. Governmental policies regarding standards sometimes fail to have the desired effect. In the railroad industry, mandated standards for track and safety have occasionally forced line abandonments. Similarly in highways it is questionable how much safety we can afford. Does a rural road which mainly serves to provide access to a few farms, and which carries only a few cars per day, need to be built to the same design standards as a rural arterial? The current trend in federal standards would suggest that we believe the answer is "yes." Is there a way that we can determine on some absolute basis what standards should be required? To what extent does public attitude dictate the minimum standards which must be adopted? And if the standards for different segments of a transportation system are not the same, how can we avoid consequent questions of legal liability?

Temporal standards, such as spring time load zoning of rural roads, can sometimes be counterproductive. For example, in an effort to reduce the serious fatigue damage that rural roads in northern areas experience during spring thaw, load limits are posted on these roads. It is often the case, however, that the restrictions are posted too early in the winter, long before the softening begins, and they are removed too late in the spring. The consequence of this practice is to hinder the farmers

adjacent to the road in trucking goods to and from the farm, thereby increasing his transportation costs. On the other hand, if he ignores the restrictions, increased road maintenance costs will raise his taxes. Researchers need to find improved methods for determining load limits and when to post them, and the costs of establishing or not establishing such limits need to be identified.

Conclusion

Thank you for the opportunity to review with you some of the problems and research needs of rural transportation that I see. It is usually far easier to point to the problems than it is to find their solutions. Perhaps some of the problems I have described cannot or will not ever be solved. Nevertheless, I hope that my observations will pose some challenges to you.

TRANSPORTATION ENERGY CONSERVATION: RESEARCH NEEDS AND POSSIBILITIES

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I am pleased to participate in this introductory session of the Workshop on Research Needs hosted by the Social, Economic, and Environmental Section of the Transportation Research Board. Only four short years ago---prior to the Arab oil embargo---no one, and most certainly no American, would have given a second thought to energy in developing a list of "Social, Economic, and Environmental Research Needs and Possibilities." Yet, as I shall try to demonstrate, energy extravagance has been a basic aspect of American transportation and now pervades every major issue facing the transportation sector. Accordingly, the transition from an era of cheap, plentiful energy to one of expensive, scarce energy will require pervasive adjustments on the part of a sector as energy-intensive and energy-consumptive as transportation is. The adjustments will affect both the consumption of energy in transportation and the transportation of energy.

Background. Transportation now accounts for one-fourth of the energy and one-half of the petroleum consumed in the United States. Prior to the embargo during the winter of 1973-74, there was a long-term secular increase in U. S. transportation energy consumption per capita, due to (1) increases in vehicle miles of personal travel per capita and in freight ton-miles per capita, (2) increases in modal energy intensities, and (3) shifts toward more energy-intensive modes. Modal energy intensities increased due to:

1. Higher vehicular speeds,
2. Better performance capabilities,
3. Greater use of energy-consuming accessories such as air conditioning and power steering, and
4. Lower fuel efficiencies resulting from the emission control technologies selected by the automobile manufacturers to meet the Clean Air Act standards.

In addition, there was a gradual shift from energy efficient modes to energy-intensive ones, particularly from rail and transit to truck and auto.

Energy Conservation. Until recent months, conservation has been relatively neglected as an option for dealing with our national energy problem.

There are a number of obstacles to conservation in the United States. First, we have an institutional preference for developing new energy supplies rather than managing old ones. With our historical growth-at-any-cost mentality, we have traditionally found it politically, socially, and economically easier to divide a bigger pie than a constant one.

Second, we have a first-cost bias in our purchasing decisions. Both individuals and firms tend to pay more attention than economic rationality would suggest to initial capital costs and less attention to subsequent operating and maintenance costs. Thus, for example, in the purchase of a water heater, people tend to minimize the investment cost (by buying a cheaper, energy-inefficient model) rather than to minimize the total discounted cost over its economic lifetime (by buying a model which costs slightly more at the outset but which is significantly cheaper to operate in terms of energy consumption).

Third, conservation investments frequently were uneconomic when oil and natural gas prices were artificially low. These habits of mind persist even though they are obsolescent in the light of today's and tomorrow's prices.

Despite these obstacles, energy conservation has the following advantages:

1. The energy savings of conservation are relatively immediate, while energy resource development generally involves long lead times,
2. Conservation is often environmentally attractive in comparison with energy resource development,
3. Conservation is often most cost-effective in that the cost per barrel of energy saved is less than that of energy produced; in addition, a barrel saved is available for future use.

Due to these advantages, energy conservation is the cornerstone of the proposed National Energy Plan.

It seems clear that the transportation sector can make a significant contribution to energy conservation, by means such as the following:

1. Technical improvements in the fuel efficiency of vehicles,
2. In-use improvements in routing, scheduling, load factors and operating characteristics, and
3. Diversion of demand to more fuel-efficient modes or substitutes.

Further, in my opinion, such actions to conserve energy in the transportation sector can be equitably achieved without undue burdens upon anyone and without fundamental changes in life-styles.

Transportation Energy Conservation: Existing Programs. Chronologically, the first legislative action involving transportation energy conservation was the 55 mile per hour national maximum speed limit. First enacted on January 2, 1974, during the Arab oil embargo (Emergency Highway Energy Conservation Act, Public Law 93-239), the 55 mph speed limit was subsequently reenacted on January 4, 1975, as permanent legislation (Federal-Aid Highway Amendments, Public Law 93-643).

The Energy Policy and Conservation Act (Public Law 94-163), enacted on December 22, 1975, contains the following transportation energy conservation provisions:

1. Automobile Fuel Economy Standards. The production-weighted average fuel economy of each