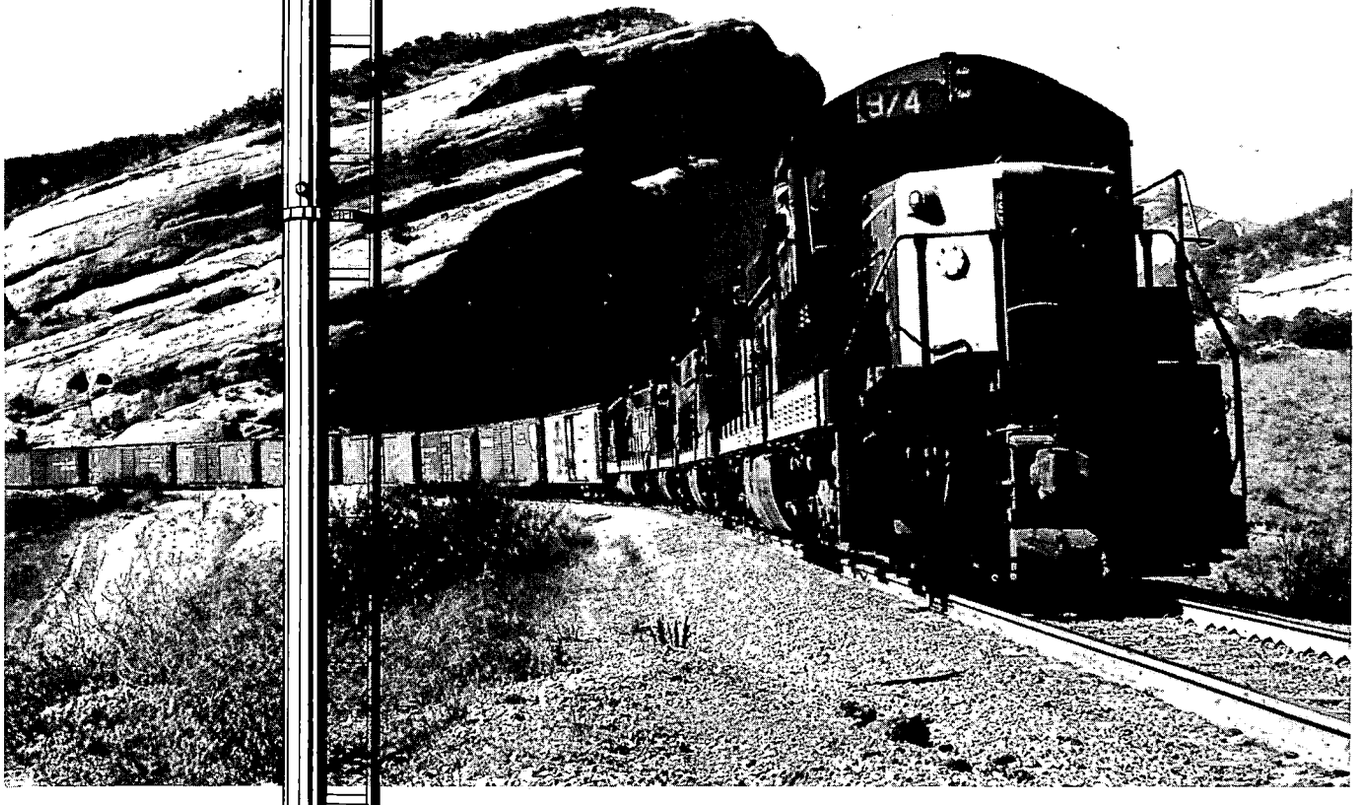
R.L. KRICK

# Rail Transport Research Needs

## Special Report 174



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# Rail Transport Research Needs

*Final Report of the*
Railroad Research Study
*conducted by the*
Transportation Research Board
*and sponsored by the*
Federal Railroad Administration,
U.S. Department of Transportation,
*and the*
Association of American Railroads


COMMITTEE ON THE RAILROAD RESEARCH STUDY
TRANSPORTATION RESEARCH BOARD
COMMISSION ON SOCIOTECHNICAL SYSTEMS
NATIONAL RESEARCH COUNCIL

NATIONAL
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**Notice**
The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competence and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The views expressed in this report are those of the authors and do not necessarily reflect the view of the committee, the Transportation Research Board, the National Academy of Sciences, or the sponsors of the project.

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[1]Deceased.
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[3]Mr. Ward joined the TRB staff in August 1976.

Cover photo courtesy of the Santa Fe Railway.

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# FOREWORD

At the request of the Federal Railroad Administration (FRA) of the U.S. Department of Transportation (DOT) and the Association of American Railroads (AAR), the Railroad Research Study was undertaken by the Transportation Research Board. The objective of the Railroad Research Study was to develop a comprehensive framework for a coordinated national research effort by industry and government and to suggest priorities in a program of research. The research program would be of maximum assistance in improving both the performance and viability of the rail transport industry and the decision-making processes of those involved with rail transport.

The study was planned and conducted under the guidance of the Committee on the Railroad Research Study, which was established by the Executive Committee of TRB on the recommendation of its Special Committee on Rail Transport Activities. The study was based primarily on a conference held in July 1975 at Woods Hole, Massachusetts. A large group of experts on almost every facet of railroading provided broad informed viewpoints concerning research needs related to the provision of rail transport in the years ahead. The presentations and discussions during that conference provided the major foundation material for this report, although it attempts to distill the essence of the presentations rather than to condense or extract them.

Some 200 participants were drawn from agencies of government, segments of the railroad industry, and pertinent academic and professional disciplines. Their names and affiliations are listed in the appendix.

The conference program, which covered a period of 4 weeks, provided an intensive review of the status, performance, and potential of rail transport in North America, as well as an assessment of the problems and issues involved in areas and subjects of possible research. The conference addressed four major fields. The first week was concerned with estimates of the nature of the environment (economic, social, institutional, physical, and competitive) within which rail transport will be expected to perform over the next 15 years and with attempts to visualize the role of rail transport in that context. The second week was devoted to problems of planning, economics and finance, marketing, and information systems for control of service quality. The third week focused on problems related to management, labor, personnel development, and human factors. The fourth week considered problems related to physical plant, equipment, and operations. A different group of authors and discussants participated during each of the 4 weeks.

During the week following the presentations and discussions of the conference, a study staff prepared an interim draft report. This study staff included the general conference chairman, a five-person "core group" that had attended the whole conference, and the four co-chairmen or moderators of the weekly sessions. They acted for the entire study committee, whose members have participated as reviewers of the work. For part 4 a special meeting of the study committee was held to reconcile divergent views on the composition of and priorities for a coordinated research program. The report represents the views of the full study committee.

The TRB and its Committee on the Railroad Research Study express sincere gratitude to many agencies and individuals who contributed to this study, including the FRA and AAR, who provided the major funding for the study; the authors and discussants who made direct contributions; the agencies whose financial support enabled many of the participants to take part; Canadian governmental, railway, and academic agencies that participated and contributed; the professional and secretarial staff of the TRB, AAR, FRA, and the Canadian National Railways; and the staff of the NAS Summer Study Center, who provided a pleasant setting for a demanding crew.

No summarizing report can express adequately or completely the many views, insights, and range of information presented by the large and diverse group of individuals who participated in the conference effort and others who responded to later calls for information. Since there was a natural diversity in the assessment of problems and priorities, the writing group was forced to express in its own words as fair a summary as seemed possible within the limitations of a single document. A separate volume of the contributed papers from the conference has been published so that the views of the authors can be read in their original form (see References and Bibliography).

There is a wide range of specialization among the potential readers of this report in government, industry, and academia—planning, financing, regulatory reform, marketing, labor productivity, operation, physical plant or equipment. Because of this divergence and because railroading is an immense subject, it is unlikely that many readers will wish to peruse the entire volume. Consequently the study committee has chosen to make each chapter stand essentially on its own. This of course leads to substantial redundancy among chapters. For this the committee apologizes to those students of the subject who will undertake a review of the entire work.

# INTRODUCTION AND SUMMARY

A number of conditions have combined to focus attention on the problems of rail transport and to raise questions concerning its future. Extensive responses have been made by government to ensure continuance of rail transport service in some parts of the nation, and further actions have been proposed. The long-term effectiveness of many of these actions is uncertain.

Opinions differ as to what policies should be adopted and what remedies will be effective. For example, recent public statements have included suggestions that the solution to the problems of the railroads (a) lies principally within the province of the railroads themselves and, through restructuring, the industry can become economically viable; (b) requires redressing a major imbalance in government treatment of modes of transport; or (c) will be provided through public ownership of railroad rights-of-way.

Underlying these and other proposals is the opinion that, while the rail mode is an essential component of the national transportation system and the investment in the railway infrastructure is an important national resource, the industry's earnings are too low to permit achievement of its full potential in terms of effective transport services. Although the diversity of views about the best set of solutions poses great difficulties for policymakers and operators alike, there appears to be a consensus emerging that acceleration is needed in the rate of change in regulating, managing, and conducting rail transport activities.

Chapter 1 discusses a variety of external factors derived from the physical, economic, social, and institutional environments in which the rail transport system must function that affect or constrain the performance of the rail transport system. Because these environments are constantly changing, evaluation of both present and future effects is difficult.

Rail transport involves actions by many participants. The movement of people and cargos is accomplished by the carriers—a variety of independent private companies that have different viewpoints and markets and, within certain constraints, make separate decisions. The supply industry produces the materials, equipment, and other supplies, and the transport consumers (shippers and passengers) provide the demand for services. Carriers, suppliers, and some segments of the users have formed associations that permit a common voice and action on rail transport issues. In addition, various federal, state, and local agencies affect rail transport through regulatory, tax, research, or promotional activities and through financial support.

These several participants have specific roles to perform in the production of transport, and their interaction is governed by various rules of the game, policies, practices, regulations, customs, characteristics of the market economy (including the choices made by the users), and even the value system of society. Actions by any one of the participants affect all the other participants in some way. Chapter 2 discusses the roles of rail transport participants and how their actions and the rules guiding those actions can contribute to improved rail transport.

The motivation for the Railroad Research Study arose from the resurgence of interest in revitalizing rail transport. It sprang from a common interest in a process whereby beneficial change can be induced by bringing better information and improved techniques to bear on the problems that confront rail transport and by delineating a national research program that will provide a basis for managing that change.

During the Railroad Research Study meeting, individuals selected for their knowledge and experience in all aspects of the production of rail transport appraised the problems and the kinds of research effort needed. On the basis of the comprehensive information provided in the papers presented and the ensuing discussions, their appraisal covered significant problem areas, the nature of significant problems, implications of the problems, possible approaches to coping with the problems, and the kind of study or research that would be pertinent; these problems are grouped and discussed in chapters 3 through 13.

The conclusions and recommendations for a national research program based on these appraisals are given in chapters 14 and 15. This rail transport research program is presented from the viewpoint of the production of transport by a composite national rail system. The many interactive elements and participants involved and the limited resources require that the research program be comprehensive and planned cooperatively, even though many research activities may be conducted separately.

The participants will have various roles and responsibilities in a national research program. There is a real need for identification of and agreement on which kinds of research are most appropriate for which agencies. A mutual recognition of funding responsibilities, as distinguished from research performance responsibilities, and agreement on priorities are also important.

The term research, in its usual sense, refers to an activity directed to discovery of explanations of the way things work, to formulation of new concepts, and to devising innovative techniques or methodology by using the approaches of laboratory and field investigations, experiments, observation, and mathematical analysis. But to deal with the challenge of inducing beneficial change and revitalization requires more than the performance of research in this sense. It may involve synthesis of avail-

able techniques and analysis of the potentials of changes in modes of operation. It may involve a process whereby the interested parties jointly plan and sponsor research whose outcome can provide guidelines for new relations among them. It may involve the implementation of research findings whose benefits are realized only if the agencies concerned agree to adopt common procedures.

Thus the formulation of a research program is here taken to mean more than the mere listing of research topics. Although needed areas of research are identified, the thrust of this study has also been to discern possible ways by which there can occur, in conjunction with ongoing research activities, a development phase, a continuing process of dissemination of information, an interchange of ideas for and stimulation of improved bases for decision making, and the implementation of improved techniques and devices.

The identified research needs have been assigned three levels of urgency. Research efforts that deal with problems pertaining to the survival of the carriers have the highest level of urgency. Efforts to improve the performance and economic health of the industry so that it continues to fulfill approximately the same role as it does at present have the second level of urgency. Efforts to extend or expand the role of rail transport in the overall transportation complex have the third level of urgency. Priorities for research vary according to the viewpoint of individual groups of participants and change with time. Thus the study committee's priority recommendations in chapter 15 should be periodically reassessed in a continuing national cooperative research program.

Following is a chapter-by-chapter summary of the contents of this report.

## PART 1. THE CONDITION OF RAIL TRANSPORT

### Chapter 1. The Environment for Rail Transport

Rail transport functions within an environment of physical, economic, social, institutional, and competitive factors. Although there are wide variations in physical conditions, most rail equipment must be standardized, be interchangeable, and meet national standards for safety. Operation of the railroads will be affected by the future availability of energy and materials. Environmental protection policies will affect the design, operation, and location of equipment and facilities. Future operations will be affected by such factors as shifts in the location of economic activity, growth in service-oriented industries, and the overall rate of economic growth. Based on various population forecasts, a growth in traffic of 30 to 75 percent has been projected by 1990. Demographic shifts, such as the increase in the average age of the population and movement of people and industry to the Sun Belt, will affect the mix of commodities to be carried. All railroads face one overriding problem to a greater or lesser degree—inadequate earnings. Competition from other modes, aided by government subsidies, has reduced rail's share of the total freight market. The effect of the Interstate highway system has been paramount in improving the motor carriers' ability to compete in service and cost with rail.

### Chapter 2. Private and Public Roles in Rail Transport

The U.S. rail system may soon face restructuring. Suggestions for restructuring to improve efficiency range from forming one big railroad to several regional railroads. In most industries competition among a number of firms leads to economic efficiency, but the rail industry is different because (a) railroads must cooperate while they compete, (b) service is no better than the weakest carriers, (c) financially strong roads may purchase new rolling stock that is incompatible with the roadbeds of financially distressed roads, and (d) interline financial arrangements are so complex that they impede unified systems operations. On the other hand, integration of all railroads into regional railroads or one big railroad also has problems, and the integration of multiple modes into transportation companies risks the demonstrated dangers of conglomerates. Both railroaders and the general public are committed to regulated private enterprise, but some segments of the industry are not financially viable as regulated private enterprises.

## PART 2. PROBLEMS IN RAIL TRANSPORT AFFAIRS THAT ARE EXTERNAL TO THE INDUSTRY

### Chapter 3. Transport Policy Problems

Although public policy in this country has always been used to encourage the transportation industry, there are still issues with which public policy has not dealt effectively, e.g., the degree to which carriers should be vertically integrated, the structure of the industry (the number and nature of the carriers), and even-handed treatment of competing modes by government. Public policy now reflects a realization that the rail industry is in trouble but is worth saving. Among many questions about concepts of public service, some of the most basic deal with how much transportation the public wants, how much support (subsidies) government will provide, and whether excess railroad capacity is needed for insurance.

### Chapter 4. Regulatory Problems

Regulation is of two types—economic and administrative. Economic regulation covers rates, services, mergers, and right of entry or exit. The Interstate Commerce Commission has authority over all railroad rates, but in trucking a large percentage of shipments are unregulated, as are the bulk of inland waterway movements. The very complex structure of railroad rates is based on historical developments and notions of value of service. Other modes have never been regulated in such detail. Historical developments in economic regulation have carried into the present and exert considerable influence on present practices. Administrative regulation is growing; regulations for environmental protection and safety have had and will continue to have major impacts on the rail industry.

### Chapter 5. National Transportation Planning Problems

Since rail transport involves the interplay of several kinds of government agencies and a variety of private organizations, there are special problems in planning and coordinated decision making. The rail industry is not a part of any national planning effort, and railroad companies have not created an intercorporate planning capability, since they consider their competitive interests more important than their common interest in overall improved efficiency and performance. The railroad system and its operation are so complex that detailed plans can only be implemented by the managements responsible for making them work. Close interaction is needed between analysis of alternatives and negotiations for change that are based on both a detailed knowledge of field conditions and the responsibility for implementa-

tion of changes. Government could perform an important role by developing new analytical techniques to forecast overall transport demand. Analysis of intermodal arrangements and a demand model to assist in making forecasts are particularly needed.

## PART 3. PROBLEMS IN RAIL TRANSPORT AFFAIRS THAT ARE INTERNAL TO THE INDUSTRY

### Chapter 6. Finance

Deferred maintenance and maturing bonds will require large capital outlays by the railroads in the next 15 years. The ability to meet these requirements varies widely among railroads. New sources of capital are needed but may be limited to government, since there is such a low rate of return on investment. Recent legislation has opened the way for government financing. The real question is whether the capital requirements are severe enough that the weaker roads might cease operations without government intervention.

### Chapter 7. Marketing

The market for transport will surely grow, even if it is at a slower pace. The question is whether the railroads can provide attractive service at a low enough cost to maintain or expand their share of the freight market. Commodity flow information is needed, along with the ability to predict market shifts. Cooperation among railroads with staffs of specialists could help in this regard. Sales promotion needs special attention on how shippers make decisions and an investigation of marketing techniques used in other industries to see whether such techniques can influence those decisions. Searches for new sources of traffic are also needed.

### Chapter 8. Costing

The need for improved information on costs for decision making, marketing, and regulation is universally recognized. Although engineered unit costs can be used for some cost estimating, better cost data are needed for much of the estimating that is required. The most pressing need is the design of affordable systems for data collection, storage, and retrieval. With improved data and better cost models, specific cost studies should be undertaken on profitability of existing lines; relation of maintenance-of-way costs to traffic; relation of use to equipment maintenance costs; cost of improved services; effect of industry structure on costs; and variation of cost in line-haul, terminal, and service components of the competition's costs.

### Chapter 9. Personnel and Human Factors

During the next 10 years, railroads may have to hire more than 200 000 employees. This means that better techniques of recruiting, training, and personnel management will be very useful. Recruiting problems extend into the academic world, since few universities include curricula pertinent to railroading. Railroads, suppliers, and government agencies at all levels need to inform the academic community of the industry's needs and to provide support with exchanges of staff and other methods of improving liaison. There is general agreement that productivity in the rail industry should be improved. Labor and management should work together to expand the experiments now under way to change the work rules in order to increase productivity. Management practices to improve morale, promotion policies, supervisory responsibilities, discipline, and career protection need study.

### Chapter 10. Organization

The organization of both the rail industry and individual railroads presents problems. Alternatives to be considered include lateral mergers into regional systems, end-to-end mergers for increased competition with larger systems, diversification, the Canadian approach of private and publicly owned railroads competing, and reduction of excess capacity in certain corridors through reduction in the number of competing private companies. The internal organization of individual carriers needs reexamination to improve management effectiveness, particularly in field operations and employee morale, and to make the most of the benefits of computers.

### Chapter 11. Operations

Operations refers here to the management of facilities, equipment, and people in the commodity transport process. The operating areas discussed are cost problems, types of service, electrification, line capacity, light-density lines, quality of service, loss and damage, and car utilization. Once corporate operating objectives are established, economic trade-off studies are needed to select the best courses of action, and good cost data are vital for this. Railroads today are engaged in four major types of service: carload, unit train, intermodal, and passenger. Each of these presents its own problems and opportunities. Electrification is not a technical but an institutional and financial problem. Economic studies have not yet shown a sufficient rate of return to induce any railroad to invest the substantial capital required. Although line capacities can theoretically be calculated from the nature of the fixed plant, better measures of capacity are needed for potential improvements and rail network rationalization studies. Procedures are available for evaluating the potential profitability of light-density lines; individual railroads must now apply this to their own lines. Quality of service is difficult to define, but reliability of delivery is a major factor for many shippers and commodities, along with elapsed transit time, availability of empty cars, loss and damage, and special services provided by the carrier. Improvements in service may lead to better car utilization as well as greater volume. Loss and damage claims have increased markedly over the past 20 years. Studies of shipper packaging and loading practices, dynamics of the ride, consignee unloading, and storage practices are needed. Reduction of fraudulent claims could be effected by formation of an industrywide insurance organization. Five factors conducive to good car utilization have been identified: high-quality service in terms of dock-to-dock speed, reliability, and frequency of service; prompt supply of the right type of empty car; efficient on-line information and control system; incentive and penalty features in rates to balance traffic and reduce time for unloading, circuitous routing, diversion, stop-off, and so on; and quick and efficient loading and unloading equipment. Demand pricing for cars to smooth peaks and valleys of demand could reduce equipment shortages, as could buffer storage, if it were expanded to additional locations and commodities.

### Chapter 12. Plant and Equipment

Although railroads have an image of being slow to change, a number of rapid technological changes have taken place in the past 25 years; still, technology remains a fertile field for research. Railroad managements have histori-

cally subsidized operations that failed to earn sufficient revenue by deferring track maintenance. With some modification and good maintenance, present track design is adequate not only for the present but also for the foreseeable future. However, increased car weight and size, along with higher speed, must be evaluated to see whether the increased cost is more than the increased revenue. Although each line of railroad track is unique, railroad vehicles must be capable of running on almost any type of track. Studies of truck steering, the effect of axle loads, coupler design, and car size are needed, as well as research on more reliable equipment, on-board monitoring of train dynamics and the condition of running gear, and designs of new terminals and yards.

### Chapter 13. Management Information and Control Systems

Every railroad has a management information and control system, whether it is completely operated by humans or assisted by computers. The amount of information processed to support operations must be balanced with the capability of the decision makers to use it. Costs used in decision making should include those figured in hard dollars (direct costs that can be specifically identified) and those figured in soft dollars (indirect costs that have been difficult to measure but that should be known). Most railroads have been engaged in the design and implementation of computer-assisted information and control systems for some time; an inventory of what has been accomplished would be most useful. Hardware for these applications is generally available, but further developments are needed in software.

## PART 4. RESEARCH AND DEVELOPMENT STRATEGY

### Chapter 14. Considerations in Establishing a Comprehensive Research and Development Program

There is a growing view among those concerned with railroads that a broadly based program of research can aid in responding to new conditions. Some of the factors to be considered in establishing, formulating, and conducting an appropriate research program in rail are objectives, priorities, and scope for a national program; the role of various participants; and the relation of such a program to ongoing research and development programs. The study committee designated broad areas within which individual research projects can be launched: planning, plant and equipment, operations, and management. Within these groups the areas have been further classified into basic research, developmental research, and applications research. Lastly, the areas were assigned to one of three categories of urgency or necessity. A comprehensive research and development program should be geared to produce ideas and concepts, better analytical models and methods, and improved standards and specifications. The new program should build on the research and development programs now under way in government and industry, not trying to replace present efforts but rather to augment them.

### Chapter 15. Recommended Research Agenda

The research agenda recommended by the study committee is presented. As a review of Table 1 shows, the survival issues (priority 1) for the rail industry are concentrated in the areas of management and planning—the soft side of research. Lack of data is all pervasive and hinders much of the research proposed by the study committee. Data both internal and external to the industry are needed; the outstanding need is for better low-cost data collection. If an extensive program of research is to be effective, the results must be stated in practical terms. Priorities must be set to make the best use of limited resources—funds, talent, and equipment.

# PART 1
# The Condition of Rail Transport

Rail transport, like all other human endeavors, must serve society and perform its functions within the context of several environments. Some conditions create needs especially suited to service by the rail mode; others may delimit its use. The roles that rail transport can or will play in providing its share of mobility for society will depend on its technological capability, its organizational ability, and its environmental adaptability. Research undertaken to aid rail transport to match future societal needs with pertinent services must include attention to both the future external conditions and the potential future functions this mode can perform. The chapters of part 1 are intended to provide a review and an outlook for the condition of rail transport in a changing world.

# Chapter 1
# The Environment for Rail Transport

As a system, rail transport functions within the context of an environment of many dimensions—physical, economic, social, institutional, and competitive. These environmental categories interact, however, and a discussion of them cannot be neatly separated. More detailed examination of external influences on rail transport is given in later chapters.

The environment of the rail transport system affects its performance in a number of different ways. Things that are produced, together with the needs of people and industry for goods and services, create the demand for rail transport services. The spatial distribution of economic and social activity not only affects demand but also influences the configuration and use of the network.

From a different point of view, the supplies of materials, equipment, and manpower used in the production of rail transport are subject to changing conditions of several environments. From still a different point of view, the general needs of society for mobility, together with the economic behavioral tendencies of an industry like rail transport, tend to result in a set of constraints that are based on economic and social factors but are finally embodied in institutional practices and philosophies.

In addition, rail transport activity is affected by the activities of other modes of transport, which impose certain limitations on the part rail plays in the transportation complex. At the same time, however, the limitations of these other modes offer opportunities for rail transport to play a vital and economically healthy role in meeting society's need for mobility.

Few observers doubt that transport in the form of the steel wheel on the steel rail will continue to meet a substantial share of transport demand over the next 15 years and well beyond. What is uncertain is the context within which rail transport will function; the conditions that affect it will interact and mesh to create the overall world in which the U.S. railroad industry will have to find its future.

## PHYSICAL ENVIRONMENT

### Nature of the Railroad Plant

The North American railroad plant is spread out over 49 states, the District of Columbia, Canada, and Mexico. It runs through congested urban areas and through undeveloped desert, through swamps and over mountain ranges. It is constructed on just about every known type of soil condition.

The North American railroad plant is subjected to extremes of climate and weather. Temperatures can range from about -50° C (-50° F) to 65° C (150° F). The moisture conditions can range from wet in coastal regions to dry in the deserts. Every kind of storm and wind can be encountered. Air pressure and air conditions range from the rare air of the mountains to the salt air of the coasts. The seasons bring conditions ranging from extreme heat and humidity to ice and snow. The climate and weather conditions have their impact on plant, equipment, operations, and costs.

Railroads haul, and are thus exposed to, a wide range of commodities. Loads may be heavy, bulky, corrosive, dirty, abrasive, and hazardous—flammable and toxic as well as explosive. Certain commodities are perishable or temperature sensitive.

There are some 52 class 1 railroads in the United States as well as numerous short lines (5). Additional major railroads and short lines exist in Canada and in Mexico. Some of the class 1 railroads are larger and more influential than others. Equipment must generally be operable over all railroads and industrial tracks, with certain exceptions, so that shipments may move in interchange service between an origin on one railroad and a destination on some other railroad; often such shipments will also move over intermediate railroads. Equipment must meet the standards of the AAR and of several government agencies. The most important regulations and standards concern track gauge, couplers, air brakes, clearances, and weights and are designed to make equipment interchangeable. Equipment must also meet safety regulations. To provide for convenient run-through operation, locomotives must be compatible in their control systems, signal system accessories, and radios.

Even on a single railroad, the plant is spread out geographically and divided into main lines, branch lines, industrial lines, yards, and terminals. Since railroads use each others' cars, the cars on any one railroad will probably be of a variety of ownerships; any railroad's car fleet will be distributed widely over the continent. Further, much of the physical plant was built long ago and was designed for the operation of passenger trains and of shorter, lighter freight trains. Equipment and lading are subjected to prolonged vibrations and to heavy shocks and rough handling. Much of the time the equipment will operate unsupervised; indeed cars may be out of the sight of the crew on a long train.

### Factors Affecting Future Operation

During the next decade and a half, rail transport will be affected by energy, materials, and equipment supply considerations and by society's concern with the quality of its surroundings. Developments in these areas and the way the railroad industry adapts to those developments will influence how well rail transport will function.

Transportation absorbs 25 percent of the nation's total energy and 53 percent of the petroleum consumed. Railroads, however, consume only 3 percent of the energy and 1.6 percent of the petroleum used for transportation. With domestic petroleum resources facing exhaustion, it is clear that petroleum price and supply will change and that the effect on rail transport, as well as on other modes, will be substantial. Even if total electrification of railroads were to occur—which seems unlikely—the effect on demand for petroleum would be slight (52).

Although it is not yet clear exactly what effect changing energy costs will have on the future of railroads, it is certain that emerging energy policies will affect the supply and demand for transportation services significantly in years to come. These public policy decisions will also undoubtedly affect the balance of demand between transportation modes as well as transportation patterns. The decisions will be made by government authorities, and it will be necessary for the railroad industry to ensure that its interests are considered, particularly since transportation considerations will probably be secondary to the fundamental public concerns.

Public policy toward energy, still in the process of development, could take the direction of impelling freight traffic toward the more energy-efficient mode. Railroads are theoretically able tc move a given amount of line-haul freight a given distance with the consumption of less fuel than would be used by trucks. However, analysis disclosed (7) that topography has a greater effect on rail fuel consumption than on fuel consumption by trucks traveling on interstate highways and that, while it is true that trucks usually require more propulsive work for a shipment than rail or piggyback, the differences between piggyback and trucks are small and in some cases trucks require less propulsive work than piggyback. Also, in branch-line operation, if a 1120-kW (1500-hp) locomotive moves two or three cars, the fuel consumed is obviously greater than the amount that would be required for a truck. Investigation is needed to show exactly how much fuel can be saved in specific freight operations. The private automobile is the largest consumer of petroleum, and actions to discourage gasoline use could create renewed demand for rail passenger service.

The supply of materials will also affect the ability of the railroads to respond to future conditions. At the beginning of 1975, for example, there was between $2.8 billion and $7.0 billion of deferred maintenance on track and roadbed (63). Studies indicate that the current capacity for steel rail production in the United States is insufficient to meet the demand that would occur if capital were available to undertake the elimination of track deficiencies. There is concern that rehabilitation programs being undertaken by Consolidated Rail Corporation (ConRail) in the Northeast and Midwest could create rail shortages elsewhere in the industry, a difficulty that arises from the industry's cyclical nature. Purchases of materials in recent years have not been consistently high enough to cause suppliers to make the necessary investments to expand capacity.

A similar situation prevails with respect to other materials vital to the rehabilitation of the rail plant. Ties, which should be replaced at the rate of approximately 24 million annually, become more rapidly available during periods when housing and other lumber-consuming industries are economically depressed. Unfortunately, these periods tend to coincide with periods of depressed rail earnings and reduced maintenance activities. Government and industry should be seeking ways of smoothing the cycles so that the availability of material will be more in balance with railroad needs on a long-term basis.

With a fleet of some 1.7 million freight cars and an average car life of 30 years, it is entirely possible that shifts in the level of traffic may occur more rapidly than capacity changes. Locomotives, of which there are some 28 000 in the fleet, are being replaced at a rate of slightly more than 1400 per year (5). The supply of equipment will affect the railroad's ability to accept new traffic or increases in existing traffic, unless the planning process is improved and the plans can be implemented. In the past, and probably again in the future, there will be constraints based on shortages of material that affect suppliers' ability to provide equipment that has been ordered.

National environmental control policies now in effect and yet to be established will also affect the railroad industry in numerous ways. Since railroads have lower levels of pollutant emissions than do trucks, air quality standards could influence the future level of traffic carried by the two modes. Land use policies could determine where industry may locate, with potential advantages and disadvantages for rail traffic. Public pressure has already altered some highway construction planning, with potentially unfavorable consequences for highway transport and a simultaneous advantage for rail transport. Concern for clean air and water has already caused the railroad industry to commit large amounts of capital to compliance activities.

The extent to which conservation policies might dictate greater use of recycled materials by industry could affect the transportation flow, with materials carried back to points of manufacture and the movement of virgin materials constrained.

## ECONOMIC ENVIRONMENT

Economic conditions affect the railroads in several ways. The level and spatial distribution of economic activity condition the railroads' markets for their services. Availability of capital funds affects the ability of the railroads to renew or readjust their physical plant. Costs in relation to income control financial health. The rates the railroads can or must charge affect their share of the transport market.

During the Railroad Research Study conference, experts from numerous industrial sectors provided insights into the future positions of their industries from the viewpoints of supply, demand, and constraint. Their composite projection was that the U.S. economy will resume its long-term overall growth pattern but probably at a slower rate than has been maintained during the past two decades. It was further agreed that, within each sector, shifts will occur that will definitely affect transportation in general and railroads in particular.

For example, it is believed that current production rates of timber from the forests of the Pacific Northwest cannot be maintained much longer and that this will cause growth in timber production to occur in the South and Northeast. On the other hand, mining experts anticipate expanded coal production—to perhaps double the current level by 1985—but expect that the greatest increase in coal production will be in the Northern Great Plains areas of Montana, Wyoming, and the Dakotas. Thus the nature of transportation markets in terms of volume, commodities, and routes is seen to be one of continuous change. Today's main lines can in some cases be tomorrow's feeder lines, while secondary lines on today's map may be of major importance tomorrow.

It is generally assumed that railroad traffic will grow over the next 15 years, with estimates for 1990 (63) ranging from 1.6 to 2.2 trillion Mg·km (1.1 to 1.5 trillion ton-miles); the 1974 level is 1.25 trillion Mg·km (850 billion ton-miles). However, such growth will require substantial rebuilding of the railroads' fixed plant and hence

large infusions of capital. The question then is where that capital is to come from, which in turn gives rise to the question of whether the railroads will continue to operate in their private enterprise status. It is clear that economic decisions that must be made in the near future will affect the nature of the institutional framework of the railroad industry as much as will the impacts of other environments.

Several caveats must be considered in assessing the future role of railroads. The experts who projected trends in specific economic sectors relied on population projections in order to extrapolate current consumption and production rates to future markets. Such projections could be seriously wrong because of extraneous variables, especially since the extrapolations were derived from the experts' intuitive feelings about their particular individual areas and specialties.

Essential to a clearer assessment of the economic environment in which railroads will operate will be a scanning of various probable developments and an estimation of their potential secondary as well as primary impacts. For example, in the case of a growing scarcity of petroleum, agricultural production forecasts should take into account the potential impact of petroleum price and supply on herbicides, pesticides, petroleum-based fertilizers, drying of grains, and the use of machinery for cultivation and harvesting.

## SOCIAL ENVIRONMENT

Demographic shifts are taking place as the growth of large cities has slowed or stopped, and there seems to be a trend toward movement back to smaller urban regions and immigration from other parts of the United States into the Sun Belt, the south and southwest regions of the country. Obviously, such shifts will mean shifts in the location of markets for transportation. In view of the relative inflexibility of the rail system infrastructure and the cost of relocations, these shifts should be a major input into the long-range planning of many railroads. Consideration of abandonments should include examination of trends of increasing or decreasing population in the service area.

Not only is the location of the population changing but so is its composition. The average age continues to increase; among other factors, this influences the desire for mobility. While this has the greatest effect on the planning for the National Railroad Passenger Corporation (Amtrak), the market for the operation of rail passenger trains does affect a significant portion of the rail network. The rate of growth of the total population is also a major factor in planning. Whether the birth rate continues at near-zero growth levels will have a profound influence on future demand for rail transport. As the nature of the population changes, needs and desires for commodities change. We are becoming a service-oriented economy, and there is a consequent lessening of importance of manufacturing activities. Does this mean a lowering of demand for rail transport, a change in the mix of rolling stock to handle different flows of commodities, or both?

Lastly, the social environment includes land use policies that will control the location of new industry and the centers of economic activity. Land use planning is the subject of great debates and is being fought on all levels of government by environmentalists, developers, and planners. One clear result is a slowing of the development of new industrial sites, but the long-range outcome is not clear.

## INSTITUTIONAL ENVIRONMENT

The institutional environment is established by public policy, regulation, labor practices, management, standardization and interchangeability, and supplier roles. These factors are so important that all but the last are covered separately in subsequent chapters—public policy in chapter 3, regulation in chapter 4, labor practices in chapter 9, management in chapter 10, and standardization and interchangeability in chapter 11.

The carriers depend on the supply industry for the development of new products. Unfortunately, many supplier firms are small, have limited resources, and cannot undertake sizeable research and development projects. Cooperative projects seem to be an answer in this situation. Cooperation among the supply industry, the railroads, and the federal government is already under way and should be expanded.

## COMPETITIVE ENVIRONMENT

Although the total traffic has increased, the railroads' share of the total freight market has dropped from 56 percent in 1950 to 38 percent in 1974. Competition from trucks, barges, and pipelines is intense. The greatest competition is from private and owner-operator truckers rather than from common carriers.

The cost of truck transportation has been lowered dramatically by the completion of most of the Interstate highway system, new equipment with lower fuel consumption, and the operations of owner-operators. In the past, truckers had a cost advantage over railroads on hauls of up to 300 to 500 km (200 to 300 miles). Today this may be 800 to 1000 km (500 to 600 miles) for many commodities, including those that are exempt from rate regulation, primarily agricultural products. Costs are also lowered by the truckers' ability to minimize empty backhauls by triangular routing or by using owner-operators who are content with infrequent returns to their home base.

Cost is not the only reason for the competition from trucks. The flexibility of trucks offers service to many shippers that railroads cannot match. Departures can be made without waiting for a train to be made up, detours can prevent long delays when the primary route is blocked, destinations can be changed en route, and local pickup and delivery can be avoided. Further, loss and damage en route in trucks is less since there is no slack action or bumping.

Thus the competitive environment is exerting tremendous pressures on railroads to lower costs and improve service. Unless these can be accomplished, the future may be bleak. Railroads could be restricted to a small number of routes with high traffic density and become primarily haulers of bulk material.

## RESEARCH IMPLICATIONS

Although the main purpose of this chapter is to provide a general overview of factors that affect railroad conditions and more detailed coverage of research topics is given in other parts of the report, the need for research on some of the topics discussed herein deserves to be emphasized.

In general, in view of the crucial effect that changes in some of the external influences (conditions of the rail transport environment) can have on the economic health and effectiveness of the rail transport system, two kinds of activities appear to be desirable—the development of a scheme for monitoring changes in these influences or environments and the development of a capability for improved analysis of the consequences of changes in en-

vironmental conditions. The ability to monitor changes is particularly to be desired in connection with markets for transport services and the availability of such things as energy and materials used in producing transportation. Analysis of the consequences of changes in the environments within which rail transport must function is particularly important in connection with changes in policies that govern the conduct of rail transport affairs.

# Chapter 2
# Private and Public Roles in Rail Transport

A research program directed toward the overall improvement of the performance of rail transport should be undertaken within the context of the roles the rail transport system should be expected to play in the U.S. economy. But the roles that rail transport may play in the future will be shaped not only by the desires and initiative of those who participate in rail transport activities but also by a number of influences now beyond the control of the direct participants, including public attitudes and policies (which have been shaped by a variety of historical factors), the availability and performance of other modes of transport, and the future markets for rail transport services.

Both external influences and conditions that have developed within the railroad industry have given rise to conflicting viewpoints and public issues concerning how the rail transport function shall be conducted in the United States. Some of these issues derive from past conditions; some have arisen more recently, as the conditions affecting rail transport have changed. The privately owned railroads have become the wholesalers of freight transport while the public role is now predominant in passenger service. The effects of these changes on the concept of common carriers are discussed in the next chapter.

## SYSTEM ORGANIZATION

Recent events and conditions affecting rail transport that have evolved in recent decades have stimulated debate over the question of whether the U.S. railroad system can perform its role effectively, or even remain largely in private ownership, if it is organized in the form of numerous separately owned railroads. Suggestions for reorganization range from the idea of one big railroad to various forms of integration, such as several large regional railroads; see chapter 10 for further discussion of the options.

While it is true that present-day U.S. railroads still tend to approach systems problems in an unsystematic way, the lack of unified system performance cannot be attributed to bad management; it is simply a product of no unified management at all. It is inherent in a system whose segments are operated by a number of independent units.

On the other hand, sole ownership of the entire U.S. railroad system, whether in private or public hands, would create formidable issues of public policy and, perversely enough, possible problems of operating efficiency. The United States is practically a continent in many respects and its sheer geographical dimensions would seem to indicate that there is less need for a single unified system than might be evident in a country of smaller physical size. At the same time, the idea of controlling railroad mergers and in other ways encouraging or even enforcing competition among railroads has historically had strong political and intellectual support in the United States.

### Problems of Separate Ownership

According to the free-market model, a number of firms competing in the same market should lead to economic efficiency. It is important to recognize why having a number of independent units tends to be a source of inefficiency in the railroad industry while it is assumed to be a source of efficiency in most other industries.

First, railroads must cooperate while they compete. The problem of separate ownership of railroad companies would be simpler if either half of this statement were not true. In the absence of the necessity for cooperation, the railroad industry would be like any other. Conversely, if railroads were solely complementary or end-to-end and could not, in any circumstances, compete for traffic, then their incentives for maximizing efficiency through cooperative arrangements would not be blurred by the present conflicting demands of competition. Therefore, on the one hand, the railroads must act as a system if they are to attain maximum efficiency but, on the other hand, a really wholehearted team player may feel that he is accomplishing very little except to make life easier for his competitors.

Second, the railroad system provides an almost perfect example of the truism that no chain is stronger than its weakest link. As a practical matter, most of the investment in ways and structures cannot be moved elsewhere. A railroad that is in financial difficulties for geographical reasons cannot simply pick up its trackage and move to a better location. But the fact that it is in financial difficulties does not diminish its importance in

the national system. Therefore, service standards for the entire railroad network and efficient use of everyone's investment in rolling stock both suffer from physical penalties inflicted by financial weakness, such as derailments and slow orders.

Third, even financial strength may create new problems of its own. Although experts on railroad finance stoutly maintain that the capital market for equipment trusts and other devices for financing railroad rolling stock is almost perfect (since equipment can be readily shifted from a defaulting debtor to another part of the system), the fact is that railroads with generally high credit ratings can negotiate equipment trust arrangements on more favorable terms. In addition, these preferred-credit enterprises tend, in general, to be among the more important originating railroads. Their systems are usually also the best maintained. But a new type of equipment that is a big success on a well-maintained and modernized roadbed may be a disaster on a line that is already out of date and undermaintained. The owner suffers from the effects of derailments. The railroad that is transporting the equipment suffers from the effects of accelerated wear and tear. No one is in a position to even calculate the appropriate trade-off between permanent way and equipment.

Fourth, the extreme complexity of interrailroad financial arrangements is an impediment both to achieving a unified systems operation and even to changing the financial arrangements. Rate divisions have often been handed down from the nineteenth century and may reflect commercial and operating conditions that have since been profoundly altered. But, in spite of the powers of the Interstate Commerce Commission (ICC) to alter rate divisions, the practical result has approached a stalemate. The very illogicality of many present-day rate divisions makes their alteration even less likely.

The problem is further complicated by two additional factors. The first is that railroad costs over the decades have not risen uniformly. Even after allowing for present diesel-fuel prices, line-haul costs have tended to be lower than terminal costs. Thus, predominantly line-haul railroads or railroads with long average hauls have tended to improve their position in relation to railroads with heavy terminal costs. The second factor is that competitive strength is not evenly distributed and in fact is becoming more unevenly distributed with the passage of time. The northeastern railroads never originated as much freight as they received. But before the appearance of competition from motor carriers the traffic they did originate moved at relatively high unit rates. Northeastern railroads therefore had a bargaining weapon at gateways that was greater than was indicated by data on weight shipped. The motor carrier has dulled the edge of this bargaining weapon, at the same time that industry has shown a persistent tendency to move out of the Northeast. All in all, rate divisions are likely to continue to be more the subject of internecine warfare than of harmonious and efficient economic allocation.

Fifth, the dynamic advantages of the independence of railroads have retreated by comparison with the static disadvantages. In the very early days of railroading, the existence of more independent railroads meant at least the possibility of more new ideas, and the existence of more new ideas meant at least the possibility of more good ideas. Thus, the possibility that many independent managements might lead to more dynamic change could easily outweigh the inconveniences caused by imperfect coordination of these managements at any given time. But as the industry matured two influences were at work to diminish this possibility. The first influence, in railroading as elsewhere, was the decreasing likelihood that major progress would stem from ideas that might occur to individual railroad managements. Barriers to the implementation of such ideas could range all the way from inadequate or uneven capital supplies to nationwide union rules. The second influence was peculiar to railroading. Most phases of railroad history have involved an inexorable movement toward greater average lengths of haul. The longitudinal growth of individual railroad systems has not kept up with this movement; there is therefore a higher ratio of interchanges to total traffic and a diminishing likelihood of successful innovations on a given system that could then be copied elsewhere.

Serious consideration of the nature and impact of these problems that are rather special to the railroad industry could well have led to the conclusion that present-day U.S. railroads are, in certain ways, too competitive to sustain a completely healthy industry. But public opinion with respect to railroads tends to be influenced by the remote past. The typical present-day approach to railroad problems is to start with the idea that railroads would be better off if they were both allowed to compete and forced to compete. The competitive answer to systems problems is to deny their existence. The opposite notion—that a better coordinated system may have even greater value than the sum of its components—remains to be seriously explored.

## Problems of Integration

Any move toward the integration of some or many present-day rail transport operations should not be made without weighing carefully the problems and disadvantages of very large enterprises in the transportation field. One type of problem has to do with sheer efficiency. Economies of scale are created by engineers and derive from exploiting certain properties of physical objects. Diseconomies of scale are created by no one in particular and derive from certain mental properties of humankind. The smaller the number of persons employed by any organization is, the fewer are the sources of friction and the greater the prospects of preserving individual interest and incentive. If people are hard to manage under any circumstances, they become still harder to manage if they are scattered all over the country. And this would be precisely the situation if all American railroads were combined into one. So, a key question is how one is to retain the personnel efficiencies of small groups with the systems efficiencies of a larger organization. As with many other economic problems, the key is in the trade-offs. But it is highly important that the alternatives be weighed against each other as carefully as possible, which creates a vital need for systems research in this area.

A second problem has to do with political weight. In some countries, the one big railroad is the largest single employer. This kind of situation creates incentives for collusion between management and labor at the possible expense of other modes of transportation or of the general public. If management is fragmented, as it now is in the United States, the risk of such collusion is lessened. If an integrated industry could stay out of politics, that would be all to the good. But, as witness Amtrak, ConRail, and practically all of railroad history in all countries, the industry cannot possibly stay out of politics.

A third kind of problem is associated with proposals for multimodal consolidation. It is argued by some that the amelioration of present difficulties faced by the U.S. railroad system lies not in the formation of an extensive system under unified management but in the formation of intensive systems under unified managements. What is needed, according to those who advocate multimodal

consolidation, is legislative authorization to permit railroads to establish or join in transportation companies—companies that would be free to transport by truck, by barge, or by pipeline as they might see fit. Efficiency would be prompt, it is claimed, because such companies would compete by using the most expeditious mode for given types of shipments. But this proposed type of integration also has its problems; it overlooks a series of built-in difficulties. When railroads get into common-carrier trucking, they get into an activity that most of them abandoned in some haste a long time ago—retailing. Most common-carrier trucking concerns concentrate on shipments smaller than that previous bane of the railroad industry, the less-than-carload lot. Most common-carrier trucking concerns are also organized under the auspices of the Teamsters Union. And all common-carrier trucking concerns, along with all railroads, are faced with the diseconomies of scale that result from adding to the number of employees. Finally, the trucking business has very little common ground, from the technical side, with the railroad business. Therefore, putting the two together must produce a conglomerate, and the recent general history of conglomerates does not inspire confidence.

## NEW ROLES IN RAIL TRANSPORT AFFAIRS

The preceding section discussed the proposition that a fragmented structure of independent railroads does not contain within itself the optimum ingredients for concerted or systematic decision making. In passing, the section also indicated that the present financial positions and future economic prospects of individual railroads seem to vary so much that a united front on the financial aspects of a systems approach is close to impossible. The section did not emphasize one important additional fact—that both railroaders and the general public are committed to the concept of private enterprise in railroading. The public is also committed to the concept of regulated private enterprise, which means that railroad private enterprises are not to be allowed to operate their businesses on the basis of unrestricted self-interest.

It turns out that under present-day conditions, regulated private operation is not compatible with financial viability for some segments or services of the railroad industry and may not be compatible with the future economic viability of other segments. For example, even if all past financial obligations were eliminated, there remains a question as to whether the present northeastern railroad network could slow down its capital consumption enough to remain economically viable. The financial situation of some of the railroads in recent years has forced the evaluation of a whole new set of decision-making arrangements. The participants in rail transport affairs must now adjust their roles in the decision-making processes that influence the nature of rail transport.

### Passenger Transport

Recent public policy decisions with respect to passenger services represent a marked departure from past practices. They not only involved splitting off the entire subsystem of intercity rail passenger service and handing most of what remains to a government-financed corporation (Amtrak), but they also involved special financial arrangements with respect to the subsystems that exist in several of the older metropolitan areas in the form of rail commuter service. Public funds are more readily available for people than for freight, partly because passenger service was the first to reach a financial impasse but also because passengers are aware of what is happening to them and capable of being exceedingly vocal if they do not like it.

The passenger systems decision is interesting for more reasons than the obvious financial one. There is nothing new about government contributions, at all levels, for transportation purposes. What is new is the combination of functional splits represented by the series of public decisions that have created Amtrak and the various forms of subsidy for rail commuter services. Amtrak is the consequence of a double split in responsibilities. The first split is that between responsibility for infrastructure and responsibility for operations. The second split is that between responsibility for passengers and responsibility for freight. The same double split is also characteristic of present commuter arrangements, although there appears to be some tendency for public authorities to go the whole way by acquiring the entire railroad operation, infrastructure and all. The public assumption of financial responsibility for commuter service involves yet another split, which distinguishes a special kind of local service.

Thus, public authorities in the United States have already grappled with a whole series of questions having to do with their roles as participants in railroad decision making. The passenger-service crisis first pushed them beyond their previous negative, or regulatory, role in the direction of affirmative decisions. The nature of the passenger-service crisis also pushed them beyond the guaranteed-loan approach, which was employed by the Reconstruction Finance Corporation during the 1930s and written into early postwar railroad legislation, into direct financing.

Government policy with respect to passengers has now gone beyond the whether, the what for, the how, and the how much; it must also address itself to questions involving for whom, for how long, and where. These questions have not been restricted to the federal level. Attempts to answer them with respect to commuter service have also been made by a number of states and cities.

### Freight Transport

What remains to be investigated and resolved is appropriate roles for private enterprise and public participation in the area of intercity rail freight transportation. A recent example of the socialization of facilities for the provision of intercity rail freight service is provided by the state of Vermont, which acquired the Rutland Railroad. This acquisition is worthy of more nationwide examination than it has received, but, given the location and size of Vermont and the relatively low levels of traffic on its railroads, Vermont's solution does not necessarily point the way toward appropriate national policy.

Because of the fragmentation of the railroad industry, even the basic issue of whether there should be any public participation is still unresolved. If the United States were served by one unified railroad system with a single corporate identity, a single management, and a single approach to financial markets, then there could be no such thing as a northeastern railroad crisis or a Penn Central crisis. A unified system would doubtless not be equally profitable or unprofitable in all of its parts. But public policy could approach two problems simultaneously: (a) how to identify unnecessary facilities or services and how to deal with them and (b) how to deal with whatever financial problems might remain. As matters now stand, an attempt to deal with railroad finances on the basis of a portion of the Northeast provides only limited access to the first question and no access at all to the second.

## INVESTIGATION NEEDED

Although it would appear that under present and future conditions some change in the way the U.S. railroad system is organized would alleviate some of the difficulties faced by many parts of the railroad industry, it is by no means clear what kind of organization would provide rail transport most effectively. As indicated in the preceding discussion, either a system that involves few railroads or a nationwide transportation arrangement that has a number of multimodal transportation companies would have definite weaknesses as well as certain advantages. Objective and thoughtful investigation is certainly called for. But, if such an investigation is launched, it should not be confined to the two arrangements that have been mentioned. Such other alternatives as functional decentralization should be included. A century ago, independent fast freight lines used the tracks of numerous railroads, and express companies and pullman service grew up on the same basis; Amtrak embodies the same principle today. It is possible that one way to both handle retail traffic by rail and assist with the small shipments problem would be to permit freight forwarders a greater range of unimpeded action.

# PART 2
# Problems in Rail Transport Affairs That Are External to the Industry

Providing rail transport involves not only operating services through dozens of discrete private organizations but also government participation—sometimes to stimulate development and sometimes to constrain. Changing conditions, with more changes to come, call for reexamination of the roles, relationships, responsibilities, and responses of the public and private participants whose ultimate aim is really the same—to provide a transport service that will enable our economy to function. The chapters of part 2 examine some of the problems involved in adapting the roles of the participants in the transport function (including the public participants) to the conditions of today and tomorrow and suggest some research-related activity that may aid in deciding on the courses of action that will affect the future of rail transport.

# Chapter 3
# Transport Policy Problems

## ROLE OF PUBLIC POLICY IN THE TRANSPORT SECTOR

Public policy in the transport sector is as old as the U.S. Constitution. The need for public policy in the transport sector was, in fact, a primary reason for drawing up the Constitution. Under the Articles of Confederation, individual states were developing public policies within a narrow framework that imposed increasing burdens on interstate commerce.

The first role of national public policy was to bind the country together. The first important manifestation of this role was the creation of the Post Office. A second took the shape of legislation about rivers and harbors. Both the National Pike and the eventually successful agitation for a Pacific railroad were within the overall framework established by national goals.

A second role of national public policy was to encourage infant industries. This encouragement was not confined to transportation. It was first supported by Alexander Hamilton soon after independence was won and first appeared as settled national policy in the tariff legislation of the 1820s. But it is to be found as an element in the early development of almost every form of transportation. Early canals were often regarded as infants worthy of support. So was an early highway from the eastern seaboard into the old Northwest Territory—the National Pike. So were railroads, in both their infancy and their adolescence. And so are inland waterways and certain aspects of the air travel industry to this very day.

This second role of public policy carries us back from the national level to the state and local. The panic of 1837 wiped out the value of state and local public investments in both canals and railroads, but it did not kill the enthusiasm for state and local subsidies. Every village wanted to become a town and every town wanted to become a city; improved transport facilities were an obvious aid to both. The preference was to obtain the facilities at the expense of some other government. But, if worse came to worst, communities were very imaginative in thinking up plans for local transport improvements and in trying to finance these plans. It may be useful to summarize the kinds of issues with which American public policy is still struggling.

The first of these involves the relationship between operations and infrastructure or, in economic terms, the degree of vertical integration. The idea behind the earliest railroad construction was the same as that behind early canal and turnpike construction: The fixed physical plant would be under one ownership and would make its facilities available for a fee to all comers. For technical reasons, this approach is workable for turnpikes and canals but not for railroads. A railroad cannot be operated successfully or even safely if the owner of way and structure must offer his facilities to every passing stranger. Therefore, if there is to be a divorce of the operator from the railroad provider, this divorce can be made workable only on the basis of a long-term contract like that between the city of Cincinnati, as the owner of the Cincinnati Southern, and a subsidiary of the Southern Railway. Public policy has not even begun to face up to an analysis of the cases for and against separation of ownership of facilities below the wheels from reasonably long-term use of these facilities. Nor has it faced up to an important question: If private ownership cannot be preserved for every phase of the railroad industry everywhere in the country, what can and should be saved, in what way, and on the basis of what decision about preserving existing patterns of vertical integration?

The second issue was discussed in chapter 2 and involves the advantages and disadvantages of Balkanization, a derogatory term in railroading as well as in Eastern European history. Efficient railroading requires either one big railroad or at least the closest possible cooperation among different systems, but American policy has never abandoned competition as a desirable attribute of the railroad industry. So the public policy dilemma becomes: How can we have competition without Balkanization? If this is impossible, what is the optimum trade-off between the two?

The third issue involves problems of shifting intellectually from the idea of infant industries to the idea of industries that are fully mature. The railroad industry is probably the oldest large-scale industry in the world that is still relying on its original basic techniques, even though diesel has replaced steam and the iron age has given way to the steel wheel on the steel rail. Behind public policy lies public psychology. And American public psychology has been much more attuned to growth and development than to resuscitation and redevelopment.

Among the policies yet to be established is the government's approach to even-handed treatment of competing modes. Effective government subsidy to trucks and barges through provision of free or discounted rights-of-way gives them economic advantage in competing for traffic. It also forces rail rates down even when there is no direct intermodal competition, since competing railroads must try to protect their existing traffic within a spectrum of rates that has been depressed by external competitive factors. In any event, public policy will determine the institutional environment to a great extent, even affecting whether the railroads remain in the private sector or come under public ownership.

Public policy has changed to a realization that the

industry is in trouble, needs help, and is a national resource worth saving. Evolutionary changes will continue and of course will impinge on all types of regulation, taxes, and subsidies. For example, creation of state departments of transportation and state transportation planning (now including rail) will bring about changes in public policy.

## PUBLIC SERVICE RESPONSIBILITIES

By its very nature, transport has a public service role. Almost from the outset, the railroads were forced to assume a heavier burden of responsibility for public service than most other industries and most other modes of transport. When the railroads had a virtual monopoly on land transport and the economic welfare of many businesses, communities, or even whole regions depended on rail services, it was perhaps only natural that public policy called for maintenance of appropriate levels, prices, and quality of service. But under present conditions, with the railroads playing a much different role than they did formerly in supplying transport to the economy, questions about the nature and extent of public service responsibilities to be met by the operators of rail transport services are pertinent. It is only a partial truth to say that railroads should no longer have to shoulder the public service responsibilities that were first imposed on them when they had a monopoly. The rest of the truth is that some of these public service responsibilities have never been shifted anywhere else. As a matter of transport practice, the common carrier hired by most shippers is not the common carrier that existed in the days of railroad supremacy. It would be premature to talk about equalization of public service responsibilities. The first step is a comparative examination of these responsibilities.

A number of factors have contributed to the accumulation of a rather special set of public service responsibilities by the railroads. These include railroad technology, certain peculiarities of railroad economics, the way in which other modes of transport have developed, and the momentum of history.

Railroads are capable of transporting a wider range of commodities than any other mode of surface transport. This is true because they are unspecialized as compared with pipelines or even barge lines and also because the scale of individual railroad enterprises is large in relation to most truck lines. This scale of enterprise is, in turn, largely a function of railroad technology. As noted earlier, it is simply impossible to turn railroad operators loose on a stretch of track in the way that separately owned trucks may be given access to a stretch of highway. Railroads have therefore always had broader responsibilities for carriage of commodities than their modal competitors.

A responsibility for providing service is not the same thing as a responsibility for providing any particular kind of service at any particular price. The earliest railroads began to charge differentiated fares for passengers before they got around to differentiated rates for freight. For the first half-century or more of American railroad history, there was not even any systematic distinction between rates on carload and on less-than-carload shipments. But as early as the 1940s, it was noted that (a) average costs for railroads tended to be substantially above their incremental or marginal costs; (b) demand elasticities of different shippers were systemically different, normally being lowest for commodities of high unit value, for which transportation costs were in any case a small part of the total delivered cost, to being highest for low-value bulk commodities; and (c) a system of differential rates for different types of shippers would enable the railroad to earn more profits. This encouraged the growth of the practice of charging what the traffic will bear. In an imperfectly competitive industry of primary national importance, this practice immediately gave railroad rates some of the attributes of taxes and therefore attracted political attention.

Whatever excess profits were produced by charging what the traffic would bear were converted into higher costs. In particular, railroads were expected to extend their systems and their services to soak up excess earnings. A system practically without branch lines, such as the old Boston and Albany, made its contribution by constructing beautiful and expensive suburban stations in the Boston area. Midwestern railroads made theirs by competitive branch-line construction that produced many miles of line that were uneconomic from the outset.

Public attitudes toward railroads grew up in a period when the railroad problem only began with the fact that the railroads had a monopoly. In the nineteenth century, the United States was still a rural and agricultural country. In the geographical perspective of the average farmer and small-town dweller, only one railroad had a monopoly. So the monopoly problem was both modal and corporate.

Two things have happened since. One has been the growth of other modes, which has meant competition not only for the railroads but also competition—even in small towns—within the highway mode in particular. A motor truck is much better adapted to service for small shippers and small towns than railroads could ever be. The automobile (for short hauls), the airplane (for long hauls), and the motor bus have provided certain service characteristics that have enabled them to supersede the railroads as major haulers of passengers. Along with this growth in competitive service capability for the less densely populated parts of the country has gone a relative and even absolute decline in the importance of rural and small-town populations. Both influences operate in the same direction—to diminish the need for public service responsibilities or obligations on the part of the railroads.

The growth of motor carriers of passengers and freight, of inland waterway facilities and barge lines, and of pipelines and other forms of nonrail transportation of energy has greatly reduced the need for public service responsibilities for the railroads; the lower volume has increased the unit cost of providing them. From the standpoint of the railroads or of any other industry with a long history, the outstanding feature of responsibilities is their inflexibility with the passage of time. As chapter 2 noted, railroads are now largely out of the passenger business, but, except for the increased volume during World War II, their departure from passenger carriage between 1929 and the establishment of Amtrak was slow and costly. The entire structure of railroad public service responsibilities has never been systematically and thoroughly overhauled to allow for application of the internal-combustion engine to rubber tires and wings.

The same inflexibility is still evident with respect to freight. Even amid the present energy crisis, for example, no one is proposing a massive expansion of the output of anthracite coal. Yet whole areas of the northeastern railroad map are still occupied by railroads that were built to haul anthracite. Redundant capacity, which was originally created for what is now an obsolete purpose, still lives on, although the formation of ConRail has reduced that capacity.

## MODERNIZATION OF PUBLIC SERVICE CONCEPTS

There are now a number of important questions about public service responsibilities in several sectors of transport that need thoughtful attention. Given the present supplies of transport and communications, what are the obligations for public service? Who is responsible for those that can be identified? How should they be financed? Detailed answers to such questions will require value judgments as to what the American public really needs compared with what they have or have taken for granted. But one could start with an examination of the existing responsibilities for service on the part of providers of services that have a strong element of public interest.

A general responsibility of the railroads, as vertically integrated firms, is to maintain their own infrastructures and to provide some minimum level of operations over them. Obviously, as both the record of deferred maintenance and the prevalence of slow orders indicate, this railroad responsibility does not result in a clean-cut obligation. However, there are obligations for safety that are not directly related to commercial or revenue considerations.

The extent of railroad responsibilities in relation to railroad infrastructure is not the whole issue. To the extent that railroads are in competition with other forms of transport, the important consideration may be the relationship between these responsibilities and the comparable responsibilities assumed or not assumed by other modes. Starting with the obvious contrast between railroad responsibilities and the absence of charges to the user for routine maintenance and operation of inland waterways, the comparison should proceed not just to the amount of responsibility assumed by different modes of transport for their infrastructures but also to the financial form that this responsibility takes. The pay-as-you-go financing involved in truck license fees and fuel taxes is different in kind from capital investment financing (borrowing) by the railroad industry.

Public service responsibilities may accrue not only because of what has to be done, but also because of how it has to be paid for. It is undoubtedly easy to exaggerate the extent of below-cost railroad rates. Certainly, the mere fact that a rate is lower than the fully allocated cost does not qualify it for consideration. But in a system of regulatory rate control, divided to some extent between national and state levels, there is always a possibility of below-cost rates. For an industry that has a shifting commodity mix and geographical distribution of traffic, this possibility becomes almost a certainty—and not just with respect to branch lines.

## SUBSIDIZATION

The issue of subsidization has been clearly raised in connection with the northeastern railroads. It has already arisen for passenger service on both Amtrak and commuter railroad lines in several large metropolitan areas. In this respect, the United States is merely catching up with what has been happening in practically every other country. The difference is that, at the national level, U.S. policymakers have not thought in terms of subsidies since 1876 and have never thought in terms of subsidies to maintain, rather than create, railroads.

The world of subsidies is a world in which government policies are not optional; they are compulsory. It is a world in which quantification is essential. It is a world in which some degree of planning is the only way to distinguish efficiency from waste. It is a world that presents new questions at every turn—how much to be paid by whom, with what promise of continuance, subject to what criteria of performance, with what arrangements to provide or preserve incentives for efficient management, and with what provisions (if any) for public direction or control; there is also the question of whether the subsidies are open ended.

It might almost be said that some American railroads have already been subsidized, from 1930 through 1940, and almost continuously since the early 1950s. This subsidy was provided by railroad security holders. Now they are in some cases unable and in others unwilling to continue to participate in the consumption of private capital. Thus the crux of the subsidy issue is how to shift at least some of the burden from private to public shoulders, without creating windfall profits for the former in the process and without irreparable loss of service quality during the transition.

Public highways, public waterway improvements, and public airports are not subject to local property taxes. In most states, railroads are subject to such taxes. Public facilities may make payments in lieu of taxes to their sponsors, but railroads must make local tax payments. Even bankruptcy only postpones some kind of reckoning. State and local bonds sold to finance improvements to public transportation do not involve new income tax burdens either for the seller or the buyer. A privately owned railroad that needs to gain new capital must reason as follows: If we choose to raise this capital in our own name, we must either incur interest obligations—tax-free, as a cost, but confined within definite boundaries both as to the balance sheet and as to the income statement—or we must try to sell new stock, which is likely to go on the market at less than book value or (for the most successful railroads) involve payment of more income tax to the extent that the new investment generates new earnings. Finally, the buyer of a railroad security must pay income tax on whatever income he receives from the security. The purchaser of a state or local debt pays no federal income tax on it at all. Thus, the supply of facilities by government is not necessarily the same as subsidy, but it does have something in common.

Since there is no major railroad outside of the United States, aside from the Canadian Pacific, that is privately owned and privately operated, the idea of public ownership is scarcely new or radical. In fact, it first came about in many countries not because those sponsoring it had any great faith in public ownership but simply because they felt that indispensable transport services could not be adequately financed in any other way.

We are already subsidizing practically all forms of rail passenger service. We are confronted with the need for a public subsidy program. We may therefore soon be faced with a number of questions about public ownership that are essentially nonideological (and therefore amenable to research).

## NEED FOR RESEARCH ON PUBLIC POLICIES

The idea of complete equality for the whole transport sector in relation to other sectors is chimerical. Quantification of what would be involved financially in an effort to achieve such equality would be a pointless statistical exercise. But progress can be made within the transport sector itself, by attacking a number of questions. How much transportation does the public want? How much, in the way of public funds, are representatives of the public willing to commit to satisfy public service requirements? What scale of physical plant, scale of operations, and modal split of traffic are deemed

to be in the public interest? To what extent is the public willing to see this modal split altered by removal, reshuffling, or new imposition of public obligation on different transport modes? Is there a case for having a certain amount of transportation insurance in the form of excess capacity in infrastructure or elsewhere? If so, which mode should be expected to provide what amounts of such insurance, in what forms, and subject to what arrangements for reimbursement? Is there a case for any form of deliberate subsidization of technical progress in the railroad industry in order to place it, in at least some respects, in the forefront of transportation progress and not stuck far behind, amid the problems of deferred maintenance?

In developing an investigation, the following guidelines are suggested.

1. The private-enterprise U.S. railroad industry is on trial.
2. The kind of market solution that is the standard economist's prescription for most private industry is compatible with neither the history of American railroads nor the current status of railroading anywhere else in the world. This investigation need not involve any appreciation of regulation as such or of any specific regulatory principle or activity. But it must involve a question that is governmental rather than regulatory: What specific public policy objectives and unusual economic characteristics combine to place railroading somewhat apart from the unrestricted operation of competitive market forces?
3. Emphasis must be placed on the longer range aspects of the railroads' position in the U.S. economy.

Topics for study should include the following.

1. What public policy objectives are imposed on railroads in other countries, and what public regulation or assistance (in the form of public ownership, public subsidy, and so on) is used to realize these objectives? What is the relevance to American conditions of these objectives and of the methods used to achieve them?
2. What are the probable consequences of different forms of government intervention in the railroad industry, e.g., complete public ownership, public ownership of rights-of-way, assistance with respect to operating costs, guaranteed loans?
3. If public ownership is deemed necessary or unavoidable, what consequences would follow from its being limited as to geographical area, duration, or financial commitment?
4. Under what circumstances is it practically possible for organizations run for private profit to receive substantial or continuing public subsidies and yet retain incentives to increase efficiency and avoid loss?
5. What would be the total incremental cost burden on other methods of transport, and on users of these methods of transport and competitors for the infrastructure they employ, of complete discontinuance of U.S. railroad service?
6. To what extent are the supposed cases for and against public ownership actually cases for and against the existence of a monopoly railroad that serves the entire country?
7. What special problems with respect to the employment, deployment, and remuneration of the labor force would be created, or alleviated, by public ownership? Could any substantial change be anticipated?
8. What are the implications of a series of such scenarios as the following:

a. Consider railroads as a historical relic or potential vestige restricted to odd corners of the United States where certain branch lines can be turned over to railroad buffs for their amusement. In short, assume not only that railroads have ceased to constitute the backbone of American freight transport but that they have ceased to be worth the cost.

b. Assume that a substantial role remains for American railroading but that this role can be performed properly only if money-losing portions of railroad operations are rigorously excised; losing portions are isolated, and losses are quantified to qualify them for public subsidy; subsidies are either withdrawn from competitive modes of transportation or awarded in forms and on bases that are not now employed; or as a matter of public policy, the whole problem is dumped in the lap of the free market—a solution that would presumably involve the first condition above if the structure of American railroading were such as to permit each separate management to respond without distortion to the market's stimuli.

Any attempt to choose among the categories listed above must first address the question of why. The answers to this question will, in turn, have substantial influence in answering the more strictly financial questions—how much, by whom, and so on. Given the present situation of American railroads, the next move must be treated as it is in chess. A move in chess is a finite and irrevocable act that must be preceded by a weighing of alternatives and their consequences as far as the human mind can reach. In short, it involves a very sophisticated form of sensitivity analysis. Moreover, the chess idea of unfolding alternatives must be combined with a probabilistic approach. Although no future event is certain, some events are less likely than others.

# Chapter 4
# Regulatory Problems

Regulatory policies are of two distinct types. The first consists of economic regulation, originated in the nineteenth century, and has always been centered on railroads; the second consists of safety, environmentalism, consumerism, and attempted response to energy problems. The first type is mature, at least; the second, except for safety, is in its extreme youth. They therefore require separate consideration.

Since the very idea of regulation is to force someone to do what he would not otherwise do, all regulation has economic results, whether they are intended or not. But in the United States the most important aspects of regulation from the standpoint of the ultimate consumers have had economic intent. Of course, they have not had their intended economic results.

Safety regulations, which have had some importance for the population at large but very great importance for railroad employees, provide a very early example of the kind of regulatory approach that is now being applied to a widening series of problems in widening areas of the economy.

In recent years there has been a considerable change in attitude toward the concept of regulation in transport, and the idea of economic deregulation of all modes of transport has received more public attention of late than in any comparable period of American history. The general idea appeals to very different groups of people—to conservatives who believe in less government in business and more business in government, to radicals who believe that regulators and the regulated necessarily form unholy alliances for the purpose of ripping off the consumer, and to harried Treasury Department officials who find that deregulation is one of the few government acts that might both gain some popularity and save the government a little money. The Civil Aeronautics Board (CAB) has already seriously considered relaxing its regulatory grip on the airlines. Although changing circumstances have caused difficulties in the application of regulations, this does not necessarily mean that the whole concept should be abandoned. But it has now become important to consider different degrees or different concepts of regulation.

In attempting here to provide a brief perspective on regulatory practices and issues, it should be recognized that regulation pervades all of the activities of society and that the regulatory problems of transportation as a whole are broader than those of the railroads. The regulatory problems of the railroads arise in part because other modes of transport are regulated differently. It would be unwise to expect that a new era for the railroads would arise merely from changes in or abandonment of railroad regulation. In other words, the railroads' financial condition won't be solved by deregulation.

## ECONOMIC REGULATION

Three basic aspects of economic regulation affecting how business is currently conducted pertain to rates, services, and change in corporate form through mergers. In addition, regulatory practice takes cognizance of right of entry (or exit, in the case of abandonment of branch lines). These regulatory aspects need to be considered in relation to other modes of transport as well as in situations that are unique to the railroads.

### Rate Regulation

The ICC has authority over all railroad rates, both directly for interstate shipments and with power to overrule state regulatory bodies if it can be established that state rate decisions place a burden on interstate commerce. The ICC has less authority, or no authority at all, over at least half of all movements by truck. It has no authority over goods being trucked from place to place by their owners, over exempt commodities (practically equivalent to agricultural commodities), or over intrastate rates (which are relatively more important for trucking than for rail). A substantial portion of the movement of goods by regulated motor carriers is performed by the contract carriers, a category that has no equivalent in railroad regulation. In practice the ICC has no authority over the great bulk of shipments on the inland waterways, including a preponderance of those that move by common carriers.

With the growth of the trucking and barge-line industries, the unregulated sector has steadily grown, both absolutely and in relation to the regulated sector. Thus, the railroads are subject to more rate regulation than other carriers, taken as modal groups. Railroad rate regulation applies to all commodities from all shippers to all consignees to all destinations (with some relatively unimportant intrastate exceptions).

Railroads have shared with all common carriers the onus of having to request and establish a case for successive rate increases in a first wave after World War II and a second wave during the inflationary surges of the last decade. In this respect, common carriers have been set apart from the average or normal business, except for brief periods during the various price control phases that began in August 1971. But railroads have one specific and important difference from the public utilities, which is the most prominent group outside of common carriers that has regulated rates. Cases concerned with the level of public utility rates revolve around such issues as what the utility is earning on its equity or on its total investment, what it should earn, and how much rates need to be increased to raise earnings to the target level. Throughout this process of rate-level determination, the guiding consideration is that the utility shall be permitted to charge rates high enough to allow it to earn enough to enable it to raise new capital without undue dilution of the previous equity. This central concept of the opportunity cost of capital is foreign to the railroad industry and has been since the repeal of the Recapture Clause of the Transportation Act of 1920, soon after the onset of the Great Depression. The guiding consideration in railroad rate-level cases is how the new rates compare with the old rates, not whether either new or old rates provide an adequate return on invested capital.

This does not, of course, mean that the ICC is depriving American railroads of their constitutional rights under the fourteenth amendment. Indeed, in the average rate-level case, railroad spokesmen first present statistics that purport to show that railroads earn a lower per-

centage of return on their assets or equity than any other privately owned U.S. industry and then go on to request rate increases that would, even in the absence of traffic erosion, still yield them only a subnormal return. So the point is not that the ICC is committed to the expropriation of railroad property. Instead, the question is whether, in an industry that is expected to remain in private ownership and therefore to raise or at least retain its own capital, regulatory practice should persistently prescribe maximum rates that, on the basis of all the available evidence, cannot produce returns sufficient to attract capital or perhaps even to retain it? If the view is that the real constraint on railroad earnings is provided not by ICC decisions but by competition from other modes of transport, they why attempt to impose regulatory rate-level ceilings at all? Or, if the view is that the asset base that is the denominator of the earnings ratio is inflated by obsolete and often undepreciated assets, why not write these off for regulatory purposes and determine what percentage is being earned on supposedly viable assets that at some point must presumably be replaced?

The rate structure for railroads differs from that for motor carriers in that the initial structure is typically much more complicated and the possible national repercussions that would be caused by changes in railroad rate structures are often greater. Railroad rate structure cases differ even more from utility rate cases. No electrical utility covers the area served by even a moderately large railroad. No utility commission would receive evidence with respect to possible competitive damage done to users of electricity in one supply area by a reduction of rates for this type of customer in another supply area. On the other hand, the ICC has had a tendency from the outset to view the structure of railroad rates as a seamless web. The structure of rates came to be regarded not simply in relation to the structure of a given railroad's costs, the costs of all railroads, or the costs of competitive modes of transport but primarily in terms of their relationships to one another. In the process, outmoded notions of value of service and inapplicable confusions of marginal and fully allocated cost have tended to creep in.

Finally, with respect to the intraindustry aspects of rate structure, the regulatory problem has been not what the ICC has done to the railroads but what the railroads have tended to do to each other. The ICC has had full legal powers over rate divisions (allocations of through rates among cooperating carriers) since 1920. It has on occasion exercised these powers. But rate divisions are now set by difficult negotiations that verge on pitched battles between carriers.

## Regulation of Services

It is an irony of history that service regulations (including standards for on-time arrival, overnight accommodations, and meal service) were imposed on passenger trains almost on the eve of the disappearance of most private railroad passenger service either into Amtrak or into oblivion. Even the CAB, which deals with a form of transport that places the greatest emphasis on service, has never specified detailed flight schedules or detailed equipment requirements. Commercial considerations, not the ICC, have regulated the quality of freight service provided by rail and especially by truck (except the requirement for reasonable dispatch).

But if neither railroads nor their competitors are held to regulatory standards with respect to when or how fast they must move freight, they are held to different standards as to what they must move. Railroads are held to be true common carriers. So-called common carriers in the trucking industry do not hold themselves out to move low-rated (bulk) commodities and typically limit themselves even more as to commodity mix by limiting the types of equipment they operate. Haulers of miscellaneous merchandise normally do not haul the kinds of liquids transported in tank trucks and vice versa. United Parcel Service, by far the largest single motor-freight carrier in terms of revenues, will accept no individual packages that weigh more than 22.5 kg (50 lb). Other motor carriers, even those who specialize in less-than-truckload freight, impose minimum charges that effectively eliminate them from this low-weight market. Pipelines are much more specialized, due both to their commercial purpose and to the inherent characteristics of their technology. The railroad is not just one of many common carriers. In a sense, it is the only common carrier.

## Regulation of Mergers

Regulation also sets railroads apart with respect to merger policy. The ICC has powers with respect to mergers of motor carriers comparable to those of the CAB for air carriers, the Securities and Exchange Commission for public utility holding companies, and so on. A merger case of any kind before any of these bodies may drag on almost interminably. But with respect to railroad mergers, since railroad cases typically involve larger enterprises than motor carrier cases, they may be expected to take longer, and, since many railroads are in poorer financial condition than practically any utility, most trucking concerns, or even most airlines, regulatory delay in merger proceedings may amount, in effect, to a sentence of slow death. For example, the Chicago Rock Island and Pacific Railroad Company was presumably a bride with an attractive dowry at the start of its proceedings for merger with the Union Pacific Railroad. By the time the proceedings were concluded, the bride was so ravaged by malnutrition that the erstwhile suitor had completely lost interest. (A provision of the Railroad Revitalization and Regulatory Reform Act calls for speedier decisions.)

## Statistical Reporting

One of the most important by-products of the regulatory process, in the railroad industry as elsewhere, has been the compilation of masses of statistical data in forms that often do not exist for other industries. Since railroads were the first group of large-scale corporations whose securities were widely held, certain financial and operating data for railroads were available long before the creation of the ICC, which was the pioneer in setting up standard reporting requirements and introducing a standard system of accounts. The general financial information thus obtained has since been supplemented by data used to establish the costs of movement of specific commodities, in specific types of car, and so on. In addition, almost every case before the ICC is embellished with vast masses of additional data, often collected on an ad hoc basis and to support an adversary position.

There is now a need for a reevaluation of why data are needed with respect to railroad transportation—who needs them, for what purposes, on what scale, and over what periods of time? The format of regulation is essentially to tell people what not to do. This purpose inevitably affects the process of establishing data requirements, collecting the data, and analyzing them. But this is at best only one aspect of the uses of data required by an efficient railroad transportation system. Moreover, many railroad data predate not only the computer but also modern cost accounting and many other tools of

modern business management. For example, the cost of moving a carload of a specific commodity between two points cannot be ascertained from the ICC cost accounts. There is a problem of confidentiality here, for no business likes to surrender to the ICC or any other outsider all the information on which it makes financial and operating decisions, but there is also a problem of expanding public knowledge. If some ICC data provide information about railroads that is not available for other industries, it is also true that the Census of Transportation, unlike the Census of Population or the Census of Manufactures, is not a true census since it is the product of a limited sample of a restricted range of commodities. Given the present condition of the railroad industry and the large areas of ignorance with respect to how goods really do move in the United States and by what mode, regulatory history is clearly of less pressing concern than current information.

## Influence of Historical Antecedents

Quite apart from the data problem, it is important to recognize that regulatory practices are by their nature a product of the past and railroad regulatory practices even more so. The most obvious regulatory carry-over of the past into the present and future occurs in connection with so-called regulatory lag. In its simplest form, this can occur because it obviously takes time to hold hearings, write briefs, and reach decisions. A plea by a carrier for a rate-level increase must be accomplished by hard data, not mere forecasts and suppositions, but there is no possible way to obtain hard data on the future. Finally, and most importantly, regulation operates on the basis of precedents and would create absolute chaos if it did not. And the force of precedent may extend not just for the months or years normally required to dispose of a major regulatory proceeding but for generations.

Moreover, this built-in lag of the regulatory process is piled atop what has to be a considerable lag in the congressional decisions that set the regulatory process in motion. The Transportation Act of 1920 was years in gestation. It was a product of some of the most careful thought that any legislative body has ever given to any legislation. As an approach to the problems of regulating railroads, it was a masterpiece. As an introduction to an era in which trucks were to provide the most rapidly growing form of freight transportation and in which public funds were to be lavished on inland waterways for the first time in almost a century, the Transportation Act of 1920 is not a guide to forward-looking transport policy but a museum piece. The ICC cannot be blamed entirely, if at all, for the decisions it rendered pursuant to this act. Instead, the entire record before and after 1920 should stand as a reminder that generals are not the only public officials with a supposed propensity for fighting the last war.

Some examples of other interactions between historical events and the regulatory process that have tended to result in extending the past into the present are inflation, antitrust activities, and the concept of private carriage. General inflation should have nothing to do with regulation of railroads or anything else, but, for a number of reasons that are extraneous to any sort of regulatory principles or to the economics of the industry being regulated, regulation tends to be at its most severe during periods of rising prices. It is in exactly such periods, moreover, that managements need maximum flexibility. Inflationary price advances are highly irregular and touch one commodity or wage agreement at a time. Data from the past are least reliable under exactly these conditions, and management time consumed on regulatory cases is very high under these conditions.

Antitrust activities might be described as "anti-regulation." One position holds that regulation and enforcement of antitrust laws are essentially substitutable, with the latter normally considered superior to the former. The presumed point of antitrust activities is to enhance the strength of competition and to obtain the improved allocation of productive resources and the more highly dynamic economy that are expected when market forces rule.

One anomaly in the railroad's position is that competition has always been viewed as a desirable supplement to regulation. In both transport legislation itself and in its administration, the expectation is clearly that railroads should be both regulated and competitive. This idea of competition as the handmaiden of regulation is only beginning to appear in federal regulation of the telephone industry and has made little headway even in principle since the development of the "yardstick" argument for public power during the 1930s, when it was proposed that, in the absence of competition among utilities, the Tennessee Valley Authority would serve as a yardstick of what the cost of power should be.

Presumably if all economic regulation of railroads were eliminated, railroads would become fully subject to all the provisions of antitrust legislation, including the Clayton Antitrust Act of 1914 and the supplementary Robinson-Patman Act of 1936. In view of the exceptional complexity of railroad tariff structures and the extreme spread of rates within that structure, such exposure might create something approaching temporary chaos. Conversely, there remains the basic issue of public policy: How much intramodal competition among railroads do we want? Where, in whose behalf, and in what form? Has the growth of other modes of transportation weakened the case for insisting on competition among railroads as well as the case for traditional regulation? And what are the competitive aspects of permitting railroads to extend their ownership to other modes in order to become transportation companies?

A major influence behind the passage of the Motor Carrier Act of 1935 was protection of the railroads. This legislation was based on a misconception even from the outset, as regulated motor carriers immediately proved by adopting railroad tariffs as their own and then beating out the railroads on the commodities of their choice by providing better service. Now, however, there is at least as much enthusiasm for regulation as a means of protecting these same regulated motor carriers. Obviously, they never did need protection from the railroads. Perhaps not so obviously, attempts to protect them from each other are subject to rigid constraints in the form of competition from private carriage. If large firms are more likely to be able to benefit from private carriage than small, we have now come full circle. Regulatory policies that once attempted with some success to protect the small shipper from the large now operate in an environment that compels regulatory bodies to leave to larger shippers advantages that small shippers cannot obtain. Research is needed to answer this question about the effect of private carriage on small firms.

## Search for a Regulatory Stance

Both current regulation and complete deregulation have their dedicated champions. For either group, research may appear to be unnecessary. Articles of faith do not bend readily before the pressures of either facts or analysis. But there remains a research area of enormous pragmatic importance that might appropriately be

described as the area of search for principles of up-to-date regulation, including the following.

1. In view of the financial condition of much of the railroad industry and the need to raise new capital even to bring some main lines up to their standards of a generation ago, how relevant is the whole question of regulation, compared with total or partial deregulation? If all modes of transport were deregulated, would this make railroads more competitive with trucks or trucks more competitive with railroads? If regulatory reform is supposed to assist the ultimate consumer, from which pocket will the assistance be taken? Unless regulatory reform could make railroad operations more efficient, how could it assist in solving the financial problems that loom very large in any overview of the industry? And, if regulatory reform were intended to make railroad operations more efficient, how would that specifically come about, and with what assurance can any forecaster predict this result?

2. Railroad operations in the United States involve almost infinite combinations of out-and-out competition, competition plus cooperation, and out-and-out cooperation. Even when the relationships would seem to be most purely cooperative, as with end-to-end connections that do not parallel each other or serve overlapping territories, there remains enormous scope for what has always been one of the railroad's favorite forms of competition—competition as to which railroad can obtain a larger division of the through rate. Moreover, end-to-end connections that may seem to have nothing to do with the competitive posture of any one railroad may in fact have everything to do with it, if the connecting line has no interest in maintaining service standards or has inadequate physical capability to handle the traffic thrust upon it. Therefore, to say that regulatory reform would mean more intrarail competition is both to take too much for granted and to pass directly over the central issue of the special attributes of competition in the American railroad industry.

Intermodal competition is a different case. Railroads have probably lost less-than-carload traffic forever and are probably none the poorer for it; they have lost practically all short hauls of high-value commodities; they have lost the heaviest and lowest value bulk commodities along the major waterways; they have lost movements of energy to the electric transmission lines and of oil to the pipelines; and they are threatened by slurry pipelines for coal. Conversely, there still may be important commodities and important areas of the country where either the railroads have a monopoly or individual railroads have a monopoly. Should rates be completely deregulated under these circumstances? And how does a collective railroad monopoly resemble and differ from an individual railroad monopoly?

The most compelling element in the case for regulatory reform is the claim that it would give railroad management more freedom, but capital obviously provides one economic boundary to management freedom; management-labor relationships have historically provided another. Will less regulation and more competition create new areas of cooperation between management and labor? Can pressures of competition ever be expected to achieve anything more for productivity in the railroad industry than has already been achieved in a more regulated and possibly less competitive environment?

## ADMINISTRATIVE REGULATION

Regulation of the administrative type is important for at least three reasons—the changes in public attitude they reflect, their tendency toward rigid standards and absolute prohibitions in contrast to the relativistic or economic approach of traditional regulation, and the fact that the assumptions about the environment and energy that lie behind some of the new regulations and the new regulatory bodies that administer them may tend to improve the economic position of railroads in relation to highway vehicles. The new regulatory bodies include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Federal Energy Administration (FEA).

Until 1970, safety regulation was confined to locomotives and signals. In that year, the Federal Railroad Administration (FRA) was given the responsibility for safety regulation in all aspects of railroad operations. Standards have been issued for track and for rolling stock. Transportation of hazardous materials, particularly toxic or flammable fluids in tank cars, has been the objective of several research and development projects and much controversy. As tank cars grew larger, the danger of catastrophy in derailments or collisions has become higher and standards for design and yard handling of tank cars have been issued. The AAR, the FRA, and the Brotherhood of Locomotive Engineers have cooperated in a project to make locomotive cabs safer for crews.

Another aspect of safety regulation is human factors (discussed in chapter 9), a number of which—job qualifications, training, and man-machine interfaces—are under study. Safety research and development should, as much as any part of rail research and development, be approached on a systematic cost-benefit basis to prevent expenditure of the limited resources available to both government and industry on projects with low payoff. Properly planned research and development could reduce the number of accidents and injuries and thereby result in net savings to the industry.

The EPA has investigated pollution standards for the rail industry primarily in regard to noise and air pollution. Particularly in the case of noise reduction, the solution may not come easily. Classification yards are now subject to local noise-level ordinances as well as EPA standards. Noise barriers have been erected in some cases, but this may be only an interim solution.

So far, however, the interaction between old and new regulation has been limited to such essentially marginal issues as the preparation of environmental impact statements or the consideration of special rates for recyclable commodities. The new type of regulation is now beginning to shake down into recognizable form, probably with a considerable degree of permanence. Therefore the time has come to start examining the entire potential impact on transport (intermodally as well as with respect to railroads) of the new regulation on traditional regulation and on the carriers, shippers, and ultimate users. Particularly important are the economic impacts of the new regulations.

## CONSIDERATIONS IN RELATION TO RESEARCH

Now that changes in the regulatory environment of railroading are being made, it is becoming urgent to face and investigate a variety of critical questions. Research in the field of regulation has been peculiarly resistant to the output of computers, but in the future both quantitative studies and objective qualitative analysis that will permit informed decisions must be brought into play.

In railroad transport, the past has in many ways become the enemy of the future. Precedent stands in the way of policy formation. Therefore a research program might appropriately approach regulatory problems thus:

1. To what extent are the economic problems of the American railroad industry irrelevant to the history and present status of regulation?
2. To the extent that regulation affects these economic problems, how does this effect operate directly on and through railroads? To what extent does it operate indirectly, through regulation or nonregulation of other modes or of specific aspects of transportation (e.g., rates charged, service rendered)?
3. Can these effects be categorized in any meaningful way as being in the public interest or not in the public interest? Since for freight transportation the surrogate for the public has to be the shipper, to what extent is there a preestablished harmony between shippers' interests and those of the final consumers whose proxies they hold?
4. If certain aspects of present regulatory policies are deemed to be obsolete, what is required to move from negative criticism of these aspects toward affirmative proposals for specific regulatory change?
5. What can be done to trace the ultimate consequences of specific proposed regulatory changes?
6. Are there specific regulatory areas that could be sheared away cleanly (e.g., ICC powers over railroad mergers) without further economic complications?
7. In the light of present intermodal competitive conditions in transportation, what is the present economic (as contrasted to legal) status of the concept of value of service in railroad rate setting and railroad rate approval?

Any study of possible deregulation should pay careful attention to the possible discontinuation of current data collection that this might entail. The ICC has been collecting information about the railroad industry for a very long time. Some statistical data on railroads are older than almost any other quantitative information about the internal trade and commerce of the United States. Some of the questions that these data may help to answer are doubtless questions that no one has asked for some time. Nevertheless, there is need for a careful study of exactly how present ICC data requirements relate to present regulatory practices and what data problems might arise if these practices were to be changed.

On the other hand, it is probably fair to say that the entire array of publicly available data relating to the railroad industry has been too much influenced by past regulatory requirements. Transportation problems are becoming logistic problems. Intermodal relationships are increasingly important. The distinction between common and private carriage is legal but not physical or relevant to economic geography. Until recent times, regulatory policy toward railroads was essentially the same as government policy toward railroads. The problem of consistency and comparability between railroad data and the information available about other modes used to be relatively minor.

Even if Congress were to decide on the complete elimination of all economic regulation of all modes of transport, this would not eliminate the need for collection and dissemination of data; indeed, it would probably add to data requirements. Data are needed for policy purposes, and deregulation itself is a policy. Moreover, as the experience of the Department of Agriculture should establish, government has special responsibilities with respect to data in largely unregulated multifirm industries.

To what extent does present railroad regulation reflect an obsolete view of railroads, both as carriers and as corporate enterprises, in relation to other corporate enterprises? To what extent are current regulatory approaches—procedures as well as decisions—relevant to current intermodal (not just railroad) transportation needs and problems? To what extent, if any, are regulatory policies designed to accomplish such objectives as (a) to facilitate the raising of capital by railroads, (b) to encourage innovation, and (c) to relate labor standards and rates of pay to those prevalent in the rest of the economy? In short, are there any positive or promotional aspects to current regulation? Are such aspects compatible with the concept of regulation?

# Chapter 5
# National Transportation Planning Problems

## TOWARD A WORKABLE PROCESS

The term "planning" will be used to include broadly those activities that help an organization to decide (a) where it should try to go (definition of goals), (b) the way it should try to get there that is most worthwhile (adopting a strategy), (c) what actions should be taken and what means should be applied to pursue the chosen strategy (working out tactics), (d) how well it is doing in trying to get there (checking whether strategy and tactics are working out), and (e) when and how much to alter goals and change strategy and tactics to respond effectively to changed conditions.

Obviously this kind of process takes place, in part and in some form, at many levels of activity both within specific organizations and among agencies that have com-

mon sets of responsibilities or interests. In some organizations and at some levels it takes place in abbreviated form or in an informal way. We are not talking here about a department or unit that puts together a plan that may or may not be adopted by management but suggesting a composite approach to dealing with problems in a complex and changing world; it involves planners and operators, an attitude and a customary way of doing things, and processes and techniques.

The preponderance of evidence presented at the Railroad Research Study conference underlines the importance of giving thought to ways and means by which the activities pertaining to planning, in the sense indicated above, can be strengthened and the processes of planning can be improved and made effective.

An important deduction that can be made from the recital of problems and difficulties that beset the railroad industry is that there is a great deal of interdependence in the complex matrix of activities that are involved in the production of rail transport. For example, quality of service is affected not only by timely schedules but also by the condition of the plant, availability of appropriate and dependable equipment, employee morale, the record-keeping and control system, management attitudes, financial resources, the constraints of public policies, and the nature of the competition, to name only a few influencing factors. The point is that planning for rail transport must increasingly be so devised and conducted as to take into account the many interacting factors. This means that the activities related to planning cannot be isolated from the various production functions.

Because the conduct of transport by rail involves the interplay of public policy, several kinds of government agencies, and a variety of organizations in the private sector of the economy, there are a number of special problems in devising and conducting a set of planning-related activities that can aid not only in the provision of rail transport but also in fostering coordinated decision making that will enable the railroad industry to perform effectively.

For the purposes of this report, the activities related to planning are considered from the viewpoint of a national approach to dealing with the problems of rail transport and involve a composite (not necessarily integrated) effort by and input from both government and the industry.

## Where We Stand

There is a widespread and growing conviction that the railroads make up a system that requires a new kind of articulation (coordinated organization), if not a measure of integration, for effective operation. Prominent in most current public policy debate over railroad problems is the notion that these problems derive in no small measure from a Balkanization of the railroad industry that has frustrated that articulation.

Despite this perceived need for articulation, the railroad industry is not a part of any formal national planning process. By contrast, leadership for the planning of our interstate highways was exercised by the Federal Highway Administration (FHWA), our inland waterway system has been assembled by the Corps of Engineers, and the planning of our system of airways and airports has been guided by the Federal Aviation Administration. Without arguing whether these systems are really planned, it certainly can be said that in the railroad sector there has been no centralized guidance to development at all. Further, in all modes but railroad, there have been federal provision for and control over investment.

Most of the U.S. railroads are private companies that have substantial control over the disposition of their assets and the details of the rail transport production process. These private companies do not currently have any intercorporate planning machinery, nor have they yet committed themselves to the development of such machinery.

As the legislatively mandated resolution to the railroad dilemma in the Northeast continues to develop and with the passage of the Railroad Revitalization and Regulatory Reform Act, the level of public interest in dealing more directly with railroad planning opportunities continues to grow. Past failures of national railroad planning (e.g., the Ripley Plan, the Prince Plan) are forgotten in the push to plan our way around what are actually a set of painful financial and political decisions brought on by the dramatic shifts in the structure of the intercity transportation market and in the capabilities of the various modes of transport that serve that market.

An all-embracing national railway plan seems neither necessary nor desirable. What is needed, rather, is strategic guidelines to point out the directions that the industry should take for the use of individual companies in planning their own future strategies, as an ingredient in the national transportation policy-planning processes, and for delineating more clearly the roles of the government agencies that have responsibilities in the transport sector.

The railroad companies have not created an intercorporate planning capability that could confront such questions largely because of their conflicting competitive interests, which they have considered more important than their common interest in improved overall efficiency and performance. The current serious financial and intermodal competitive situation in the industry, however, now puts these conflicting and common interests into a new perspective. (It should be noted in this connection that the railroad companies have some legal problems in concerting their plans; these are problems that require help from the Congress.)

For its part, the federal government has a clear interest in coordinated nationwide planning, but there are four crucial constraints.

1. The federal government does not have any significant measure of control over what railroad companies do with their plant and equipment, although it appears to be moving in this direction.
2. The federal government is not directly involved in the technical complexities of the railway system operated in the private sector.
3. There is no industrywide planning entity that acts in behalf of all segments of the industry.
4. There is no accepted or customary arrangement for joint planning activity by agencies of government and the industry.

## The Issues

The basic issue in national railroad transportation planning is to determine how the whole nationwide railroad system can best respond to the changed and changing demands for intercity freight and passenger transportation. More specifically, questions such as the following must be confronted:

1. Where should the money for rehabilitating, modernizing, and expanding fixed plant be put?
2. How should the operation of the railway system be restructured to make it more efficient and to provide better service?
3. How should the ground rules for railways be changed so as to facilitate restructuring and revitalization?

4. What should be the long-run policy on branch lines, redundant main-line capacity, and excess urban facilities?
5. What should be the relationship between investment in railroad facilities and government investment in infrastructure for other modes?

Beyond such immediate questions there are questions concerning how to reconfigure common railroad technology (e.g., equipment) to better meet the demands of both a reconfigured system operation and a changing market; how to improve productivity as it involves labor, operational practices, and techniques; how to better integrate railroad services with those of other modes; and so forth.

## PROBLEMS IN DEVELOPING A PLANNING PROCESS

Because the railroads have not heretofore concerted their interests and because the problem has only recently come into focus as far as the federal government is concerned, the concepts and methodology for coordinated planning in the rail transport sector are skimpy and underdeveloped. The important exception to this, of course, is some of the work done by the U.S. Railway Association (USRA) in connection with the problem of the Northeast. Here much has been learned that can provide a base of knowledge and analysis for future planning by the industry.

Probably the most important lesson that has come out of the USRA work is that the railroad system and its operation are so complex as to preclude the implementation of detailed plans except as they have been developed through or by the managements responsible for making them work. Thus, the approach taken by USRA under its enabling statute has not worked quite the way it was originally expected. The USRA work has instead demonstrated a need for close interaction between the analysis of alternatives and negotiations for change that are based on both a detailed knowledge of field conditions and the responsibility for implementation of whatever changes are proposed.

To restate this lesson, the peculiarities and complexities of the railroad system call for the creation of a process of change, not a set of fixed plans. The need therefore is not for plan making per se but for the initiation of a process that is assisted by the sort of analysis that we often call planning. The initiation of this process requires that we develop and implement effective incentives for railroad companies to participate in it. Both the federal government and the railroad industry have a role in the development of these incentives and in making the process work.

For its part, the railroad industry must investigate more carefully the opportunities for improved performance that a program of intercorporate cooperation could provide. That is, the industry needs to know more about the economic benefits that could accrue from an accelerated program of selective consolidation, joint use of facilities, pooled operations, and so forth. The industry also needs to identify more precisely the existing legal obstacles to more rapid consummation of such cooperative actions, in expectation of the removal of these obstacles by government where necessary.

For its part, government needs first to do the conceptual work to develop alternatives to the thus far unproductive centralized planning for the restructuring of our railway system. It needs then to work on ways to catalyze and facilitate the sort of detailed restructuring at local levels that in the aggregate would provide the most important opportunities for improved railroad performance with respect to both cost and service. These can include such things as grants to facilitate improvement, labor relocation payments, development of standard procedures for government approval, and so forth.

As part of this effort, government must work with the railroad industry to identify and find ways to relax existing statutory and regulatory constraints that constitute real impediments to the industry's adjustment to changed competitive and economic circumstances. Through programs of research and demonstration, government could contribute to an evaluation of eliminating the transit rate structure, the implementation of demand-responsive pricing for the use of freight cars, and the relocation and reconfiguration of railroad terminal facilities in urban areas.

Finally, industry and government can work together to develop better analysis techniques for use by the railroad companies in assessing their opportunities for cooperative action and in conducting an effective intercorporate planning activity. These analysis techniques can borrow from the work of the USRA, the FRA, and various railroad companies. The capability exists for developing such techniques in the industry, in government, and in various universities. A more vigorous program to exploit these capabilities seems in order.

### A Particular Governmental Role

Government can perform an extremely important role in providing a crucial element in transport planning for both the government and the industry—forecasting overall transport demand. Modification of both the transportation infrastructure and transport service patterns and practices requires long lead times to respond to substantial changes in demand. Changes in conditions such as the following have a long-term and lasting impact on the market for rail transport services:

1. Changes in the supply of materials to be transported by rail and of materials to be used in transport operations (e.g., energy, timber, ores, agricultural products, building materials),
2. Changes in the location of resources that provide materials,
3. Changes in the product mix of the manufacturing industries and in the location of such industries,
4. Changes in world markets and foreign trade,
5. Changes in patterns of population location and in travel habits,
6. Changes in the availability of capital, and
7. Changes in the role and capability of other transport modes (e.g., government policies, energy availability and cost, accessibility to new markets).

An arrangement for the acquisition and analysis of the information required to forecast demand on a comprehensive basis would undoubtedly require cooperation among a number of other departments of government. It is important that the data and information be translated into such a form that long-term as well as intermediate and short-term estimates of the nature, magnitude, and location of future demands on the rail system can be made. Such estimates should be made on the basis of analytical forecasts and not entirely on projections of trends of production of particular commodities or ratios of consumption to general population trends. Effort should also be made to forecast the shifts in use of various products and the effects of such shifts on demand for the various modes of transport. Monitoring such changes is needed both to provide guidelines for the long-term decisions on structure and investment that confront the industry and to provide a basis for public transport policy decisions.

Somewhat associated with this monitoring of potential demand is a need to have some kind of sensor for detecting demographic, economic, and social changes that affect the use and role of transport. There are, of course, various kinds of indicators of population and economic and social conditions, but these need to be translated into a form or extracted in a kind of detail that will facilitate discerning the implications for transport.

### Government Responsibility

In the present climate of crisis and change, long-standing public transport policies are bound to give way to new ones. While such decisions must be made through the democratic political process, informed input is needed to aid in avoiding disrupting consequences. The development of an improved basis and methodology for policy-impact analysis is needed in the transport field. Procedures must be devised that will both permit participatory inputs from those affected and ensure as objective and equitable appraisals as possible.

Somewhat allied with policy analysis but of importance also in planning and development by the industry are the problems of multimodal transport. To provide an overall transport system with reasonable balance among the modes calls for arrangements that will provide equitable and effective transport of goods and people by using two or more modes. Different arrangements will undoubtedly apply to different situations. We need a comprehensive analysis of intermodal arrangements as they now exist and possibly an effort to devise new concepts of intermodal transport; in any case, a wide-ranging estimation not only of benefits to traffic but also of consequences on the longer term viability of carriers would appear to be in order.

### Special Problems of Rail Passenger Transportation

Rail passenger transportation poses special problems in planning that are the inescapable responsibility of Amtrak and DOT. These problems revolve largely around questions about how much service on what routes at what speeds should be supplied—questions whose answers are crucial to plans for both fixed-plant investment and the structure of the industry.

These questions, in turn, depend on how the market for intercity passenger travel develops. Relatively little has been done in analysis of intercity demand and related planning tools since the pathfinding research of the Northeast Corridor Transportation Project (in which the first regional multimodal demand forecasts were developed). The situation requires both further methodological research and research into the special characteristics of specific intercity markets.

## IMPLICATIONS FOR A RESEARCH PROGRAM

This chapter deals with certain aspects of the development of an improved capability for conducting planning-related activities in rail transport. It is not directed toward the idea of a grand plan; it is instead concerned with the development of arrangements and information that will help in the management of change. It is particularly concerned with the development of processes that can be an aid in reaching decisions about issues of nationwide scope that affect the various participants in the production of rail transport.

Two major kinds of activities are visualized as being essential parts of a national transport planning effort: (a) a monitoring of external conditions and factors that affect the rail transport system and (b) an evaluation activity concerned with the impact of transport policies and proposed changes. These activities should be conducted from a broad systems perspective.

The development of a monitoring process that deals with external conditions and factors should be aimed at providing a better basis for forecasting both demands on the system for transport services and requirements of the system for materials, energy, manpower, and so on. Among other things, research is needed on better indicators.

The development of capabilities and techniques for analysis of the consequences of proposed major policy changes for the performance and economic health of the rail transport system will in itself be a subject of research. Widespread interest in recent years on the subject of policy analysis is resulting in some approaches that may be useful in the context of rail transport.

Although not much can be said about how to improve corporate planning, there are two points to be made. The first is that planning, whether on a national or a corporate level, cannot be done without good data. Second, forecasting for planning as well as marketing and other purposes could be improved considerably if good demand models were available. Freight demand modeling is in its infancy compared with passenger demand modeling. The inadequacy of available data hinders the development of models on a sufficiently disaggregated basis and an ability to handle modal split properly. However, there are signs that usable models may be developed in the near future.

A major research priority should be the development of a level-of-service and commodity-sensitive demand model for use by the rail industry as a planning tool in making investment decisions.

# PART 3
# Problems in Rail Transport Affairs That Are Internal to the Industry

There have been many technological improvements in rail transport since the ingenious idea of operating a powered vehicle and its train of carriages on a guideway came into use a century and a half ago and provided a vast improvement in land mobility. Additional technological improvements can augment the potentials for the physical aspects of movement. But crucial problems of today and tomorrow in providing effective transport by rail now revolve around questions of how and how well the services provided by this mode can be performed. Changing markets for transport service, changing roles of alternative modes of transport, and changing availability of physical and human resources combine to make the ways in which the industry conducts its affairs a paramount factor in meeting new conditions. The chapters in part 3 address the problems associated with a series of key activities that add up to transport service, with a view to identifying research efforts that may aid the industry in deciding about ways of conducting business in order to get business.

# Chapter 6
# Finance

Any discussion of railroad financing must be prefaced by a recognition of the problem of strong and weak roads. The strong roads do not need the same type of assistance that may benefit the weak roads. The strong western roads would probably not be much better off if government purchased the right-of-way, whereas a marginal road might find such a purchase would lower costs enough to substantially improve their profit or decrease their deficit. Discussions about typical railroads are meaningless, but a look at the aggregated needs of all class 1 railroads makes some sense.

## PATTERNS OF RAILROAD FINANCING

Traditionally, railroads have been financed by a combination of equity capital and borrowed capital. During the early growth stage of the industry, when expansion of fixed plant and facilities required great amounts of capital, the predominant form of raising borrowed capital was the long-term mortgage. In more recent times, the rising cost of new rolling stock has been the cause of the great need for capital. Equipment of this type is easily financed by the equipment trust or the conditional sale. Although it is virtually impossible for a railroad to raise capital through mortgages today, the ease of repossession of equipment and the ready market for it have enabled financially pressed railroads to obtain capital for new equipment.

The use of mortgages has several implications for railroads. The specific portion of the plant is tied to the specific mortgage, and this can complicate things when plant is abandoned or relocated or when mergers are contemplated. It would be desirable for railroads to be able to pay off their mortgages rather than be faced with refunding them when they come due. Another problem with mortgages that faces the railroads is that much of the mortgage debt now outstanding will mature within the next 25 years.

### Capital Requirements

In the face of increasingly limited forms of financing, class 1 railroads will face outlays of more than $100 billion in capital expenditures, debt service, dividends, and income tax payments over the next 10 years (70).

The total amount of deferred roadway and equipment maintenance reported to the ICC in Ex Parte 305 (a railroad request for a general rate increase) as of December 31, 1974, was $2.8 billion. This understates the railroads' position since, in addition to the buildup of deferred maintenance, there is the problem of delayed capital improvements. Class 1 railroads reported an estimated $4.1 billion in delayed capital improvements of road and equipment. Some estimates of deferred maintenance alone run as high as $7 million. An update of deferred capital expenditures and maintenance is in preparation by DOT.

With regard to maturing mortgages, there are two periods of peak activity, one in the next five years, and another in the 1990s. Current interest rates are considerably above both the rate on the mortgage bonds maturing and the railroads' present rate of return on investment. The railroads therefore face some serious problems in retiring or refunding these mortgages.

As the external financial needs described indicate, there must be substantial new sources of funds for railroads, and prime among them should be the sale of permanent capital, i.e. stock, if it can be made possible. In the absence of these new sources, there appears to be growing agreement that the few alternatives open to railroads mostly revolve around a change in the present configuration of rail plant to a size that is more consistent with the railroads' earnings base and their ability to generate internal funds. Therefore, it would appear that railroads should be looking toward maximizing cash income and reducing all debt except equipment debt. The industry should be planning its cash flow so that, as far as possible, the old debt is paid off rather than refunded.

### Rate of Return

Looking at the rail industry in relation to the other regulated carriers, it is apparent that railroads generally earn a very modest return on investment. The rail industry must have its ability to earn comparable rates of return restored or it will inevitably continue its downward trend. In assessing how railroads got into their current situation, it becomes clear that, for one thing, railroads were forced to hold down their rates as a means of avoiding even greater traffic losses. The result of our improved highways, airways, and waterways and of major shifts in population and industry has been to reduce the demands on some of the railroads that were built (sometimes overbuilt) for nineteenth-century demands.

Other factors have also been at work—regulation and competition—and research is needed in both. As discussed in chapter 4, research into regulatory reform should look at the impacts of rate of return, rate increases, and rate-adjustment lags in the industry. Increased attention should be paid to the impacts of highway- and waterway-maintenance subsidies on the rate of return of their respective carriers.

Had the railroads earned an 8 to 10 percent rate of return in the past, as other industries have, obviously

the industry's financial needs would be far fewer today. Although these earnings have been foregone forever, it is interesting to project future earnings at the same rates—allowing for a 50 percent payout of dividends, it would indicate an earnings retention over a 10-year period (at an 8 percent return) of nearly $5 billion more than at the current rate of return (70). Allowing for a 2:5 ratio of debt to equity, this translates to an additional $7 billion of financing. This halves the railroads' external financing need, projected in constant 1974 dollars and, were it not for accumulated deferred maintenance and for inflation, would allow the railroads to be self-financing.

What significance, if any, can be attached to the idea of a fair return on fair value that was first enunciated in a railroad case (Smythe versus Ames) and is currently applied in terms of ability to raise new capital and maintaining integrity of the investment? Can an 8 or 10 percent rate of return have any meaning unless the rate base to which it is applied has equal meaning? And can anything rational be said about the value for current purposes of the historical information contained in either the original-cost or reproduction-cost versions of the railroad rate base?

### Raising New Capital

The major financial question facing the United States is how the bill for rehabilitating and modernizing the essential core of our railway system is to be paid. There are, of course, other financial problems also facing the industry. Getting rid of mortgage debt requires an infusion of capital that seems to be beyond the present ability of the railroads. On the other hand, there is a demonstrated need for very large amounts of money immediately if the railroad industry is to remain within the private sector. The private markets for capital represent by far the largest source of funds available for financing, and a wholly private solution would be most favorable. As mentioned previously, the basic cause of the present financing difficulties of the railroads is the low rate of return of the rail industry. At the same time the current trends of rising debt, decreasing profit margins, and shrinking disposable income are having a serious effect on the ability of the private sector to raise money for all its capital needs.

Railroads as competitors for private money are at the bottom of the investors' list of options. What we are faced with today is an abandonment of the railroad industry by the investing public. It would appear that, at least for some time, the credit market institutions will be forced to concentrate increasingly on improving the quality of their holdings so that seekers of higher risk funds will find them difficult and costly to obtain. It is apparent that the only immediate source of large amounts of money is the U.S. Treasury. One method of providing government funds to the railroads that would satisfy the need of Congress to get something tangible for the money would be for the government to buy the land under a railroad right-of-way and preserve it as a national resource, with the railroad renting the use of the land.

Since the Railroad Research Study conference, Congress has passed the Railroad Revitalization and Regulatory Reform Act of 1976, which will provide a source of capital to the industry and affect railroad financing. No analysis can be made of this legislation since it has not been fully implemented, but it does represent a commitment to government participation in financing requirements of the industry with many strings.

## BACKGROUND DATA REQUIREMENTS

### Railroad Sources

Problems about financial data on the railroads arise not only from the inadequacy of the data but also from questions of interpretation. These will be reserved for subsequent sections. However, there is one area that requires exploration—how would railroad accounts look now, or have looked in the recent past, if they were uniformly presented on the basis of depreciation accounting instead of retirement accounting? A full set of historical data for both depreciation and retirement accounts would be ideal; failing that, information for any one recent year would be extremely helpful, even more so if some relatively noninflationary test year before 1974 could be compared with 1974. ConRail has given an insight into the difference with their financial statements to the public based on depreciation accounting and to the ICC based on retirement accounting. This type of research on railroad accounting should be useful in evaluating some of the criticism that has recently been directed at retirement accounting.

### Legal Sources

The legal character of the indentures accompanying the issuance of railroad bonds is obviously an important issue. The traditional railroad mortgage bond creates special problems for new financing that are not inherent in other arrangements with creditors; this is because of the hereafter-acquired clause that automatically extends a mortgage to cover future additions or improvements to the fixed plant that exists at the time of the original loan. Research in this area could take two forms: (a) a straight factual presentation of the provisions with respect to the rights of existing creditors vis-à-vis new holders of debt, the instructions for which should be worked out in collaboration with one or more railroad legal departments; and (b) analysis of typical indenture provisions, which would be a perfect topic for research by law-review editors (they might be employed in research for one summer, with the expectation that their research would be the basis for a law-review article).

### Capital Market Sources

Data on the capital market are needed from two different standpoints. The first is that of the demand side of the railroad finance market—the nature of the sources of capital. Quantitative answers are needed to questions such as: Who holds what railroad securities? Has there been a trend of changing ownership? What sales of long-term securities have there been since World War II, and why have both the total number of offerings and the dollar value been so low? How do the terms of leases compare with the terms of equipment trusts for the same equipment? Are any trends visible in the relative quality of equipment trusts in relation to other corporate and government securities?

From the supply side, the first quantitative operation is to derive earnings and cash flow for each class 1 railroad; then each of these for the last 20 years should be related to the separate questions of financial increases or decreases in capital, including debt increase or retirement and physical increases or decreases (investment or devestment).

### Taxation

The difference between tax treatments for the various modes of transportation was pointed out in chapter 3;

since other modes do not own infrastructure, only railroads pay property taxes on right-of-way. Relief from taxes has been granted in some states, but proposals continue to be made to provide complete relief from state and local property taxes, which would provide additional funds from earnings for capital investments. Before any great efforts are exerted toward tax relief, research should be done on property taxes paid, year by year and railroad by railroad, to determine how much money could be made available and whether it is enough to really help the financially troubled roads, as well as to see whether, if complete tax relief were impossible, the railroads are assessed at a higher rate than other industries, given the ratio of property taxes to investment throughout the taxing jurisdiction.

## CAPITAL-RELATED RESEARCH NEEDS

There needs to be comprehensive research on the sources of capital from nonbanking institutions, not just for railroads but for all modes of transportation. Financial analysis also has a new tool that highlights cash management in the source and application of funds; it shows the source of all income and how it will be spent. While the increasing application of cash management to railroad data in the past 5 years has been impressive, the use of this tool has not been as widespread as it should be. Research is needed to enhance the development and usefulness of this statement of the flow of funds.

Research in the area of accounting is needed, especially beyond ICC accounting, including comparison of retirement and depreciation accounting to determine their relative advantages and disadvantages and which is better for railroad accounting. There is the question of the extent, if any, to which railroad accounting bears on the need for and ability to obtain capital. Another problem that comes to light more and more often is the historical structure of the division of freight revenues. A real solution would be to change the industry structure so that divisions would apply only to small portions of the total traffic. If the industry is not restructured, research is needed to develop objective procedures for the division of freight revenue.

A general analysis of the possible effects on the industry's financial condition of its relative ability to sell equipment trusts versus its general inability to sell long-term debt and common stock might reveal future benefits or problems to be considered in planning. Additional research is required to determine just what effect ownership of railroads by holding companies or conglomerates has had on railroad finances. Has capital flowed out of railroads? Does the conglomerate's strength make raising capital easier?

Is the problem of refinancing maturing mortgages simply a problem involving locked-in creditors that can, at worst, result in bankruptcy, or can it cause cessation of operations? To what extent is this problem influenced by division of ownership among many different railroad companies? Could railroads also generate more cash flow from their present volume of business, from their present assets, or from a shrinkage of the latter (i.e., even if they need new investment, could not these needs be met from internal cash flow or from cutting back on some older forms of investment)?

### Methods of Financing

To what extent, if any, is the problem of railroad capital one of imbalance caused by: (a) greater ease of financing equipment than of financing plant; (b) less than optimal decisions as a result of the fact that only certain railroads have both the financial strength and the need to finance massive new equipment purchases, whereas the new equipment has to run over the tracks—and perhaps run down the tracks—of all railroads; or (c) inefficient use of equipment due to Balkanization?

There is also the possibility of alternative arrangements for ownership of equipment. Short-term rental, long-term leases, car-assignment pools, owner pools (e.g., Trailer Train Corporation and American Rail Box Car Company), and shipper-owned or shipper-leased cars are all arrangements that are now in use to one extent or another. Each has some effect on utilization, often in reducing the opportunity for loaded backhauls. Evaluation of the ability of these arrangements to reduce capital expenditures and to determine the specific effect on car use is needed.

In addition, research should be done to determine whether either the shippers or the consignees or both could assist in financing specific geographical components of way and structure (e.g., branch lines), segments of terminals, entire terminals, and part or all of new security issues.

The possible means of government financing (federal, state, and local) are almost infinite. This is especially true for forms of government subsidy. The reason for including them here is that government assistance must be faced as at least a contingent policy for the entire industry; therefore no purpose is served by purely ideological expounding of the virtues of private enterprise (which, in the field of transportation, has always been associated with special government assistance or special governmental constraints or both, often at the same time). Failure to examine every possible kind of government financial assistance, on a comparative basis, means an inability to respond to possible crises as well as an inability to be prepared to approach the momentary whims of congressional committees with reasoned arguments. Such subjects as the following should therefore be investigated:

1. Relief from taxation by local government of real property and other such items,
2. Implications of the Railroad Revitalization and Regulatory Reform Act for federal lending and the need for additional legislation,
3. Possible federal bail-out of existing creditors as part of a clear-the-decks operation for new financing,
4. Benefits and disadvantages of federal ownership of the right-of-way in the Northeast and nationwide, and
5. Additional subsidies (beyond those for branch lines) for special equipment or deferred maintenance, either one time or continuing.

# Chapter 7
# Marketing

Marketing is a systematic process of identifying and exploiting market opportunities by satisfying customers' needs profitably. There are three basic railroad marketing objectives. The first is systematic identification and quantification of the markets and the market opportunities for rail transportation. The second is the determination, in markets where significant opportunities exist, of the buyers' transportation requirements and what volumes of service they will buy at the various combinations of service and price that can be offered. The final objective is the implementation and promotion of those services that can be produced efficiently, priced competitively, and marketed profitably. All three objectives require major research support.

From an individual railroad's point of view, any strategic planning for the railroad must have as its basis a reasonable forecast of that company's market before it can develop an overall plan to support this forecast. There is a need to develop an inquiry into the shape and pattern of the possible railroad market.

The market for transport will not evaporate for a lack of commodities to move. It will in fact enlarge, even if at a slower pace than it has over the past decade or so. The question to which this leads is whether the railroads can provide a sufficiently appropriate service at a sufficiently attractive price and low enough cost to maintain or expand their share of the transport market and to make a profit—in short, to be viable members of the private economy.

Research is needed in the categories of commodity flow, market shifts, user requirements, competition, demand elasticity, and sales promotion. While the development of commodity-flow data may not be considered basic research, current commodity-flow data must be the foundation for marketing research in any effective railroad marketing effort. Prior to the 1963 and 1967 censuses of transportation we had no useful commodity-flow data except the 1 percent waybill sample, which was for rail only. The current value of the census is limited by its lack of coverage of shipments from nonmanufacturing establishments; by its small sample size, which limits adequate disclosure of traffic flows between geographic locations by commodity characteristics; and by the late publication of the results. One of the major research needs in transport concerns getting commodity-flow data, particularly for nonrail movements, on a more timely and economic basis.

In our rapidly changing society, transportation markets, commodity flows, and market shares will most certainly be different next year and 10 years from now. The capability to predict what is likely to happen must be developed. There has been little basic research in this area. Most projections of future demands are simply extrapolations of past trends. Various plausible scenarios could be constructed and strategies postulated for each of the scenarios.

Many railroads have developed staffs of market specialists who research user requirements. On the basis of these requirements they design service offerings for specific markets. More cooperation within the railroad industry would help reduce the cost of this major activity. In marketing rail services it is necessary to understand both private and for-hire transportation alternatives. Too little is known about the impact of public investments in highways and waterways on the demand for rail transportation. Estimates of the sensitivity of rail volume to changes in price and service are critical to effective marketing of rail transportation. Speed and reliability are among the elements of service that generate cost, and the object has to be to optimize the service elements and price.

The carriers' sales promotion research must analyze the nature of their customers to learn how to sell to specific markets. Research should be undertaken to determine why the traditional marketing techniques are not used with more regularity in the railroad industry. The next suggested research project is an investigation of the transport decision-making processes of the (potential) customers of rail. Such a project would yield information as to who makes the decisions and what exactly it is that captures their attention. Also the organization of the marketing function needs examination, particularly whether it is centralized or decentralized.

Research into specific markets can be approached as a search for new sources of traffic. New sources of traffic for the railroads can be of three types. The first is traffic that is regained or diverted from other modes, e.g., the shipment of new automobiles. The second is commodities that are not now moving at all but that can be moved, e.g., Wyoming coal. The third is totally new products or new concepts and approaches to moving traffic, e.g., urban solid waste.

The highest priority railroad freight-marketing research needs for the next 5 to 10 years are

1. More timely and complete nonrail traffic-flow data, including farm, forest, and mineral products as well as manufactured products, and an analysis of modal traffic volumes between specific geographic areas for various commodities;
2. Expansion and verification of past research on the elasticity of demand for rail transportation for both price changes and service changes in specific market segments;
3. The future impact of economic, environmental, political, social, and technological changes on specific transportation markets; and
4. More extensive research on the impact of public investments on the service capabilities, capacities, and economics of intermodal competition, with emphasis on private unregulated highway and waterway transport, including regional variations.

# Chapter 8
# Costing

Federal regulators, railroad rate makers, academic economists, technological researchers, marketing experts, railroad brotherhood executives, and railroad management officers are rarely all to be found on one side of any given issue. Yet, with respect to the need for better cost information, they cry out in unison. While there is nothing really new in this universal demand, there is a good deal that is new in the optimistic expectation that at last something can and will be done to satisfy it. The twin panaceas of our times, federal funding and computer technology, are once again expected to produce solutions to problems that were heretofore considered insoluble.

It is rather widely understood that railroad expenditures bear only slight resemblance to railroad costs. Expenditures are made long before, considerably after, and sometimes while the costs are incurred. There is thus a significant difficulty in relating, pro rating, and ascribing expenditures to the events that generate those costs. Unfortunately, most cost data that are currently available are merely historical records of expenses. While it can be argued that, over a long period of time, expenditures should equal costs, such an argument fails to recognize the time value of money and the effects of inflation and, most importantly, makes unreliable assumptions about the physical status of operating property at any given time.

The challenge of developing useful railroad cost data is not therefore one of merely gathering from a multiplicity of sources a huge complication of expenditures and attempting to relate them to services and activities. While such an exercise may be part of a properly structured study of railroad costs, of and by itself it will not suffice. The alternative has been referred to as engineered costs, which is here taken to mean the measurement of the physical units of effort, energy, labor, and material that must be provided or consumed to provide railroad transportation. A very simple example would be the calculation or measurement of the consumption of fuel oil in transporting a given commodity from a shipper to a consignee rather than the accounting entry of the paying of a fuel oil bill and subsequent pro rating of that expenditure to a variety of services.

An example of the lack of cost information is found in the inability of operating departments to provide comparative costs of alternative levels of service for management decision-making or marketing purposes. If a railroad marketing man is trying to decide whether to offer a shipper next-morning or second-morning delivery, he is unable to estimate the difference in cost. A large part of the difficulty comes from not having proper allocations of cost.

A part of the difficulty in costing various levels of service is the inability to cost track maintenance. Several major efforts have been made, starting with Wellington in 1878, to determine maintenance-of-way costs with some accuracy and to relate costs to the type of service. But what a railroad spent, as reflected by historical cost allocated to a segment of line, and the true cost reflecting wear and deterioration are often not the same. Cost models are being developed and such research should be continued.

Both government and industry need data on costs in almost every aspect of their activities. The government needs data on costs for regulation, legislation, abandonment proceedings, and the establishment of research and development priorities. Railroads need data costs for rate making, marketing, analysis of operations, equipment needs and maintenance, labor negotiations, establishment of priorities for research and development, and, above all, determining the profitability of services offered and lines or routes operated.

The FRA can sponsor and undertake research designed to address theoretical cost research that has been too expensive for railroads to undertake. It can undertake education in the use of cost research tools and develop rail-costing methodologies. These can be adapted and used by individual railroads to obtain estimates of specific actions or programs and to aid in decision making. Costs for decision making are also discussed in chapter 13, and costing in operations research is discussed in chapter 11.

The most important participant in cost research must be the rail industry itself. Without direct participation by the industry itself, cost research can be no more than an exercise in futility. The industry must take steps to ensure that it is asking the right cost questions and then demand definitive answers.

As mentioned earlier, costing systems, particularly the data-collection components, can be enormously expensive. Initial research and planning should be aimed at reducing the cost of collecting detailed expenditures and yet obtain sufficiently disaggregated as well as overall data sets to obtain data as efficiently and inexpensively as possible. One way to reduce the cost of data collection would be to combine efforts across the industry and share available data as well as the efforts to collect additional information. There may be concern about protecting proprietary information, but procedures to safeguard such information are being used in the census and might be adapted to costing. Another way to reduce the cost would be to attempt to use the experience gained by other railroads throughout the world to see whether their procedures apply to North American railroads. A survey should be made of organizations like the Organization for Economic Cooperation and Development and the international railway organizations, as well as individual railroads in the developed countries, to determine what procedures are available and whether they would apply here.

The fundamental problem in railroad costing is the allocation of joint and common costs. Every allocation scheme that has been proposed has been based on assumptions that are pertinent to the purpose of the allocation. What is needed is an objective allocation scheme. There has been discussion in the industry of developing cost systems that will dispose of allocation issues. Allocation can't be disposed of, only done as objectively as possible. Cost research needs to concentrate more on defining cost structures and cost relationships than on determining cost levels. There are many well-established one-dimensional relationships, such as cost/distance, but cost models to handle interactions and combinations do not really exist.

Although both the railroad cost analyst and the budget analyst typically view unit costs as being independent of changes in volume or service levels, there is some indication that unit costs do vary with volume and service levels, particularly at the high and low extremes. Some theoretical work has been done; there is an urgent need to link the theory with actual railroad operating data in order to either verify the theoretical concepts or develop new ones. What may be needed is a series of costs for origin to destination, not just average costs.

Research into data collection should include better input and output devices for data processing, improved coding procedures for data storage and retrieval, and better training for data systems personnel. The consensus of the conference was that there is need for work in the field of econometric modeling, so that the cost of existing operating methodologies may be compared with the cost of proposed changes. Such research would require validation of the data base for the econometric models before cost trade-offs would be meaningful.

Research should be undertaken to investigate variable costs and the extent to which they vary under altered circumstances, such as longer or shorter transit times, heavy or light cars, and higher or lower frequency of departure. Terminal costs should be included in variable cost research. There is no such thing as an average or representative terminal cost. The carriers should have the ability to estimate the variable costs in various terminals as they are affected by congestion, the geography of the terminal area, and work rules.

One of the critical areas to be researched is the industry's relationships of cost to volume. Are there significant economies of scale in the rail industry? In order to answer this question there needs to be some agreement on the units of output on which to base costs. Perhaps car-kilometer or train-kilometer should be substituted for the universally used kilogram-kilometer. As mentioned elsewhere, the railroad industry needs to know more about its competition, and this includes the competition's costs. Comparisons of costs with other modes are needed to plan marketing and investment strategies.

In addition to these suggested research areas, chapter 11 contains a number of suggestions for cost research. Specific cost research projects that should be undertaken include

1. Development of improved tools—cost models and data banks;
2. Profitability studies of existing lines;
3. Relationship of traffic to maintenance-of-way costs, including axle loads, speeds, and type of rolling stock;
4. Analysis of the costs associated with improving service reliability;
5. Understanding of the effects of the industry's structure on costs (see chapters 2 and 5);
6. Estimates of variations in costs associated with line-haul, terminal, and service components of shipment movements;
7. Analysis of the competition's costs to determine where rail can afford to compete; and
8. Relationship of usage (distance per year) to maintenance of equipment costs (locomotives and cars).

Although participants in the conference concluded that significant research is needed in all areas of railroad costing, such research should not be approached lightly for a variety of reasons:

1. Research into railroad costing, even if it is approached carefully, is expensive, and railroad costing systems are expensive.
2. Carelessly formulated, simplistic approaches will produce either results that are not acceptable to potential users or, worse, misleading answers that could bring about improper or invalid decision making.
3. The unwarranted assumption that costing can produce results with great precision could lead to endless revision, with escalating expenses and delays, or could prevent the application of results. It has been pointed out that costing is an inexact science, at best an approximation. To expect significantly more would be misleading to potential users, frustrating to researchers, and unnecessarily burdensome to funding agencies.

# Chapter 9
# Personnel and Human Factors

Railroads, like any enterprise, bring together capital and manpower, with management responsible for the efficient meshing of these resources into a vibrant economic entity. All too often, the personnel area tends to be overlooked in considerations of research opportunities, needs, and priorities. At the present time, however, the broad area of personnel and human factors offers one of the largest research needs. Without personnel there can be no railroad to manage or operate.

## RECRUITING REQUIREMENTS

As an indication of some of the problems and challenges facing the industry in the next decade, USRA has prepared a profile of the unionized work forces available to the bankrupt railroads of the Northeast and Midwest. These railroads show the effects of shrinking employment—from an industry total of more than 1.3 million at the end of world War II to approximately half a million

today. Of some 94000 employees of the bankrupt railroads, more than 30000 or 36 percent will reach the normal retirement age of 65 between 1975 and 1985. If retirement becomes attractive at age 60, then 54 percent of the work force on these railroads will retire within this period. It is not unreasonable to extrapolate these numbers to the industry as a whole; for management, the percentages reaching retirement age may be even greater. It is in the lower supervisory levels that railroads have been able to make reductions in force most easily in recent years; higher management levels show no reduction. Thus, even at current levels of activity and without allowing for significant changes in the way railroads are organized and operated, as many as 200000 railroad industry employees will have to be replaced during the coming decade. This presents both opportunities and problems.

For nonsupervisory employees, the problem is one of obtaining sufficient numbers of workers to carry out the tasks associated with operating a railroad. This will require personnel managers who are more than mere procurers of warm bodies. The personnel manager will have to secure the required number of workers, within the constraints of the equal opportunity laws and in a society that regards railroad jobs as being among the less desirable. It will not be enough to simply hire those who are unable to secure desirable employment elsewhere. Railroads are going to have to attract—and keep—the best talent our society produces. This will entail knowledge of the sources of labor. Means will have to be found to attract workers to where the jobs exist. This is, of course, a problem that faces all of American industry. Thus, research into the attraction and retention of employees should be coordinated by individual railroads with ongoing research undertaken and underwritten by organizations outside the railroad industry.

For supervisory personnel and professional staffs, the problem is virtually the same as for rank-and-file employees, but railroads have been such sporadic recruiters in recent years that most colleges and universities have discontinued railroad engineering programs. Railroad-oriented courses seldom appear in transportation planning or business management curricula offered by universities; railroads do not even appear in case studies. Few textbooks on railroad subjects have been published since the 1920s. If entry-level professionals are to be attracted, work with the educational community will have to be undertaken so that the best young people will be available to railroads. And, with women making up fully half of the nation's people resources, railroads will have to find ways to fit more women (and minorities) into the system both because public policy requires it and because railroads are not so deep or rich in talent that they can afford to ignore any capable people who can produce efficiently. For an industry that has traditionally presented a railroad job as a virtual way of life, this opening up may require greater adjustments than other industries will experience. Railroads can no longer afford the luxury of taking traditional views of workers and potential workers.

Railroads will undoubtedly have to increase the amount of training in the near term as more new workers enter service. Research into training methods may reveal ways of gaining better workers, workers who are more inclined to observe safety regulations as a matter of course and who will therefore constitute a more economical work force.

Also, as other industries have found, new workers entering the work force are different from workers in past generations. Not only are women, blacks, Indians, and other groups demanding their place in American society, but also the young tend to have different values. Managements, including those of the railroads, will have to understand these changes if they are to deal with them. If bright young engineers will not agree to move every year or two from one part of the system to another, then management will have to determine how necessary the moving cycle is. At the least, if it is absolutely essential to the development of maturity and experience, this will have to be articulated in terms that relate to the values of the new employee. Again, this is not a unique problem for the railroads, and the need for research would appear to be shared with other industries.

Regardless of the future of the railroad industry, these problems and challenges will have to be dealt with by personnel managers and by top management as well; they will undoubtedly require policy changes in many companies because of the numbers of current railroad employees who will have to be replaced. If the volume of business turns significantly upward, as has been indicated by many forecasts, the problem of attracting new employees may grow from one of replacement to one of replacement and addition.

## PRODUCTIVITY

There is general agreement throughout the railroad industry that productivity should be improved. Improvement would obviously help the carriers' financial situation and assist in improving their competitive position vis-à-vis other modes. Contrary to some opinions, progress toward increased productivity has been made over the last 10 years. This progress has been largely due to investment in new equipment; further progress will have to be made by changes in labor practices. Results are encouraging in several joint labor-management experiments, notably the St. Louis terminal experiments. This project, involving changes in work practices, has been under way for several years. Its excellent results are being applied in other locations, but implementation throughout the industry in a reasonably short time would be difficult to bring about. This type of joint project could mean not only significant improvements in productivity but also improvements in service to shippers; it would be a major factor in keeping the rail industry alive as private enterprise. Labor and management need to attack what may be the greatest single problem in the rail industry.

## AREAS OF RESEARCH

With large numbers of managers leaving, and the number already shrunken because of past financial considerations, the rail industry is presented with a major problem that may be susceptible to research. Rather than simply replacing departing managers with their alter egos, who will continue to do things as they have traditionally been done no matter how successful or unsuccessful this has proven to be, perhaps research can disclose new ways to structure the organization.

This is not advocating change for its own sake but rather suggesting that research may be a problem-solving tool for management. The need to infuse thousands of new workers into the system provides the possibility that the organization can be made more efficient. It also provides an opportunity to bring in or promote people with different thinking, who may make changes in the way of doing things.

Thus, railroads may be able to project the image of an industry in change—an industry that needs and wants the best people, rather than just those who are available. In itself, such an image, if it is based in reality, will provide the stimulus to attracting better-than-average

talent. Values in our society have not changed so radically that good young people will not respond to challenging opportunities.

Structural change in the industry, in addition to its effects discussed elsewhere in this report, could contribute to the quality of work and of management. Today, the railroad industry is thought of (rightly or wrongly) as one in which promotion is based largely on longevity. If one can outlive his supervisor, he can aspire to his or her job. This attitude contributes to rigidity of thought and action. Opportunity for advancement that is based on performance may be the personnel policy change that will enable railroads to compete for the best talent. Research on how to measure performance will be necessary. Recognizing the need for staff members with technical expertise in relatively esoteric fields, it is still possible that organizational changes can be made that will permit the development of more staff members with broader ranges of experience in addition to their specialties; i.e., new promotion ladders could be developed to enable specialists to be rotated into operating departments at various periods.

Closely allied to this as an area for research is the problem of the span of control. A foreman in a factory can usually see the people under his supervision. On a railroad, employees are spread over great distances, with many units operating virtually autonomously for long periods of time. Many of the activities that may produce a need for managerial decisions take place far away from managers. If it is presumed that economics makes it unlikely that railroads are going to greatly expand the numbers of supervisors in relation to the total number of employees, then ways must be found either to improve the status and quality of first-line supervisors or to provide greater contact between the field and management.

Human-factors research can be intimately intertwined with the personnel area, although it will recur throughout the spectrum of railroad operations. The term human factors is generally associated with the interface or relationship between man and machines. Human-factors research is being conducted in many areas, such as the locomotive cab environment, ways of improving safety on the job, and ways of otherwise improving the operation of the railroad. In the personnel context, human factors is the interface between people.

The financial distress of many carriers and the continuing shrinkage of the number of jobs throughout the industry, along with other factors, have made it difficult to maintain morale. Improvement in morale is probably one of the most necessary of research activities. Out of improvement in morale may come improved performance and efficiency on the part of employees. This usually will be accompanied by greater productivity and greater adherence to safe practices. Because safety is a concern that runs through every operation of a railroad, it is in the area of human-factors research that the safety issue can best be confronted. Industrial studies in other industries have found a correlation between employee safety and morale; improved safety will improve the economics of the industry.

If labor is convinced that its future is inextricably tied to the industry's future it may be ready to participate in joint problem solving. It goes without saying that management must share that attitude—that its future is tied to that of labor. Research that is jointly undertaken by labor and management may determine where labor's further involvement in joint undertakings may be appropriate. This could also aid in delineating those areas that are, or should be, exclusively the preserve of management. This kind of clearing of the air could contribute to improved morale and job performance. It cannot be stated too strongly that this is an area of human factors research that requires the utmost candor and genuine commitment. Only in such an environment can the substance of the research be viewed without its becoming lost in traditional labor-management adversary relationships. Successful research, along the lines of the joint labor-management task force projects in locomotive cab safety under way in St. Louis, could contribute greatly to improving morale by relating the worker to the job and the company, while at the same time doing nothing to erode workers' ties to the union.

Human-factors research may have applicability to the ranks of management as well. During the course of the Railroad Research Study conference, considerable concern was expressed for the role of the "plateaued" manager who, though some time from retirement, has reached the maximum level of capability. Not only does such a supervisor block the progress of younger and better supervisors, but he can become a morale problem as well.

Other supervisory problems lend themselves to human-factors research. First-level supervisors face serious problems of role and function that affect their morale and performance. There are questions of authority—are they given sufficient authority to make their responsibilities meaningful? In some instances it has been suggested that first-level supervisors are barely supervisors at all. It may be that there are so many tasks that they become overloaded and cannot perform the job in a reasonable manner.

At the conference, representatives of both labor and management expressed strong views that the whole subject of discipline should be researched. The current system, in which a manager acts as prosecutor and judge, has created problems of morale and has affected performance, even though a complex grievance procedure is available. Without sacrificing the organization's requirement that rules be observed, research into the rules themselves and the concept and need for discipline could contribute to both improved morale and increased productivity.

Another way to improve morale and productivity would be to investigate new ways (other than early retirement) of protecting the careers of railroaders without protecting the job. Perhaps transfer from a carrier that is shrinking to one that is growing could be looked at from the viewpoint of solving seniority problems and such other problems as relocation costs.

# Chapter 10 Organization

An area that appears to be vital to almost all railroads is the adequacy of their organizational structure and management style, in relation both to the industry as a whole and to each company. The whole question of railroad organization may need a thorough examination and research in the light of the present environment and with an eye to future trends in the transportation industry.

The railroad organization was evolved at a time when the railroads were in their developmental phase. Since field communications were difficult and there were many isolated units, a military style of organization evolved. This type of management philosophy, although it is still effective in some aspects of railroad operations, has its shortcomings in handling the most difficult problems facing railroads today.

Traditional roles and operating policies play a large role in the philosophy of railroad management, since they provide the framework or arena in which the system operates. However, tradition must interact with technological, economic, and social changes that take place on the larger scale of the society. This changed environment of competition, technology, economy, and society has placed great strains on the industry and has been gradually eroding the industry's share of the market and its profit picture. An indication of the industry's economic problems is the increasing number of mergers. Every merger involves intricate adjustments between organizations, ways of doing things, interpersonal relations, policies, and union contracts. They also usually involve a shutting down of excess facilities and reduction of personnel. Consider the magnitude of the organizational problems to be faced if all railroads were merged into a handful of regional systems or a nationwide system.

Along with these changes will come changes in the role of the government and changes in transportation policies. Government operation or strong intervention in some form seems inevitable for some systems; this will surely involve drastic changes. There is talk of changing the role of the ICC, which will change the controls it has imposed. All of these problems confronting the industry create unusual challenges to railroad management, which may not be fully equipped to cope with them under the old management system.

In addition, the increasing use of computers in operations may dictate different organizational forms. There is danger that the benefits of computers will not be taken full advantage of or even used at all by managers in the existing organizational structure (discussed in more detail in chapter 13).

Research on railroad organization has to address two problems, one associated with the industry as a whole and the other in relation to the internal organization of the individual railroads.

## INDUSTRY ORGANIZATION

The future could bring significant changes in the nature of the railroads' business, e.g., being limited to hauling only bulk materials. Would such a change in the nature of the railroads' business mean the optimum organization would be different than if general cargo were hauled? Since no one knows, one area of investigation that could guide future organizational changes in the structure of the industry and individual carriers would be to develop several scenarios for the course the industry will follow and then attempt to see whether optimum organizational structures for a company or for the industry differ for different types of business.

As was discussed at length in chapter 2, there is a need to take a close look at the structure of the industry, i.e., the number of carriers and size of their territories. These are important elements if the industry is to survive, be cost effective, and be profitable. Research should focus on the question of the optimum shape and pattern of the industry's structure and investigate the economies of scale and levels of scale that will be most effective. Several alternatives have been suggested for structuring the industry. Some of the ones most worth researching are

1. Reorganizing the industry into regional systems (lateral mergers) or transcontinental systems (end-to-end mergers that will enlarge systems and increase competition);
2. Diversifying the industry into high-profit and high-growth markets, thereby offsetting the losses from railroad operations;
3. Turning to the Canadian approach of one public and one private railroad in order to maintain competition and efficiency; and
4. Limiting the number of private railroads that compete in major markets since there are corridors that have excess competition and excess capacity.

## INTERNAL RAILROAD ORGANIZATION

The internal organizational structure of the railroads appears to be a particularly important area for research. Research should be directed to examining the effectiveness of possible management styles and to identifying management philosophies that could be most effective in enhancing productivity and in providing incentives to all groups and elements of the industry. A properly conceived management organization would foster greater cooperation between management and labor. Research should be directed to discovering management arrangements that will give employees major incentives for making cost savings and service improvements and for enhancing profitability. The idea of profit sharing or other means of rewarding outstanding employees should be investigated.

The sprawling character of the industry, with its geographically scattered assets, presents a peculiar organizational problem. Research should be directed at examining this character of the industry to see what kinds of organization are most suited to the industry's needs. The degree and extent of centralization or decentralization should be examined and the questions of levels of supervision and responsibilities should be addressed.

Organizing by profit centers has been repeatedly suggested by various people; this concept should be explored and researched to determine how effective it would be in the railroad industry in increasing productivity and the

profit picture. The administrator of a profit center would integrate marketing and operating functions with responsibility for management decisions. Profit centers would require kinds of reporting not now done on most railroads. Procedures for dividing revenues and costs would have to be created. Profit centers could divide a railroad into more manageable units, which would provide overall experience to managers before they are promoted into top management. The methods of allocation used would have to be credible to the managers, and, since many railroaders believe it can't be done, this could be a major obstacle. Research into methods of allocation is necessary to overcome such an obstacle.

Integration of functions could take place without the use of profit centers if the top managers were able to do it, but few of today's top railroad managers have had the broad experience outside their specialties that is needed. Of course, if the new top managers were dedicated to the integration of functions, this could be remedied by arranging for outside education and transfers into other functions.

Decentralization could also be achieved by breaking railroads into smaller companies. This would have the obvious drawbacks of additional Balkanization and the fact that the industry has been working vigorously to move in the opposite direction—toward larger companies.

Communications and computers can be used to provide local managers with the information and support necessary to make decisions. The discussion in chapter 14 on computers and communications applies here. Another problem is fragmented authority. Many railroads have multiple layers of management; this presents a risk of misinterpretation or loss of substance. Can the layers of supervision be reduced? Research on corporate organizational structure could give the answer.

Division of responsibility between departments should be examined, especially in the field, where there is no unified command and each department's people report back through their own departmental channels. Are there alternate ways that the field organizations (usually divisions) could be structured? Organizational requirements have not been thoroughly researched to see whether those assumed over the years are really valid. If they are not, what requirements do exist?

The competition and jealousy between departments of most railroads, along with the dominance of the operating people, may be contributing to failures in marketing and loss of service to shippers. Any organizational changes that could improve relations and redress the balance of power should be looked into.

Since the people are the most important assets of any organization and the success or failure of any organization depends to a very large extent on the people, research should weigh heavily on the human side of the organization. The question of what kind of an organization is best suited to solve the problems of the changing environment must be answered. Railroads, by tradition, have tended to fill the positions from within by promotion. This practice has prevented the industry from benefiting from the experiences of other industries in improving organization and productivity. Studies of successful and unsuccessful railroads should provide answers helpful to the entire industry.

# Chapter 11
# Operations

Rail operations, in the limited sense addressed in this chapter, refers to the management of facilities (yards, main line, and so on), motive power, freight cars, and people to transport commodities between customers in a timely and efficient manner. The emphasis is on servicing customers rather than on how many or which kind of customers to serve. The operational areas discussed are cost problems, types of service, electrification, line capacity, light-density lines, quality of service, loss and damage, and car utilization.

Research into rail operations has been and will be influenced by some of the characteristics of the railroad industry that make it unique. Some of these characteristics make research more difficult or decrease the likelihood of success of traditional research approaches.

Railroad operation involves a very large number of components and activities, each of which influences and is influenced by many of the others. Research efforts that involve one component or activity but neglect its interaction with others have not achieved significant success. On the other hand, efforts that attempt to consider everything have generally been overwhelmed.

The burden of trying to make a profit or even stay solvent while meeting public service obligations leads to conflicts in decision making, as does the attempt of rail operations managers to operate with sets of ambiguously defined and potentially conflicting objectives, such as to decrease daily demurrage payments, reduce car shortages, and minimize empty runs, all at the same time. Multiple objectives, each of which alone might require actions opposite to the others for realization, can only be effectively achieved when an overall measure of utility has been accurately defined.

Railroading is a dynamic process. Today's events were influenced by yesterday's actions, and today's events lead to decisions that will affect tomorrow's. But rarely do identical events occur, even though similar events do occur. The differences in day-to-day or area-to-area problems are one reason that seat-of-the-pants management is commonplace. The uniqueness of each

manager's problems has led to a lack of quantitative accountability of managerial performance. Research into methods of regularizing the environment and developing appropriate planning and control systems is needed as a prerequisite for quantitative accountability.

Conventional wisdom often attributes rail problems to ineffective management when, in fact, many of these problems are so complex that classic business management probably wouldn't perform as well, and certainly not any better. The sheer size of some of the problems, number of components and interactions, inadequacy of data, and institutional constraints frustrate even the best managers. Historically, railroads have attacked complexity by fostering functional specialization with organizational separation. This has led to some serious suboptimization and increases the difficulty of solving problems that involve more than one function or department. Research is needed into methods of partitioning problems into small parts so that they can be effectively managed without neglect or interaction.

The existing plant, financial condition, and institutional constraints of the railroad industry have developed over a period of 150 years. This presents an inertial barrier since it tends to limit the areas of research to those that are politically or institutionally acceptable. Furthermore, current procedures have evolved to meet these constraints and often represent very delicate equilibriums. Research that can threaten these balances is viewed with natural concern and often meets with sincere resistance. Before research on operational functions can be truly effective, appropriate corporate and operating objectives must be defined. Once the objectives are known, economic trade-off studies can be conducted to select the best tactics for achieving the objectives.

## COST PROBLEMS

As was discussed in chapter 8, a major consideration in railroad operations is the problem of assessing cost—the cost of operational alternatives and the cost of service improvement. Existing costs must be known so that they can be used for controls (see chapter 13) in the analysis of various operating changes.

Many suggestions were made during the conference that could result in improved operating practices and in service improvements. While there was an intuitive feeling that they would, in most cases, result in lower costs or greater traffic levels, there is no clear way of proving so at this time. Problems about the cost of service therefore offer a wide variety of research possibilities that could lead to significant reductions in costs or to operating improvements. If at the same time the ability to compete for quality-sensitive traffic is enhanced, there would be a further justification for undertaking this research. It is probable, considering the pervasive cost problems faced by the industry, that this research should be expedited, with other operating improvements explored concurrently.

As discussed below in greater detail, cost problems in many operating areas often involve the trade-off of capital costs for operating expenses of one kind or another. Without a clear understanding of the costs involved, it is virtually impossible to make calculations of the trade-off possibilities necessary for accurate engineering-economic studies. Some conference participants expressed the view that railroads should adopt a practice of dispatching shorter and more frequent trains rather than the current practice of operating longer, heavier, and less frequent trains. This would involve an increase in direct labor costs, assuming crew-manning requirements are not changed. The corollary benefit would presumably be gained through better car utilization, decreased congestion in terminals, closer adherence to schedules, and better customer service. At the present time, some roads are experimenting to find out whether the benefits of such changes outweigh the costs.

Cost research is a prerequisite to better understanding and knowledge of service elasticities. Service improvement appears to be desirable, and certainly the prospect warms the hearts of many marketing people. However, service improvement may involve cost increases elsewhere in the total transportation equation. Without research in this area, it is impossible to know whether the potential traffic increases justify incurring additional costs.

Many shippers have demanded assigned cars, most of which have special equipment installed. Without the results of cost research, it is impossible to set rates and establish prices that properly reflect the economic cost of this service. The degree of car utilization enters into these costs, further complicating the problem for management of pricing rail services or even of making new capital investments.

Thus, it is clear that cost research must accompany, or even precede, exploration of other operating areas. This need, as is discussed in other chapters, pervades the railroad industry. The prospect of a multiplier effect is tantalizing—shorter, faster trains lead to improved terminal operations, which leads in turn to better rail service and the possibility of response from shippers in the form of greater revenue. Industrywide research in this area appears to be one of the most important projects. Its need was voiced during every phase of the Railroad Research Study conference.

Research concerned with operations should also consider the trade-offs involved in the use of freight cars with heavier axle loading versus increased maintenance-of-way costs. In the last 10 years, competitive market pressures have made large high-capacity cars necessary to produce the efficiencies that permit lower, more competitive rates. The result was cars with a gross weight of 145000 kg (315000 lb). The need to hold down equipment costs led to the use of two-axle, four-wheel trucks on these heavy cars, which resulted in heavy axle loadings (the use of three-axle, six-wheel trucks would have spread the weight distribution and reduced the loading of each axle, thus reducing the wheel load on the rail). Experience during this 10-year period has shown that any significant use of these cars with heavy axle loadings causes serious damage to the track, particularly to the rail. This cost is not fully known and therefore cannot be given its proper weight in the decision-making process.

Experience with unit trains (generally but not always those carrying coal or grain exclusively) during the last 10 years has shown that there are serious effects on the track from the frequent passage of such trains. Although the typical unit-train car—120000 kg (263000 lb) gross weight on four-wheel trucks—is not of itself extraordinarily heavy, the frequent passage of unit trains of such cars moving at relatively high speeds has a much more pronounced impact on the track than the passage of a few such cars scattered through ordinary freight trains. Although deferred maintenance is undoubtedly a major contributing factor, track-related accidents are also caused by accelerated track deterioration from the use of heavy cars and unit trains. Reported track-related accidents rose from fewer than 2500 in 1970 to more than 4200 in 1975 (9).

Research must be directed to the question of whether the economies realized in the purchase and operation of heavy cars and unit trains are worth the costs in track damage and track maintenance. A similar situation, that

of the recently introduced six-axle locomotives, revealed that their effect on the track, including rail wear, is not fully understood.

## TYPES OF OPERATIONAL SERVICES

Not too many years ago, railroad freight service was divided into just two types: less-than-carload (LCL) and carload service. Within the last 20 years, LCL services have been abandoned as too expensive and noncompetitive with highway transport. Trailer-on-flatcar (TOFC), container-on-flatcar (COFC), and unit-train services for mineral freight and certain agricultural commodities have been instituted. Passenger service first virtually disappeared and then began a resurgence under entirely new economic rules under the single nationwide management of Amtrak and metropolitan commuter lines.

These changes in the types of services offered by the railroads reflect socioeconomic changes within the country, changes in the competitive transportation system, and changes in technology. The railroads today are engaged in four basic types of service: carload, unit-train, TOFC/COFC, and passenger service. Each of these has its own implications for research.

### Carload Service

Carload service has for many years been the keystone of railroad freight service. Much of the current style of operations; operating management structure; and location, size, and design of yards, terminals, and track have been developed to handle carload traffic. At the same time, however, there is increasing concern about both the cost and the quality of carload service. Many recent studies of railroad operations have identified switching costs as a major impediment to profitability. Carload service depends, of course, on frequent switching for its very existence— switching to deliver empty cars for loading, switching the loaded cars in pickup service, switching individual carloads into trains for movement, switching en route, and switching to place loaded cars for delivery. Not only does each of these switching operations add to transportation expense, but each also offers its own change of delay and unreliability, as well as potential damage, to the lading.

There is little question that a good deal of carload service is profitable and provides shippers with the kind of service they require. However, there is now evidence that an increasing amount of carload service is not profitable or does not meet shipper requirements or both. A good deal of research, particularly operations research, must be done to determine the future place of carload service. In addition, there is need for traditional hardware research and engineering-economic studies on improved standardized cars and component designs for carload service to reduce the cost of car ownership and improve reliability.

### Unit-Train Service

True unit-train service offers significant economies of scale and huge reductions in switching expense at terminals. Where solid trains of single commodities can be moved repetitively from a single point of origin to a single destination for unloading, railroad productivity can be greatly improved. Unit trains are heralded by many railroad experts as the hope of the future. The performance of such trains has indeed been spectacular in the movement of coal, ore, and grain.

There are, however, some shadows in an otherwise bright picture. Have the effects on track and roadway (discussed earlier) been properly considered in pricing unit-train service? Are cars that were essentially designed to meet the demands of carload service optimally designed for the high level of travel of unit trains?

In addition, what aspects of unit-train service can be adapted to other service? What additional markets can be exploited by unit-train service? What about integral trains or individually powered cars?

### TOFC/COFC (Intermodal)

Although the movement of highway vehicles on railroad flatcars goes back many years, dramatic increases in the use of this service began only in the late 1950s. Since TOFC service, in theory, combines the flexibility of truck service in pickup and delivery and the efficiency of rail for the long haul, many experts have held the view that it should rapidly replace carload service to a large extent. TOFC service has shown modest growth, but nothing resembling the spectacular growth that was expected by some has materialized. A host of reasons, excuses, and causes have been offered to explain this apparent failure; they are used here as a basis for outlining research needs in this area.

1. Institutional and physical constraints have kept terminal delivery and pickup costs much higher than predicted.
2. The TOFC share of many markets has been too low to justify trains dedicated only to TOFC service. Therefore, much TOFC traffic has been handled in conventional trains that are subject to the kinds of delay such service entails.
3. TOFC traffic, as it is now moved, offers a high center of gravity and high wind and air resistance because of the turbulence at high speeds.
4. Owner-operators, contract truckers, and irregular-route common carriers who operate over the Interstate highway system are highly competitive in price and service in many corridors.

### Passenger Service

With a good deal of federal support, Amtrak operates an increasingly higher level of both quantity and quality of service over the tracks and rights-of-way of the privately owned freight railway networks. The cost to the railroads of providing these routes is currently reimbursed, but the carriers are not allowed a profit. Much of this service is offered on a one-train-per-day or less frequent schedule. It is felt by many that political and emotional concerns will outweigh purely commercial considerations and that such service will not only not disappear, even where it is underpatronized, but will expand. If such is the case, the implications to railroad research are profound. Research in the areas of passenger equipment, locomotives, and cars has been reinitiated in areas where it was dormant for years, but new issues, particularly in operations research, will have to be addressed. Typical of these is the question raised in chapter 12 about the incompatibility between widely differing train speeds and uniform track design. Mixed-speed traffic also raises signaling and scheduling problems.

## ELECTRIFICATION

The subject of railroad electrification has been one of almost universal interest both within and outside the industry for a good many years. The present concern with energy and the environment, especially the former, has merely served to stimulate even greater interest. The major questions raised by this study, in oversimplified form, are how much does the present and predicted

energy situation change previous economic analyses and, if these analyses suggest large-scale railway electrification, what are the implications with respect to the supply of capital?

Several points should be made at the outset. First, electrified operations may not save energy. The high thermal efficiency of central-station power plants is offset by losses in the overhead catenary lines so that it just about equals the overall thermal efficiency of diesel electrics. The balance might be tipped in favor of electrification by the reduction of fuel consumed in idling that is possible with electric locomotives. However, electrification makes possible improved train performance through rapid acceleration and higher sustained speeds (which cost additional energy). Because either coal-fired or nuclear-generating plants can be used to produce electricity, electrification does permit shifting energy sources away from petroleum.

Second, the savings possible with electrified operations are not in fuel or energy but in locomotive costs, both in maintenance and improved availability of locomotives. Since there are fewer moving parts, maintenance of electric locomotives is less costly in time and money.

Third, railway electrification uses mature technology. The first U.S. main-line electrification project, on the Baltimore and Ohio Railroad through Baltimore, was made operational in 1895. Since that time, there have been many installations throughout the world. A vast amount of operational experience has been gained and substantial technology has been developed and implemented in other countries.

Fourth, the amount of energy use that can be converted from oil to coal or nuclear energy through railroad electrification is relatively small. Transportation consumes 53 percent of the petroleum used in the United States. Of this, however, railroads use only 1.6 percent (52). Since under no circumstances would all rail energy be converted to electricity and since not all electricity will be generated from coal and nuclear sources, a much smaller percentage shift can be made through electrification. One very optimistic estimate of future railway electrification anticipates that 20 percent of total railway freight could be electrically hauled. This would represent a 0.3 percent reduction in U.S. consumption of petroleum.

Even the most optimistic supporters of electrification readily admit that the initial price is high— so high that the typical return on investment will not call forth the private capital required. Unfortunately, it is not economically feasible to electrify small segments of a railroad except for rare and peculiar circumstances. The possibility of public funding has therefore been raised in connection with railroad electrification. To make any sense at all, electrification must usually be installed on lines with high-density traffic over relatively long distances. This brings with it the need for concentrating traffic flows and the problems of upsetting the present competitive balances between lines of separate ownership. Thus, electrification raises some serious questions of public policy (see chapter 3).

Several technological problems that warrant further investigation are those related to regenerative braking, phase breaks, procedures for installation of electrification under traffic, cost of catenary, optimum integration of diesel and electric locomotive operations, potential electromagnetic interference, and signal system design. Regenerative braking represents a possible power savings and reduction of on-board equipment since it eliminates the need for power-dissipation resistors. The problem of phase breaks might be most technically challenging since railroads cross the boundaries of different electric companies. It is estimated that the conversion from 25 to 60 Hz of ConRail's existing electrified system between New York and Washington will entail no fewer than 10 interruptions to a continuous line feed. Each of these represents potential difficulty where none exists today. However, the advantages to using off-the-shelf components for the equipment and power grid of 60-Hz commercial power sources far outweigh this difficulty.

A second area of technological challenge is in operations research. More economical use of electrification demands reduction in peak-power requirements to avoid penalty charges. At the same time, economical use of electrified lines entails minimizing catenary construction on low-density lines. The problem here is one of judicious scheduling of diesel power to reduce peak demand on main lines and serve branch lines of the system when main-line motive power requirements are low. To accomplish both these ends without adversely affecting service quality and car use is a large order but one worth study.

Electrification brings with it a new set of problems with respect to labor requirements and contracts. In many cases, different skills and fewer people are required to maintain electric locomotives. New people with another set of skills are required to erect and maintain catenary.

In the final analysis, the question of the extent of electrification will have to be answered on a basis of economics. Previous inquiries into this matter consistently determined that analyses must be specific to the line to be valid. It appears that a generalized engineering-economic study method should be developed at an early date; such specific variables as capital cost, traffic data, fuel and energy cost, and operating and maintenance factors can then be applied to make realistic forecasts of when and where electrified operation is justified. Sensitivity analysis must be a part of such a method so that the degree of risk can be anticipated.

If electrification is to be financed by the carriers, the decision will be an economic one, based on the rate of return on investment versus risk. However, the federal government should be (and is) examining electrification from a broader viewpoint, looking at the conservation of petroleum and the environmental impact as well as efficiency.

## LINE CAPACITY

Conventional wisdom holds that railroad capacity is determined by the nature of its fixed plant (primarily the main-line trackage) and that railroad capacity exists in excess. In reality, capacity is influenced by many factors and probably does not exist in significant excess, at least in the short run. The character, number, and tractive effort of locomotives; the size and makeup of the freight-car fleet; terminal configurations; signaling systems; and the number of qualified train service employees are also significant contributors to capacity. These factors can be adjusted to demand more quickly than can the size, nature, and extent of the trackage.

The time has long since passed when railroad managements could afford the luxury of maintaining significant excess capacity in terms of locomotives, car fleet, or numbers of train service employees. Consequently, if railroad capacity must be reduced for any reason, such adjustments are made relatively quickly, especially with respect to equipment and personnel. Adjustments to the fixed plant are also made but not as quickly. While the fixed plant may, therefore, at a given time have some degree of surplus capacity, it is much less likely that the remainder of the system does also. Furthermore, increasing this capacity cannot be accomplished instanta-

neously. What all this says, of course, is that a railroad is a system, as is the entire industry. The capacity of that system is dependent on many subsystems, any of which can be its limiting factor.

In theory, at least, determinations of line capacity can be made on the basis of the number of tracks, location and length of sidings, speed limits, motive power characteristics, types and spacing of signals, and train length and weight. Such studies now most often use computers to simulate operations. They are useful in identifying bottlenecks, testing alternate strategies, and so forth, but they tell only part of the story.

To this point, the term "capacity" has been used in a very vague fashion as a generalized term to describe some qualitative measure of the ability of railroads to produce transportation. At other points in this report the inadequacy and misleading nature of measures used to describe transportation output have been discussed. The same problems exist with the measures of capacity. While such a measure as kilogram-kilometers per unit of time may be useful for some purposes, it tells nothing about the nature of the commodities or passengers moved, the reliability of the time of movements, the cost, or the quality of service involved. A good deal of effort is necessary in the area of proper and adequate definition of capacity alone. Further work certainly is called for in the area of developing techniques for estimating those measures for which suitable definitions exist.

Signals were first used for safety, but, as signaling systems became more sophisticated, they also became useful tools for expanding capacity. Automatic block signals and then centralized traffic control (CTC) greatly improved the line capacity of the trackage to which they were applied. CTC not only made it possible to increase the capacity of given lines but also offered a technique for handling existing traffic on fewer tracks. Where two tracks with conventional automatic block signals were necessary, often CTC would enable one track to suffice. Similarly, multiple-track lines of four, five, or six tracks could be reduced to two or three, with the attendant savings in material and maintenance expenses but at the cost of increasing the traffic density on the remaining tracks.

Several factors, discussed at length in other parts of this report, indicate that savings can be made by concentrating traffic flows from many lines onto just a few. When the traffic density rises, the likelihood of congestion and conflict also increases. Thus, when traffic is to be concentrated on a line that may already be heavily used because of CTC-prompted track abandonment, the potential for congestion and conflict grows greater. Lastly, lines with high-density traffic require maintenance on a more frequent basis to remedy the destructive effects of high traffic volume and to provide the high quality of track that is commensurate with this kind of traffic.

Proper estimates of anticipated traffic and line capacity are essential for network planning and studies of major rationalization. Technological assessment of potential changes and improvements to plant and equipment should be made with specific reference to their impact on capacity, especially in areas with high traffic density.

## LIGHT-DENSITY LINES

The collapse of the Penn Central Transportation Company and the studies of the northeastern railroads by USRA that followed highlighted the dilemma presented by light-density lines. On the one hand, such lines cost more to operate than they earn. On the other hand, the traffic they generate contributes to the profitability of high-density lines. Also there is significant political pressure to maintain rail service to communities served by the light-density lines. Thus, the major areas of research significant to light-density lines are economic and political.

Nonetheless, some aspects of the problem do relate to operations. Are there operating scenarios and techniques that differ significantly from those used on main lines, that are appropriate to light-traffic branch lines, and that can contribute significantly to changing the economics of branch-line operation? If there are, how can they be coordinated with the remainder of the system?

If main-line electrification appears attractive on the basis of purely economic considerations or public policy reasons, how should the contiguous branch lines be operated? Should they also be electrified so that facilities for diesel servicing are unnecessary and the diseconomy of the branch line is increased? Can both an electric-only hybrid and a diesel-electric locomotive be justified?

What labor questions should be considered? If branch lines are abandoned, jobs are lost. Are concessions in the areas of crew size, territorial rights, and craft jurisdictions justified to save these jobs? If they are, are they sufficient to reverse the branch-line economics?

The work of USRA has produced procedures that can do a better job of evaluating the potential profitability of light-density lines than anything available in the past. The real job for the railroads now is to assimilate USRA's work and learn to apply the methods to their own branch lines.

## QUALITY OF SERVICE

Many critics of the railroad industry have called for improvement in the quality of service offered. Although this sounds attractive, it is not so easily accomplished as might be expected. There is a need first to define quality of service and then to quantify it so that meaningful analyses can be carried out. Aspects of quality of service include service reliability, average transit time between origin and destination, availability of empty cars, special services provided by the carrier, and loss and damage. The problem of loss and damage is discussed in the following section.

In attempting to analyze the value to individual railroads or the railroad system of improvements in quality of service, management must know which traffic is sensitive to variations in service quality and how sensitive it is to what kinds and levels of service, and it must have a method of calculating both the gains to be derived and the costs to be incurred by improving the quality of service.

It should also be clear that railroad management must take into account the relationship between quality of service and the many other factors that impinge on it and upon which it impinges. In judging the value of the railroad's transportation product, the shipper has numerous measures of the level of service and specific shippers emphasize different measures. It is also clear that specific commodities are affected differently or have differing service elasticities. The rational shipper judges the railroads by the total economic impact they have on his business. He is concerned with service, from the time he orders empty cars until the time his goods are delivered to the consignee. He considers transportation just one segment of his overall distribution planning. The railroad industry should focus on shipper-oriented measures of rail service and productivity rather than on internal measures that are meaningless from a marketing standpoint.

There is by no means complete agreement in the industry or outside of it on what constitutes service and

how service relates to demand. Some rail officials contend that the shipper does not see himself as buying reliability from the industry and that only modest changes in volume, if any, would occur if service reliability were dramatically improved. By the same token, other rail officials have indicated that service improvements can lead to a substantial attraction of new business. In fact, neither contention has been supported by a comprehensive set of data, models, and analysis. Again, the need for economic cost data becomes obvious. Costs must be known if we are to develop consistent and usable demand models, which are themselves a prerequisite to understanding the degree of elasticity involved in evaluating the impact in the quality of service changes. In order to know what level of service it should provide, a railroad must know how service levels affect traffic volume.

A brief look at the myriad factors that contribute to service quality may clarify the need for research to provide railroad management with a tool to use in the planning process and to provide the shipper with a tool to use in evaluating his transport choices. The broad applicability of work in this area is such that government and industry can justify undertaking the work jointly or at least developing the measures of productivity and cost models that individual companies can apply to their own needs and circumstances. Any discussion of the quality of service, particularly with respect to reliability of delivery, should take into account the work done by MIT for FRA and with the Southern Railway Company (11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25), which has shown that improvements are possible. This type of research should be expanded.

Improvements in service may lead to better use of equipment by the shippers who currently control rail cars for a significant portion of their cycle. Simplistically, this change in shipper's practices could contribute to improved car utilization, which may reduce the need for capital for equipment and increase the return on investment since existing revenues would cover a smaller capital base. The cycle would continue, with improved rail service leading to greater rail use by shippers, which produces greater revenue at the same time that costs are declining. Such a happy situation, were it ever to occur, would generate an increasing rate of return on investment.

Indirect subsidy to the railroads' competitors by government has permitted improvement of service quality in competitive modes. The Interstate highway system, for example, has allowed dramatically increased truck speeds and significantly greater time reliability for trucks. This has permitted trucks to serve clients in an increased radius with fast overnight service at a lower cost through more efficient use of fuel and labor. Deepening channels and enlarging locks have permitted larger barges and resulted in lower operating costs on inland waterways. Knowledge of the measures of service quality would also contribute to the decision-making process about public policy on equalizing government treatment of transportation modes.

## LOSS AND DAMAGE

Payments of claims for loss and damage incurred in connection with rail freight service have markedly increased over the past two decades. While some of this increase has resulted from inflation, there has also been a long-term trend for payment of such claims to increase in relation to revenues. In 1974, freight claim payments by U.S. railroads for loss and damage amounted to $291 million, or 1.8 percent of gross freight revenue. Control of the sources of loss and damage offers one possibility for savings that could enhance net income.

At the present time, information concerning loss and damage exists largely in terms of claims, reports, and payments. In current practice, such information falls short of providing a basis for assigning causes and taking cost-effective corrective measures. Further, claim reports do not reflect internal losses sustained by a railroad in connection with damage to cargo, nor do they afford insight into the secondary losses sustained by shippers or consignees that, in turn, affect the choice of mode for shipment.

Major categories of loss and damage claims include theft, delays in delivery, and physical damage to shipments. Claim payments in the last category account for the bulk of total claim payments—estimated at about 87 percent in 1974. It should be observed that, since each type of loss and damage is related to some other aspect of providing rail transport service, they cannot be analyzed in isolation.

In developing a corrective approach through research to the problem of loss and damage, it is useful to view it as an element in the larger subject of quality of service. A systems approach would be aimed at identifying the conditions and events that lead to loss and damage, establishing relationships of cause and effect, assessing the costs and effects of corrective measures, and enabling the development of cost-effective management control procedures. Research aimed at a broader understanding of the problem of loss and damage should consider establishing such originating factors as:

1. Inherent characteristics of the commodity;
2. Shipper practices (e.g., packaging, loading);
3. Behavior of the cargo in relation to the conditions of transit (dynamics of the ride), i.e., (a) interaction of the cargo and car due to the static vibrations and impact forces that can occur in transit and changes in the density and position of cargo as the result of such forces (taking into account the loading, stacking, and blocking requirements for different kinds of cargo) and (b) changes in the cargo that result from changes in the in-car environment, e.g., temperature, air circulation, moisture; and
4. Unloading and storage practices of the consignee.

In addition, some attention might well be directed to reducing losses that stem from the claims-settlement procedure itself. Documentation derived from such research as that suggested above could be of value in identifying false claims and in avoiding claims for which the railroad need not take responsibility. Also, some study of alternative legal remedies in the field of loss and damage might be pertinent. Industrywide sharing of claim experience through a clearinghouse approach could develop patterns that might detect fraud or identify products that are unable to withstand transport.

Perhaps an entirely different approach to loss and damage should be taken, removing it from the individual firm to coverage by an industry-sponsored insurance plan. There are many alternatives to be studied since, for all the data available, there is still a dearth of knowledge. Recently the AAR's freight claims devision has taken steps to bring into operation a computerized national system to collect data on loss and damage; this should help to identify the areas in which concentrated efforts will pay off.

## CAR UTILIZATION

A report by the Secretary of Transportation pointed out that the greatest potential for improvement of productivity lies in increasing the rate of utilization of the fixed

plant (right-of-way and yards), increasing the productivity of equipment, and eliminating unnecessary capacity. This report goes on to point out that the impact on the industry's cost structure utilization of plant and equipment is evident if one considers the large amount of capital that is currently invested in freight cars. The report indicated that 33 percent of the class 1 railroads' investment in road and equipment, based on 1972 figures, represented freight cars owned by the railroads. If non-railroad-owned equipment is added to the figure, it was estimated that freight cars account for approximately 50 percent of the total net capital investment involved in providing rail service.

More recent figures published by the ICC for 1973 indicated that the total net investment of class 1 railroads in road and equipment—including cash, equipment, material, and supplies, after deducting depreciation and amortization accrued under ICC accounting rules—was nearly $28 billion. Of this amount, the net depreciated value of freight cars amounted to $8 million. Using the average value per car and expanding this to include other railroads, car companies, and shipper-owned cars, the total becomes $12 million, or 42 percent of railroad assets. It is interesting to note that at the close of 1951 freight cars (two million cars) represented a net investment of approximately $3.7 billion or 15½ percent of the $25 billion then invested by those lines in road and equipment. The increase to almost 50 percent of the total assets shows the trend in capital investment in the railroad industry and how it is being channeled into the freight car (1, 2, 5). Since a large portion of the fixed plant consists of nondepreciable property, it is evident that in an inflationary time an increasing percentage of the total assets of a railroad will be represented by its rolling stock, primarily the freight car.

Cash generated by depreciation accounting under an inflationary economy does not provide adequate replacement costs. Using the 1958-1959 price as the base index of 100 will give a rise to 204 for the cost of freight cars in 1974 (6, p. 370)—the cost of a freight car having more than doubled in the last 15 years. A depreciation life based on an almost 30-year life of use certainly cannot generate anywhere near enough cash to replace an asset that, if trends continue, may have quadrupled its original cost. Observing this inflationary trend in the cost of equipment and considering the fact that the average freight car will make a little more than 14 trips a year certainly gives clear indication that a potentially very rewarding area for research is car utilization. Another significant factor in the poor performance of a freight car as an asset is the amount of time during which this car travels empty. A recently completed study indicates that the average freight car spends more than 40 percent of its life empty (8). Looking at it from a car-kilometer standpoint, the latest report of the ICC indicated that a freight car travels empty for 42 percent of its total distance traveled (3).

Although substantial empty travel is beyond the control of the carrier or shipper, it is quite obvious that one of the lucrative areas for improvement of railroad operations lies in corrective action to decrease this high percentage of empty movement. Figures for 1937 indicated that the percentage of empty travel to total travel for all types of cars in class 1 U.S. railroads ranged from 37 to 40 percent and at times was as low as 35 percent (1). The trend seems to be going in the wrong direction, obviously accentuated by increasing amounts of specialized equipment, which tends to guarantee a 100 percent empty return movement.

In order to correct the railroads' problem of not earning enough to generate a sufficient return on investment from its principal asset—freight cars—the following areas require immediate corrective action:

1. The average car cycle must be altered to provide not 14 loads a year but many more. Future rate adjustments and changes in future cost of cars are impossible to predict with accuracy, but they bear upon the economics of the number of loads per month needed to generate an acceptable return on investment.
2. The ratio of empty freight-car-kilometers to loaded freight-car-kilometers must be reduced for general service equipment.
3. The capacity of the freight car, either in volume or in weight, must be better used by industry.

This is an industry problem, one that involves many carriers and cannot be resolved in isolation by any one carrier. The statistics for 1974 indicate that total car loadings were about 26 million, only 12.5 million of which originated and terminated on the same line; some 52 percent of the cars loaded involved handling by more than one carrier (4). These figures describe the interdependency of the industry. The problem of freight-car utilization is a problem that must be resolved by an industry-wide approach. Five factors have been identified that would be conducive to good car utilization:

1. High-quality service for loads in terms of dock-to-dock speed, reliability, and frequency of service;
2. Prompt and predictable supply of the right type of empty cars in the right condition;
3. An efficient on-line real-time information and control system that covers movements of loads and empties and ultimately includes the forecasting of loading requirements and a disciplined scheduling of the movement of empties (see chapter 3);
4. Incentive and penalty features in rates and charges to balance traffic by direction and season and to reduce the time for loading and unloading, circuitous routing, diversion, stop-off, and so on; and
5. Quick and efficient loading and unloading.

A 6½-year research program begun by the AAR in 1975 addresses these five factors. One area of study in this research program relates to the problem of peaks and valleys in the demand for cars. As stated in chapter 5, there is a great potential for research in forecasting for demand and, particularly in the pricing and marketing area, for added incentives that tend to reduce or minimize the peaks and valleys of demand. A proposal to develop a method of demand pricing for cars was advanced by the Staff Studies Group of the AAR in November 1973; this could have a profound impact on the survival of the railroad industry. As it did for the motor carriers and inland waterways, demand pricing could greatly reduce problems of equipment shortages, improve car utilization, and improve the railroad industry's profitability. As this report was being written, the ICC was considering setting up demand-sensitive rates.

Arrangements for buffer storage (unloading, stockpiling, and reloading bulk commodities such as ore and coal rather than direct transfer from ship to rail cars) with appropriate financial incentives for both the shipper and the carrier would seem to offer a tremendous potential, as illustrated by the Bessemer and Lake Erie Railroad Company coal and ore storage facilities at Conneaut, Ohio. The growth in the size of marine and lake vessels and the interaction of water and rail transport make such buffer storage capabilities more and more important to both shippers and railroad equipment utilization. Solving the problem created by the practice of storing coal in cars at ports, either in order to blend it with other coal or to await a ship, offers significant early reward if it

is successfully understood and researched. As in the case of peak-demand pricing, this subject affects not only operations and engineering but also marketing and rate making, and the benefits of more rapid turnaround affect both utilization and equipment maintenance. Dynamic blocking—assembling blocks of cars from immediately available traffic to minimize yard handling—also warrants development and demonstration.

The problem of the mechanical condition of the freight car and its ability to perform service in a dependable manner warrants continued research and improvement (see chapter 12). The freight car of 1975 still has a long way to go before it can achieve the degree of service reliability that the industry needs.

The matter of car distribution practices is another area that merits continued research. The ultimate objective of being able to assign a freight car in advance of its being made empty has been approached by many carriers and is even now being researched by one large carrier that hopes to achieve a complete monitoring of the car cycle, both loaded and empty, in a method described as positive car control. The use of today's data processing equipment puts these goals within reach. Distribution of car supply between areas of surplus and areas of shortage can be better controlled by an understanding of forecasting. A project to develop demand forecasting for cars is currently being carried on by the FRA through the AAR. In addition to completing the present program of demand forecasting, the potential for supply forecasting for cars should be explored. This research should build on data for the local railroads but expand to the standpoint of nationwide car distribution. The AAR has developed a system that records interchanges between carriers—TeleRail Automated Information Network (TRAIN).

Knowledge of car condition is a necessary ingredient to good car distribution; such knowledge, together with the AAR TRAIN system, would help the industry to more efficiently distribute empty cars when forecasting is developed. To date, no industry-accepted grading system to describe the condition of a car and its suitability for loading has been developed, although many individual railroads have implemented their own systems. Many railroads do not physically inspect cars for such grading but depend on the last commodity handled as an indication of its quality. This ensures that a car will always be downgraded in quality, never upgraded. It is also too general and may result in rejection by customer or, worse yet, a loss or damage claim. The trend within the industry not to physically examine a car's loading suitability results from ignorance of the true cost of not inspecting cars, e.g., lost car-days, extra car handling, loss and damage. Studies are needed to determine the cost to the industry of not inspecting cars and not having a uniform car-grading system. This problem is being addressed in part by the Freight Car Utilization Research Program and the Labor Management Study (St. Louis).

The problem of assigned cars or privately owned cars is one that is growing in significance to the industry. The operation of small privately owned fleets serves to skim off the higher class rail traffic and return hauls, leaving the railroad-owned fleet to deal with the overflow, which results in obvious inefficiencies in the use of railroad-owned assets. The railroads must devise a way to reliably supply cars to shippers in order to negate the need for such assignment.

The final phase of the AAR research program involves improved education, equipment design, work rules, questions of railroad policy, and questions of public policy, all of which have a direct bearing on freight-car utilization. Some specific areas of research that could be pursued follow.

1. The design of freight cars should allow for greater utility, especially in the area of return loads or subsequent loads. The inefficiency of crosshauling empty auto-rack cars because automobile manufacturers use different tie-down arrangements exemplifies the need for design change.
2. More practical and less expensive methods of cleaning car interiors are needed. To clean cars economically requires considerable plant investment and a move away from the traditional broom-and-shovel approach. For example, although the covered hopper has increasingly become a general purpose car, only two really effective car-cleaning plants in operation today permit such equipment to be randomly used for various commodities. It would seem logical for railroads that share traffic flows to jointly design, locate, and operate such facilities to best serve these flows.
3. Further experiments with the work rules, like that described in the 1974 Progress Report of the Labor-Management Task Force on Terminals, should be conducted. This certainly ties in with needed improvements in reliability and lends itself to more frequent service, if the economics can be adjusted so that both labor and management benefit. Railroad performance is inextricably tied in with the economics of its labor agreements. More frequent service and shorter trains may be economically feasible if adjustments can be made in the traditional work practices. Eventually, such changes in operating practices could resolve many problems about terminals and could, in fact, generate additional employment if the carriers enjoy added business.
4. In the area of regulation, the present ICC and AAR directives are punitive in that they generate unnecessary empty car-kilometers. While the need for protecting ownership of equipment is obvious, research is required to develop a more economical way of achieving this objective. It may well be that the concept of carrier-owned equipment should be phased out and the kind of national fleet exemplified by Trailer Train Corporation and American Rail Box Car Company should be the wave of the future. Economic research is needed to explore the possibilities of such a national fleet. The Clearinghouse Experiment, which was expanded from 3 railroads in spring 1976, provides an alternative to the strict control by car-service rules of freight-car use and empty flow and should be further developed under the present concept of carrier-owned equipment. It has demonstrated the potential for reducing empty car-kilometers and reducing car-days, but it also demonstrates a need for expansion and refinement.

A closer liaison between major shippers and railroads could generate control systems that would be beneficial to all involved in the movement. For example, the movement of grain in multicarrier operations often involves the problems of loading at the point of origin without regard to the requirements of the destination, at least insofar as timing is concerned. If the shipper's or buyer's information is used cooperatively, all the carriers involved could generate a system of better control with fewer cars used as warehouses and fewer congestion problems. Research is needed not only on the psychology of management incentives toward greater car utilization but also on the development of control systems that effectively manage and measure or monitor performance (see chapter 13).

It has been suggested in this report that research into such management strategies as profit centers could be beneficial in a general way to the railroad industry. The whole area of car utilization might benefit dramatically from such an approach, especially if costing and information systems have been established to provide accurate and valid evaluations of decisions that affect profits.

Railroading is essentially a mass-movement form of transport. Any operating practices that tend to disrupt this character, e.g., individual car switching, detract from this inherent advantage. The unit trains that handle coal and ore in specially designed runs with nonstop loading and unloading illustrate this quality at its best. At the same time, most higher valued processed goods do not lend themselves to this type of operation. It would appear that research directed at reconciling this difference of character and service demands is warranted. How can we mesh the mass-transport character of the railroad, preserving its economics and service potential, with the need for reliable service in shipping the manufactured goods for the nation? It would seem intuitively that the solution lies in greater intermodal activity, at a level far more developed than the present state of the art. Research in this area could help preserve the future of the industry.

In summary, it appears that research in car utilization is urgently needed to improve service reliability and achieve greater equipment productivity. Specific work is needed in

1. Train-scheduling and blocking practices;
2. Peak-demand pricing;
3. Management incentives to improve car utilization;
4. Provision of realistic performance goals for terminal management, particularly for reduction of idle yard time; and
5. Improved methods of distributing empty cars that can (a) forecast anticipated supply and demand; (b) match supply and demand, taking into account the dynamic environment of car availability and need; and (c) determine the effect of train schedules on freight-car distribution.

# Chapter 12
# Plant and Equipment

It is widely accepted that railroads are efficient movers of people and goods and efficient users of land and energy. This is in itself evidence that the industry does not suffer from a large technological gap in the engineering design of its physical plant or in the utility and design concepts of the equipment offered to its users. However, there is a widely reported view that railroads are, by the very nature of their business, slow to adopt new technology. This public image of the railroads will not withstand thorough analysis, for railroads have, in fact, responded quickly to new technology when it can be shown to provide immediate financial return. The critical factor at work in this situation is the low level of gross railroad revenue since, no matter how attractive new technology may be, it cannot be purchased by firms that are without cash.

The industry's response to technological change is exemplified by the rapid changeover to diesel locomotives; its massive use of the computer for accounting, financial, administrative, and operational controls; its use of advanced communication techniques that combine microwave and cybernetic systems in such applications; its use of advanced technology in the operational and administrative control of freight classification yards; and advancements in track design and maintenance, including the almost universal use of welded rail in replacement and in mechanization of track maintenance.

Despite the advances that railroads have made in plant and equipment technology during the past 25 years, there remains a fertile field for research. Many of the most pressing problems about plant and equipment that railroads face relate to the use of these assets rather than to their design. Solutions to these problems often have only a long-term financial return. By contrast, the survival issues that face the industry are overwhelmingly short term and economic in nature. Without a solution to these economic difficulties, there is little incentive for private industry to research questions of plant and equipment technology that provide only a distant return on investment.

For these reasons, this chapter addresses two types of plant and equipment research. The first deals with research having immediate and short-range returns. The second assumes that solutions are found to short-term funding crises and is concerned with research required for the industry's long-term viability. By their nature, however, these research issues involve long lead time and have longer term payoffs.

Examples of the first type involve improvements in operations, equipment design and utilization, train handling, and train makeup through systems analysis, by using advanced communication and cybernetic systems and simulation techniques. In the second category are improvements in basic equipment and structure, e.g., alternative material for crossties, investigations of support systems, investigations and innovations in soils and drainage, and economic studies of routes and alternate power and fuel sources, including electrification.

Railroads were among the earliest enterprises in industrial and technological history to recognize and capitalize on the system effect. They were surely the first enterprise that had such enormous complexity, requiring the interaction of components and subsystems and involving great distances. Much of the early engineering effort of the industry was devoted to these issues. Failure of early railroads to adequately understand and compensate for both internal interactions and their external interdependency severely restricted railroads in the developmental phase. This was reflected not only in differences in gauge and coupling systems but also in the way the in-

dustry was organized and administered.

The industry attacked these problems through great efforts expended on standardization. The development of separate plants capable of free interchange was neither accidental nor achieved without pain and expense. Consequently, there remains an understandable reluctance to jeopardize the idea of compatibility at any point in the system—couplers, braking subsystems, track design, or simply the locomotive electrical coupler system. There has been less of an effort within the organizational and administrative aspects of the industry to acknowledge and accommodate its systematic nature; further examination is needed.

Nevertheless, it now appears evident that a good deal of technical advancement and even ability to exploit potential markets hinges on selective noncompatibility. Throughout the Railroad Research Study conference, there were questions related directly to this issue. If every element of the system remains forever compatible with every other element, either there can be no innovation or else the cost and risk of retrofitting will become astronomical. Research in most aspects of plant and equipment must consider these issues and attempt to make reasonable compromises between optimization and innovation on the one hand, and compatibility and standardization on the other. For example, unit trains could have couplers and brakes that are not compatible with the entire fleet.

## TRACK AND ROADWAY

Railway track in North America has recently been the subject of much public interest and concern. Railroad managements have historically subsidized operations and services that failed to earn sufficient revenue by deferring track maintenance. This amounted to a temporary loan from a wholly owned bank. When the lack of revenue was temporary, the loan was paid back (generally with interest based on inflation) by accelerated maintenance when traffic increased. However, because of shifting population, industrial relocations, and the like, there are now cases in which the lack of revenue has continued until the loans are past due. The consequences have been slow orders, increased interference with remaining traffic, and a very poor public image. The true cause of poor track condition is often obscured, and the public is left with the impression that poor track results from antiquated design and is the cause of the railroads' problems rather than the result, as well as that the entire industry is so afflicted.

Expert engineering testimony at the Railroad Research Study conference was unanimous in declaring that the currently maligned conventional track design, given appropriate modifications and regular maintenance and replacement, is not only adequate for present requirements for freight-hauling railroads but is also probably the best alternative for the foreseeable future on this continent for both freight and passengers. Nonconventional track that transmits rail loads to the supporting subgrade with structural elements other than crossties and granular ballast is, in all the designs so far proposed, more expensive and offers technical limitations that detract from its primary advantage of lower and less frequent subgrade loading pulses. If there is a place in North American railroading for such designs in the reasonable future, it would appear to be in either ultra-high-speed operations—faster than 240 km/h (150 mph)—or in very high traffic densities with subgrades that cannot be stabilized by less expensive techniques. Its further use may be to solve such special construction problems as tunnel inverts, elevated structures, and station tracks.

The major challenges for research concern developmental evolution, refinement of component design, techniques for fine economic tuning, choosing trade-offs with the design requirements, better understanding of the interaction among components, and continued improvement in the growing understanding of the interaction between track and the vehicles that operate on it.

The Railroad Research Study conference unearthed an increasing number of situations in which incompatibilities between track, vehicle, and operations are thought to have adverse economic consequences. There is a need to determine the engineering and economic trade-off points not only within the track structure system but outside it as well. No longer, for example, can the industry use increased car size and weight and higher speeds as a basis for determining track design. The engineering and economic costs in track construction and maintenance must be weighed against advantages in car costs, maintenance expense, and operational economic advantages to define a system that will be in economic and technical harmony. Several other specific technical areas were identified and are discussed below.

### Track Compatibility

Compatibility of tracks for mixed passenger and freight traffic is an old issue. For several years it seemed to be going away, but there is a reemergence of passenger traffic and indications are that, at least for the near term, this growth will continue and possibly expand. High-speed trailer trains that have a high center of gravity have been introduced. These trends present several aspects that deserve reexamination. What compromises are most suitable with respect to superelevation and speed in negotiating curves? Recent changes in freight-car design, including coupler design, car length and weight, and changes in the center of gravity, present different engineering criteria concerning unbalanced superelevation, negotiating turnouts, and crossover design. These changes need to be reevaluated for lines on which passenger-train traffic is expected. If passenger traffic is to operate on tracks dedicated to the exclusive use of passenger trains or if freight traffic only at uniform speed is expected, the problem is less difficult than when, for whatever reasons (passenger traffic being only one), trains with wide variations in speed, weight, and center of gravity are to be accommodated. It may be more economical, for example, on multiple-track lines to separate traffic by speed rather than by direction and to use each track as a single-track bidirectional line.

### Track Maintenance Techniques

The basic philosophy of North American track maintenance has heretofore relied heavily on the renewal and adjustment of individual components, largely because of variations in the useful life. Specialized work procedures and machinery have been developed to a high degree for such specific activities as lining and surfacing, ballast cleaning, spot tie renewal, and rail renewal. These operations have been automated and in general made more economical. In real dollars, the cost per unit of the individual operations has been substantially reduced. There is, however, growing concern that this approach may be reaching the limit of its potential efficiency. The alternative philosophy is one of complete rebuilding of the entire track system. This approach, used extensively in Europe, should receive careful evaluation in terms of machinery expense; traffic interruption (extent and frequency); effect on the interactions among material, components, and life expectancy; labor cost; and maintenance of track geometry.

## Track Research

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and geometric condition;
5. Welding and gluing techniques for joining rails in the field;
6. Alternative materials for crossties, including investigation of their life-span costs and their effects on the remainder of the system;
7. Better understanding of inspection techniques and costs and their interaction with maintenance philosophies;
8. Development of improved safety standards that incorporate maintenance incentives based on systems investigations of the tolerances of track geometry and the condition of track components in relation to loads imposed by vehicles; and
9. Analysis of the performance of rail-tie fasteners, especially with respect to lateral loading.

## EQUIPMENT

Although a fundamental and unique feature of railway track is its ability to guide individual vehicles, track can only perform this function with respect to appropriately designed and compatible vehicles. A given line or route of track is truly singular because of the geometry, design, materials, combinations, and arrangements of its track facilities. In order to be of greatest utility, however, equipment must be in largely universal use. It must be capable of negotiating the particular nature and configuration of the track that leads to its intended destination. From a technological point of view, therefore, a railroad is a system that encompasses unique track configurations and equipment that is capable of being joined together into trains and of negotiating a vast number of unique track configurations. Most of the technological questions on equipment-design engineering are based on this necessary compatibility between wide variations in track geometry and conditions and the capacity to be joined into and operated as trains.

bogies, provide the interface between the
d track in the railroad system. They repre-
one-third of the investment in a typical modern
. When there is incompatibility in the track-
stem, it is most often reflected at this inter-
ucks are intended to be self-steering. Ideally,
flanges never strike rails, since the conicity
heels should impose self-correction whenever
attempts to stray from the direction established
ails. Unfortunately, wheel flanges do frequently
the rails. In the understeered truck, wheel
are continuously guided by the rail, resulting in
e wear to both. Conversely, overcorrection leads
k "hunting" and resulting periodic lateral impacts
n the wheels and rails. Significant interest was
ssed by a number of participants in the need to ex-
and expedite studies of truck steering and hunting.
e studies should also include a review of basic de-
concepts.

he axle-load problem was discussed earlier. One
n-proposed solution to maintaining the advantages of
n-capacity freight cars, while alleviating the penalties
ociated with heavy individual axle loads, is the use of
ee-axle trucks in place of the conventional two-axle
ucks. This is a solution employed in the USSR. The
tractiveness of such a plan, however, seems to be some-
hat offset by the high maintenance cost of such trucks.
lso, its effect on rail wear on curves is not known. A six-
wheel truck that could be easily maintained at low cost might
e welcomed by both track and equipment officers.

Springs are employed as intervening elements in most truck designs to reduce direct impacts caused by track irregularities. In a simple freight-car truck, the truck springs act between the truck frame and truck bolster so that the mass of the truck bolster and car body above it are separated from the truck frame, wheels, and axles. In more sophisticated truck designs, even the truck frame is separated from the mass of the wheels and axles by springs. The unsprung mass in a vehicle design exerts a greater destructive force on truck and car components as the speed of the vehicle is increased. The importance of spring design and placement increases as speeds increase. The amount of unsprung weight becomes critical in higher speed operations. Many participants were interested in additional engineering development work that would lead to reductions in unsprung weight, especially in the case of locomotives, where the weight of traction motors has traditionally been added to or hung directly from axles.

## Couplers

Couplers permit individual elements of equipment to be joined together into trains. The basic Janney coupling system now in use on North American railroads was invented 108 years ago. Some of the identifiable deficiencies of this system are that

1. Coupling is not always accomplished, since at least one knuckle must be open to operate,
2. It has an insufficient gathering range,
3. Uncoupling can only be accomplished manually and when the coupler forces are in compression,
4. Air hoses must be manually connected, and
5. There may be jackknifing forces in compression and string-lining forces (a tendency to pull in a straight line rather than following the arc of the track on a curve) in tension.

The degree to which automation is introduced in cou-

pling cars and locomotives will be, in a large way, responsible for determining operating practices. Over the years, many improvements over conventional couplers have been suggested and patented, but few, if any, of these improvements have been incorporated. Once again, the question of compatibility is a significant issue. Must all cars and vehicles be equipped simultaneously with a new and different system? Must the system be able to be incorporated in some parts of the equipment fleet and still function with unconverted equipment, or is it possible to operate with elements that are incompatible with the total equipment fleet? The AAR-RPI-FRA joint coupler project that is now under way is investigating the engineering-economic questions and the functional requirement for automatic couplers, i.e., the cost and benefits related to the alternative operating practices that are required by or made possible with the design changes. In addition to automatic coupling of the air lines, electrical lines could also be coupled automatically. Train lining of electrical control circuits opens many possibilities, e.g., electronic pneumatic brakes.

## Brakes

The question of compatibility is also influential in the study of railroad braking systems. The current railroad air brake system came into being about 100 years ago and has undergone adaptive evolution. The basic limitations of the existing system are that it has a single pneumatic train line, which cannot be recharged automatically except when the brakes are released, and that the application of brakes throughout the train is not instantaneous but is propagated along the length of the train. Electronic control of brakes could solve the last problem.

Some of the problems that have been identified as resulting from the existing system include the thermal cracking of wheels due to absorption of excessive energy, air leakage in cold weather, and the hazard to employees when they are connecting air lines. As it did in considering further automation of couplers, the question arose as to whether the railroad industry really needs or can afford total compatibility with respect to braking systems. There is also the question of the extent to which cars can be permanently coupled. Permanent coupling could improve braking systems by reducing leaks.

## Freight-Car Design and Configuration

Freight cars have been getting larger and heavier. The average carrying capacity of a car in the fleet has increased from 42 000 kg (46 tons) in 1929 to 67 000 kg (74 tons) in 1975. A good deal of the increase in railroad productivity is attributable to this increase alone. Increasingly, track engineers, operating officers, and equipment engineers have expressed concern and called for a comprehensive economic and engineering review of the trends. As noted earlier, high centers of gravity reduce the stability of cars and increase the detrimental effects to track of unbalanced superelevation, and heavier cars also increase the unit loads on ties, ballast, and subgrade, causing more rapid deterioration of track line and surface and the materials. These larger cars have higher center plate loads and stresses and, consequently, higher failure rates than smaller cars. Long cars produce more severe coupler angles during negotiation of curves, which increases the tendency for both string lining and jackknifing.

Obviously, trade-offs must be made, and optimal designs based on true engineering economy are needed. This calls for extensive cost-benefit studies and quantification of expenses and costs. The research need here crosses many traditional departmental and disciplinary boundaries. It should include commercial, marketing, and financial perspectives, as well as the classical engineering points of view.

## Reliability

Service failures of equipment components lead to human injuries, train delays, derailments, damage to cargo, poor service, lost business, and added expense. Operating officers who have previously been embarrassed by train delay caused by breakdowns in motive power are inclined to assign additional locomotives as insurance. If a coupler knuckle fails on the road, its replacement is expensive, the train is delayed, and, on densely traveled routes, other trains are delayed as well. Service failure of wheels, axles, and truck frames can cause serious—even catastrophic—derailment and associated expense, damage, and line blockage. Ways to avoid such problems should receive considerable attention and have a high priority in research needs.

Improved reliability of components can and should be approached in a variety of ways. Better design to reduce the effects of fatigue and wear, based on better knowledge of the environment and improved application of materials science, is certainly needed. At the same time, new and improved techniques for inspecting components both on the road and in terminals and shops are indicated.

## On-Board Monitoring

Closely related to over-the-road inspection systems is on-board instrumentation for the monitoring of train operation. Train dynamics is becoming increasingly important as the industry presses close to the tolerable limits of track and car geometry, train length, speed, and weight. Systems that measure train forces should provide invaluable feedback to crews for both operating efficiency and purposes of safety. On-board monitoring of running gear conditions, such as bearing temperatures, would add to safety and reliability.

Similarly, as the need to conserve costly energy increases, it would seem advisable to provide information to locomotive engineers on the rates of fuel consumption and power output. Such data would also be useful in analyzing locomotive performance and in the anticipation of remedial maintenance requirements. In passenger service, continuous monitoring of the environmental systems of passenger cars also seems appropriate. Data on ride quality could be useful in the control of lading damage, in the anticipation of running-gear problems, and as a continuous check on track quality. Any or all of the above types of information could be stored on magnetic tape for after-the-fact analysis, as well as for immediate surveillance.

## Yards and Terminals

Railroad equipment and operations have changed significantly since most of the existing freight yards and terminals were designed and constructed, and some advances have been made in yard and terminal design. However, there is a need for a total systems approach to terminal and yard design. Research and development work in this area should be conducted in full awareness of today's larger and longer cars, the new blocking and scheduling concepts now in use (including run-through trains), the generally changing nature of the freight handled by the railroads (including the loss of most short-haul traffic), the increased use of TOFC/COFC service and unit trains, and the flexibility achieved (and expected to be expanded) in work rules.

Significant progress in the automation of yards has been made in the last few major yards recently constructed or now under construction. Additional work is needed to accelerate the research and development under way to provide better current information for input into management control systems, as discussed in chapter 13. The design of intermodal terminals should be given particular attention. Improvements in efficiency and service to shippers could make the future of TOFC/COFC service far brighter and provide greater profits for the railroads. Reductions in loading and unloading time, as well as in the time trailers and containers are in the terminal, are necessary to cut both costs and time spent in transit.

Selection of the location of yards and terminals has always been given serious study, but using operations research methods might give better results. Here the work of USRA should be used and built on. As in design, location of intermodal terminals needs special emphasis since experience has demonstrated that high volume is crucial. Without high volume the capital investment to provide good service and profitable operation cannot be justified. The early TOFC terminal plan to provide a ramp for circus-style loading of trains at almost every town came under question long ago.

Finally, there are many opportunities in urban areas to consolidate terminals and yards in order to increase volume and reduce costs. Such consolidations can, through relocations, eliminate grade crossings and aid in urban renewal. The capital requirements for major consolidations are large and present major barriers to implementation. Any research should include an investigation of ways to raise the necessary capital.

# Chapter 13
# Management Information and Control Systems

To accomplish the desired objectives of any system—large or small, simple or complex—the working of the component parts must be guided and controlled so that they work together effectively. At the same time, a timely feedback of information is necessary to assure corrective action when the inevitable perturbations occur in the flow of production. This complex task of providing guidance, monitoring, and continuous adjustment of the working of the system involves a management information and control system. This does not refer to a particular level or segment of the organizational structure but to the flow of information throughout the entire organization.

Every railroad, of course, has a management information and control system, whether it is operated completely by humans or assisted in part by computers and communication systems. The purpose of this chapter is to summarize some of the potentials for improvement in the management information and control process and to point out some of the kinds of research that are pertinent to the development of such potentials. The difficulties of imposing the changes implied by automated systems on a functioning organization's day-to-day operations are recognized. Although this chapter is focused primarily on the problems of day-to-day operational control, it is useful to consider the position of such activity in the overall scheme of general organizational planning and control.

The general management process involved in producing rail transportation service includes what may be called, in somewhat idealized form, strategic planning and analysis, tactical planning and evaluation, operations control and monitoring, execution, and appraisal. Operational control and monitoring involve the day-to-day operations of the railroad. The actual work in process is monitored and compared with the operational plans, and adjustments are made to reconcile any differences. The modified plans are then translated into specific schedules, assignments, and dispositions for implementation. Specific work orders are issued to train crews, terminal forces, and maintenance forces. Operational control and monitoring must be performed continuously 7 days a week and 24 hours a day. The time periods associated with control activity vary from less than an hour up to a few days. Lower levels of operating management are involved in monitoring and controlling operations.

The work orders issued by operational control are executed by the work force and the results appraised by people at the first level of supervision. The work actually performed and the exceptions taken to the work orders are then fed back to the higher levels of management. Supervisors and the work force are continuously involved in the execution of the instructions developed from operational plans and are aware of what work is currently being performed. This information is summarized in the form of plans accomplished and forwarded to the tactical planning and evaluation group. Here the feedback is further summarized and sent to the strategic planning and analysis group in terms of goals met.

Use of the management information and control system is a major factor in securing cost-effective rail operations. This is true not only with regard to the transportation aspects of the freight-car cycle but also to the

maintenance of the rail plant, motive power, and rolling stock. During the past 20 years, the U.S. railroad industry has made some very significant technological advancements and has introduced automation in several areas of rail operations. These innovations have been very beneficial to the industry, although of course they cannot directly deal with problems that are external to the operating aspects of the system. Indirectly however, the information derived from the guidance and control activities provides the essential basis for longer range planning, financial decisions, and many other aspects of the larger problems of running a railroad.

## EFFECT OF THE RAILROAD ENVIRONMENT

In assessing the research requirements for management information and control systems, it is necessary to look at the nature of the physical operation and at the physical and managerial processes that dictate the requirements for the supporting information and control system. Railroad operations are quite decentralized because of the sprawling nature of the rail plant. Even in the same terminal complex, physical operations can be several blocks or kilometers away from immediate supervision or the information center. The operation involves a large plant sprawling over several states with year-round, 24-hour-a-day operation regardless of weather conditions.

On railroads, the generation of data about physical or commercial transactions at remote points encounters the difficulties of distance and time. People who exercise control either must be at the scene or, if they are remote, must have at their disposal adequate means of communication and data-collection systems that can process the data into usable information; in turn, capabilities must exist to issue instructions and corrections back to the point of action. This remoteness of operations presents many challenges to the techniques of collecting data, the use of input-output devices, and the reduction and reporting of the data.

The very nature of the data-collection environment for railroads can be characterized as error prone. It is totally different from a bank or airline ticket office. The reporting of freight-car movements is beset with unique obstacles. The personnel who reduce and report the transactions are physically removed from the personnel who perform the physical operations. The conditions and urgencies of operation make paperwork and reporting difficult and low in priority. The reporting of information and events by oral communications or by messenger-relayed documents is random and often out of sequence with the physical transaction. There are also considerable differences between the peaks and valleys of the occurrences of events; this necessitates a large clerical force for certain periods, although this force will be underused the rest of the time. The physical facilities and environment at data-collection sites often cannot support modern office equipment without costly upgrading; communication at data-collection sites is often difficult or costly to achieve.

## GENERAL AREAS FOR RESEARCH

### Relationship Between Organization and Information

The greater the uncertainty in operations and the greater the need for interaction among areas of operations, the better must be the information provided to decision makers to achieve a specified level of performance. The particular way a railroad has organized the management functions associated with operations and the emphasis placed on each area reflects that railroad's method of dealing with the uncertainty inherent in railroad operations and the strong interactions among operations. Uncertainty is produced by variations in traffic volume and mix, in the time taken to execute tasks, and by such unpredictable failures as derailments and bad orders. Strong interactions occur among terminal schedules, train schedules, power and caboose assignments, crew assignments, car dispositions, and car-movement schedules. The amount of information processed to support operations must also be balanced with the capability of the decision makers to use it. Since the balancing determines the type of organization, information and organization are interrelated in a fundamental way. There are four strategies that a railroad can follow to match the amount of information processed with the capacity of the decision makers who use it:

1. Reduce the amount of information required by degrading performance,
2. Reduce the amount of information processed by creating self-contained geographic organizations that use generalists,
3. Increase the capacity to handle more information by creating vertical information systems, and
4. Increase the capacity to handle more information by creating an integrating organization that uses specialists.

The strategy or mix of strategies that has the lowest total cost should be identified and implemented. Otherwise, worse performance will take effect automatically. Therefore, organization design and specification of the information needed to support it are important research needs.

### Costs Used in Decision Process

A major difficulty in selecting the best strategy is finding the proper balance of costs. The capacity to handle information can be increased by adding clerks, computers, or communication equipment, the costs of which are direct and visible. On the other hand, the cost of reducing the amount of information needed, which can result in ineffective decisions, is a cost that is indirect and difficult to identify and quantify.

The direct costs have an immediate impact on the cash flow and can be expressed in terms of hard dollars. With indirect costs, on the other hand, it is difficult to determine when and to what extent the cash flow will be affected. These costs are expressed in soft dollars. It is difficult for railroad management, which has traditionally emphasized the reduction of direct hard-dollar costs, to include consideration of soft-dollar costs in the decision-making process. Research is needed in the measurement of soft-dollar costs and benefits so that proper consideration can be given in the decision-making process to soft-dollar improvements, rather than continuing to overemphasize reductions in hard-dollar costs. This is an important research need because the problems of hard dollars versus soft dollars occur throughout the management of resources.

### Implementation of Research

The implementation of management information and control systems in the railroad industry is difficult. In fact, research is needed to determine why the implementation of programs of change of this sort is so difficult and time consuming and then to develop both an approach that will encourage the more rapid acceptance of new ideas and a

cadre of personnel who have a strong analytical ability and an in-depth knowledge of railroad operations.

### Current Status of Management Information and Control Systems

Most railroads have been involved in the design and implementation of information and control systems for some time. Any research program must therefore give proper recognition to the accomplishments that have already been made and the changes that are currently under development. One of the first tasks in the research program, then, should be to take an inventory of the management information and control systems that have been installed or are under development. A representative survey of six railroads was made for FRA in 1976.

## SPECIFIC RESEARCH NEEDS

The specific research needs discussed here are subject to modification as additional information is obtained from research in the areas suggested above. Most railroads have installed on-line computer systems to disseminate information on car movements and to collect data on the work performed. These systems also provide data to support the traditional railroad accounting functions. Operational control and monitoring groups are becoming increasingly dependent on these systems as the primary source of their information. Although real-time computer systems are now firmly established in railroad operations, there are many improvements that could make them more effective.

### Schedules, Assignments, and Dispositions

If master files containing the operational plans are added to them, on-line computer systems can be used to generate specific schedules for trains, terminals, and cars; assignments for power, cabooses, and crews; and disposition of cars. These files would be subject to adjustment by the operational control groups to reflect the current status of railroad operations. The addition of a master file of block-to-track assignments has enabled the computerized terminal-inventory system of some railroads to generate switch lists that describe precisely the work to be performed by the switch crews. The addition of train schedules and terminal blocking files to a railroad's on-line computer system would make it possible to schedule cars from origin to destination. The next scheduled move can then be disseminated to the work force on advance makeup lists and other work orders.

Empty cars released from consignees or received from interchange can be disposed of automatically if the master files are set up to contain preplanned assignments—pool or assigned service; car distributor's movement instructions, control orders, and flow rules; AAR car-service rules and relocation directives; and ICC orders. These dispositions can be added to the advance makeup lists and other work orders.

### Automated Data Collection

The earlier discussion of the railroad environment pointed out the need for reliable automated data collection, more cost-effective computer terminal devices, and new communications techniques. The extreme interdependence of the industry makes industrywide coordination of development and implementation of systems in these areas crucial.

In currently available data-collection systems, 30 to 50 percent of the application processing associated with centralized data bases involves the editing and auditing of input data. The lack of reliable field input data has resulted in a centralized brute-force approach that is extremely complicated. A better balance between centralized and field checks should lead toward a reduction in the cumbersome editing and auditing procedures. Developments that advance the reliable automated collection of data can reduce costs and eliminate an important source of errors.

### Waybill Generation

Part of the information needed by the operational control group to translate the operational plans into specific schedules, assignments, and dispositions comes from shippers in terms of waybills and car orders and from other railroads in the form of interline bills and interchange lists. The most significant research opportunities exist in automating the collection of such data.

Railroad operations are highly repetitive in nature. The bulk of the traffic consists of the same commodities moving between the same origins to a limited number of destinations from the same shippers to the same consignees over the same routes in the same freight-car equipment. The recent repetitive waybilling systems that have become operational on a number of North American rail lines are but a preview of what is ultimately possible. Master files that contain the billing data for repetitive shipments are used to expedite the preparation of waybills, reduce the cost of data collection, and improve the quality of data with regard to accuracy and completeness. Additional research is needed to advance this concept and to accelerate its adoption throughout the industry.

### Shippers' Car Orders

When there is a repetitive loaded movement, there also is a repetitive order for the empty car. Application of the concept of repetitive master files will permit the collection of these data with little additional clerical cost. Shippers' car-order data are needed to support the car-distribution systems, which are becoming more sophisticated. At present, car orders are prepared manually and are not entered into computer systems. (Sometimes the orders are even prepared after they have been filled.) Although one railroad is progressing with the development of a computerized car-order system, additional research is needed in collecting car-order information and in determining how it can be used in demand forecasting and car-distribution systems.

### Shipper-Carrier Data Exchange

The Transportation Data Coordinating Committee (TDCC) is conducting research on the exchange of data between shippers and rail carriers covering exchange and preparation of data on bills-of-lading and waybills, preparation and transmission of freight bills, freight payments, shipment tracing, and ordering empty equipment. At the present time the TDCC is addressing the problem of the format of the bill-of-lading message. It is being designed around logical message segments that will permit the use of standard codes as well as free-form descriptions. The purpose of such permissiveness is to provide a means of moving toward the more extensive use of standardized codes and the gradual elimination of text.

The underlying potential of great consequence for this effort is the ability to capitalize on the repetitive characteristics of the traffic by using repetitive waybill coding (RWC). The repetitive waybilling systems that have come into operation on various railroads have indicated

that 80 percent of the freight moved over certain routes by some shippers can be identified by RWC. The potential reduction in data transmission between shipper and carrier and the increased accuracy, which would result in a reduced need for auditing, are powerful incentives for extending RWC to the exchange of data between shipper and carrier. Developmental efforts along these lines should be encouraged and strongly supported.

### Exchange of Data Between Carriers

Two-thirds of the nation's carload traffic moves over two or more railroads. Present methods of data collection are so unstandardized between carriers that each railroad that handles a shipment must reeenter all the waybill data into its system. Although the rail sector of the transportation industry has provided leadership in standard codes and formats, direct exchange of data on waybills and train makeup is simply still not as interchangeable as the freight car itself. Each carrier in turn must undertake redundant keystroking to obtain data on traffic received in interchange. This represents an unnecessary cost and a source of errors and delay.

Three recent developments offer some promise for progress in this area— interrailroad agreements involving RWC, the message-switching capability of TRAIN II, and the research projects of data on the exchange between shippers and carriers. Additional research is needed to tie these developments together and to achieve automated exchange of data between carriers. Six carriers have such a data exchange under way and plan to continue their development.

### Automated Feedback

The completion of work performed and the identification of exceptions to the work orders must be reported back accurately and in time for the operational control group to generate the proper schedules, assignments, and dispositions. There are currently three significant approaches to automating feedback on work performed.

The collection of accurate and timely feedback information when cars have been moved past a predetermined point is essential for the effective control and monitoring of operations. The concept of automatic car identification (ACI) is directed toward this need for securing feedback from critical points, such as the entrances and exits of a yard. The cost of collecting this information from all the desired locations by clerical means is high and the quality tends to be low. With the use of ACI, hard-dollar clerical costs would be replaced in part by hard-dollar equipment and maintenance costs. But there are soft-dollar benefits to the reduction in costs now incurred because inappropriate decisions could be avoided through more effective operational control and monitoring. The proper balancing of these costs and benefits requires additional knowledge and insight.

Automated car sensing merely reports the time that a car or locomotive passes a particular point and the direction in which it is moving. The car is not identified. However, if sensors are positioned at switches in a classification yard, the track-to-track movements can be detected and a computer inventory file can be automatically updated. Once the identity and track sequence of the cars have been established by other means, automatic car sensing can keep the computer inventory file synchronized with the actual yard inventory. In this way, the identification, location, and sequence of all cars in the yard can be known at all times. There are many ways to combine identification and sensing in automated input systems that would make the feedback of information on cars and engine movements independent of clerical record keeping. Automated car sensing could also provide data on the time required to make track-to-track movements. There have been a few demonstration projects on automated car sensing, but the problems of establishing workable systems are by no means solved. Further research and demonstrations are needed.

Well-designed exception reporting could greatly reduce the amount of data that must be fed back. For example, when a crew switches cars according to work instructions, the only necessary feedback is a single item that indicates "switched as marked, no exceptions." Exception reporting is a valid technique only when there is an explicit plan understood both by those who are controlling the operations and those who are executing the work instruction and when the exceptions are nominal. This basic principle can be applied by entering the operational plans into the on-line computer system and using the computer to translate them into specific schedules, assignments, and dispositions. The operational control group would make any modifications required to keep the plans synchronized with actual operations.

Research is needed in the display of information for management control purposes. In the monitoring of operations it is essential that the location and status of cars, locomotives, cabooses, and crews can be quickly determined. Assessments of a current situation with regard to train and terminal operations must be readily available (within minutes) to operational controllers in a form that can easily be related to actual physical operations. These assessments should include a prediction of whether current operations are behind or ahead of the operational plans. The operational controllers should be able to put unstructured questions to an on-line data base and receive accurate revelant answers within a few minutes. The display of information is also important for performance evaluations. Periodically, information should be compiled according to the needs of the tactical planners. There should be sufficient flexibility to allow for the quick and easy restructuring of the output reports. Research is also needed to determine the most appropriate performance measures to use in the evaluation of operations. These evaluations should also include an assessment of whether the operational plans are being implemented according to the established goals. The difficulty in displaying data that relate performance to goals is centered around the problem of aggregating a large volume of data into meaningful measures of system performance. Since the display of information can be costly in terms of programming, equipment, and computer time, trade-offs need to be analyzed.

### Decision-Making Support

If schedules for cars, trains, and terminals can be generated through on-line computer systems, then the next step is to select the best trade-offs between service, utilization, and efficiency. In making a selection between alternative operational plans, the potential effect of each alternative scheme must be stated in terms of service, utilization, and cost. In an operational control environment, however, such an assessment must be based on current information and must be performed quickly. On-line simulation using the on-line data base without updating the inventory files is an operational control technique that should receive some research attention.

Research is needed to develop systems that will generate the cost of transportation services on request. The most complex and poorly understood part of operations is determining the cost of the transportation service. Central as it is to rate, marketing, service, and investment decisions, a full knowledge of rail costs remains elusive. The most difficult part of the problem is the

allocation of joint costs. Not having data on rail costs may, however, be more expensive than the considerable cost of establishing a complete cost-analysis system. Such a system would provide cost information for use in both tactical and strategic planning.

### Computers and Communications

The recent technological developments in computers and communications present both opportunities and problems. The availability of computer terminal devices opens the way for the decentralization of computer-based functions. There are many applications that should be developed around this concept. The decentralization of communications networks by means of message concentration and remote switching appears to offer some advantages by avoiding a totally centralized network. Placement of data communications centers at points other than the computer in the corporate headquarters can offer some potential advantages in economy and in better service during peak hours by providing alternate paths to the corporate computer center.

Equipment design must emphasize easy diagnosis of modular breakdowns and ready modular replacement. The equipment should also be designed to withstand the harsh environment at remote locations characterized by dusty offices, fluctuating power, electrical storms, and extremes of temperature and humidity.

Some kind of checking system for centralized programming activities is needed to prevent computer operations from being jeopardized either by a half-trained programmer with laudable intentions or a well-trained programmer with malevolent intentions. Such a checking system would need to be extended to include remote computer operations. Communication networks are now required to handle various rates of data transmission and to have buffers in their terminals even though they are made up of facilities owned and operated by common carriers, independent telephone companies, and railroads. The task of monitoring such a complete communication system for abnormal conditions is one that desperately needs automated support. A "meta-compiler" or "meta-assembler" is needed to make it possible to transfer a computer system from one railroad to another, independently of the vendors and without reprogramming.

### Data Storage and Retrieval Systems

As has been implied, there is a need for improved data-storage and data-retrieval systems. By and large, the improvement of data-storage and data-retrieval systems for external data is the logical responsibility of the federal government. Existing capability in this area is fragmentary and uncoordinated. Proposals are currently under discussion for a national transportation statistics center, which may or may not come to early fruition. Without taking any position on whether such a center is needed, we believe improved data storage and retrieval capability should be created somehow.

As for internal data, it would seem logical that the railroad industry should look to its own resources, perhaps through the AAR, for creating improved data-storage and data-retrieval capability that could be of mutual benefit to all the operating companies. TRAIN II constitutes a small step in this direction, but that system does not encompass the largest part of the data spectrum that is relevant to the long-range investment planning and policy decisions the industry must confront. In all of this, the problem of long lead times seems inescapable. A commitment to a more effective program of research across the board, however, necessitates an investment in the required data base, regardless of the slow payoff that can be expected from new data-collection efforts.

## SUMMARY

Most railroads have been engaged in the design and implementation of computer-assisted information and control systems for some time. An inventory of what has been accomplished would be very useful. Many railroads have on-line computer systems to disseminate information on car movements. On-line computer systems can be used to generate schedules for trains, terminals, cars, power, cabooses, and crews. Addition of a file of block-to-track assignments enables a computerized terminal system to generate work assignments for switch crews. Disposition of empty cars can be made automatically if the master file contains preplanned assignments (pool or assigned service), car distributor's movement instructions, control orders and flow rules, AAR car service directives, and ICC orders.

Other opportunities for using computer systems include waybill generation, car orders, exchange between shippers and carriers, and exchange of data among carriers. Automated car sensing has been used experimentally to detect track-to-track movements in yards and provide an up-to-date inventory of the locations of all cars in a yard. The demonstration projects so far have left much to be done.

Hardware for these applications is generally available; the developments needed are in software. Improvements are needed in exception reporting and the display of information for management control. The hardware developments that are needed are replaceable modules for quick maintenance and equipment designed to withstand the harsh environment of remote locations.

# PART 4
# Research and Development Strategy

The role and functions of rail transport, the markets for rail transport services, and the conditions under which rail transport can be provided are all changing. Better information, improved understanding, and new techniques are needed to manage the inevitable changes. The chapters of part 4 discuss some of the considerations in mounting a comprehensive and coordinated national program of research and development aimed at aiding rail transport to meet the challenges of change. Suggestions and recommendations are made as to the nature of such a program, which would involve the participation of both government and private industry.

# Chapter 14
# Considerations in Establishing a Comprehensive Research and Development Program

The preceding chapters have reviewed a range of important problems that confront rail transport. These problems vary widely in nature, in complexity, and in the urgency of their need for attention. Such problems are symptoms of the changes—some direct and obvious, others underlying and subtle—that are affecting the demand for and the provision of rail transport services. Obviously, appropriate research in a cooperative national program can help.

Some of the factors to be considered in establishing, formulating, and conducting an appropriate research and development program in rail transport are its objectives, its priorities, its scope and nature, the role of various participants, the relation of ongoing research and development to a new program, data requirements, and the implementation of the results. The first five of these are discussed in this chapter and the last two in chapter 15.

## OBJECTIVES OF A COOPERATIVE NATIONAL PROGRAM

While the participants in the initiation of a national cooperative research program in rail transport will ultimately refine the objectives and delineate the scope of such a program to their satisfaction, some suggested objectives are

1. To identify the problems in rail transport for which solution could be expected from appropriate research;
2. To stimulate the undertaking of needed research;
3. To provide mechanisms for the coordination, review, synthesis, evaluation, and interpretation of research and the dissemination of its findings;
4. To encourage the implementation of useful results;
5. To provide a forum for the interchange of ideas and information among persons involved in performing research and persons using the results of research; and
6. To provide a basis for the establishment of industry and government standards and government regulations.

In order to muster support for the program, the activities must be structured so as to engage the clientele who may be expected to benefit and to attract the interest of capable research people.

## PRIORITIES FOR A NATIONAL PROGRAM

It has been possible to identify a considerable range of major researchable issues, questions, and problem areas from the papers and discussions of the study. In many cases, the subjects crystallized from a review of both written and oral material. No single dimension exists that would enable all of these disparate research areas to be simply ranked in priority order, nor would the perceived ranking be the same for all the parties involved. Rather, the topics have first been grouped into four general functional groups: (a) planning, (b) plant and equipment, (c) operations, and (d) management. These functional groups have been chosen because each is represented by an identifiable class of knowledgeable persons who can address the problem area. Thus, within each area, an assessment of research priorities could be made. Within these functional groups, the research areas have further been classified according to the nature of the research response that is needed: (a) basic research (research aimed at developing new concepts or new knowledge of phenomena, system behavior, processes, and so on), (b) developmental research (research aimed at developing new materials, devices, methods, procedures, and so on when basic knowledge of the phenomena already exist), and (c) applications research (research aimed at improving the functioning of an existing device, improving a method or procedure, and so on).

The research areas recommended by the committee for inclusion in the program were then assigned to a category that, in the judgment of the committee, indicated a degree of urgency and necessity. In a sense, these categories represent priorities. They were chosen by the committee because they are allied to expressions of relative urgency proposed by a number of the experts at the conference. These categories are (a) problems pertaining to the short-range survival of the railroad system (priority 1), (b) problems pertaining to maintaining the long-term health of the rail transport mode (priority 2), and (c) problems pertaining to improvement and extension of rail transport services (priority 3).

## SCOPE AND NATURE OF A NATIONAL PROGRAM

A comprehensive national research and development program in rail transport should, of course, include consideration of new or improved technology—methods, procedures, devices, materials—that can help to solve or ameliorate certain kinds of safety, physical, or operational problems. At the same time, there are problems whose ultimate resolution will require changes in policies, practices, and organizational structure. Here, a kind of research product is called for that aids decision makers in identifying and evaluating the consequences of decisions. Thus, the program should be geared to gen-

erate products ranging from ideas and concepts or better analytical methods and models to improved hardware standards and specifications.

The kinds of research and development activity that will produce such outputs will have to go beyond the classical research processes of laboratory or field experimentation, case studies, surveys, theory development, and devising of analytic procedures. The program should include organization and critical evaluation of existing information. But it should also somehow manage to encourage the illumination of difficult issues in the field of policy. It must, of course, include attention to human and social factors as well as physical and economic factors. And it should give attention to the design of a feasible data system for the use of industry and government.

A very important aspect of such a program is a modus operandi to aid in implementing the useful results of research. Also required is a feedback mechanism that will ensure that problems encountered in the field are considered in the research planning process. This implies that people engaged in operations, management, and policy development must be involved in research planning and throughout the research process. The structure of a national cooperative research effort should be such as to permit systematic performance of the establishment of a research agenda, agreement on responsibilities for funding and action, monitoring of ongoing research, the interchange of ideas, dissemination of information, and encouragement of implementation.

## ROLE OF VARIOUS PARTICIPANTS

There are many participants in the production of rail transport. All of them make decisions that affect some phase of this very involved process. There are also a number of research and development agencies that participate or could participate in a research program in rail transport. Institutions and agencies that may be involved would include the following:

1. Production industry: (a) railroad industry—AAR, individual companies or government corporations, and terminal operators and short-line railroads; and (b) supply industry—Railway Progress Institute (RPI) and individual companies.
2. User group: (a) shippers—individual companies and agencies and trade associations; and (b) travelers—National Association of Railroad Passengers and other associations (for the elderly, handicapped, and so on).
3. Government agencies: (a) federal government—DOT, FRA, UMTA, and Materials Transportation Bureau, ICC, other agencies (environmental agencies, Bureau of the Census, and so on), Congress, and National Transportation Safety Board; (b) state governments—state departments of transportation and state public utility commissions; and (c) local governments—municipal governments and special districts or regional authorities.
4. Research and development agencies—research institutes, consultants, universities, and federal and state government laboratories and research departments.

A number of these institutions may be expected to perform research themselves, participate in a cooperative research program, or contribute financial support to such a program. Some governmental and other agencies that are not specifically involved in rail transport affairs collect data or perform research that may also be pertinent and useful. This is particularly the case with the other modes of transport. In the pursuit of a national research and development program in rail transport, the work of such agencies should be noted and systematic liaison established with them even though they may not participate directly in the program.

In very broad terms, the FRA, AAR, and the industries have interests that range from the general to the specific and from basic to applied research. Since many rail problems are industrywide or involve common action among a number of carriers, they are appropriate for the involvement of the AAR, the American Railway Engineering Association, or RPI. Many, however, are of such a scope and impact that they require government input and support, e.g., multimodal data collection (such as total commodity flows) and test facilities that require large investments. Traditionally, a significant proportion of aviation, marine, and highway research and development has been supported by the federal government either directly or indirectly. The FRA should ensure that comparable resources are directed toward rail research.

The AAR provides the link to individual roads for the interchange of information and for marshalling participation and support and helps to identify problems and opportunities. The FRA, through several mechanisms, including its Railroad Research Information Service in the TRB, provides the link to work being done by foreign railroads. The FRA has a responsibility to identify issues that may affect the direction or character of rail transport, particularly as they may evolve from existing government regulations, policies, and programs or from changes under consideration.

The joint efforts that exist among the FRA, AAR, and RPI can be strengthened and extended into a national cooperative program. Such a joint effort would further common understanding of needs and priorities, common knowledge and concurrence as to who is doing or should do what, and concerted efforts to ensure the implementation of results. To the greatest extent possible, shared funding and management of jointly sponsored research should be used as it has been in several existing programs, since it provides the incentive for adequate communication among the interested parties.

If a national program is to be effectively coordinated, a new organization should be established to monitor the program. It could be a committee with a full-time staff or a full-time staff reporting to a board of directors of participating organizations. The participants in a national coordinated program would supply progress reports and planning information to the staff, which would analyze submitted information and present the results to the committee or board. The committee or board would recommend changes to and concur in plans of the participating organizations on the basis of the priorities and total resources available. Government agencies have certain responsibilities that are not compatible with industry objectives. Therefore, the government program must include projects that cannot be cooperative. Some research that supports regulation may be in this class.

There are two aspects to the funding problem. One is the need for funds to underwrite the development, management, and monitoring of the overall cooperative national research program and the publication and dissemination of useful results. The other is the funding of specific projects. Some projects may, of course, be directly funded and conducted solely by one organization. Others may be funded and conducted as the joint effort of two or more participants. It is desirable, however, that such research activity be made known and recognized as a part of a rational national program, not only to obviate duplication but also to induce the widest possible dissemination of the results.

An additional arrangement that should be considered is exemplified by the National Cooperative Highway Re-

search Program (NCHRP), in which participating agencies pledge an annual budget and their representatives formulate an annual work program. This program is administered by TRB for the sponsors. TRB generates and circulates solicitation of proposals, reviews proposals, selects research agencies, monitors the work, and publishes and disseminates the results. No source of funding like the planning and research funds of the Highway Trust Fund is apparent.

The prime sources of rail research and development funding and support are DOT through FRA, the AAR and individual railway companies, and the supply companies. To a lesser extent, support can come from other federal departments and agencies, state governments, and foundations. For these, support will be given for specific projects that bear direct relationship to the missions of the contributing organizations.

## RELATION OF ONGOING RESEARCH AND DEVELOPMENT TO A NEW NATIONAL PROGRAM

There is currently an appreciable amount of research directed at rail transport problems under way in or sponsored by governmental and private organizations. The FRA budget for research and development in fiscal year 1976 is on the order of $60 million a year and the AAR's is about $4 million, which is used in cost-shared projects, so that the actual value is at least double this amount. The funds available have grown steadily over the last 5 years. A new national program is not intended to displace or supersede existing programs. Rather, it is intended to augment present efforts through the provision of a means by which other problems can be considered for programming and funding in a systematic way. The new Railroad Revitalization and Regulatory Reform Act of 1976 calls for a number of studies that the Study Committee judged to be important. Attention to these problems under the auspices of this legislation thus emphasizes a portion of the research agenda recommended herein.

### Background

Research and development by and for the North American railroad industry is not a new phenomenon. More than a century ago, the Master Car Builders Association had a committee of industry representatives examining the problem of the unusually high tare weights that were evolving in wooden freight cars to counter the stresses imposed by the longer trains that were becoming standard. While such an industry approach to certain problems has continued and, in some cases, has been expanding, efforts have been far from consistent. Projects have often been ineffectively coordinated, and until recently there was no comprehensive overview of the goals to be achieved.

There is full information on the activities sponsored by the AAR, the DOT (FRA, UMTA, FHWA, and so on), and by other federal departments (Agriculture, Commerce, and so on). Methods for obtaining data from government-related agencies, such as USRA and the National Research Council of Canada, have been less well defined, but the information is available. Investigations undertaken by individual railroads and by suppliers are not normally disclosed unless they are of public relations or image-building value, since the competitive advantages accruing from such research investments are expected to be of primary benefit to the sponsoring organizations.

Any overview of the present status of research and development within and for the benefit of the rail industry must be considered with an appreciation of certain constraints. The proprietary nature of research and development done by individual railroads and by their suppliers must be recognized in appraising the present status of railroad research and development. This is a fact of the competitive system that will continue to affect the nature of revealed research and the extent to which cooperative activities may be expected to be carried on. Increasingly, however, it is coming to be appreciated in the industry that fragmented and superficial attacks on many problems of the industry can be wasteful and ineffective. The increased support given by member railroads of the AAR to that organization's research and development activities on behalf of the entire industry is a fact of railroading in the 1970s. Despite the financial problems of the railroads in 1974 and 1975, support continues for the AAR research program, pointing up the industry's appreciation of the effectiveness of coordinated efforts to surmount certain of its problems. There is a substantial volume of research already being conducted that either directly involves the rail industry or can produce results that will be of benefit to the industry. The planning of research expenditures and programs should take into account the existence of such investigations.

The total funds available for railroad research and development are unknown, since proprietary work is done by private companies. However, the greater part of the total effort is funded by AAR and DOT. The AAR budget in this area is about $4 million per year, and at least an equal amount is contributed in cost sharing by carriers and suppliers (through the RPI). The DOT budget is between $60 million and $75 million a year for both FRA and UMTA. This is many times more than was available 10 years ago, when there was no federal budget and the AAR budgeted less than $1 million.

### Research and Development by the Railroads

The AAR and the individual railroads perform and support research and development projects. Individual railroads tend to do their own research and development on matters related to their commercial interests (marketing research, efficiency studies, and so on) and to work through the AAR on matters of interest and benefit to the whole industry.

The AAR has been serving as the coordinating agency in much of the research and development that is being conducted on hardware. Since 1973, virtually every major AAR research program has been funded jointly by one or more other agencies or companies. The FRA has increasingly participated in these cooperative projects. Probably the most noteworthy of these cooperative efforts is the International Government-Industry Research Program on Track-Train Dynamics. Increasing awareness of problems with the dynamic stability of trains and the dynamic interaction of the train and the track showed the industry that there was a need for a comprehensive coordinated program in track-train dynamics. This program required development of a cooperative approach to research that had not previously been used extensively. The entire range of problems associated with track-train dynamics was assessed, and priorities were established for projects to be undertaken. This program, which involves the supply industry, the government, the AAR, and the U.S. and Canadian railroads, began in 1972 with an initial 2-year phase aimed at immediate improvements to operating practices; it has now moved to a second 2-year phase in which performance specifications are being developed for track structure, cars, and their subsystems. The projected 8-year program will include a third phase in which advanced

concepts will be considered. Part of the program is the development of methods of dynamic analysis for cars and locomotives to aid in the development of suitable rolling stock. There is also an effort under way at a major midwestern university to develop finite-element analysis techniques for use with car design.

Design of car components is the specific focus of several joint projects—track-train dynamics, tank-car safety, coupler safety, and advanced freight-car braking systems. Various facets of railway wheel design and inspection are being studied in a half-dozen projects in the United States and Canada. In addition to investigations of conventional freight-car running gear, advanced concepts are to be studied in the FRA-sponsored Truck Design Optimization Project (for which the Southern Pacific Transportation Company performed the first phase), in the privately sponsored Articulated Rail-Car Truck Development, and in studies for improving the riding qualities of passenger cars.

The industry's Tank-Car Safety Research and Test Project, Railroad Coupler Safety Research and Test Project, and Railroad Truck Safety Research and Test Project have also used the planning concepts developed in the Track-Train Dynamics Project. Since 1971 a number of special projects have been directed at establishing safety improvements in the operating crews' work space in locomotive cabs. Here a coalition among labor, government, and industry has been enhancing the safety of locomotive crews.

Research on propulsion systems is primarily the goal of passenger-related projects, for both conventional and unconventional systems. Electrification is involved in some of these studies, as well as in some of the studies of proposed northeast corridor projects. Advanced control and signaling techniques are also under investigation.

Although the investigations of hardware have received much of the attention, there is a substantial volume of systems research and software research in progress. FRA and AAR have been sponsoring several projects aimed at improving actual rail operations. Among these are the Freight-Car Utilization Research Program, Yard and Terminal Subsystem Project, Installation of a Rail Terminal-Management System, Analysis of Classification-Yard Technology, Parametric Analysis of Railroad Line Capacity, and Freight-Car Demand Information and Forecasting. Several similar investigations by USRA have been aimed at applying the results of its consultant's studies in preparing a plan for ConRail. The AAR's recently implemented TRAIN II project is the result of a previous investigation by the industry of freight-car utilization.

The following is an outline of programs of the Research and Test Department of the AAR.

1. Track research—track structures, rail, ties, and axle loads.
2. Equipment research—wheels, freight-car trucks, car stability, couplers (advanced coupling), advanced braking, tank cars, car design, and locomotives.
3. Track-train dynamics—Facility for Accelerated Testing.
4. Signal systems.
5. Operations—yard and terminal, freight-car utilization, loss and damage, train hauling, car demand, and ACI.
6. Safety systems—flaw inspection and accident analysis.
7. Environment—emissions (noise and effluents).
8. Energy.
9. Metric conversion.

## Research and Development by the Railway Supply Industry

The research and development efforts of the firms that supply equipment, materials, and other supplies to the railroads are both cooperative and competitive. The supply firms tend to participate in joint programs that are of major significance to the railroad industry, but their product-development work is proprietary and highly competitive. Research and development in signaling and control systems and in braking systems are largely done by the suppliers of those systems. Locomotive research and development, with the advent of the diesel-electric locomotive, became a supplier effort. Freight-car and passenger-car research and development have also been largely an effort of the supply industry, which has been deeply involved in concrete crosstie development and other work of that nature.

In some cases of product development, particularly of freight cars, the supplier has performed marketing research before introducing the car that would do credit to a railroad marketing department. The research and development efforts of the supply firms have been and will continue to be a major part of the total effort.

## Government Involvement

### Research and Development Programs and Support

In the past 10 years, the federal government has emerged as a new and major force in the rail research sphere. Its most noteworthy previous efforts had probably been the development and imposition of uniform equipment designs on U.S. railroads during the time of World War I when all lines were operated by the U.S. Railroad Administration, and its support of studies of rail coordination and consolidation that were authorized by the Transportation Act of 1920.

The federal involvement with railroad research began as a result of the High-Speed Ground Transportation Act of 1965. The development and growth of the federal effort can be followed through the reports that have been issued (generally one each year) pursuant to this act (since 1973, these reports have centered on the Railroad Technology Program). Federal railroad research was originally under the Office of High-Speed Ground Transportation but is now under the Office of Research and Development of the FRA. There is also a federal effort in management research under the FRA's Office of Policy and Program Development that includes such areas as improved rail service, improved freight-car management, and cost analysis.

Although the initial thrust of the federal effort in fixed-guideway technology was directed toward rail passenger service and high-speed ground transport, including such exotic systems as air-cushion vehicles and magnetic-levitation vehicles, FRA's technological research has been redirected to focus more sharply on near- and intermediate-term conventional rail problems. FRA continues to place the highest priority on safety. In the area of passenger systems, FRA is emphasizing developments that will help Amtrak to reduce operating costs and improve service. FRA's freight research and development activities are focused on product evolution, leaving product development and implementation to the private sector. A major thrust is FRA's effort to provide railroads and suppliers with useful test and evaluation capability at the Transportation Test Center near Pueblo, Colorado.

Federal concern about the condition of railway track structures has been reflected in major FRA funding of

projects on such topics as methods and procedures for analyzing the economic cost of railroad roadway and on deferred plant maintenance, as well as a series of track-response investigations. The Track-Train Dynamics Project has several track-oriented facets. FRA has undertaken tests of advanced track structures in Kansas and at the Transportation Test Center. Test track segments are being subjected to programmed loading with extensive instrumentation. Widespread adoption of welded rail has led to sponsorship of various stress and rail-inspection studies by AAR, FRA, and individual railroads. Similar studies are being conducted in Canada.

DOT has been significantly involved in railway plant construction through its support for improvements in tunneling technology—useful mainly for rapid transit and highway construction but also applicable in railway-line construction. FRA sponsored a major subsoil stabilization study, an activity previously the sole concern of FHWA. Work was also performed by the U.S. Army Engineers and the U.S. Navy in underwater construction, piling foundations, wood preservation, and other technology useful to bridge builders. FHWA sponsors investigations of steel and concrete bridge design and technology that are applicable to railroading.

Involvement of the government in safety activities is already substantial and will grow with the new orientation of FRA's Office of Research and Development. There may be participation by other government agencies involved in various facets of safety and human factors study. Among current research projects sponsored by DOT or FRA are ones on human factors in railroad operations, job-knowledge requirements (of trainmen), physical parameters of transportation accidents, factors affecting railroad crew vigilance, and dynamics of train rear-end collisions.

Other federal research programs can supply valuable input for rail research or, in some cases, may make it unnecessary for separate rail programs to be conducted. The Department of Health, Education, and Welfare has programs relating to worker well-being that could be transferable to rail programs. Typical of these are studies on the combined effects of noise, work, and heat on human hearing; laboratory studies of noise-induced hearing loss; and causal factors in accidents.

Since the government has recognized the public responsibility for investments that enhance the safety of the rail-highway grade crossing, it is fitting that substantial research is being conducted in this area by government, e.g., locomotive crash-attenuation device, controlled grade-crossing impact tests, rail safety and grade-crossing protection, innovative railroad-highway grade-crossing protection system, standardization of grade-crossing protective systems and devices, and optimization of audible warning devices. Programs in Canada include railway advance-warning sign and human factors in collisions at railway crossings.

The marketing and traffic-forecasting functions in railroading are already the subject of numerous research programs and projects. The Department of Agriculture has many projects to investigate the export shipment of various agricultural products from perishable citrus and vegetables to soybeans, grain, and forage in containers. Grain traffic is the primary object of several other studies and a related area in investigations of changing grain collection and distribution systems. Two ongoing projects that can be expected to yield new tools for analysis of traffic patterns and potential deal with the development of a standard transportation commodity description and coding system and a multiregional input-output study of U.S. commodity freight shipments. Several Canadian projects have investigated the freezing of bulk materials in open-top cars.

## National Transport Planning

It will be noted that so far we do not have the comprehensive planning approaches undertaken in Europe and Japan, where the major part of the railroad system in each nation is government owned. Typical investigations cover such topics as an appraisal of investment in long-distance passenger transport by the German Federal Railway and in air transport within the Federal Republic of Germany up to 1980, based on a cost-benefit analysis. It is out of such deliberate government planning that Germany's high-speed network, Russia's emphasis on rail freight transport, and Japan's new Tokaido line have been funded and brought into being. It should be noted that DOT did issue a National Transportation Report in 1972 (37) and another in 1974 (38).

Problems in many areas are being studied by agencies of the U.S. and Canadian governments, e.g., public investment in transit facilities (DOT); urban consortium for technology initiatives (DOT); transit fare policies and their implications (DOT and UMTA); rail network and model for analysis and evaluation of alternative rail systems within the United States (DOT); national container network feasibility (DOT); simulation model for estimating the effects on the prairie economy of rationalizing the grain collection, handling, and distribution system (Transportation Development Agency of Canada); organization and performance of transportation systems (U.S. Department of Agriculture); effect of transportation rates, facilities, and institutions on the grain-marketing system in Montana (U.S. Department of Agriculture); use of space by economic activities in metropolitan areas (DOT); socioeconomic indicators (DOT); constitutional and government aspects of transportation policy (Canadian Ministry of Transport); economic effect of transportation subsidies in a multiregion economy (Canadian Ministry of Transport); and Canadian freight transport model (Canadian Ministry of Transport).

## Current FRA Research and Development

The following provides an outline of the FRA's railroad research and development effort for 1976 through the Office of Research and Development.

1. Rail freight systems (improved freight service)—fuel consumption, railroad noise abatement, assessment of classification-yard technology, freight-car management and control in yards, truck-design optimization project, advanced braking concepts, automatic coupling concepts, intermodal freight systems technology, dynamic analysis and evaluation of railroad vehicles, trailer-on-flatcar evaluation, track-train dynamics program, and Department of Defense railcars.
2. Rail safety: (a) rolling stock—tank cars for hazardous materials, personnel protection, and prevention of component failure; (b) human factors—simulators; (c) accident avoidance—on-board systems and grade crossings; (d) controlled systems; (e) improved track structure research—track accident reduction and improved track performance; and (f) improved inspection, detection, and testing—track inspection and testing, automated track inspection, vehicle inspection, and safety life-cycle testing.
3. Passenger systems: (a) systems analysis and technical assessment—improved passenger service, status of prior and current related systems, and Metroliner improvement program; (b) supporting technology—electrical traction and propulsion, propulsion system for tracked levitated research vehicle, testing of linear induction motor research vehicle, and suspension, support, and guidance; (c) advanced systems—tracked levitated

vehicle technology and magnetic levitation technology assessment; and (d) railroad electrification.

4. Transportation Test Center (includes Rail Dynamics Laboratory, Facility for Accelerated Testing, Dynamics Test Track, and Impact Test Track)—operations: advance systems, rail systems, and transit systems (UMTA).

The research programs of the FRA's Office of Policy and Planning for 1976 are

1. Intermodal freight systems demonstration,
2. Freight-car management program,
3. Improved rail freight service (joint),
4. Safety research program (joint),
5. Cost analysis,
6. Financial analysis,
7. Labor-management program (including rail employee training, job content improvement, and strike impact analysis model),
8. Railroad network model,
9. Commodity service,
10. Waybill statistics program, and
11. Passenger service analysis.

### All Other Railroad Research and Development

#### University Research

At one time the universities played a major role in railroad research and development. The decline in interest and support for railroad research and development that marked the middle of this century took a heavy toll in this area. Now, with renewed interest by the railroads and with the governmental support that followed the establishment of the Department of Transportation, the university research and development effort in the railroad area is growing.

#### Foreign Research and Development

Although railroad operations on other continents differ in some respects from those in North America, there are some ideas, methods, designs, and developments that can be used here. Amtrak is currently operating French Turbotrains and test running a Swedish and a French electric locomotive. The Electro-Motive Division of General Motors has obtained a license to use designs developed in Sweden for freight locomotives. Information on railway developments around the world is available in the trade and technological literature and from the International Union of Railways (UIC) in Paris. FRA has access to UIC information through the Alaska Railroad and the Southern Pacific Transportation Company, each of which has UIC membership.

FRA has bilateral agreements with several foreign countries to cooperate in the exchange of railroad technology through visits to each others' railroads and the exchange of technical literature. Two of the more active agreements are with the USSR and West Germany.

#### Transportation Research Board

Since 1972 TRB has operated the Railroad Research Information Service as one of its family of transportation research information services to provide researchers with ready access to abstracts of important research reports, technical papers, and so on. In 1974, TRB formed the Special Committee on Rail Transport Activities to evaluate the need for TRB research activities in the areas of rail transport. In 1975, at the suggestion of this committee and with the support of AAR and FRA, TRB undertook the Railroad Research Study. In addition, NCHRP has a project entitled Freight Data Requirements for Statewide Transportation Systems Planning that includes rail considerations.

## RECENT DEVELOPMENTS IN RESEARCH AND DEVELOPMENT

During the conduct of this study and the preparation of this report, several new research projects have been undertaken that should be taken into consideration in planning research and development programs. The ICC has engaged a joint-venture accounting and consulting team to assist in carrying out the provisions of section 307 of the Railroad Revitalization and Regulatory Reform Act of 1976. The three general objectives are

1. To ensure proper implementation of the railroads' new uniform system of accounts subject to ICC regulation, which shall become effective not later than January 1, 1978;
2. To develop uniform railroad cost-accounting standards and to revise and develop costing methods and procedures to obtain the most accurate cost information on rail service; and
3. To define data requirements and evaluation methods and procedures that relate to branch-line operations and line-abandonment decisions.

At the same time, several functional groups have been organized that should likewise be taken into consideration:

1. Railroad Safety Research Board—a major cooperative effort to use and increase knowledge in the interest of railroad safety involving rail labor, railroad management, railroad suppliers, and government;
2. Materials Transportation Bureau—a unit within DOT that develops regulations for the transportation of hazardous materials by all modes of transport and for the transportation of gases and liquids by pipelines;
3. AAR-FRA Committee on Amtrak Equipment—a joint committee to review passenger-equipment characteristics and specifications to ensure that they will be compatible with AAR practices; and
4. Freight Claim and Damage Prevention Division—a unit of AAR aimed at giving more emphasis to the prevention of loss and damage.

# Chapter 15 Recommended Research Agenda

The research agenda recommended by the study committee is given below. The listing is first by functional group and then by the type of research response within each functional group. In using this framework, however, the study committee found that there are certain kinds of problems, such as safety, that pervade each functional area; there is therefore also a group designated as general research areas. Within each group the category of urgency assigned by the study committee is shown for each major research area.

The basic structure of the recommended research agenda is shown by assigned priority in Table 1, which reveals that the survival issues for the rail industry are concentrated in management and planning—the soft side of research. Although a lot of technological research is recommended, these projects are in the third level of priority. There is a clear message that the urgent needs are improvements to planning and management procedures. Obviously cost reduction, improved service to shippers, and more effective marketing are keys to survival and health.

## PLANNING

### Basic Research

#### Structure of the Railroad Industry and Trade-Offs (Priority 1)

While the question of the number of railroads and the structure of a reorganized railroad industry has long been discussed and examined in a general way, we need some analytical means of examining the trade-offs of possible new arrangements in terms of efficiency, intramodal competition, and service levels. This analytical capability may also be needed in connection with studies under title IV of the Railroad Reorganization and Regulatory Reform Act of 1973.

#### Methods of Restructuring (Priority 2)

The recent sequence of bankruptcy followed by legislation may work as a means of changing the structure of the railroad industry, but better mechanisms of change should be sought. Assessment of possible mechanisms of change is needed. Alternatives to mergers and consolidations, such as new coordinative arrangements, should also be considered.

#### Regulation (Priority 1)

In addition to economic regulation (sometimes called vertical regulation since it pertains primarily to a specific industry, such as that exercised by the ICC), administrative regulation (sometimes called horizontal regulation since it pertains to the regulation of certain activities across all industries, such as that exercised by EPA or OSHA) now affects the conduct of rail transport functions. While some notable studies of the economic regulation of railroads have been made in the past and the Railroad Reorganization and Regulatory Reform Act of 1976 calls for changes in economic regulatory policy, neither the positive nor the negative impacts of regulation (economic, administrative, or both in some combination) on transportation in general and on railroads in particular are fully and clearly understood. An in-depth study of these impacts is needed to provide understanding of how relevant and effective regulation will be in meeting transportation needs and problems under the conditions and environments of the future.

#### Multimodal Ownership (Priority 3)

Tradition, reinforced by regulation, has inhibited or constrained multimodal ownership. An examination of this situation, in the light of changed conditions and under possible rearrangements to provide useful competition of a new order, is pertinent to establish whether continued denial or future encouragement would be preferable.

### Developmental Research

#### Public Service Responsibilities (Priority 1)

The levels of service and the extent of the network that would represent an adequate discharge of the railroads' public service responsibilities must be defined with respect to both the common carrier and the national development aspects. Governmental responsibility for additions and modifications to the level of service and extent of the network, together with the role of subsidies and public ownership in meeting these responsibilities, must be defined. Some of the studies to be undertaken under title IX of the Railroad Reorganization and Regulatory Reform Act of 1976 may be germane to this problem.

#### Railroad Models (Priority 2)

Railroad planning at the industry and government levels needs adequate economic and operational models for exploring and evaluating alternative futures. Generalizing and extending the work already done for the Northeast Corridor Transportation Project studies would be a practical method of approach. Care must be taken to ensure that model work is realistically grounded.

#### Ownership of Equipment (Priority 2)

Alternative arrangements for equipment ownership—rental, leasing, pooling, and so on—need to be explored and evaluated in terms of the ability of the railroad industry to raise capital and their impact on utilization and availability of equipment.

#### Ownership of Infrastructure (Priority 3)

Alternatives to the present patterns of individual or pri-

Table 1. Outline of the recommended research agenda.

| Type of Research | Priority 1 | Priority 2 | Priority 3 |
|---|---|---|---|
| Planning | | | |
| Basic | Structure of the railroad industry and trade-offs<br>Regulation | Methods of restructuring | Multimodal ownership |
| Developmental | Public service responsibilities | Railroad models<br>Ownership of equipment | Ownership of infrastructure |
| Applications | | Transport demand and commodity flow<br>Restructuring of planning data | Marketing studies |
| Plant and equipment | | | |
| Basic | | Investment trade-offs<br>Terminal and yard design | Energy systems |
| Developmental | | | System design<br>On-board measurement<br>Car design |
| Applications | | | Component improvements<br>Life-cycle design<br>Urban facilities |
| Operations | | | |
| Basic | | Service quality | |
| Developmental | Equipment utilization | | Hazardous materials<br>Electrification |
| Applications | | Blocking and scheduling | Terminal management |
| Management | | | |
| Basic | Cost structures | Demand and marketing | |
| Developmental | Sources of capital<br>Studies of human resources | | |
| Applications | Information technology<br>Productivity | Training methods<br>Demand pricing | Indirect costs and benefits<br>Management structures<br>Accounting methods |
| General areas | | Safety<br>Role of railroads in the economy<br>Cooperative research program<br>Data | |

vate ownership of the rail system infrastructure need to be devised and evaluated. These alternatives include joint ownership, public ownership, and mixed public-private arrangements.

Applications Research

Transport Demand and Commodity Flow (Priority 2)

Incompatibility between railroad data and data from other modes has too often led to partial and fragmentary approaches to dealing with transport policy and planning. There is a clear need for both national and international data bases that can form a basis for improved forecasting of transport demand, as well as a need for better techniques for aggregating data on modal and regional commodity flows for the analysis of major transport problems and issues. Both shippers' needs and demands on existing networks and services should be considered in devising improvements in an analysis of this type. This is, by congressional mandate, a responsibility of the federal government.

Restructuring of Planning Data (Priority 2)

There are a lot of data concerning demographic trends; trends in production; estimates of future activities and locations of the extractive, manufacturing, and service industries; indexes of economic conditions, resource availability, and social conditions; and trade as affected by changing economic and resource development or depletion in foreign countries. These conditions and trends all work together to create the future environment for transportation and bear on the role of rail transport. Relatively little has been done to structure, interpret, and synthesize these data in different scenarios that would be useful for planning in the rail transport field.

Marketing Studies (Priority 3)

Although various marketing studies and shipper behavior studies have been conducted in relation to rail transport, a critical evaluation of marketing techniques in other fields with a view to evolving a more aggressive approach to marketing railroad services would appear to be worthwhile.

PLANT AND EQUIPMENT

Basic Research

Trade-Offs Between Way and Structures Investment and Equipment Investment (Priority 2)

Although the problems stemming from the adoption of heavier axle loadings have become well recognized and considerable effort is going into technical analysis and solutions, there is still insufficient understanding of the relationship between heavy-axle or high-speed operations and damage to the track system. Development of an in-depth understanding, including overall benefit and cost relationships, should be pursued. Cars with a high center of gravity require a similar research effort.

Energy Systems (Priority 3)

Changing energy costs may make feasible the use of alternative fuels or energy sources (in addition to electrification), such as lignified coal or methane. An in-depth study of all promising sources of energy and of the technology needed to use them should be made. Demonstrated technological solutions, supported by economic considerations, must be developed before any major decisions are

made on the use of the alternate energy sources.

Terminal and Yard Design (Priority 2)

There is a need for continued improvement in yard and terminal design. Intermodal terminals are particularly important since terminal design is a major factor in service and profitability. Selection of locations for yards and terminals, always critical, should improve with application of operations research techniques.

Developmental Research

System Design (Priority 3)

A number of aspects of car and track design are potentially able to improve utilization or reduce operating costs. These need to be looked at, in various combinations, in terms of overall system improvement. This approach would include development of less specialized or more adaptable designs, of designs to improve ease of maintenance, and of design of maintenance techniques more appropriate to new equipment, plant, and operating conditions. In conjunction with a systems approach to the design of improvements, attention should also be given to achievable levels of adhesion, since the effective utilization of locomotive power is constrained thereby; small changes in adhesion can be significant and may practically be attainable only by improvements to some combination of system components. In the context of system design, further attention needs to be given to interacting major subsystems, including the growing importance of accommodating intermodal facilities.

On-Board Measurement (Priority 3)

Means of recording operating data, such as forces on couplers or truck vibration, combined with methods of analysis and display, may have direct impact on improvements in safety and train handling and on maintenance needs. Practical development of on-board measurement capabilities is indicated here, and such development should include heavy emphasis on improved safety of operation resulting from on-board measurement and display.

Car Design (Priority 3)

Overall car designs need to be assessed as part of the train as a movement or a system and of the car or yard as a switching system.

Applications Research

Component Improvements (Priority 3)

Deficiencies of various kinds in key equipment and track components should be identified. Couplers, wheels, trucks, and braking systems have undergone little basic change since their initial evolution. Developmental work should be aimed at making the most cost-effective changes or modifications (using the system design approach), bearing in mind the constraints of the industry's need for compatibility and interchangeability, as well as the new demands imposed by high-speed service.

The increased volume of transportation of hazardous materials, the development of new hazardous materials that must be transported, and changes in equipment and operating conditions constitute a serious problem. There is a need for the development of equipment (e.g., tank cars) that will reduce the risks of transporting hazardous materials, particularly the risk of accidents.

Life-Cycle Design (Priority 3)

There is a strong need for research and development in life-cycle design to minimize the sum of discounted investment and lifetime maintenance costs. This research and development effort must take a total systems approach with an awareness of today's heavier loads, higher speeds, long-distance unit trains, and new knowledge and appreciation of the dynamics between track and trains. The effort must also consider the ever-present need to maximize the use of the available funds. Life-cycle costing should be an integral part of this research.

Urban Facilities (Priority 3)

In the urban areas of the nation, there are many opportunities to consolidate tracks, yards, and other facilities to reduce costs, improve operations, eliminate some grade crossings, and aid in urban revitalization. There are also opportunities to improve intermodal coordination.

OPERATIONS

Basic Research

Service Quality (Priority 2)

There is a general agreement that existing measures of railroad service are incomplete and often inadequate. There has been too much dependence on kilogram-kilometer statistics. It is necessary to identify a more comprehensive group of measures to service quality that would satisfy both managements and users and to find means of making them operational. Included in the package of measures of service quality should be some measure of loss and damage.

Developmental Research

Equipment Utilization (Priority 1)

A number of closely interrelated problems combine to make improvements in equipment utilization difficult. There is a need for better forecasting of supply and demand, for a means of equalizing demand, for buffer storage and assigned cars, and for a means of distributing control that will reduce car cycles and the ratio of empty time to loaded time. Coupled with a means of fully using car capacity and matching inspection and grading to traffic demand, solutions to these problems can improve overall utilization. Current work on car utilization by the AAR needs to be augmented and accelerated. Investment decisions should consider the cost of increasing equipment utilization as well as an alternate to new equipment or facilities.

Hazardous Materials (Priority 3)

In addition to improved equipment (discussed above), procedures for safer handling, shipping, control, and monitoring of the transport of hazardous materials (e.g., switching and classification) need further development.

Electrification (Priority 3)

Electrification provides an opportunity, where operating conditions justify it, to reduce operating costs, improve service, and conserve petroleum fuels. The technology of electrification has improved greatly in recent years, but there is still some work to be done, particularly in the area of electrical and electromagnetic interference.

Most research must be done on the institutional and economic problems that face electrification, particularly the problem of financing it. There is a problem of interaction between electrified and nonelectrified sections of railroad, and there needs to be a thorough investigation of integrating an electrified section into the balance of the railroad. Continuing research is needed to determine whether electrification of specific lines is a good investment.

Applications Research

Blocking and Scheduling (Priority 2)

There is a need for continuing research and development in the blocking and scheduling of trains. Such research and development must be undertaken in full awareness of the changing patterns of service, the loss of short-haul freight traffic, the increased use of run-through freight trains and unit trains, the growing volume of TOFC/COFC traffic and its special needs, completed and planned railroad mergers, and the new and expanding flexibility in work rules. The extensive USRA work in this area should be a starting point for further and continuing research and development. The current effort in freight-car management must also be considered.

Terminal Management (Priority 3)

Research and development in terminal management should be undertaken with an awareness of the factors noted in the sections on terminal and yard design and on blocking and scheduling, as well as with an appreciation for the newly developed management information and control systems now becoming prevalent in the railroad industry. Operations research techniques should be used to increase the volume and to decrease the length of time cars stay in yards and terminals.

MANAGEMENT

Basic Research

Cost Structures (Priority 1)

The present models that form the basis for railroad cost information have been largely derived from regulatory accounting processes. They are too often inadequate, when applied to marketing and operating questions and problems. Little attempt has been made to design any costing procedures for technological evaluation and forecasting. A major effort needs to be mounted, probably on an industrywide basis, to develop a range of cost models, together with techniques of collection and analysis, to meet these needs, including needs for investment policy. In developing costing models and the design of a data system to support their use, attention should be given to including factors and data that would permit a new examination of the questions of economies of scale. The FRA should take the lead in model development; DOT should provide the data system as part of a total transport data system that includes all modes.

Demand and Marketing (Priority 2)

A more definitive examination of demand elasticities for railroad service would be of direct assistance in market and capacity planning. In particular a new examination of the bases for shippers' needs and choices is indicated. Far too little information is available on intermodal demand.

Developmental Research

Sources of Capital (Priority 1)

Traditional sources of internally generated funds and debt instruments have been found inadequate to meet future needs. Fresh sources of capital need to be identified, or innovative approaches to supporting new capital investment need to be devised. There is a need to flexibly examine a range of alternatives that includes organizational realignments. An effort to maximize the use of existing funds would be helpful, since capital would obviously be available if investments in railroads were more productive.

Studies of Human Resources (Priority 1)

Changing conditions of operation, changing viewpoints on the organization and management process, and changing values, expectations, and life-styles are changing the human aspect of conducting an organizational effort like that involved in producing railroad services. Considerable work has been done in recent decades in the human behavioral field as related to industrial organizations. Research and practices in fields other than railroading should be imaginatively examined and their adaptation to the railroad situation seriously considered. Railroads are heavily dependent on the contribution of skilled and experienced people. There are indications that retaining this experience and encouraging and attracting the new and replacement skills that are needed may require special efforts. Some deeper understanding of the motivations and mechanisms involved, in terms of present-day life-styles and attitudes, is needed. The diverse, diffused, and continuous nature of railroad operations has resulted in a high ratio of middle to senior managers. Current expectation levels and value systems militate against the acceptance of a static career. New approaches to providing mobility, job enhancement, and career planning are needed.

Railroads retain a uniquely paralegal approach to discipline. Apart from its questionable effectiveness, it is increasingly antithetical to today's life-styles. Its elimination is impossible, however, until some adequate and acceptable alternatives are devised. Railroading continues to be both labor and capital intensive; necessary major changes and improvements must inevitably involve modification of the quantity and content of work. New approaches are needed for the successful implementation and continuing support of programs that involve change in working conditions. There is a need to examine and evaluate alternative approaches, such as joint participation in experiments with new work rules. The large-scale application of computers to railroad operations provides an improvement in communications. A research effort is needed to exploit this computer capability for the improvement of human communications. A substantial effort should be made to provide university training, at both the graduate and undergraduate levels, to prepare young people for railroad careers and to improve the skills of railroad professionals and managers.

Applications Research

Training Methods (Priority 2)

Railroading operating skills have traditionally been acquired and transferred through on-the-job experience. Greater mobility for personnel and a shorter job life, together with greater availability of transferable knowledge, emphasize the need for the development and implementation of training methods and programs.

Information Technology (Priority 1)

Several aspects of information technology need to be developed or adapted for railroad needs, including scheduling algorithms, automated data collection, waybill generation, and car-order systems. Traffic-related data-exchange mechanisms and procedures are needed, both between shippers and carriers and among carriers. Railroad information systems would be significantly improved if confirmatory data-feedback methods could be further developed. In addition to automatic car identification, which is now undergoing further evaluation, car sensing and exception-reporting techniques could be made operational.

Indirect Costs and Benefits (Priority 3)

Planning, design, and application of new or changed operating or management information systems are often inhibited by the lack of means to evaluate the indirect benefits and costs of such systems. Techniques for this evaluation in the railroad environment are needed.

Management Structures (Priority 3)

Railroad management has traditionally been structured on geographic and functional lines. Developments in communications and information processing have led to both the crossing of old boundaries and the centralization of control. Modifications and alternative approaches to management structure need to be experimented with. It has been proposed that a form of management incentive could be developed through the use of profit centers. Lack of adequate cost data has inhibited moves in this direction. There are fears that profit centers might lead to suboptimization, but the concept has sufficient merit for providing better incentives for middle management that it should be investigated. This and other alternative internal structures need to be examined to see whether internal transfer pricing would be beneficial.

Accounting Methods (Priority 3)

Conventional railroad and ICC accounting processes are proving to be inadequate for management and planning purposes, particularly in the handling of capital assets. The application of alternative methods that draw experience from other sectors would be beneficial. Compatibility with other accounting systems should be considered; funding might be provided under the Railroad Reorganization and Regulatory Reform Act of 1976.

Demand Pricing (Priority 2)

Demand pricing should be developed and used to level directional, seasonal, and regional commodity flows.

Productivity (Priority 1)

Improving the productivity of labor offers great opportunities to lower costs and to improve service. Although the greatest opportunities appear to be in operations, the research effort should cover all phases of railroad activity and should preferably be carried out with the active cooperation and participation of the labor organizations. The research effort should also include examination of the productivity of capital equipment.

GENERAL PROBLEM AREAS

There are certain kinds of problems that so pervade the entire activity of producing rail transport that they cannot be neatly categorized as pertaining solely to a major functional area such as operations or planning. Two of them—safety and maintaining a clear view of where the industry should be directing its efforts—require continuous attention, and the need for them is highly important.

Safety (Priority 2)

Safety involves many things that require attention in the whole range of activities that produce the final product of transport service: planning, design, equipment, materials, operational methods, management attitudes, and human behavior. Safety also costs money, although expenditures to achieve other ends, such as efficiency, may also enhance safety if the design is appropriate. The interaction between a railroad and some part of its environment, such as railroad-highway grade crossings, may require the joint attention of a number of agencies. There is already considerable research activity on safety in both the industry and government. The study committee urged that such efforts be continued actively and that particular safety research projects that evolve from this program be planned with full cognizance of existing research activities. In the field of safety research, it is important to maintain a broad overview of both safety needs and safety activities, since the changes therein will affect the priorities assigned to projects that may be included in any program. Possibly some joint group—such as the recently formed Railroad Safety Research Board, a joint effort among management and labor in the industry and government—could perform this function.

Role of Railroads in the Economy (Priority 2)

Planning by government and industry would be greatly improved if a clearer description and evaluation of the railroads' role in the national and regional economies could be obtained. This should be done within the total transportation context; would involve analytical models of transport demand and supply in relation to measures of performance; should establish the rail-service product in terms of space, cost, and volume; and should include the impact of railroads as consumers of material, energy, capital, and labor.

Cooperative Research Program Management (Priority 2)

An organization along the lines of NCHRP, for example, should be established to manage the recommended cooperative rail research program.

Data (Priority 2)

The lack of appropriate data for undertaking some of the kinds of research thought to be essential for dealing with current and future problems of rail transport is a consistent theme in the earlier chapters of this report. The lack of data seems especially to plague areas of needed operational and economic research, including research into financial and investment problems, but it spills over into important technological research and development questions as well. These data deficiencies, moreover, seem in most cases to be problems of long standing. While the U.S. railroad industry has probably provided more publicly recorded information on its finances and operations over a longer period of time than any other industry, much of that information is not in suitable form for use in dealing with many questions of fundamental importance to the future of the railroads. For example, the total cost of fuel purchased by a carrier is of no use

in costing operations over a specific line or in comparing operational costs of different locomotives.

External Data Needs

The lack of data on traffic flows, rates, and service characteristics of other competing modes of freight transportation (particularly intercity trucking) is a major obstacle to understanding the present and prospective markets for rail transportation. This, in turn, affects planning for the future of the railroad industry in various ways. These inadequacies derive from long-standing industry practices and more recently from the inability of the federal government thus far to organize an effective program of data collection in this area, despite a legislative mandate to do so in the High-Speed Ground Transportation Act of 1965.

The problems here derive in part from the unworkability of a waybill sampling technique, such as that used for railroad traffic, to capture information on private and otherwise unregulated truck transportation. This is compensated for, but only in part, by the Census of Manufactured Goods Transportation, which is collected once every 5 years by the Bureau of the Census; these efforts leave much to be desired in terms of detail on transportation charges or on the characteristics of the transportation provided by the carriers involved. The use of the census data also suffers from disclosure problems that make it difficult in many cases to look at the transportation market in sufficient detail to understand the nature of the competitive interface between various modes and types of transportation services. This problem could be overcome partly by larger sample sizes and partly by supplementary data-collection activities.

The sort of data collection that is required can, as a practical matter, be undertaken only by the federal government. Thus far, there has apparently been inadequate interest on the part of successive administrations to spend the public funds required to close these information gaps. This lack of interest stems from basic dependence on industry reporting and at least in part from the very long lead time involved in such efforts, lead time that means that the money spent today will produce results usable only by some future administration. This lack of commitment to what can be thought of as basic research must somehow be overcome if both the public and private decisions that turn on an adequate understanding of the intercity freight transportation market are ever to be made on a rational basis. The NCHRP's Freight Data Requirements for Statewide Transportation Planning Project, sponsored by the American Association of State Highway and Transportation Officials in cooperation with FHWA and administered by TRB, has made a start by cataloging existing sources and identifying unmet data needs. Collection of new data may not be required, but reorganization of existing data resources almost certainly will be.

There is also a special requirement for external data on the functional costs of the various modes of intercity transportation. A number of crucial public and private policy decisions turn on better knowledge of what the various modes do well and poorly in an economic sense. Yet we have done relatively little research in this area and have relatively few of the requisite cost data in hand.

Internal Data Needs

The lack of adequate data for costing was mentioned repeatedly in the course of this study as a major obstacle to research; it seems clear that there is much to be done on the development of improved data acquisition, storage, and retrieval capability in connection with railroad costing. Certainly, the cost of collecting sufficiently disaggregated data on railroad operations, railroad facilities, and railroad expenses has been an important obstacle to the development of better costing methods. In an era of financial difficulty it is not reasonable to propose that the railroad companies, even with government assistance, devote large sums of money to this data-collection requirement. Thus, the need for more sophisticated and more efficient data-collection procedures is apparent.

Beyond this critical need for improved data bases for internal costing, a need has also been identified for improved data to be used in measuring the performance of the railroad system. This, in turn, gives rise to a need for research into improved systems for measuring performance. Without a clear definition of how best to measure railroad performance, it is not possible to specify data-collection requirements with sufficient precision or to establish the parameters of the research into data-collection techniques both in the aggregate and in detail. The data with which to measure service quality are partly in hand, but they are not properly organized and are partly missing from present and past data-collection programs. Any improved program for internal data collection should take explicit account of this problem of measuring service quality.

In general, the important internal data needs are for more functionally disaggregated data on operations and the use of assets. The need here is not for improved accounting systems per se (although there is such a need) but for improved banks of data that can be analyzed on both a tactical and strategic basis. Decisions that require such improved data inputs are many and involve technological developments whose economic usefulness is uncertain without an improved ability to assess that usefulness through the analysis of the appropriate data on past and present operations. For example, the hardware necessary to operate very long trains might not have been developed if data had been available to show the deterioration of delivery time as train lengths increased.

Implementation of Results

If an extensive program of research in rail transport is to be effective, the results of the research must be stated in practical terms and then, if they offer potential benefits, their use must be implemented. Advantageous new concepts, methods, devices, materials, or other innovations may not find their way into use for a number of reasons:

1. Potential users (operators, decision makers, and so on) are not aware of their existence;
2. The research findings have not been translated into usable form;
3. Agreements have not been reached on the use of some innovation that affects all segments of interconnecting systems;
4. A potential user cannot adapt the innovation to his situation without outside help or resources;
5. A potential user may not know how to use the innovation; or
6. In an industry that has not been expanding, it may be especially difficult to justify the use of capital to introduce new devices and methods.

It is important that special steps be taken in this national cooperative program of rail transport research to facilitate implementation of research findings wherever a payoff can be expected. Some of these steps are to

1. Encourage the participation of a broad cross section of people from industry and government in activities associated with the program, such as committees and technical workshops;
2. Use a variety of means of disseminating information on the results of the research—technical meetings, task committees, publication programs, briefing sessions, and demonstrations;
3. Exchange personnel between research and operating groups, letting the researcher apply his findings in the operating environment;
4. Set up education and training programs for potential users so they can understand and effectively use new methodologies and new types of hardware;
5. Seek appropriate legislation where necessary; and
6. Where necessary, seek to establish proper regulations and standards.

## PRIORITIES

To make the most objective use of limited resources—funds, talent, equipment—it is desirable to determine as far as possible the relative importance or the priority of the items in a research agenda. Assigning priorities involves making value judgments about the acceptable objectives to be sought in the area of activity under consideration. In a broad and complex area like rail transport, the points of view of the many participants vary widely, so it might be expected that definitions of objectives as well as evaluation of a research agenda would also vary widely. Further, as the conditions affecting the area of activity change, relative urgencies (or priorities) for information, better methods, safer operating conditions, and so on will also change. Regardless of the difficulties, some improved way of establishing priorities needs to be developed for research in the field of transportation.

Although the problem of research priorities has been addressed with some success in industrial research programs, research programs like that contemplated for rail transport have to be judged against a much more complex set of objectives, and a far greater variety of subject matter is involved than is ordinarily dealt with in the research program of a single industrial organization. Discussion of some of the techniques that have been considered or proposed for setting research priorities are contained in the last section of references in the Appendix. In any assessment of priorities, a decision may have to be made between time priorities and substantive priorities, for they do not always mesh. The priorities discussed in the preceding section are considered to be substantive priorities.

# APPENDIX

# References and Bibliography


1. E. W. Coughlin. Freight-Car Distribution and Car Handling in the United States. Association of American Railroads, Washington, D.C., 1956, 338 pp.
2. Transport Statistics in United States for Year Ended December 31, 1973—Part I: Railroads, Their Lessors, and Proprietary Companies, REA Express, Inc., and Electric Railways. Bureau of Accounts, Interstate Commerce Commission, 1975, 124 pp.
3. Financial and Operating Statistics for the 12 Months Ended December 31, 1974: Class I Railroads. Bureau of Accounts, Interstate Commerce Commission, Dec. 1974, 19 pp.
4. Freight Commodity Statistics for Class I Railroads in the United States for Year Ended December 31, 1974. Bureau of Accounts, Interstate Commerce Commission, 1976, 33 pp.
5. Yearbook of Railroad Facts, 1976 Ed. Economics and Finance Department, Association of American Railroads, Washington, D.C., 1975.
6. Field Manual of the Association of American Railroads Interchange Rules. Mechanical Division, Association of American Railroads, Chicago, 1975, 427 pp.
7. E. K. Morlok. An Engineering Analysis and Comparison of Railroad and Truck Line-Haul Work (Energy) Requirements. In Measuring Energy Efficiency in Freight Transportation, American Trucking Associations, Washington, D.C., 1976, pp. 39-70.
8. D. P. Ainsworth, D. J. Liba, and M. J. Keale. Toward an Effective Demurrage System: Final Report. Reebie Associates, Greenwich, Conn.; Federal Railroad Administration, FRA-OE-73-1, 1972, 363 pp.
9. Track Safety. Railway Age, Sept. 13, 1976.
10. D. D. Wyckoff. Railroad Management. D. C. Heath and Co., Lexington, Mass., 1976.

References 11 to 25 were published as volumes in a series, Studies in Railroad Operations and Economics, by the Department of Civil Engineering, M.I.T., Cambridge.

11. A. S. Lang and R. M. Reid. Railroad Car Movement Reliability: A Preliminary Study of Line-Haul Operations. Vol. 1, 1970.
12. C. D. Martland. Rail Trip-Time Reliability: Evaluation of Performance Measures and Analysis of Trip-Time Data. Vol. 2, 1972.
13. K. Belovarac and J. T. Kneafsey. Determinants of Line-Haul Reliability. Vol. 3, 1972.
14. R. M. Reid, J. D. O'Doherty, J. M. Sussman, and A. S. Lang. The Impact of Classification-Yard Performance on Rail Trip-Time Reliability. Vol. 4, 1972.
15. J. Folk. Models for Investigating Rail Trip-Time Reliability. Vol. 5, 1972.
16. J. Folk. Some Analyses of Railroad Data. Vol. 6, 1972.
17. J. Folk. A Brief Review of Various Network Models. Vol. 7, 1972.
18. A. S. Lang and C. D. Martland. Reliability in Railroad Operations. Vol. 8, 1972.
19. J. M. Sussman, C. D. Martland, and A. S. Lang. Reliability in Railroad Operations: Executive Summary. Vol. 9, 1972.
20. C. D. Martland. Improving Railroad Reliability: A Case Study of the Southern Railway. Vol. 10, 1974.
21. J. M. Sussman and C. D. Martland. Improving Railroad Reliability: A Case Study of the Southern Railway—Executive Summary. Vol. 11, 1974.
22. C. D. Martland. Procedures for Improving Railroad Reliability. Vol. 12, 1974.
23. J. T. Kneafsey. Costing in Railroad Operations. Vol. 13, 1974.
24. P. A. Kerr, J. M. Sussman, C. D. Martland, and C. E. Phillip. Models for Investigating Train-Connection Reliability at Railroad Classification Yards. Vol. 14, in preparation.
25. B. C. Kullman. A Model of Rail/Truck Competition in the Intercity Freight Market. Vol. 15, 1974.
26. Conference on Transportation Research—Report of a Study Group Convened by the National Academy of Sciences at Woods Hole, Mass., Aug. 1960. National Academy of Sciences, Publ. 840, 1960, 88 pp.
27. Transportation Design Considerations. Division of Physical Sciences, National Academy of Sciences, Publ. 841, 1961, 243 pp.
28. U.S. Transportation: Resources, Performance, and Problems. Division of Physical Sciences, National Academy of Sciences, Publ. 841-S, 1961, 319 pp.
29. Science and Technology in the Railroad Industry. Committee on Science and Technology in the Railroad Industry, National Academy of Sciences, Rept. to Secretary of Commerce, Aug. 1963, 130 pp.
30. America's Sound Transportation Review Organization—The American Railroad Industry: A Prospectus. Association of American Railroads, Washington, D.C., June 30, 1970.
31. Progress in Railroad Research. Association of American Railroads, Washington, D.C., 1973.
32. C. Harral. Preparation and Appraisal of Transport Projects. Transportation Research Program,

Brookings Institution, Washington, D.C., Oct. 1965.
33. R. G. Noll. Reforming Regulation— An Evaluation of the ASH Council Proposals. Brookings Institution, Washington, D.C., 1971.
34. A. F. Friedlaender. The Dilemma of Freight Transport Regulation. Brookings Institution, Washington, D.C., 1969.
35. 1972 Carload Waybill Statistics— Territorial Distribution: Traffic and Revenue by Commodity Classes. Office of Economics, Federal Railroad Administration, May 1974.
36. Improving Railroad Productivity. Task Force on Railroad Productivity, National Commission on Productivity and Council of Economic Advisors, Washington, D.C., final rept., Nov. 1973, 329 pp.
37. 1972 National Transportation Report. U.S. Department of Transportation, July 1972.
38. 1974 National Transportation Report. U.S. Department of Transportation, Dec. 1974.
39. R. J. Barber. The American Railroads: Posture, Problems and Prospects. U.S. Government Printing Office, rept. to U.S. Senate Committee on Commerce, 1972.
40. Special Study Group on Transportation Policies in the United States— National Transportation Policy. Preliminary rept. to U.S. Senate Committee on Interstate and Foreign Commerce, Jan. 3, 1961.
41. U.S. Senate Commerce Committee Special Staff. The Penn Central and Other Railroads. U.S. Government Printing Office, rept. to U.S. Senate Committee on Commerce, Dec. 1972.
42. Train Accidents Attributed to the Negligence of Employees. National Transportation Safety Board, Washington, D.C., 1972.
43. K. J. Dueker. Wisconsin Census of Transportation— A Recommendation. Division of Planning, Wisconsin Department of Transportation, Sept. 1968.
44. D. Ashton. The Coordination of Transportation. Institute of Transportation Journal, April 1930.
45. G. J. Stigler. Free Riders and Collective Action: An Appendix to Theories of Economic Regulation. Bell Journal of Economics and Management Science, Vol. 512, Autumn 1974, pp. 359-365.
46. About the White Paper: Integrating Road and Rail Freight. Modern Transport, Vol. 99/2472, Jan. 1968, pp. 16-18.
47. A. L. Morton and J. S. Caflisch. Priorities in Rail Technology: Report to the Committee on Automation Opportunities in the Service Industries. Harvard Business School, Cambridge, Mass., Sept. 1972.
48. The Man in Railroad Management. Railway Systems and Management Association, Chicago, May 1964.
49. A. Martin. Enterprise Denied. Columbia Univ. Press, New York, 1971.
50. Short Haul Markets for Railroads. Railway Management Review, Vol. 73, No. 2, pp. A1-A131.

**References 51 to 125 cover the papers prepared for the Railroad Research Study and presented during the course of the conference held at Woods Hole. These papers were published in a volume entitled Railroad Research Study Background Papers by Richard B. Cross Company, Oxford, Indiana, July 1975.**

51. A. H. Hall. Research and Development: A New Accountability. Pp. 1-5.
52. J. J. Brogan. Energy in the Next Fifteen Years Vis-a-Vis Transportation. Pp. 6-11.
53. J. R. Coxey. Ecology— The Next Fifteen Years. Pp. 12-17.
54. D. Hair. The Timber Supply Outlook and the Implications for Railroads. Pp. 18-23.
55. J. E. Clayton. Manufacturing— The Next Fifteen Years. Pp. 24-36.
56. R. Sammartino and A. G. Smith. Agricultural Transportation Projections. Pp. 37-45.
57. E. E. Johnson. Mining and Extractive Industries Over the Next Fifteen Years. Pp. 46-62.
58. W. B. Lovejoy. International Trade Over the Next Fifteen Years. Pp. 63-68.
59. J. C. Spychalski. Motor Freight Transport—The Next Fifteen Years. Pp. 69-76.
60. S. E. Klingelhofer. Air Transportation—The Next Fifteen Years. Pp. 77-82.
61. H. E. Olson. Inland Water Transport: The Next Fifteen Years. Pp. 83-89.
62. F. Sharp. Inland Navigation Systems Analysis. Pp. 90-92.
63. R. E. Briggs. The Railroad Role Over the Next Fifteen Years. Pp. 93-100.
64. C. D. Baker. Transportation Policy and Requirements— The Next Fifteen Years. Pp. 101-109.
65. J. L. Weller and L. H. Keely. Capital Scarcity and Transportation Planning. Pp. 110-121.
66. E. G. Jordan. USRA Plans for the Northeast. Pp. 122-126.
67. G. Evers. Amtrak Plans for Passenger Service in the Next 15 Years. Pp. 127-129.
68. A. F. Friedlaender. Issues in Evaluating Transportation Regulation. Pp. 130-138.
69. P. H. Banner. Research Needs in Traffic Forecasting. Pp. 139-141.
70. J. W. Ingraham and J. R. Whitman. A Capital Markets Approach to the Financial Needs of the Railroad Industry. Pp. 142-150.
71. J. M. Ostrow. Railroad Marketing Research Needs. Pp. 151-155.
72. W. B. Allen. Research Needs on New Sources of Traffic. Pp. 156-169.
73. H. H. Livingston. Research Needs for Transportation Companies in the Corporate, Accounting and Financial Areas. Pp. 170-176.
74. A. F. Daughety, F. S. Inaba, and L. N. Moses. Competition, Regulation and Efficiency in Transportation. Pp. 177-181.
75. J. W. Barriger. Research Needs for Long-Range Planning. Pp. 182-189.
76. G. K. Davies. Research Needs in Railroad Costing. Pp. 190-194.
77. J. W. Egan. Research Needs in Rail Rate Structures. Pp. 195-204.
78. R. A. Nelson. Research Needs in Rail Rationalization. Pp. 205-210.
79. M. L. Mannion. New Concepts in Transportation Research Needs. Pp. 211-216.
80. J. M. Sussman. Research Needs and Priorities in Rail Service Reliability. Pp. 217-229.
81. R. A. Wells. Research Needs for Railroad Loss and Damage Prevention. Pp. 230-236.
82. D. P. Ainsworth. Intermodal Systems Concepts: Research Needs. Pp. 237-243.
83. G. S. Sines. Research Opportunities for Railroad Information Systems, 1975-1990. Pp. 244-252.
84. A. E. Pisarski and W. E. Cantey. Data Required for Research Needs. Pp. 253-260.
85. A. D. Dingle. Research Needs in Data Required for Operations. Pp. 261-267.
86. L. F. Mullin, Jr. Research Needs Related to Management With Computers. Pp. 268-273.
87. A. D. Dingle. Operational Research Needs in Management and Information Systems. Pp. 273-282.

88. G. S. Paul. Management Research Needs of the Railroads. Pp. 283-287.
89. H. E. Bixler. Railroad Management Development Research Needs. Pp. 288-292.
90. D. E. Pergrin. Professional Talent Research Needs. Pp. 293-309.
91. V. Roggeveen. Career Opportunities for Professional People in Railroad Companies—Views of the Industry From a University Setting. Pp. 310-313.
92. B. B. Gardner. Research Needs in Personnel Policy and Employee Morale in the Railroads. Pp. 314-322.
93. J. A. Sheridan. Railroad Labor Supply Research Needs and Priorities, 1975-1985. Pp. 323-333.
94. R. D. Hedberg. Training Program Research Needs. Pp. 334-338.
95. J. F. Roberts. Railroad Labor Relations Research, 1976-1986. Pp. 339-344.
96. D. B. Devoe. Human Factors Research Needs. Pp. 345-354.
97. W. M. Homer. Railroad Employee Benefits of the Future—Research Needs. Pp. 355-368.
98. P. L. Conway, Jr. Research Needs in Accounting Systems. Pp. 369-372.
99. E. J. Gentsch. Material Management Research Needs. Pp. 373-376.
100. D. W. Collins. Research Priorities and Needs for Joint Labor-Management Activities. Pp. 377-378.
101. F. H. Horn, G. R. Phare, F. E. Gray, and R. E. Eilerston. Panel Discussion: Human Communications. Pp. 379-383.
102. R. L. Gray. Conventional Track Research Needs Over the Next Fifteen Years. Pp. 384-387.
103. H. C. Meacham. Nonconventional Track—Research Needs Over the Next Fifteen Years. Pp. 388-404.
104. J. G. German. Track-Train Dynamics From an Operating Viewpoint. Pp. 405-408.
105. G. Reed. A Carbuilders' View of Railroad Research Needs as Related to the Track-Train Dynamics Research Project. Pp. 409-413.
106. M. W. Bellis. Truck/Rail Dynamics and Economics. P. 415.
107. G. C. Martin. Track Research Needs in Track-Train Dynamics. Pp. 416-418.
108. J. T. Wilson. Braking Systems Research Needs. Pp. 419-426.
109. J. D. Loftis. Freight and Passenger Car Draft Systems Including Couplers and Draft Gears. Pp. 427-430.
110. A. J. Gellman. Economic and Market Analyses in Support of Freight-Car Programs. Pp. 431-439.
111. W. P. Manos. Freight Car Research Needs. Pp. 440-442.
112. P. H. Reistrup. Amtrak: Its Present Status, Its Operations, Its Equipment, and a Look at Its Future. Pp. 443-462.
113. R. H. Wright. Research as Viewed From FRA's Office of Safety. Pp. 463-467.
114. J. G. German. Research Needs in Railroad Safety From a Railroad Man's Viewpoint. Pp. 468-470.
115. R. L. Jacobsen. Research Needs in Freight-Train Planning. Pp. 471-472.
116. J. J. Schmidt. Passenger Train Research Needs. Pp. 473-477.
117. W. V. Williamson. Research Needs in Yard Operations. Pp. 478-480.
118. C. W. Hoppe. Research Needs in Yard Network Design. Pp. 481-492.
119. E. J. Sierleja. Line Capacity Research Needs. Pp. 493-501.
120. J. J. Eash. Research Needs in Railroad Signaling. Pp. 502-503.
121. N. C. Pace. Needed Railroad Communications Research. Pp. 504-509.
122. E. T. Harley. Research Needs in Electrification of Freight Operations. Pp. 510-513.
123. J. W. Hawthorne. Research Needs in Motive Power. Pp. 514-520.
124. S. Landy. Intermodal Research Needs. Pp. 521-525.
125. G. M. Leilich. Research Needs in Car Utilization. Pp. 526-532.

References 126 to 130 represent major reports on recent and current research projects. References 131 to 160 represent reports on organizing research programs and setting research priorities.

126. Industrial Shipper Survey (Plant Level). Office of Transportation Planning Analysis, U.S. Department of Transportation, Sept. 1975.
127. Inland Waterway Transportation. TRB, Transportation Research Record 545, 1975.
128. Final System Plan. United States Railway Association, Washington, D.C., July 1975, 2 vols.
129. RRIS Bulletin. TRB, issued semiannually.
130. 1974/1975 Biennial Report. Research and Test Department, Association of American Railroads, Washington, D.C.
131. A. H. Rubenstein and others, eds. Army Material Command Value Methodology Experiments. Department of Industrial Engineering and Management, Northwestern Univ., Evanston, Ill., 1970.
132. D. R. Augood. A Review of R&D Evaluation Methods. Transactions on Engineering Management, IEEE, Vol. EM-20, No. 4, Nov. 1973, pp. 114-120.
133. N. Baker and J. Freeland. Recent Advances in R&D Benefit Measurement and Project Selection Methods. Management Science, Vol. 21, No. 1, Sept. 1974, pp. 1164-1175.
134. E. A. Premier and N. R. Baker. Project and Program Decisions in R&D. R&D Management, Vol. 2, No. 1, Oct. 1971, pp. 3-14.
135. W. E. Souder. Achieving Organizational Consensus with Respect to R&D Project Selection Criteria. Management Science, Vol. 21, No. 6, Feb. 1975, pp. 669-681.
136. K. H. Tauss. A Pragmatic Approach to Evaluating R&D Programs. Research Management, Vol. 18, No. 5, Sept. 1975, pp. 13-15.
137. T. W. Ruefli. A Generalized Goal-Decomposition Model. Management Science, Vol. 17, No. 8, April 1971, pp. B-505-519.
138. H. A. David. The Method of Paired Comparisons. Hafner Press, New York, 1963.
139. G. R. Gargiulo, J. Hannock, D. B. Hertz, and T. Zang. Developing Systematic Procedures for Directing Research Programs. Transactions on Engineering Management, IEEE, Vol. EM-8, No. 1, March 1961, pp. 24-29.
140. J. R. Moore and N. R. Baker. Computational Analysis of Scoring Models for R&D Project Selection. Management Science, Vol. 16, No. 4, Dec. 1969, pp. B-212-232.
141. J. R. Moore and N. R. Baker. An Analytical Approach to Scoring Model Design. Transactions on Engineering Management, IEEE, Vol. EM-16, No. 3, Aug. 1969, pp. 90-98.
142. C. M. Motley and R. D. Newton. The Selection of Projects for Industrial Research. Operations Research, Vol. 7, No. 6, Nov.-Dec. 1959, pp. 740-745.

143. C. M. Motley and R. D. Newton. A Scoring Methodology for Assessing the Suitability of Management Science Models. Management Science, Vol. 18, No. 10, June 1972, pp. B-526-543.
144. A. F. Helin and W. E. Souder. Experimental Test of a Q-Sort Procedure for Prioritizing R&D Projects. Transactions on Engineering Management, IEEE, Vol. EM-21, No. 4, Nov. 1974, pp. 159-164.
145. F. V. Kerlinger. Foundations of Behavioral Science. Holt, Rinehart and Winston, New York, 1965, pp. 581-599.
146. W. E. Souder and A. F. Helin. Source Field Results With a Q-Sorting Procedure for Evaluating R&D Projects. Univ. of Pittsburgh Technology Management Studies Group, Jan. 1974.
147. N. C. Dalkey and O. Helmer. An Experimental Application of the Delphi Method for the Use of Experts. Management Science, Vol. 9, No. 3, April 1963, pp. 458-466.
148. N. C. Dalkey. The Delphi Method: An Experimental Study of Group Opinion. RAND Corporation, Santa Monica, Calif., RM-5888-PR, June 1969, 88 pp.
149. N. C. Dalkey. Delphi. In An Introduction to Technological Forecasting (J. P. Martino, ed.), Gordon and Breach, New York, 1972, pp. 25-30.
150. B. Brown and O. Helmer. Improving the Reliability of Estimates Obtained From a Consensus of Experts. RAND Corporation, Santa Monica, Calif., P-2986, Sept. 1964, 13 pp.
151. N. C. Dalkey and D. L. Rourke. Experimental Assessment of Delphi Procedures With Group Value Judgments. In Studies in the Quality of Life—Delphi and Decision-Making. D. C. Heath and Co., Lexington, Mass., 1972, pp. 55-84.
152. S. F. Love and R. H. Irving. Delphi Decision Processes. Research/Development, Vol. 26, Sept. 1975, pp. 30-32.
153. H. Houg, J. F. Schwar, and L. O. Talbert. A Study of Highway Research Needs and Resources. Ohio Department of Transportation, Columbus, Rept. EES-299, March 1970.
154. Bertram D. Tallamy Associates and Wilbur Smith and Associates. Research Needs in Highway Transportation. NCHRP, Rept. 55, 1968.
155. Goals and Objectives: Problems, Programs, and Priorities. U.S. Department of Transportation, May 1, 1968, 23 pp.
156. J. D. Ward, D. H. Rubin, and V. A. De Marines. Research Development and Demonstration Program: Objectives, Goals, and Criteria. Office of Research and Development Policy, U.S. Department of Transportation, Rept. DOT-TST-73-7, June 1973.
157. R. E. Seiler. Improving the Effectiveness of Research and Development. McGraw-Hill, New York, 1965.
158. C. W. Churchman and R. L. Ackoff. An Approximate Measure of Value. Operations Research, Vol. 2, No. 2, May 1954, pp. 172-187.
159. A. L. Edwards. Techniques of Attitude Scale Construction. Appleton-Century-Crofts, New York, 1957.
160. N. R. J. Maier. Assets and Liabilities in Group Problem Solving: The Need for an Integrative Function. Psychological Review, Vol. 74, No. 4, July 1967, pp. 239-249.

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