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Part 1
Rail Planning Perspectives

Policy Issues in State Rail Planning

John W. Fuller, Wisconsin Department of Transportation

Recent federal legislation has given a major stimulus to rail transportation planning. Virtually every state is now preparing its own rail plan. It is argued that such state rail plans should be produced in a multimodal context and should attempt to address critical policy issues in transportation. A list of 10 critical policy issues was prepared by the Transportation Research Board, but to date federal legislative focus, administrative rules, and state rail plans have been much more narrowly conceived. This focus must be broadened if state rail plans are to meet emerging policy needs.

Railroads in the United States have been suffering a long decline that began before World War II. The reduction in their relative traffic share and the erosion of profitability of the rail industry have been fully chronicled and analyzed (1, 2, 3). Recent insolvency of the Penn Central Transportation Company and other eastern railroads, therefore, came as no surprise to many. Today, as a predictable consequence of past government policy, present traffic conditions, and worsened operating capabilities of their railroad plants, several major midwestern railroad firms are in a precarious financial state. Continuation of these trends will only lead to the demise of the industry as an important part of the transport sector.

In contrast to the hands-off approach of previous decades, government took substantial direct action to subsidize the railroads in the 1970s and provided the sole means by which a high level of rail service is being retained in the eastern states. Eastern dependence on rail movements at a time of general economic recession, coupled with uncertainty and fear of the results of reorganization under bankruptcy, was sufficient to initiate federal and state rail support. Government action meant, primarily, short-term payment of operating losses followed by long-term financing as a lender of last resort. Although government support came initially in the East, the realization that rail transport is an interconnected, nationwide system has opened the door to government financing throughout the country. The Rail Passenger Service Act of 1970 also played a role, but the key instruments for action were the Regional Rail Reorganization (3R) Act of 1974 and the Railroad Revitalization and Regulatory Reform (4R) Act of 1976.

Just preceding and concurrent with passage of the 3R and 4R acts, unprecedented federal rail planning effort took place; the private sector rail firms had always done any necessary financial or market development planning for themselves as a general matter of normal business operation.

The chief products of planning efforts by the Federal Railroad Administration (FRA), the U.S. Railway Association, and the Rail Services Planning Office involved rail system restructuring and the rationalization of light-density rail branch lines (4, 5, 6, 7).

As a basis for comment on federal planning, and to meet the requirements of the 3R Act for rail subsidy funds, approximately 17 eastern and midwestern states began their own rail planning efforts in 1973 and 1974. Initial state rail plans were completed in December 1975 and revised and updated on August 1, 1976. According to a federal ruling, further revisions will be made annually in August. Since the original midwestern and northeastern states entered rail planning, these planning activities have spread to virtually every one of the contiguous states.

A national rail planning effort is now well in hand, and we are moving from a first substantial experience with restructuring the rail sector, toward a level of government involvement in railroad management and operations that has been unknown in this country since 1920 when the railroads were returned from federal control during World War I to private operation. Now is a logical time to step aside from such detailed concerns as the appropriate data and methodology for rail planning, the measurement of primary and secondary impacts of branch-line abandonment, or the calculation of elements of subsidy determination, and to focus on the policy issues that should be faced in state rail planning.

Each state should ask what future role its railroads should play in freight and passenger transport. Other questions we must ask are: Should present rail technology continue indefinitely? To what extent are railroads in competition with other forms of transportation? Is rail financing a private sector responsibility or a public requirement? If the public must pay, how are the sums to be raised, and who will benefit from these expenditures? What is the role of the state in railroad safety and economic regulations? Because such policy issues seem to be glossed over more often than not by state planners newly charged with rail responsibilities, this paper will present a set of rail policy issues, describe state planning requirements under the 4R Act, and evaluate how well these important policy issues are being handled in state rail planning.

RAIL POLICY ISSUES

In 1976 the Transportation Research Board's executive committee developed a list of transportation issues it considered to be the most critical for the near future (8). With some adjustment to fit the nature of the rail mode, these policy issues can be discussed as basic to the state rail planning process.

Energy Efficiency in Transportation

There appears to be no national issue of more immediate and pervasive importance to transportation than that of minimizing the use of energy, especially petroleum. Railroads are generally portrayed as more energy efficient than highway and air transport but less than water and pipeline transport. This is a simplistic notion because certain rail operations, such as ones typified by light density branch-lines, may be large users of energy compared with motor carriers (9). Likewise, railroads are not as energy efficient in moving people as they are in moving freight. However, for high-volume movements railroads need not rely on the internal combustion engine; they can use electrification. If state policy is to promote energy efficiency, how does achieving such a goal enter a state rail plan?

Transportation and the Environment

Air, water, and noise pollution can be produced by railroad operations. General national and state policy is to minimize the generation of pollution by the transportation modes. A rail planning process can weigh alternatives to determine the relative effects on the physical and social environments of rail movements compared with other modes. For some states, the movement of western coal by unit train can be compared with a pipeline alternative or mine-mouth generation of power. In a microanalysis, the planning process may uncover unusual environmental findings—such as the discovery in Wisconsin of endangered vegetation on rail branch-line rights-of-way, protected by the continuation of possibly uneconomic services (10). It then clearly becomes a policy issue as to whether concern for environmental protection outweighs economic costs in deciding to continue a branch-line operation. An explicit way of making environmental trade-offs is basic to any rail planning process.

Transportation Safety

Although the railroad is our most general common carrier, track conditions may be so poor that rail movement of certain hazardous materials is unwise. On the other hand, to avoid densely populated areas and to isolate hazardous cargo, it might be desirable to improve special sections of the rail system and, through regulation, to shift hazardous materials to the railroads. Safety can also be an issue concerning passenger trains running on poorly maintained track or grade crossings. While full grade separation between railroads and highways could be desirable if safety is accorded a very high priority, such possibilities as line consolidation and train scheduling to prevent conflict are alternatives for rail planners to investigate.

Intergovernmental Responsibility for Transportation Systems

Should states be the primary subnational focus for rail planning? States differ tremendously in area, interests, government powers, and other attributes related to rail transportation. Rail systems commonly traverse state boundaries, thus making regional compacts or close coordination necessary for such significant actions as revising mainline configurations. Which division of responsibility between states and the federal government is best? The question of intergovernment relations extends to local government units that may have direct interests in rail services or may even actually operate short lines or maintain rail stations. Which should be the lead government agency, and how should each unit be involved in a planning process?

Transportation, Land Use Control, and City Form

Railroads shaped the geography of many American cities and greatly influenced the distribution of industry throughout the country. The present rail system operates in a broad sense to permit regional competition and on the small scale to divide neighborhoods. The effect of railroads on land use remains quite strong. Therefore, depending on whether city form is a concern in a particular state, urban rail relocation may be a major study item for state rail planners. Because of railroad influence on regional growth, every state rail plan should investigate the effects of changed rail services on export industries that engage in production for regional and national markets.

Improvement of Existing Nonurban Transportation Facilities

The issue is in part how to efficiently use present systems in lieu of expanding. This raises the question of whether, and if so to what extent, rail transport is competitive with other forms of transportation. The answer is likely to be found only by detailed examination of city pair markets, by investigating present and potential flows of goods and movements of people. From another standpoint, the issue is one of measuring excess capacity in railroading. If capacity can be reduced by branch-line abandonment, yard consolidation, and mainline mergers, then lower cost rail transport might result. Likewise, cost reductions can occur if excess capacity can be put to work by offering prices that cover operating costs and make some contribution toward capital recovery. A rail plan should be sure to investigate the extent of scale economics and economies of utilization, and the extent to which any such economics might be offset by a loss of competition.

Transportation System Performance Criteria and Design Standards

Before improving existing facilities or making investments in new railroad track, yards, or equipment, investment analysis methods must measure the effectiveness of the various proposed expenditures. Analyses should be performed regardless of whether the investments are made with public or with private resources. In the foreseeable future the federal, state, or local funds that may be spent on the railroads will be limited. With a 1.2 percent rate of return in 1975 (11, p. 20), the railroads are able to generate very little private capital. Any state rail plan must determine which level of service or what economic return will accrue from the application of these limited funds.

Financing Requirements and Alternatives for Transportation Systems and Services

Are railroads to be treated as public goods, or should rail users continue to provide the great majority of rail revenue needs? The pricing of rail services for users is a complicated issue that depends for resolution on the allocation of railroad costs, public treatment of competing modes, and determination of the extent to which value of service pricing can continue in the industry. If the public is to finance some or many railroad operations as public goods, tax sources need to be found. Perhaps, as Secretary of Transportation Adams has suggested, the federal government should be considered a lender of last resort for all transportation right-of-way capital needed (12, p. 5).

On the other hand, transit has only recently escaped the capital bias problems of such a public policy. Moreover, right-of-way subsidy through low-interest loans may not be sufficient to bring about desired public purposes and can create inequities from different modes' production functions or different mixes of capital and operating expenses. Any state rail plan will have to resolve funding sources, amounts, and controls if rail services are to be supported in part by state and local government. In a broader sense, states will have to decide whether they wish to aid all the competing modes of transportation, even in some "balanced" way, because of the stimulus given to production of transport services rather than other goods and services generated by the economy.

Effects of Transportation Regulations

Extensive economic regulation of rate and service competition has been cited as a major reason for the poor performance of the rail industry. Regulation takes place at the state level as well as under federal statutes. Should state rail plans analyze the impact of varying state regulatory controls? Regulation is said to stifle innovation. How, then, might innovation and change in railroading be encouraged through regulatory revision? Because regulation of interstate rail rates has sometimes been applied as a protective device for a state's industry, the removal of state rate regulation should be analyzed to see if it would have broad effects on industrial location and employment.

Transportation System Maintenance Technology and Management

The challenge of developing a transportation system, such as the building of the railroads, seems to encourage the quick advances in technology needed to put the system in place. Maintenance of that system, however, attracts less interest and encourages less innovation. Making an established rail system work better through joint usage, support of intermodalism, and coordination is difficult, but these issues cannot be neglected by state rail planners.

The Transportation Research Board's 10 critical issues, of course, do not cover everything. State rail plans should probably be even more comprehensive than the above discussion would suggest. For example, the 10 issues relate only tangentially to labor and management relations in railroading. The evident need, however, is for state rail plans to be concerned with addressing and resolving as many of these critical policy matters as are important to each individual state.

Let us now turn to a review of what state rail plans must encompass under present federal laws.

STATE RAIL PLANS

The 3R and 4R acts, taken together, constitute the most far-reaching legislative changes made in the past 50 years regarding railroads. In addition to authorizing $2.1 billion for the Consolidated Rail Corporation start-up costs, $1.75 billion for Northeast Corridor passenger trains, $1.6 billion in loan guarantees plus redeemable preference shares for nationwide rehabilitation programs, and $125 million for rail commuter services, the 4R Act revises Interstate Commerce Commission procedures and institutes a large number of studies. However, none of these activities mandates the input of states, nor do six of the seven substantive titles of the 4R Act require comprehensive transportation planning as a basis for expenditure or implementation. (Title I contains policy statements and definitions; Title IX requires studies and contains miscellaneous provisions.)

Title VIII—local rail service continuation—is the one portion of the 4R Act that calls for state plans. It establishes a national rail service assistance program for freight lines, through which states can direct funds in accordance with an approved plan to keep abandoned services in operation for 5 years. Some $360 million are authorized for rail operating subsidy, line purchase or rehabilitation, and "the cost of reducing the costs of lost rail service in a manner less expensive than continuing rail service."

In order for states to receive funds, the law requires a state to "establish an adequate plan for rail services in such state as part of an overall planning process for all transportation services in such state." These state planning requirements of the 4R Act differ from the 3R Act only in ordering the rail plan to be part of an overall planning process. Earlier versions of the 4R Act were worded so as to make the rail plan part of an overall state transportation plan.

FRA Requirements for State Rail Plans

The rules and regulations under which the 4R Act is administered by the FRA interpret congressional direction for an adequate state rail plan in considerable detail. The requirements may be summarized as follows (13).

1. Rail plans are to be based on a comprehensive, coordinated, and continuing process for all transportation services in the state. Participation in the process by the public and adjacent states is mandated.
2. States are to explain the philosophical framework guiding development of the plan and to specify the planning process used, giving particulars as to state rail policy and objectives, data, assumptions, methodology, and special problems or considerations.
3. The state rail system is to be mapped and classified. Services and traffic are to be described. A broad overview of all services is anticipated, but concentration is expected to focus primarily on services eligible for subsidy.
4. For lines eligible or potentially eligible for subsidy, detailed freight flow, revenue, cost, plant equipment, and demand information is to be provided. Effects of abandonment on the state's transportation needs are to be analyzed. Relative economic, social, environmental, and energy costs and benefits involving alternative rail services or modes are to be calculated; competitive effects and potential operating economies are to be investigated. Pros and cons of all alternative projects are to be described.

Narrow Focus of State Rail Plans

Although the general federal requirements for the urban transportation planning process common to all modal administrations of the U.S. Department of Transportation are repeated in the rail plan regulations, the chief focus of the plans is on potential projects for subsidy funding. Only for those lines where funds might be applied are full analyses to be made. Lines not eligible for subsidy, rail bottlenecks, and rail services generating substantial shipper dissatisfaction are not matters for detailed study. Although this focus is defensible given the nature of the 4R Act, the result is to segment state rail interests and to prevent the comparison of subsidy-eligible projects under Title VIII with other potential rail investments. Only a very few of the critical rail policy issues discussed earlier are covered by the FRA planning requirements.

CONCLUSIONS

At this stage in federal and state rail planning, conclusions about the applicability of various planning methods, the need for particular data, the cooperative institutional framework in which planning will take place, or even the end results of having begun a rail planning process are purely speculative. Yet, it is clear that rail planning has been envisioned as short run in terms of the planning horizon and narrow in scope from the standpoint of approaching rail industry revitalization, largely in regard to branch-line changes. It is equally clear that such a focus neglects addressing at least 10 critical policy issues. Ideally, a more broadly based plan and planning process would describe how a state can attain input efficiency and generate superior technology and therefore create a better product—improved rail transport services. The key concerns of utilizing excess rail capacity and equalizing competitive opportunity among the modes of transportation would be resolved in the all-mode context of the state.

If state rail plans do not become more broadly based to encompass critical policy issues, rail planning will suffer the worst possible fate: It will become superfluous and have little policy impact. Rail planning has advanced too far in the few short years of its existence not to meet this further challenge.

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Current State Rail Planning and Research Needs

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The major problems of the railroad branch-line subsidy program are identified. An alternative program that utilizes rail and motor carriers is proposed. This alternative appears to be more efficient from economic, environmental, and energy perspectives. Other research areas related to state rail branch-line planning include areas of competition, shipper roles, liability risk, taxation, prioritization and the identification of alternatives, state role in rail traffic generation, structure of management incentive fees, and labor cost issues at the macrolevel. Other problems presented are in areas of freight forecasting, rail patron credibility, energy utilization and environmental pollution, transportability of products, and highway impacts at the microlevel.

The origin of what has come to be called state rail planning has been presented by Kinstlinger (1), Fuller (2), and others (3, 4). The process itself grew out of the bankruptcy of seven eastern railroads and the federal legislation enacted to cope with that problem.

The purpose of this paper is to evaluate present state rail planning and what its future field will be. A number of significant research needs will be presented. First, however, two major problems related to state rail planning must be identified, because they are so large in scope that they are either accepted as given or ignored.

TWO MAJOR PROBLEMS

The first major problem is that there are rail lines being operated under subsidy that should not be. Specifically, most companies that now use subsidized rail service do not need it. They do need transportation, but the motor carrier sector could provide the service at a lower total cost than the rail sector does. The term "cost" as it is used here is broadly defined and incorporates social, environmental, energy, and economic components.

The second major problem is that no one appears to be looking at the rail situation as part of the total national picture. Apparently we do not have the bureaucratic or organizational ability to integrate the disparate visions into a single scene. If we did, we would not be either abandoning more than 4830 km (3000 miles) of rail line this year or subsidizing another 4025 km (2500 miles). In a period of concern over energy consumption, it is unreasonable to remove rail lines from service; at the same time, it is unnecessary to operate branch-line service if trucking is more efficient.

Although the former says we are subsidizing too much and the latter too little, the problem is not insoluble.

What we need is a program that would hold all lines slated for abandonment or subsidy on file for acquisition, leasing, or some other mechanism by the federal government. These lines may very well be necessary rights-of-way at some future date. Efficiency, economics, and regional development should determine whether a line should be served or "rail banked" and by whom.

This is not the case at present. One alternative would be to subsidize not the losses per se of continued rail service, but the difference between the branch-line rail rate and the motor carrier rate for the same haul. The railroad in most cases could continue to transport the traffic over the bulk of its move after it was delivered by motor carrier to one of its stations. The program could impose a limit on the length of the motor carrier haul. Accounting would be much simpler because there would be no need to calculate costs; the mode freight rate differential would equal the subsidy. Of course this is only a rough sketch of a more economical and efficient program, but it is worth further analysis. There is no reason to believe that the existing program cannot be altered.

STATUS AND PROSPECTS OF STATE RAIL PLANNING

Apart from the problems noted, state rail planning appears to have become an integral part of the planning activities in many states. States in the Midwest and the Northeast completed their initial planning efforts nearly a year ago; some even filed amended plans last fall.

Outside this major bankrupt railroad impact area, there is less evidence of overwhelming support for the process of rail planning or for the concept of branch-line subsidies. The prevailing attitude is that uneconomic branch lines should be abandoned, not subsidized. Federal monies should go to the railroads to ensure continued viability. These states also seem to believe that the funds involved do not merit the amount of planning required by the subsidy program.

It is reasonable to ask if there would be state rail planning in the absence of the U.S. Department of Transportation, the U.S. Railway Association, or other national rail planning organizations. Until now states' rail efforts have been reactionary. There is very little actual planning in state rail planning. At most some data are analyzed, and projects identified—nothing more than deciding whether a line should be subsidized or not.

Goldstein (5) reviewed a number of the state rail plans from the perspective of previously completed urban transportation plans and found them deficient. Compared with their counterparts in highway planning, state rail planners at present have no control over the location of routes, their width (number of tracks), or surface type (rail gauge). One and a half kilometers (a mile) of four-lane limited access highway in almost any urban area would take the entire annual rail subsidy for a typical state. Viewed from this perspective, state rail plans are much better than the funds involved might indicate.

Someone once said that the 1960s were the decade of highway planning, and that the 1970s would be the decade of rail planning. It is unlikely that state rail planning will ever be that important, and the 1970s will more likely be seen as the decade when railroads were integrated into the transportation planning process.

RESEARCH NEEDS

Research needs may be divided into macrolevel and microlevel needs. Macrolevel research is generally systemwide or regional in scope, whereas microlevel research is oriented more to branch lines. Both research levels are needed if the integration of rail planning into a comprehensive, intermodal transportation planning process is to be accomplished. There are also a number of research needs related to the existing rail service continuation program.

Macrolevel Research Needs

It should be apparent that a major research problem is whether the entire rail service continuation program as it currently functions should be terminated and replaced by a motor and rail carrier program. At a glance, such a program would be more efficient and more economical. However, feasibility studies should be undertaken for the utilization of the differential in freight rates between modes as a basis for subsidy payments.

A second major research issue is to what extent existing rail subsidy programs negatively impact on regional competition. For example, there are at least three instances of subsidized rail freight service operated with the approval of federal agencies but in violation of the Interstate Commerce Act provisions covering competition. Either the act should be revised or the service should be performed by another railroad. There may be others, and a legal-geographical research study of the region should be undertaken to identify them. A related question is whether the presence of subsidized rail in rural areas is detrimental to or in competition with marginally profitable motor carrier operations.

Another type of policy research question involves the general structure of a federal and shipper subsidy program as opposed to the current federal and state local program. There are indications that the primary beneficiaries of subsidized rail service are the shippers receiving that service; i.e., there do not appear to be the extensive secondary impacts on communities that Congress anticipated when the existing program was proposed. As a result, we must decide whether states or local areas should contribute to the subsidy. In addition, there are numerous instances where a shipper could simply divert a small portion of traffic from motor to rail and in the process make a rail line viable. In these situations, it is inappropriate for public funds to be used for subsidy.

Still another area needing substantive research is the area of branch-line liability and insurance costs. This was a major issue in the first year of negotiations between the Consolidated Rail Corporation and the states in which it now operates subsidized rail freight service (6). An estimate of this liability was made at that time. However, this question needs closer scrutiny. A study will soon be initiated by the Federal Railroad Administration to resolve some of these problems.

Immediate research is necessary in the area of rail taxation by states. An estimated $55 million is now collected from railroads through state and local taxation practices (7). Whether their taxing systems are discriminatory will undoubtedly be addressed by the courts in the next couple of years. The Railroad Revitalization and Regulatory Reform (4R) Act of 1976 gives states three years to eliminate discriminatory tax practices, yet very little has been initiated.

Railroad taxation practices vary both within and among states (8). This in itself is not a basis for rejecting existing procedures. The point is the railroad tax rate compared to other state economic activities. A uniform taxation procedure must be established according to profits as opposed to value. In addition, each state cannot continue to use the valuation formulas most advantageous to it, if, on the whole, railroads overpay taxes (9).

One portion of the rail plans completed to date is that concerned with prioritization and the evaluation of alternatives. Although these two areas are not necessarily the same, setting priorities for the alternatives identified can result in a decision on the proper alternative for a given line that affects the priority subsequently assigned to it. Research is needed to determine not only the most important decision-making criteria but also the appropriate weights that should be assigned to each criterion. Some research has been initiated, but far more work is necessary (10).

Another macrolevel research area is state and railroad subsidy negotiations (6). States are currently paying a management fee to railroads operating subsidized service. Several states would like to have this be a management incentive fee; that is, they would like to vary the fee based on railroad performance. What types of incentive fees are possible and desirable from the perspective of the two parties involved in subsidy negotiations? A research project evaluating alternative models would be of considerable value. Their growing interest in the economic viability of railroads within their borders has prompted states to ask exactly what they can do to enhance that viability. One thing would be to lighten the tax burden, but there may be others. Many state institutions are potential patrons of railroads: universities; prisons; hospitals; various types of state homes; highway divisions responsible for construction, resurfacing, sanding, or snow removal; and others. The question is to what extent laws requiring the transportation of certain materials to these institutions by rail would increase viability. This problem has not yet been addressed.

One final macrolevel problem concerns labor costs in railroad operations. Research completed to date suggests that a crew member accounts for approximately 10 percent of the on-branch operating costs (11). Could crew sizes be reduced on all trains? This is a sensitive research and policy area. Congress has ignored the problem completely in most of its recent rail legislation (except for labor protection provisions), even though at Senate hearings many identified labor costs as a crucial problem for the industry. A related question is the impact of crew size on safety. There are numerous contradictory statements in this area. One side states the need for larger crews to ensure safe operations; another claims the greater the crew size, the more accidents. An objective evaluation is clearly in order.

Microlevel Research Needs

At the microlevel, the research questions differ to some extent, although the findings of most of the macrolevel studies would affect them. This microlevel also carries some separate research questions. As it is used here, the microlevel refers to branch-line level. The problems in this area are directly related to specific branch-line questions in the state rail planning process.

The first research needed at this level is a method of forecasting rail traffic on branch lines, if possible. Most plans have treated future traffic as stable. In view of the unique character of each branch line, it may not be possible to do any more than use growth factors to estimate aggregate traffic.

Also at the microlevel is the question of to what extent rail patrons can be trusted to supply honest abandonment impact statements. A number of states were misled by shippers in terms of the rail traffic they had generated or would generate if certain lines were subsidized. Today a shipper's credibility is rather weak when he states he will go out of business if he loses rail service. Goldstein (5) criticized many state rail planners for accepting such statements as fact. However, an interesting study on the impacts of rail abandonment by Simat, Hellisen, and Eichner, Inc. (12), suggests that such impact statements are true most of the time.

Another aspect of branch-line rail planning is measuring energy consumption and environmental pollution. Contrary to common belief, branch-line operations are not necessarily energy efficient or environmentally desirable. This has been verified to some extent by two studies (13, 14). However, we need to know exactly where the breakpoint between energy efficiency and energy wastefulness is. Train size for realizing environmental advantages also needs to be determined.

Problems of energy consumption and environmental pollution stem from the alternate mode analysis of the rail planning process. Specific procedures should be followed in setting up an alternative that involves the use of another mode such as motor carriers. If a rail line is abandoned, will its traffic move by motor carrier to the nearest rail freight station offering service? Or will the motor carrier make the whole trip? Although the former is the more logical, some states prefer the latter.

During the hearings on branch lines conducted by the Rail Services Planning Office, one often heard statements that a particular firm must have rail service. The rationale was frequently the oversized or overweight nature of the shipment or the nature of the shipment (such as radioactive waste) and safety. There are very few products or materials that cannot be shipped by motor carriers, even though oversized or overweight products might need to be disassembled. If this is the case, the cost of assembling the parts should be considered and compared with the estimate of rail subsidy. This particular area, nevertheless, needs examination to determine cases where rail transport is a necessity.

Some states oppose rail abandonment because of what they identify as the negative impact on their state highway systems. Recent in-depth case studies of two branch lines in Indiana (15) revealed that in one case the highway could handle the rail traffic without any improvements, but in another case a capital expenditure of \$145 000 would have been necessary (this exceeded annual highway maintenance costs). However, rehabilitation of the rail lines involved to meet class I standards would have cost approximately \$281 000 in the first case and \$660 000 in the second. It is unwise to generalize from two case studies, but these two do not appear to support a rail subsidy decision. More of these case studies should be undertaken to clarify the local impact of rail traffic diversion on highway systems.

These, then, represent the major research needs in the area of state rail planning. Among the further problems are operating cost estimations, the relations between rail network geometry and operating costs, and the feasibility of what the state of New York has called "negotiated solutions." There are some states interested in mainline system planning, and research methods for analyzing trunk lines have recently been proposed (16). However, some believe that mainline system planning should be a federal or rail industry planning function and should not be a part of the state role in rail planning.

CONCLUSIONS

This paper has attempted to identify the major research areas related to state rail planning. Planners must clearly delineate these areas if objective rail planning is to become a reality. However, even if some answers are known, this is no guarantee that the quality of state rail plans will improve; for example, a simple decision to subsidize every line is not much of a decision. At the same time, states should not be content to look only at branch lines scheduled for abandonment. No state has reached the point where it will recommend that a railroad abandon a given line. This is admittedly a difficult role, and some do not like the political implications of it. However, if states fail to accept the role, how can there be state rail planning?

At the outset of this paper, I noted that rail planning would be integrated into the transportation planning process during the 1970s. However, objectivity is clearly a prerequisite to such integration. If we conclude that state unwillingness to abandon rail lines stems from a desire to analyze the lines in more depth, resolution of the research problems and questions noted here should lead to a general improvement in the quality of rail plans and to the establishment of a true state role in rail planning.

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One State's View of State Rail Planning

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This paper describes a variety of views on rail planning now held by states. It differentiates between the state role in planning for rail lines that have interstate significance and those that do not, and it describes three possible levels of involvement for the states with regard to each type of line. The paper also discusses the way in which state rail planning relates to planning by the railroads and federal rail agencies.

Although it is a major railroad center, Illinois to date, compared with a number of the northeastern states, has lost relatively little rail service by abandonment. Today, Illinois supports continued rail service on only 292 km (182 miles) of track and leases another 15 km (9 miles) on which no service is currently provided. We are entitled to less than 4 percent of the rail service continuation funds provided pursuant to Title IV of the Regional Rail Reorganization (3R) Act of 1973. However, Illinois is involved in 8 of the 10 corridors of consolidation potential defined in the Final Standards, Classification, and Designation of Lines of Class I Railroads in the United States published by the Secretary of Transportation on January 19, 1977, and 1952 km (1213 miles), or 11.3 percent, of the state's railroad system has either been filed for abandonment or identified as potentially subject to abandonment by the railroad companies. We do anticipate playing a major role in rail planning in the future.

This paper reflects one state's view, not the states' view. In my capacity with Illinois and with the National Conference of State Railway Officials, which is a confederation of state rail planners and administrators from all regions of the country that is affiliated with the American Association of State Highway and Transportation

Officials, I have been exposed to a number of widely divergent viewpoints on state rail planning. If there is a single state view on what state rail planning should be, it has eluded me; some states are even skeptical about what some other states are doing. This is true both within each region and among regions. It is going to be some time before a single state view of rail planning emerges, and I am not sure it ever will.

From our point of view in Illinois, this is as it should be. First, the questions associated with how to best approach the prospect of a rapidly contracting rail network are relatively new. Thus it would be remarkable and not necessarily healthy if a single approach were now being followed by the states. Second, divergent state views on rail planning reflect the variety of underlying approaches to transportation and economic development among the various states and regions.

Some states have chosen to approach rail planning primarily as an exercise in job retention and economic development. These states have placed relatively little emphasis on the current and in some cases the potential economic viability of each rail line. Other states, at the opposite end of the spectrum, have embraced a policy of minimizing public subsidies to transportation, greatly stressing the ability of each rail line to stand on its own in the near future. Many states, of course, have chosen positions in the center of the spectrum. Several, for example, have distinguished between public subsidies for capital improvements and public subsidy of operating expenses, embracing the former and discouraging the latter. The Federal Railroad Administration (FRA), to date, has recognized this variety of approaches and has permitted the states to develop significantly divergent rail plans based upon significantly different philosophies and objectives.

In Illinois we believe that as long as each state consistently applies its chosen philosophy and objectives to each line within its boundaries we ought not to be disturbed, and in fact we ought to be encouraged, by the fact that the states are approaching rail planning from a variety of viewpoints.

In addition to holding various viewpoints on how to approach state rail planning, the states also hold a variety of opinions as to which rail lines ought to be subject to state planning. Some states have adopted system-oriented viewpoints in an effort to evaluate every line within their borders. Other states have taken a narrow point of view and have concentrated only on those lines that have been or may be abandoned. In Illinois, we believe that the state should distinguish between lines that have interstate significance and those that do not, and that the state's involvement with the former should be less direct than its involvement with the latter.

The problem with this viewpoint has been that the breakpoint between the two categories of lines has been less than clear cut. It could be argued that the breakpoint lies between those lines designated by the Secretary of Transportation as A mainlines and those designated as B mainlines. Lines designated A carry 18.1 million megagrams (20 million tons) each year, or are required to provide rail linkage between transportation planning zones generating 75 000 or more carloads of freight annually or form important parts of the strategic rail corridor network. Lines designated B fail to meet these requirements but carry at least 4.5 million megagrams (5 million tons) of freight each year. It might also be argued that the breakpoint falls between B mainlines and A branch lines, which carry at least 907 000 megagrams (1 million tons) of freight per year. The breakpoint may lie elsewhere. It would be helpful if the Transportation Research Board, or another organization of acknowledged expertise, were to examine this question and determine an appropriate measure for lines of interstate significance.

LINES WITHOUT INTERSTATE SIGNIFICANCE

Let us turn first to those lines that are found, by one measure or another, to be without interstate significance. In Illinois, we see three scenarios that might develop with regard to state involvement with these lines.

The first might be called the reaction scenario and is where we are today. The northeastern states became involved in the planning process under the 3R Act only after the United States Railway Association (USRA) found that a line was not necessary for inclusion in the Consolidated Rail Corporation (Conrail). Subsequently, the states become involved only after the Interstate Commerce Commission (ICC) rules that a line may be abandoned. In each case, the state is reacting to another party's decision in which it has had only minimum involvement. In this scenario state rail planning is planning only in the sense that it allocates resources among lines chosen by someone else.

The second scenario might be called the affirmative scenario. Here, each state would target for investment not just lines that are abandoned but also lines that because of their physical condition are likely to become candidates for abandonment in the future. This latter category would include the category 1 and category 2 lines identified by the railroads pursuant to 49 CFR 1121.20(b). The rationale for this scenario is that, by identifying lines that could be viable but for their physical condition and by directing public investment to them before they enter the abandonment cycle, the states could be more effective in planning for their transportation systems. This approach would not, of course, prevent states that desired to do so from awaiting the abandonment of a line before making a public investment in it. The federal role could remain virtually unchanged, save for a change in the entitlement formula reflecting the change in the types of lines eligible for assistance.

The final scenario might be called the comprehensive scenario. This would assume the existence of a federal funding mechanism, such as a unified transportation fund, in which money would be made available to each state for transportation investments, regardless of mode, chosen by that state. The rationale for this scenario is that it would emphasize the intermodal trade-offs that should be examined to maximize the effectiveness of public transportation investments. For example, the decision as to whether public investments to facilitate the movement of heavy freight in rural areas ought to be made primarily in highways or railroads would come into better focus, because the dollars available for such investments would be interchangeable. Again, each state could segregate both its transportation dollars on a modal basis and its planning in a similar manner. Those states that desired greater flexibility would have it. The federal role would, of course, be substantially altered to reflect the more flexible decision making at the state level.

LINES WITH INTERSTATE SIGNIFICANCE

Let us now turn to the states' role in planning for lines that are found to have interstate significance. Again, Illinois sees three possible levels of involvement.

The first level might be called the no-role level, which is approximately what we have today. In some instances the states are asked to comment on national rail planning documents produced by the FRA and other federal agencies, but no extra weight seems to be given to the states' comments and no particular effort seems to be made to solicit them. For example, a number of states recently asked for the opportunity to comment on a report about to be published in final form by the FRA and were told that they would have to come to that agency's library in Washington to see a copy. That is something less than seeking the full participation of the states. In some cases, of course, the states are not asked to comment at all.

The second level of involvement might be called the comment level. This could be established either administratively or by statute, and it would provide a guaranteed mechanism through which the states could evaluate plans developed at the federal level with regard to rail lines with interstate significance. While a state veto of federal plans is clearly not contemplated, some mechanism for assuring that the states' comments were thoroughly considered would be implicit in this level. The rationale for this level of state involvement would be that the states, which have an intimate knowledge of their own rail systems, could provide a cross-check on federal planning for the interstate rail system.

The final level might be called the cooperative level. Here, the states would become involved early in the process of national rail planning through such mechanisms as briefings, cooperative data gathering and analysis, loaned state manpower, early state review of specific preliminary findings, and final state review of the finished product. The rationale for this level of state involvement is that it would enable the federal government to undertake more detailed planning for the national system. It could complete its products more quickly because of the increased resources.

STATES' PHILOSOPHICAL ROLE

So far this paper has dwelt on the mechanics of the state role in rail planning. Let us turn briefly to the states' philosophical role. In Illinois, we believe that the role falling to the states in the national debate over rail planning is that of keeper of the long view. While some railroads would surely disagree, we believe that the severe economic pressures confronting the railroad industry are forcing the companies in it to embrace the short view of railroad planning.

This was recently illustrated at a luncheon meeting of the Chicago Traffic Club. One speaker advocated at some length the necessity of keeping most current railroads in place until a definitive national transportation and energy policy can be established, perhaps until demand for rail transportation increases toward the end of this century. At the conclusion of the speech, a representative of one of the more economically marginal midwestern railroads addressed the speaker and, while agreeing with much of what he had to say, wondered who was going to pay the considerable expense of preserving the current rail system until such time as all of its component parts were once again economically viable. He clearly felt that this responsibility should not fall to the railroads.

The short view of rail planning held by the railroad industry is, perhaps, more dramatically illustrated by the several railroad companies currently engaged in massive abandonment programs that seem to have, among their primary motivations, the desire to obtain second-hand track materials to repair those lines that will be spared. In many cases, Illinois believes, the lines being cannibalized could be made viable if they were physically upgraded.

The federal government also seems to have staked out a short-term position on railroad planning. In the view of Illinois, USRA pursued a policy of minimizing initial investment in Conrail's physical plant even if by doing so it accepted higher long-term operating costs. This led to a decision in Illinois to utilize a longer route with severe geometrics and operating limitations instead of a shorter, more geometrically favorable route that would have required rehabilitation. In at least one instance in Illinois, USRA decided to abandon a profitable market, basing this decision largely on the fact that servicing it would have required a high initial investment in track rehabilitation. FRA's insistence on using traffic density, which as common sense indicates tends to correlate with good current track condition and a low requirement for government financial assistance, rather than using length, geometrics, operating characteristics, and long-term operating costs as indicators, also seems to us to reflect short-view railroad planning.

The states, on the other hand, are charged with comprehensive transportation planning. It is appropriate that we raise the long-term questions concerning the transportation implications of future energy conditions, industrial development, mineral recovery, and passenger demand. In fact, we raise them routinely in planning for other modes. This is not to say that the states should not be concerned with short-term questions, or that the railroads and federal planners will invariably take an exclusively short view. It simply seems to us in Illinois that we can fill a role in rail planning by making sure that the long-term questions do receive attention.

CONCLUSION

In summary, we in Illinois believe that the states' role in rail planning is just beginning. We are still in the very early stages of development, and many states have yet to begin at all. We are still merely reacting to developments on those lines that have no broad, interstate significance. And we are playing virtually no role at all in the national decision making that will mold the interstate rail network. We have the potential to assist in the national rail planning effort by taking primary responsibility for planning for public investment in lines without interstate significance, by lending our detailed knowledge of local conditions to those making national rail planning decisions, and by assuring that the long-term considerations implicit in comprehensive transportation planning are fully considered.

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One Railroad's View of State Rail Planning

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The Railroad Revitalization and Regulatory Reform Act of 1976 encourages and, in some ways, requires the development of a whole new set of relations between states and railroads. This paper examines these relations as they exist today and presents opinions on the directions they should take to be of greatest benefit to both the states and the railroads. State rail planning under the Railroad Revitalization and Regulatory Reform Act is judged to be a means by which the old adversary relations between states and railroads can change to the considerable advantage of states, railroads, and the general public.

The Railroad Revitalization and Regulatory Reform (4R) Act encourages and, in some ways, requires the development of a whole new set of relations between states and railroads. I shall examine these new relations and present some opinions about the directions they should take to be of greatest benefit to states and to railroads. First, a few basics essential to an understanding of a railroad's view of the state's role in rail transport, such as matters of economics, industry problems, and the relations between railroads and state government before and after the 4R Act, are necessary. I shall then discuss the areas where states can and should, for their own self-interests, help the railroad industry. Finally, I shall deal with the status of rail planning today, at least in the West, and suggest some areas that hold promise for the future.

Railroads are in the private sector of the economy, and I believe they should stay there. The world is full of examples of the burdens nationalized railways place on taxpayers. Belonging to the private sector means that competition is a part of our business life. We have competition among modes, competition among carriers, competition for capital, competition for industrial property and siting, and competition in several other areas.

Competition is all pervasive in our business world. The entire railroad industry does have serious problems, but there are great differences in the financial health and physical development among carriers. Here in the East, where most of the railroad bankruptcies occurred, the Chessie System and the Norfolk and Western Railway Company are quite strong. There are two strong and very competitive systems in the South. The West is a mixture. There are, depending on how you make these judgments, five quite profitable, generally very well maintained large railroads. There are a dozen smaller lines ranging from very successful, profitable, and well maintained to run down and bankrupt.

My own railroad, the Santa Fe System, has been constantly and continuously improved by large spending programs overlaying a heavy and continuous maintenance program, so that today the railroad is at a higher state of physical development than at any time in the past. Some other railroads can also make this same claim. It is largely because of our competitive environment and because of the differences in the financial condition and the physical development of various companies that the industry has such difficulty in presenting unified positions on matters of importance to it and to the public. For this reason, I shall present a railroad's view, not the railroad view.

There are many strong and profitable railroads; one wonders, then, why there is an industry problem. At the risk of oversimplification, the problem is twofold. First, the industry is starving for traffic; second, in order to stay in business, we must constantly and continuously invest increasing amounts of capital on which we earn unsatisfactory rates of return. In some manner, all industry problems relate to these two conditions.

Is it important that we have a railroad industry? Of all of the forms of overland transportation, railroads use less energy, less land, less capital, and fewer people and cause less pollution per unit of transportation than any of the competing modes. This is an important birthright, without which the industry would have gone the way of the stagecoach long ago. It is only because of these inherent strengths and advantages that the railroad has survived 80 years of punitive regulation and discriminatory public policy.

STATE AND RAILROAD RELATIONS

Areas of Prejudice and Competition

What have the state and railroad relations been? Before the 4R Act, states and railroads were basically adversaries. Our fundamental relation was that of the regulator and the regulatee. States regulated rates, often keeping intrastate rates unreasonably low. Working conditions were often legislated to levels the unions would not be able to achieve through collective bargaining. Further, taxes were sometimes intentionally discriminatory. States generally promoted other forms of transportation—highways, airports, waterways. They built roads that eliminated rail development from industrial properties and opposed abandonment of uneconomic lines and uneconomic services. In short, railroads have not found states to be particularly sympathetic or helpful. This explains the apprehension of some railroad managements toward the courtship now beginning. But, in my opinion, the 4R Act has formed a basis for improving state and railroad relations.

In which areas can state and rail relations be improved and on what basis? Some areas entail planning, others regulations. States should reconsider policies that force cross-subsidizing services under common carrier requirement, and they should not burden carriers with unreasonably low rates. Nor should they legislate changes for safer working conditions when safety is not the real issue.

Taxation is a particularly vexing problem. Railroads carry a heavy burden of property taxes that other modes do not, and some states have intentionally set higher tax rates on railroad property than on other industrial land. Other states unintentionally discriminate by assessments that do not reflect the actual value of the property. This whole matter needs significant revision in view of the California School Tax Case. Our tax counsel tells us that the decision in that case will in all likelihood cause a shift of school tax funding from property taxes to the general tax funds and, therefore, may bring a reduction in all property taxes including railroad property taxes. Whether or not this occurs, state rail planning should address the inherent inequities and unfairnesses of burdening only the railroads with property taxes on rights-of-way.

The problem of starving for traffic is largely the result of inequitable economic regulation. Here states can be very helpful. The motor carrier industry is heavily subsidized from the general tax funds, including the highway trust fund, and is cross-subsidized by the automobile. According to many state rail planners, the

Interstate system is suffering rapid deterioration from the increased weights and excessive speeds, particularly in the wetter states. Harsh, in another paper in this Record, refers to this problem on the Illinois county road system. Coleman has also spoken of increasing weights and widths by 1985 and permitting more double and triple operations. All of these proposed changes will seriously affect railroad traffic and must be considered when proposing legislation and advising legislators. Some states are doing little or nothing to enforce speed limits, to say nothing of the weight and economic regulations. Railroads do not fear competing with the legitimate common carrier truck companies, but the unregulated carriers hurt us badly. The illegal trucking industry can kill the railroad industry.

The most unfair competitors of all are the waterway carriers. They pay nothing for the building and operation of waterway systems and receive direct and indirect subsidies far out of proportion to their value. State planners must consider carefully the effects on their local railways of extensions in the waterway system (and many are being proposed by the Corps of Engineers), of continued operation without user charges, of increased waterway capacity as proposed in the rebuilding of locks and dams—all at taxpayer expense. In all of these areas states are involved and railroads are affected.

Areas of Improvement and Cooperation

Probably, the best hope of the railroad industry to improve its traffic volume is the return of the country to coal generation of electricity. Stories about railroads not being able to handle the additional traffic are nonsense, but, if the heavier movements are syphoned off to other modes, particularly to coal slurry and barge lines, badly needed rail traffic will be lost.

The branch-line abandonment problem gets the largest share of state and rail attention. Some specific issues being raised in Santa Fe states concern section 802 5(a) of the 4R Act and the supporting regulations that require railroads to identify lines they want to abandon and lines potentially subject to abandonment. The former requirement presents no problem. The latter is a sensitive issue, because industrial development on a branch line that has been labeled marginal might consequently cease. On the other hand, some western state planners express very little interest in taking over and operating branch lines that are clearly losers but are interested in spending state time, money, and effort in helping marginal lines. Obviously, this situation requires a high degree of state and rail cooperation.

There are many local problem areas where state railroad relations can be improved. Probably the best understood and longest of these associations is the highway grade crossing protection and separation matter.

Industrial development is another area where states and railroads can help one another. Because railroads cannot usually build lines to serve new or existing industries, they must locate industries on their lines. State and local zoning ordinances should encourage industrial development, and highway construction must not sever potential industrial land from areas where cooperation is possible. Urban renewal projects can also help railroads out of congested areas. In short, improved and enlightened state rail planning can be the basis for creating conditions wherein the railroads' natural competitive advantages can be permitted to function to the public's considerable advantage.

Current Activities Toward Cooperation

There has been a series of conferences to help us to understand one another's problems. I am sure they will continue.

Over a year ago, the Association of American Railroads (AAR) formed a state rail planning steering committee, which meets every three or four months and has accomplished a number of things. It has suggested that a formal organization of railroad people be established in each state to work with state planners. It has also put together a recommended data package each railroad should furnish to each state.

State railroad advisory committees have been formed and are functioning in many states including Kansas, Oklahoma, New Mexico, Colorado, and Arizona (among the 11 Santa Fe states). In a few states, railroads have furnished supplementary information to the AAR rail data package. Also, railroads are helping to educate and inform state planners on railroad transportation, maintenance, and economics.

Most states are now involved in preparing state rail planning work statements. Seven states have asked the steering committee to review their work statements prior to submission. A few states have decided not to involve the railroads at all. To the extent that railroads want help, they will be assisted.

CONCLUSION

I mentioned that state rail planning is much more extensive than dealing with the branch-line problem, although this problem is important to certain northeastern and midwestern states; but there are many states where it is minor or nonexistent. State rail planning should deal with those issues that will create a climate in which the railroads' inherent advantages can be exploited for the public good.

Positive benefits from state and railroad planning can accrue to the states, railroads, and, of course, the general public. By becoming involved in rail planning as part of their other traditional transportation planning, states must aim at a higher, more complete, more comprehensive level. State planning people must gain a better understanding of railroad problems and opportunities, of their competitive situation, and of the financial realities that this industry faces. Railroad managements, also, must better understand the political, social, environmental, and economic needs of the states.

State rail planning under the 4R Act can be the means by which the old adversary relationship of states and railroads changes to one of cooperation and understanding, to the benefit of states, railroads, and the people.

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State Rail Planning and the Public Interest

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Although there is general agreement on the overall aim of the public interest in transportation planning—which is to provide service to the people, areas, and institutions needing it—there appears to be a problem with rail planning. An examination of the legal backdrop against which planning is conducted suggests that the states should play an active role in the planning process, that many of the federal government's objectives are in conflict, and that not all of the multiple objectives of the public interest are of equal importance. The critical issues are improving railroad economics and determining the impact of decreased or increased service on specific areas. While the federal government is looking at pricing, production, and plant, the states should concentrate on plant. State highway planning has long been in effect; state rail planning is long overdue.

Consideration of the role of the states in rail transportation planning involves deciding what the states should do, how they should do it, with whom they should do it, and why they should do what they do. I believe the public interest should be consulted; that is, we must decide what the public interest would require the states to do.

In this paper I hope to provide some guidance to the major parties at interest and to suggest some appropriate areas for research and analysis into issues about which we seem to know a good deal less than we should.

It has been suggested that the perspectives of the Interstate Commerce Commission (ICC) and the U.S. Department of Transportation (DOT) are clearly and greatly at variance. This view holds that the ICC does not take the part of the railroads but instead sides heavily with the shippers, whereas DOT is concerned only with the economic well-being of the railroads. Such arguments are probably both mistaken and counterproductive, because they divert us from the basic issues.

To suggest that the ICC consciously and explicitly advances the interests of users at the expense of the carriers is to suggest that the ICC is shortsighted and derelict in its duties. Even the most virulent critics of the ICC would admit that it is aware that without railroads there is no transportation service. On the other hand, to argue that DOT is not concerned with shippers and communities seems pejorative in the extreme. No one at DOT would advance the notion that transportation is an end in itself; transportation exists only as a service to people, areas, and institutions needing it. Thus, the basic aims of ICC and DOT strike me as being quite congruent. There is, nevertheless, a problem.

We might begin by examining the legal backdrop against which the current planning is conducted: the Regional Rail Reorganization (3R) Act of 1973 and the Railroad Revitalization and Regulatory Reform (4R) Act of 1976. The former requires, in general, that DOT look at the rail network in the Northeast, that appropriate support be made available to potential participants in planning who might, because of limits of finance, otherwise be constrained from participating, that standards for analyzing railroad economics be developed, and, finally, that DOT assist the states. The specific criteria to be considered are economics of the railroads, needs of regions, particular rail passenger possibilities in the Northeast Corridor, existing patterns of traffic, and explicit concern for energy, preservation of competition, and concern with the environment, efficiency, and employment. It remains to be explained how all this promotes the public interest and state participation in rail planning.

First, it suggests that the states—as representatives of areas, regions, and communities—should play a very active role in the planning process. (Note that this is by no means an issue for the Northeast alone, because the 3R and 4R acts together extend the issue to all 50 states.) I interpret this to mean that unilateral, heavy-handed, highly directed, federal execution is clearly and openly in conflict with the intent of the law. Indeed, I think it is against the public interest.

During the late 1960s, we as a nation learned that major decision making—whether it concerns Southeast Asia or the Interstate highway program—that is formulated, decided, and executed in Washington without the involvement, participation, and understanding of the people affected, or their local representatives, is going to be bad decision making. The law does not call for consensus decision making, but it does call for extensive local participation in the decision-making process, and this would support a substantial role for the states.

Second, this review suggests that many of the federal government's objectives are in conflict. We know that energy concerns are not always compatible with environmental concerns and that both may be in conflict with economic issues. Thus the public, who have multiple objectives, must accept measures of compromise and resolution of positions that may be, to a significant degree, incompatible. This suggests, for all participants in the process, what in the terminology of labor negotiations would be called "collective bargaining in good faith."

Third, all multiple public-interest objectives are not equally important. Some clearly deserve extensive attention, while others deserve a good deal less. Certainly the economic well-being of the railroads must receive high priority. The alternative, nationalization, has caused problems in virtually every country where it has been tried. Transportation is not an end in itself. Answers that are good for the railroads but poor for the regions are nonanswers. Energy and the environment are important issues, but probably very little that any of us do in this area of planning will have much effect on either. As for competition, the railroads are already subject to heavy competition from trucks, barges, pipelines, and each other. Employment, as it relates to regional economics, is naturally a major point of public interest; as such, it receives proper attention under the heading of regional impacts.

All this means, for the public interest, that, first, we should all work to improve railroad economics and, second, we should carefully and realistically examine the impact of altered service on specific areas. After these two, the issues quickly become less critical.

I commented earlier that DOT is concerned with quality of service; let me now admit that it appears to be spending most of its energies on trying to "right the capsized railroad boat," in the implicit belief that this will automatically improve matters in the Northeast.

Washington seems to be concentrating on pricing, production, and plant. Some think that, under present regulations, rail prices are out of line and that regulation should therefore be modified. I wholly concur; I regard noncompensatory rates and cross subsidization as abominations, and I devoutly hope that someone can make sense of the ICC's endeavors. But the question is how this affects planning by the states. For our immediate purposes, there is only an indirect effect. Much the same applies to production or productivity. Work rules, car utilization, interlining, and per diem and demurrage charges are all important and worth great efforts. But, again, these are not of immediate concern to state rail planning offices. Plant is.

DOT has concentrated many of its energies on abandonment or downgrading of portions of the system. The response of many regions and shipper interests, not surprisingly, has been substantial opposition. Very few people like to see reduction or cessation of any form of transportation service. What emerges from the dialogue to date, as I perceive it, is a great deal of disagreement about the value of abandonment or reduction of service. The states must therefore take the dominant role in assessing regional impacts.

There are two alternatives. One is that DOT could rate the states' analyses of needs and distribute funds accordingly, but this would have very serious political implications.

The other option is to introduce financial constraints into the states' deliberations. This would increase the states' share of subsidies but raise serious questions about the formula used to apportion the funds.

The answers to the questions of which actions improve railroad economics, of whether the states should worry about this, and of whether it should be left to the railroads, DOT, and ICC seem to be that, if the states do not play the devil's advocate on the issue of abandonment, nobody will. Doubts have been expressed recently that abandonment will improve the economics of the railroads, but DOT firmly believes that significant reductions in trackage will significantly improve the economic well-being of the remaining system. Overall, the railroads themselves appear to believe that abandonment will help.

I think the public interest will be better served if some party that would be inclined to oppose abandonment (e.g., the states) forces the issue. A detailed examination of the dollar advantage of sectional abandonment of lines of the Boston and Maine Corporation clearly shows that (a) the real savings would be much less than claimed and (b) this is a very complicated subject. We need to know what the real value of abandonment is.

Just before the demise of the Penn Central Transportation Company in 1970, the plans for salvation included abandonment of 5000 km (3000 miles) of track, which was estimated to save the necessary amount of dollars. And then there was a series of models of the Penn Central system that estimated first that abandonment of 17 700 km (11 000 miles) would produce the magic and correct result, the second time that 27 000 km (17 000 miles) would be required, and the third time that it would require 22 000 to 24 000 km (14 000 to 15 000 miles). On the day the line declared bankruptcy, the total trackage proposed for abandonment was 150 km (93 miles). Abandonment is often invoked as a panacea for the resolution of railroad problems. I suspect that its economic impact on operations would be much weaker than has been claimed.

This brings me back to the point about state participation. If the states do not stand and challenge on this issue, we will have abandonment whether it is good or bad. Perhaps, if the states make enough noise, the railroads and the Federal Railroad Administration will together develop techniques of analysis that will make it possible for us to approach the subject with a good deal more confidence.

Certainly the states—all of them—must participate. The law suggests this, and the public interest calls for it. Assessment of the local impact is best performed at the local level. State highway planning has been around for a long time. State rail planning is long overdue.

Publication of this paper sponsored by Committee on State Role in Rail Transport.

State and Interstate Commerce Commission Rail Relations

Robert J. Brooks, Interstate Commerce Commission

This paper presents an outline of state and federal roles in inter- and intrastate rail decisions. Regulating intrastate rates came under Interstate Commerce Commission jurisdiction in 1920, and as late as 1958 the federal role was being extended. The Railroad Revitalization and Regulatory Reform Act of 1976 reversed the role, giving jurisdiction over intrastate rate questions to the states, but with certain strict rules. Passenger service and standards of service adequacy fell largely to Washington under the Urban Mass Transportation Act of 1964. Today, the Interstate Commerce Commission and Urban Mass Transportation Administration are calling for more state and local participation in the planning for survival and operation of passenger service. Line abandonments may also be avoided through state planning and state and federal subsidy under the Railroad Revitalization and Regulatory Reform Act.

Many state and local governments are experiencing a movement into their ranks of highly qualified people who are professionally competent, public-spirited, and anxious to find solutions to serious social problems. This movement might be the single most important factor in making our system work. Reflecting the strength of this local development, a number of federal laws are being amended to accommodate and encourage local participation in federal programs.

In the following I shall plot the course of this phenomenon in three matters affecting railroad service: intrastate rates, railroad passenger service, and abandonment of rail lines.

INTRASTATE RATES

In 1914, the U.S. Supreme Court sustained an Interstate Commerce Commission (ICC) finding that it is unlawful for a railroad to maintain intrastate rates that discriminate against interstate commerce. It held that the ICC had jurisdiction to eliminate the discrimination, even when the rates were required by state law. This concept was codified in 1920 in Section 13(4) of the Interstate Commerce Act. However, over the years the ICC, as a matter of comity, was reluctant to exercise its jurisdiction when a railroad was already seeking rate relief from state regulatory agencies.

The Transportation Act of 1958 modified Section 13(4) by requiring the ICC to expedite action in deciding a railroad's petition for removal of the discriminatory rate, regardless of whether or not the matter was pending before a state agency. This change in the law gave a railroad the option of proceeding first before a state agency or of coming directly to the federal agency (ICC).

In 1976 the law was changed again, this time to accord state governments the first—and exclusive—opportunity to address the matter. Under Section 13(4) as amended by the Railroad Revitalization and Regulatory Reform (4R) Act of 1976, a railroad that alleges that intrastate rates discriminate against or unduly burden interstate commerce must first go to the state agency for redress. The state then has sole jurisdiction for 120 d, after which time the railroad may come to the ICC, whether or not the state has rendered a decision within that time.

The problem as visualized by Congress and stated in the 4R Act was that, over a 10-year period, the railroads had been denied $100 million in needed revenues because of delays in adjusting depressed intrastate rates to interstate levels. In a period of steep inflation, the ICC authorized eight general rate increases to enable the railroads to keep pace with mounting costs, and the railroads were contending that they were continuously in a catching up posture.

Now, after tracking a general rate increase proceeding before the ICC, a state will have the additional 120 d to render its own decision on the intrastate rates. If a responsible decision is given in time, litigation at the ICC will be unnecessary.

RAIL PASSENGER SERVICE

At one time regulation of railroad passenger service lay exclusively with the states. Every state had laws or constitutional provisions requiring railroads to provide adequate service. After World War II, when passenger business was good, the railroads invested heavily in new, ultramodern passenger equipment. But their enthusiasm was short lived. By the early 1950s, half the peak number of intercity passengers had deserted, and the trend seemed permanent.

Public programs emphasized the new interstate freeway system and elaborate air travel facilities. The tilt probably occurred in 1952, after which there was no way to switch the mail and the businessman back on the train or to overcome America's love affair with the private automobile.

At that point, the railroads made a conscious decision to minimize their losses on passenger service. One way was to eliminate the deficit trains. They went to the states for authorization, but, as Congress later decided, the pace was too slow. The states testified that they were allowing discontinuances as fast as feasible, but in 1958 Congress enacted Section 13a, creating for the first time federal jurisdiction over the matter.

One part of Section 13a covers interstate trains, the other intrastate trains. Section 13a(1) begins by saying that, when the discontinuance of an interstate train is prohibited by state law, the railroad can circumvent the state by filing a notice with the ICC. More important, it directly authorizes the railroad to discontinue the train, unless the ICC steps in to investigate, under the terms of the notice, taking the matter wholly out of state hands. The railroads cannot do this in matters of intrastate trains but must first seek discontinuance authority from the state. Then, if no decision or an advance decision is made within 120 d, it may petition ICC jurisdiction.

In the early 1960s, five southwestern states complained to the ICC that a railroad crossing them was not providing adequate passenger service. They said that as individual states they could not contend with the problem. We can only speculate as to whether joint or coordinated action might have provided a solution. The ICC concluded that jurisdiction over the adequacy of rail passenger service had not been assigned to a federal agency but that it would take the problem to Congress.

In 1972, then, Congress created Amtrak to take over intercity rail passenger service and directed the ICC to establish standards of service adequacy. Such standards have been established, but many questions remain. One is whether Amtrak is capable of satisfying all the standards all the time. Another is how much public funding of rail passenger service is fiscally provident.

In 1964 Congress enacted the Urban Mass Transportation Act, which provides federal funds for local and regional rapid transit projects. However, the understanding is that local governments must actively participate with the Urban Mass Transportation Administration (UMTA).

The Amtrak act has been modified a number of times. The ICC feels that states should participate fully in the development of new routes called for in the 1975 amendment. New intercity routes could be tied in with local bus and rail routes and schedules and with UMTA-financed projects. The pendulum could profitably swing toward the states and they could have a separate office—perhaps patterned after our Rail Services Planning Office—apart from Amtrak and the U.S. Department of Transportation (DOT), to assist them in passenger route selection and development. States should also be represented on the Amtrak board of directors.

RAILROAD ABANDONMENT

When the federal government took over the railroads during World War I, it became aware of the fact that, as a system, the railroads of this country were not very efficient. There had been a proliferation of lines into areas that did not produce enough traffic to sustain them; yet, in other localities, railroad facilities were unable to meet public needs.

Congress concluded that the country needed a fully integrated rail system comprised of privately owned, independent railroad properties. It envisioned, however, the consolidation of railroad properties into a limited number of systems, with productive competition in all sections of the country.

Congress conceived of an agency of the federal government that would monitor the changes in the structure of the system and its evolution into the kind of a system it set as a national goal. The monitoring would be regulated by the ICC, which would be aware of changes in the corporate structure, the physical structure, the competitive balance, and the revenues, costs, and profits. The jurisdiction was spelled out in the Transportation Act of 1920.

Paragraphs 18-22 of Section 1 of the Interstate Commerce Act governed the extension of rail lines and the abandonment of service and lines. The concern at that time was with a national system. Consequently, the role of arbiter in extending and contracting lines within the national system was placed within the sole jurisdiction of the ICC. Later, after World War II, the economy of the Northeast began to founder, and many of the heavy industries the railroads served in the last century were gone. Anthracite coal, silk, textiles, leather, steel—all big supporters of the railroad system in "official territory" (east of the Mississippi and north of the Ohio River)—had dwindled, dried up, or fled to other areas.

Even poultry, once a substantial industry in New England, was driven elsewhere by economics. The emergence of the Interstate highway system, the almost explosive growth of air transport, and the dispersion of populations and industries to truck-oriented locations further added to the demise of railroads.

Some rail systems in that area succeeded in timely realignments and consolidations and were able to maintain viability, but nine major railroads in the territory either failed to take effective action or saw their economic foundation evaporate. By 1972, about half the railroad trackage in official territory was in reorganization under Section 77 of the Bankruptcy Act.

Section 77 was designed to help distressed railroads achieve reorganization by providing a respite from creditor pressure and thus produce a positive cash flow. Operations were to have continued while a reorganization plan was being formulated and implemented. Unfortunately, the circumstances in the Northeast were not susceptible to successful handling under Section 77.

Recognizing the inadequacy of Section 77, Congress enacted the Regional Rail Reorganization (3R) Act of 1973. In effect, it created a super bankruptcy proceeding and court. Substantial federal funding was made available to assist the court in reorganizing the bankrupt railroad properties in the territory. The Consolidated Rail Corporation (Conrail) is the offspring of that legislation. Another product was the exclusion of substantial rail trackage from the final system plan. For the unincluded trackage, the 3R Act provided for subsidies under which agencies of state or local government could designate rail operators who would continue rail service. To assist local governments and people of the impacted states in preserving service on the deficit branch lines unincluded, the 3R Act created the Rail Services Planning Office, a semiautonomous adjunct of the ICC. Today, service is being provided on substantial branch-line trackage by designated operators guaranteed a profit through the subsidy provisions of the 3R Act.

In 1976, Congress extended to the rest of the nation, the 31 states outside the Northeast and Midwest, provisions for subsidization of financially deficit rail branch lines. The 4R Act established a $360 million subsidy program for a 5-year period ending July 1981. Patterned roughly after the 3R Act, the 4R Act enables states to step in and avoid abandonment of rail branch-line service.

To maintain such service a state must establish a planning agency responsible for devising a railroad plan that is an integral part of its transportation plan. The agency must also be responsible for the expenditure of funds and the implementation of the subsidy program. The state must match federal funds to the extent of 10 percent of the subsidy in the second year, 20 percent in the third year, and 30 percent in the fourth and fifth years. During the first year, funding is to be undertaken 100 percent by the federal government.

Subsidy funds may be used to pay for the cost of continued operations, the cost of acquiring the rail line for continued operation, the cost of rehabilitation, the cost of reducing the cost of lost rail service, and the cost of planning. For the planning function, the law specifies that $5 million be made available.

As I interpret the 4R Act, Congress concluded that a sound transportation system leaves the operations and properties in private hands, but the privately owned railroads should not be required to subsidize chronically deficit lines indefinitely. Congress also recognized that, for the economic and social well-being of certain areas, railroad service, even though inherently deficit or deficit because of seemingly insurmountable financial obstacles, may be required. This service would be subsidized while steps are taken either to improve the economics of the rail operation or to make provision for the use of alternative transport.

The plan of the 4R Act stipulates that states have planning agencies and integrated transportation plans and that, before a rail line can be abandoned or become eligible for federal subsidy, an abandonment application must be presented to the ICC. The ICC then decides if the line in question, in terms of national transportation policy and the national system, is required by public convenience and necessity. If the finding is negative, the state can then proceed to the Federal Rail Administrator in DOT and obtain the subsidy funding provided for in the act.

A number of unique provisions in the act assist states in establishing planning agencies, prioritizing rail branch lines for public funding purposes, and determining whether and when to proceed under the subsidy program. The ICC issues regulations implementing its part of the program. These regulations require a railroad to give considerable notice before undertaking abandonment. First, each railroad must publish a system diagram showing its rail lines in five categories:

Category 1. Depicts all the segments the railroad intends to abandon within the coming 3 years;

Category 2. Shows the lines potentially subject to or under study for abandonment;

Category 3. Shows the segments already subject to abandonment applications.

(The other two categories are not pertinent to this discussion.)

The ICC cannot issue an abandonment certificate for any segment not on the diagram for at least 4 months. That prohibition would not apply where an application has no opposition.

In chronological order, the steps to be taken under the abandonment regulations are as follows.

Step 1. The railroad must give notice of its intent to abandon by directly apprising each state in which the abandonment line lies and certain users of the line. It must publish this intent for 3 consecutive weeks in a newspaper of general circulation in each county through which the abandonment line passes. This notice must be completed at least 30 d prior to the filing of the application.

Step 2. The public will then have at least 65 d to express any opposition. It may file a protest petition requesting the ICC to investigate or it may simply file comments providing information but not indicating whether an investigation is desired. The public response must be in the hands of the ICC 35 d after the application is filed.

Step 3. Once the abandonment application is filed, the ICC must, within 55 d, decide whether to investigate. If the situation does not warrant an investigation, the ICC must forthwith under the law issue the certificate of abandonment.

Step 4. If the ICC decides to investigate, it must notify the applicant within 55 d after the date the application is filed. Once an investigation is undertaken, the ICC has 180 d to complete the process and an additional 120 d to render the initial decision.

Step 5. When the ICC decides after investigation that continued operation is not required by public convenience and necessity, it must publish that finding in the Federal Register and withhold the issuance of an abandonment certificate for 30 d.

Step 6. Within those 30 d a prospective offeror has 15 d to notify the ICC of its financial responsibility and its wish to provide the subsidy.

Step 7. The Commission then has 15 d to determine first whether the offeror is financially responsible, and second whether the subsidy offered is adequate.

Step 8. If the answer to both those questions is yes, the ICC will postpone issuing the abandonment certificate for up to 6 months to provide time for the offeror and the railroad applicant to negotiate the terms of the subsidy for continued operation or for the offeror's acquisition of the line for continued operation.

Step 9. If, at the end of the 6 months, the negotiations are unsuccessful, the ICC has a number of options: (a) it can reopen the proceedings on the grounds, among others, of a change in the material facts—namely, the fact that continued operation would be at a deficit; (b) it can submit the subsidy question to arbitration with ultimate review by the Commission; (c) it can grant the certificate subject to the condition that the line be kept in operation for a period of time, perhaps up to 1 year, provided the opponents to the application or the users of the line will pay an amount of compensation prescribed by the ICC; (d) or it can grant the certificate subject to other conditions, including one required by statute—namely, that the line be made available for 120 d for acquisition by a public body for some public use.

It is obvious that the statutory schedule requires important decision making with relatively short lead time. The first tight period is the 4 months after the railroad places a segment of line in category 1. Once the railroad decides it will seek abandonment of a particular segment, it will apparently place it on the diagram immediately and then, within the shortest possible time, file the application.

If this is correct, the state will have about 60 d after the line appears on the diagram before notice is sent. There will be an additional 30 d while the railroad is posting its notices in the stations along the line and publishing them in the county newspapers. Then, there will be the final 30-d period before the application is filed. Thus, the state will have about 120 d prior to the time the application is filed. It will then have an additional 35 d to notify the ICC of its intent.

In all, the state will have a little more than 4 months to make its decision and then take the steps necessary before the 155th day. It must decide whether to oppose the application or to join with the railroad in seeking a quick affirmative decision from the ICC as the preliminary to seeking a subsidy from the Federal Railroad Administration (FRA).

The second critical period will be the 20 d the ICC has given itself to determine whether to investigate, that is, the period between the 35th day after the application is filed and the 55th day before which it must notify a railroad if an investigation is to be undertaken.

The third critical period is the 15 d after the ICC publishes in the Federal Register its finding that "public convenience and necessity" permit or require the proposed abandonment. In those 15 d, the offeror must establish its eligibility and make its offer.

The next critical period is the 15 d during which the ICC must decide whether the offeror is financially responsible and the offer adequate. And the next critical period is the 6-month period of negotiation, during which the railroad will be required to continue operations at its own expense.

Each of these periods is critical, because the state, ICC, or railroad must make important decisions in a short time and sometimes on limited information. In 1976, FRA conducted a series of seminars throughout the country to acquaint state representatives with the 4R Act features dealing with the railroad abandonment and subsidy program. At those seminars the railroads expressed a willingness to provide state planning agencies with a package of information upon which the state plans might be, at least to some degree, predicated.

It occurred to a number of ICC members that if the information the railroads provide state agencies were meaningful (accurate enough to provide a basis for states to determine whether they should or could afford to continue rail operations under subsidy) it might well be accurate enough for use by the ICC and the parties in abandonment proceedings.

Much of the information needed by states for planning purposes, and by the ICC for the abandonment application, is in the possession of the applicant railroad in the form of the physical characteristics of the abandonment line; the originating, terminating, and overhead traffic on the line; the revenues attributable to that traffic; the costs incurred as a result of operating the subject trackage; the value of the railroad properties involved in the operation; and the cost of capital to the applicant railroad. Time and anxiety in the regulatory process could be avoided if the railroads were willing to share that information with the other interested parties as soon as it is obtained. State planners, the ICC, and FRA could begin their own preliminary evaluations on the basis of the available information, with the understanding on the part of all that the railroad would be free to refine and modify the data input as it prepares its abandonment application.

If a state planning agency is concerned about retention of service on designated branches and develops data of its own, it could exchange its data with the railroad and other parties. Conceivably, state and railroad, by agreement, could reduce the areas of controversy so that by the time the application is filed many issues of fact will already have been resolved.

This system of early data exchange would be worthwhile even if it were used only when a state decides to participate as offeror under the subsidy program and even if it served merely to limit the issues in the ICC abandonment proceeding. The railroad and the state planners could conceivably approach the issue of rehabilitation costs and other revenue and cost issues simultaneously and perhaps in collaboration with each other.

A computerized data bank shared by the railroads, states, FRA, and ICC could facilitate the quick decisions required of the state and the ICC within the first 35 and 55 d respectively after the application is filed, by the state within the first 15 d after the ICC publishes its finding in the Federal Register, by the ICC within the 15-d period following the time set for the receipt of offers, and by the railroads and the states in the 6-month negotiation period following the ICC decision as to the adequacy of the offer.

If, on the basis of pre-exchanged information, the ICC can be moved to a "no investigate" decision, and the FRA and the offeror state can come to terms on rehabilitation to an agreed safety standard, and the railroad, the states, and FRA can agree on the amount of subsidy and the availability of subsidy funds, the disposition of the abandonment application by the ICC could be accomplished in the minimum time, possibly in less than 3 months after the application is filed.

Benefits could accrue to all concerned in terms of the immediate abandonment application and in the use of the compiled data for future programs relative to light density lines.

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Present Rail Transport Organization

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This paper suggests the possibility of converting the federally directed Consolidated Rail Corporation and other financially weak railroads to public toll roads open to a broader group of users. Highways and airways have common tracks over which diversely owned vehicles operate and have a multiplicity of users that the monopoloid rail organizations lack. The institutional factors involved in such a change are seen as posing greater problems than the technological. Established status positions might be changed, and trade-offs are likely to be required. Broader use could range from extending trackage rights to the remaining successful companies to opening the railways to any competent operator willing to pay the tolls. The railway might remain in the private sector or be maintained and controlled by government agencies. Analogies would be to state highway and motor vehicle departments and to the Federal Aviation Administration. Projected federal rail funding requirements in the next decade appear substantial. Adoption of the public highway concept might leave the transportation function in the private sector, while shifting the maintenance function to the public sector. Political support of that latter function could be expected from transportation operators in the private sector.

This paper suggests the possibility of a return to the idea of railways as public highways that would be open to those who would like to pay the tolls and run trains. Railway transport technology has been showing marked indications of enjoying the status of a declining industry, partly because of rigidities and limited maneuverability of the technology and party because of the obsolete form of business organization and obsolete patterns of government control. Much is irremediable, although the step to trailers (or containers) on flatcars is a good one toward greater flexibility. The business organization of railways and its implications for government regulatory and management structures form the subject of this paper.

Modern transport technologies often provide a common right-of-way over which the vehicles of many users operate. The right-of-way is usually provided by a government agency: the Corps of Engineers, the Federal Aviation Administration (FAA), or state or local highway and street departments. Distance between vehicles is dictated by a recognized set of rules governing behavior and priorities. Where vehicle operators cannot normally be expected to judge their own separation distances, this is managed by traffic controllers—the FAA or the Coast Guard, who also enforce the recognized code of behavior, as do the highway patrol and the police. In most cases there is a fee structure for vehicles using the common track, and, in addition, a charge for the ownership of the vehicle.

The cost of the government track is fixed for the community as a whole, but the general practice of user fees varies this cost to the user.

When the railways were established in the early 19th century, the organization was appropriate to the state of technology at the time. Then the thought was that the railway would be just another version of the highway: open to all users. But it became immediately apparent that the flanged wheel on rail lacked flexibility and that meets between trains would have to be organized differently from those between wagons, which led to the adoption of a single organization that both owned the tracks and operated the trains. The military was the best known large owner. The chronometer was familiar; the telegraph had yet to be invented. Thus, discipline and timetable became at least the ideal organizational factors of early railroads. Undoubtedly much was learned by trial and error, especially the latter. That single large organization, responsible for both tracks and vehicle movements, continues in railway organizations today (1).

In some countries, railways were government owned and operated from the start; in others, they were initially private businesses. Only in this country and in Canada do railways still exist as private enterprises. The French and British railways, among the last holdouts of private enterprise elsewhere, became government owned about the time of World War II. The general pattern was that a railway became a government responsibility when it was no longer economically viable as a private enterprise. That stage was reached in this country only in this decade, where as elsewhere it occurred before the development of sophisticated communications technologies.

In most countries railways were accepted as a government responsibility in the last century, but here the Consolidated Rail Corporation (Conrail), with a majority of its directors federally appointed, did not assume responsibility for the railways until 1976. The irretrievable bankruptcies of the eastern railways and the assumption of their operations by a federal agency lead us to ask whether a more advanced form of organization might not feasibly be applied to Conrail.

A version of that, called ConFac, was mentioned by the United States Railway Association (2, p. 49; 3, p. 38, 4) but not explored further. Fishwick, in his 1975 ex parte testimony before the Rail Services Planning Office (RSPO) of the Interstate Commerce Commission (ICC), supported the ConFac concept. The RSPO rejected the idea as being generally opposed by the industry (5, p. 79). In its simplest version, ConFac is only an extension of the trackage rights concept, well known for a century or more. That is, the tracks would belong to one railway, but trains of other railways could also operate over them, ordinarily under the rules of and subject to the control of the owning company. Examples abound. The Santa Fe System uses Southern Pacific Transportation Company tracks between Bakersfield and Mojave. The Union Pacific Railroad uses Santa Fe tracks between San Bernardino and Daggett. The Southern Pacific and the Western Pacific Railroad Company use each other's tracks between Wells and Winnemucca. There, each company's tracks are used one way: one company eastbound and the other westbound. The Terminal Railroad Association of St. Louis would be an example of a railway over whose tracks many other railways operate.

The concept of railways as public highways could be adopted for negative cash flow bankruptcies, that is, for those railways that in bankruptcy show no promise of being reorganizable on an income basis. Conrail would be a prime example. The congressionally mandated goal of profitability followed by a return to the private sector may well be more the result of pious hope than of rigorous analysis (6, p. 1; 7, p. 36; 8, p. 118). The Rock Island Lines may also fall into that negative cash flow category, and possibly still others do as well (9, p. 184).

While it is by no means clear that such a concept is operationally feasible, if it were, there could be a substantial reduction in federal expenditures. Luther Miller has said that in the first half of this decade federal assistance to the rails ran to at least nine figures, largely on an ad hoc basis to maintain the operation of midwestern and northeastern railways. Much of that operation has now been assumed by Conrail, but billions are still required for track rehabilitation (10, pp. 16, 21, 27). The operations of Conrail alone will require an estimated $2.2 billion in federal funding by the end of the 1970s, and a total of $2.9 billion during Conrail's first decade (11, p. 55). For 1976, Conrail's total operating expenses were estimated at $2.6 billion, which will almost double a decade later. But 40 to 45 percent of those operating expenses are for transportation; maintenance of way accounts for only 12 to 15 percent of operating expenses. If transportation and maintenance costs were shifted from Conrail to its toll customers, Conrail's operations and budget would become much more manageable and would reduce federal funding requirements.

In its present 19th century form, Conrail is the country's largest railway. Some have expressed the view that with such heavy requirements for federal funding, Conrail will be politically unable to drive hard bargains with the unions. Isabel Benham has been quoted as saying that this can then set a pattern of inflationary wage and work rules for the entire rail industry. The withdrawal of the Chessie System and the Southern Railway Company from the Final System Plan lends credence to that fear. As Arthur Lewis and James Hagen pointed out, the employees of those parts of the estates of the Erie Lackawanna Railway Company and the Penn Central Transportation Company chose to stay in Conrail and to renegotiate their labor contracts rather than to accept the established wage and working conditions of Chessie and Southern.

That large organizations come to exist in order to maintain themselves as their primary goal is a well-recognized phenomenon. But the development of rail management and the cost of rail labor in other industrial countries does validate some of the concerns expressed above. In 1973 the labor costs alone of the state railways in both West Germany and Italy exceeded the gross operating revenues of those organizations. And even after substantial subsidies, both operated at a deficit (12, p. iv). Both the German and the Italian state railways, however, were organized before present communications techniques were available. Conrail is still young and flexible. It might be capable of pointing the way to a more innovative form of organization. State railways elsewhere show what can happen when a 19th century bilateral monopoly continues into the late 20th century.

If Conrail were to become a landlord highway, rather than a transportation company, one could expect that the first users of the new road would be the solvent companies; for example, successful western roads might be delighted to be able to operate their own trains, under their own control and for their own account, directly into the far eastern markets. Fishwick, in his testimony before the RSPO, proposed trackage rights for his road, Chessie, and Erie Lackawanna into the northeast terminals over government-owned rights-of-way.

Then it might be expected that, if entry controls permitted, innovators would appear on the scene. Freight forwarders, truckers, and unit train contractors might be the initial backbone of that development. Many bright young people now excluded from the industry by entry controls would be happy to enter if they could.

Some aspects of operating railways as public highways are easy to comprehend. The over-the-road operation would hardly change, and train movement could continue to be controlled by radio or signal indication. The train controllers might be employees of the landlord railway as at present, of the Federal Railway Administration (FRA), parallel to the FAA, or of a state, as a component of state departments of transportation.

Train personnel could be certified by the FRA in a fashion analogous to the certification of pilots by the FAA or by the state departments of motor vehicles in a fashion analogous to the licensing of commercial chauffeurs and truck drivers.

Specialists could then be expected to develop from train personnel, as they have in the cases of flight crews or truck drivers. Crews might possibly be supplied through a union hiring hall as is the practice for longshoremen on the waterfront.

Large-scale train operators could lift some of the certification burden from the certifying agency, as major airlines now do in assisting the FAA in the administration of pilot certification.

The end result might be a better trained and more professional group of train operators. It is worth noting that one outstanding impression that comes through from reading the accident reports of the National Transportation Safety Board (Reports T4-4; 75-3, 4, 6, 8, 9; and 76-2, 3, 7) is the inadequate training of railway train staff, a somewhat haphazard use of radio communication, and sometimes a certain lack of discipline. Perhaps accidents do not occur with sufficient frequency on any one railway for its management to feel that the full development of a code of operating behavior and radio use is worthwhile. Standardized procedures developed by the FRA or by the associations of state agencies could be expected to improve railway safety.

As indicated, one would suppose that the principal users of the northeastern public railways would be solvent rail companies. These large-scale and experienced operators would presumably have their own regular employees who would work under established contracts and according to standardized practices governing the movement of trains and their safety and the use of radio communication. The small train operator could lease locomotives and cars, hire such crews as needed from professional suppliers, pay the tolls for that run, and avoid almost all fixed costs, just as truck users do. The present freight forwarders, for example, might emerge as the professional entrepreneurs, occasionally leasing locomotives, hiring professional crews, and assembling and transporting the cars of their shipper clients.

It could be supposed that shorter and more frequent trains might require smaller and lighter locomotives. It has been charged that current track problems arise not only from giant new cars but also from the heavy locomotives required to meet rail management's present operational philosophy of long heavy trains (13).

While a rail analogy to airlanes and highways can easily be visualized, this does not seem true for the terminals. Modern rubber-tired transporters can easily be wheeled around and drawn up in the desired cluster patterns in terminal areas. The linear nature of rail movement, restricted by the inflexibility of the flanged wheel on rail, poses problems for terminal operations. The organization of essentially linear terminals requires analysis, and it may be the point on which the concept of the public railway founders.

But most technical problems can likely be solved. The concept will more probably founder on institutional matters, especially the problems associated with any large transition, such as avoiding shock to established positions, entrenched property rights, and professional skills.

Beginning with the certificate requirement for railways in 1920 and extending to highway, air, and water carriers during the pre-World War II depression, entry into the transportation business gradually closed and finally reached freight forwarders at the end of World War II. With entry controlled, the right to operate transportation services became scarce; scarce items became expensive. Over time, operating rights have been bought and sold, and the intangible assets have become incorporated into the financial structure of the transportation industry.

If entry were opened to all, those intangible assets would become valueless, although established operators would clearly have a head start on potential competitors. However, a threat to asset values would obviously produce a strong political reaction from those threatened. There are equity problems in any case, and there may be constitutional problems.

Moreover, Congress has permitted the industry to cartellize its pricing procedures. The prices so made may be reviewed by the controlling economic agency: the Interstate Commerce Commission, Civil Aeronautics Board, state public utilities commissions, or others. A whole group of specialists in transportation pricing and the techniques for its variance have emerged. Their knowledge would become obsolete and their livelihood seriously affected if the market should take on the characteristics of open competition.

Most existing transportation operators and the professional corps of traffic managers can be expected to be opposed to opening entry into the transport industry. Moreover, our usual government decision-making process involves holding hearings and presenting evidence and argument. The industry will obviously be consulted and can be expected to provide the preponderance of witnesses. The innovators and other would be entrepreneurs have been excluded from the industry by the certificate requirements. They are outsiders and do not have the same standing before the committees as do those already established in the industry, and most of them, of course, having been systematically excluded from the industry over many years, have looked in other directions for their activities and may have lost interest in transportation. It is hard to see how a legislative body could favor something opposed by established industry. It will be much easier for that body to provide substantial subsidies to the establishment than to follow the unknown route of innovative competition.

If entry control were to be abolished generally, many years of hard thinking and hard bargaining would be required. On the other hand, open entry could be limited only to government-owned railway facilities—Conrail and such other lines as may later fall into that category. That would circumvent the problems of entrenched economic interests. Conrail might even successfully play the role of a demonstration project. It could be that there would be other railways, still in private hands, that might consider it advantageous to assume the role of a landlord toll road and permit others to provide transportation along their roads. That might be concurrent with the maintenance of their own transportation service, improving utilization of their tracks. To make that possible, some relaxation of entry controls would be needed.

One familiar route for coping with vested interests that impair productivity is to calculate some value for those vested interests and then to buy them out. That route was followed by the waterfront employers, as a sequel to the San Francisco Port Study (14), as a method of persuading the waterfront labor union to abandon unproductive working rules. That change made possible the conversion of shipping operations from manual breakbulk stowage to today's container ships. An enormous increase in the productivity of the waterfront labor force followed, as did a significant increase in the productivity of capital. Ship port time was reduced in proportion to the increase in labor productivity, and the ship was left free to make more voyages per year. The cargo-handling equipment was transferred from on board, where it could be used only when the ship was in port, to the quay, where it could be used whenever a ship required it. The longshoremen's union used the payments from the waterfront employers to compensate its members for their increased productivity by offering them well-funded early retirement. In that fashion the union was able to maintain full employment for its active members.

The Regional Rail Reorganization (3R) Act of 1973 followed a similar route when it provided for lifetime payments to any employees of the bankrupt northeastern rails who might be displaced by the formation of Conrail.

If railways became public highways and users operated more frequent and shorter trains, some similar reward might be needed in order to increase railway workers' productivity. One possibility, of course, might be the analogy to the highway, where not all transport labor is provided by a monopoly union. Another possibility might be to argue that the total demand for railway labor would expand if trains were operated by two men instead of four. One southeastern railway has already done that, but only after a long and difficult period of labor unrest. That railway also operates its trains with no caboose; two men in the locomotive use a radio beacon on the coupler of the last car to provide distance measurement (15, p. 22; 16, p. 645). The caboose, which can require extra switching movements, has been criticized by the National Commission on Productivity's Task Force on Railroad Productivity as being made necessary only by the excessively large crews used on American trains.

There is obviously room for the ingenuity of labor relations experts here. Increased employment on the rails that the public highway concept should bring should offer a quid pro quo, along with other rewards, for increasing the productivity of train crews. And many rail employees are old enough to welcome retirement.

A similar labor work rules block appears to inhibit the use of rail containers and trailers on flatcars (COFC/TOFC) by large trucking organizations. Apparently the usual working rules provide that if an over-the-road driver is available, he must be paid for the run even if the trailer is shipped by rail. What prevents employers from reducing their force of drivers by attrition, and so finding no one available, is not clear. There would seem to be possibilities for economies if labor negotiators were to find a way to reward truck drivers for permitting their loads to be moved by rail. In that way large trucking organizations, instead of worrying about double or triple trailers on the highway, could move as many as desired on one train.

One reward possibility might be that the truck drivers learn to drive the train. A prerequisite to such a change, of course, from the customer's point of view, is that rail service be upgraded to the speed, reliability, and freedom from claims of the present trucking service. Moreover, the present owner-operated trucking of exempt commodities can hardly be integrated into a COFC/TOFC operation, which requires someone at the destination with a tractor to receive the arriving trailer. The individual hauler of exempt commodities is not in that position, and it is hardly feasible to put tractor and trailer on the train and ride along. The established smaller entrepreneur would, at best, be unaffected by the application of this concept.

As the physical organization of terminals poses a problem requiring analysis, so does the business pattern of terminals. While present intercity rights-of-way can easily be conceived as becoming toll roads, with charges based on gross ton kilometers, possibly adjusted for axle weights or speed, or both, terminal organization is less clear. Modern transport technologies have their own terminals under their control. But the physical structure of rail yards implies the continuation of a common controlling agency. It seems improbable that the toll-road users, those who provide the transportation service, would want to acquire their own yards and terminals. Present yard facilities are probably quite adequate, but they would need to be adapted to common use.

A possible analogy is with airport and seaport organization. Airports and seaports are typically owned by a local government agency and are open to all users. Airports and seaports are rarely operated by the local government agency, although some aspects of the operation are provided by federal agencies such as the FAA, the Coast Guard, and the Corps of Engineers. The most common function of a local airport or seaport is to play the role of landlord; the tenants then undertake the actual operation. The airlines are among the tenants of an airport and pay rent for their counters, ramps, freight sheds, maintenance, and so forth. For seaports, shipping companies are sometimes direct tenants of the port, but the regularity of shipping services is less than that of air services and gives intermediary terminal companies a larger role in seaports than they have in airports.

One might suppose that freight-train movement over a public railway might more nearly approximate the nature of shipping movements than air movements. Some successful western railways might operate their own trains regularly, even daily, but hardly more than that, into the dense northeastern markets. Some industrial customers could be expected to be doing the same: power companies with their unit trains of coal, automobile manufacturers with raw materials for their plants and new cars off the assembly lines. But there would be a large group of less regular users such as freight forwarders and other developing specialists.

Some large users might break up trains for traffic at many intermediate points, and the important yards will then be those near the points of origin and destination of the cargo. Large intermediate classification yards would diminish in importance. Trains, like planes and trucks, could move directly from origin to destination with little or no intermediate switching. Service would be faster; loaded cars would no longer spend 45 percent of their time in the yards but would move faster and in shorter trains. Labor requirements may well increase, providing an incentive for the improvement of rail labor productivity.

In this framework, Conrail might possibly be able to offer to local government agencies those yards near freight-generating economic activities. Those agencies could adopt the management patterns of airports and seaports. They could maintain the properties, contract with tenants to operate them, in whole or in part, collect rents, and use fees analogous to landing fees and wharfage and dockage.

Large intermediate classification yards might offer promise for industrial parks and be offered to local agencies for that purpose. Some local governments are likely to be eager to improve their economic bases.

Local government agencies need not, of course, operate the yards. They may contract with local entrepreneurs for their maintenance and with others to provide the transportation service, including sorting cars, fueling, maintenance of locomotives, and pickup and delivery of cars to the district's industrial sidings. This last need not be monopolized; more than one local entrepreneur might undertake it.

The revenues from local taxes would not necessarily be tapped and would surely be more secure than in if a private enterprise railway went bankrupt. The landlord's toll railway would presumably continue to pay taxes based on the assessed valuation of the property (which is more than can be said for turnpikes). Locally owned airports and seaports are presumably off the tax rolls in most jurisdictions, but some tenants are taxed on the value of their leaseholds and improvements.

A system like this, if technically and economically feasible, would do a number of things, not the least of which would be the elimination of 19th century railway monopoly characteristics, which are the foundation on which the elaborate and stifling systems of public control over the transport industry were erected. The technological development of unitary transport vehicles running on publicly provided tracks was not accompanied by an institutional reorganization to exploit the flexibility of the developments in this century. Instead, the newer technologies were forced into the 19th century organizational mold established by the railways. Administrative and regulatory machinery was concurrently expanded to control and limit the newer technologies and to establish them in monopoly roles analogous to those of the railways. As long as some shippers continue to be dependent on traditional and expensive railway transport, the argument in favor of the maintenance of the status quo continues to flourish.

But if there is free entry and innovation throughout our transportation systems, then the arguments for treating transport as a special case to be politically sheltered from market forces evaporate. There remains only the question of compensation for the loss of intangible values resulting from the restoration of competition.

CONCLUSION

If railways were to assume the form of public highways, railway organization would parallel that of highways, airways, and waterways. Many operators could provide transportation over a common track. Among the benefits from such a transformation of the railway industry would be

1. Retention in the private sector of the transportation function (as distinct from the maintenance of way) of railways;
2. Substantial reduction in federal funding, since the transportation function would not be a government responsibility;
3. Encouragement of innovation and entrepreneurship in (railway) transportation;
4. Encouragement of innovation and entrepreneurship in state and local government terminal development;
5. Encouragement of more competition in transportation;
6. Reduction or even elimination of the need to regulate transportation on a basis distinct from other industries; and
7. Development of a user constituency, analogous to those constituencies of the other transportation modes, to support funding of the railways.

The forecast is that Conrail will be operating profitably by the end of this decade. If so, this concept may be explored leisurely; if not, there is a risk that the last century's railway organization pattern will become uncritically entrenched. We should explore the alternatives before we subsidize nostalgia.

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Part 2
Rail Management Methods

Survey of Rail Network Rationalization Proposals

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This paper surveys and summarizes eighteen proposals from the public domain since 1958 for railroad network rationalization in the United States. Network rationalization is defined as a reduction in size and shape and number of railroad companies comprising the national rail network. The proposals are compared in terms of rationalization criteria, number of railroad company systems proposed, and depth of detail. An observation is presented regarding the adequacy and potential usefulness of the proposals. The paper is intended as a synopsis for the reader of network rationalization proposals.

The purpose of this paper is to present a brief survey of recent proposals for network rationalization. First, however, I shall point out a few salient background items.

1. The rail industry, viewed historically as the first large American business, presented government with the largest industrial reorganization in our history, the Penn Central Transportation Company bankruptcy.
2. Amid a depressed 1975 economy, the industry experienced its lowest net railway operating income and lowest rate of return on investment ever. Its cyclical performance was never so evident.
3. Significant research on its most competitive transportation mode—trucking—has challenged the once unassailable idea that trains are less costly than trucks for transportation.
4. The generally declining fortunes of the railroad system, in the broader context of the transportation sector, have resulted in a declining work force and have heightened concern over issues of labor productivity.

On the brighter side for rail transportation, public awareness of rail problems has never been higher, and an understanding of the necessity of certain rail services is increasing. Government involvement in rail transportation, too, is at a recent all-time high. In 1975 there were over 100 rail-related bills before Congress that culminated with passage of the Railroad Revitalization and Regulatory Reform (4R) Act on February 5, 1976, which addresses many (but by no means all) railroad industry ills. Its many opportunities have caused it to be viewed as the most significant transportation legislation since the Transportation Act of 1940, which, among other accomplishments, established the Interstate Commerce Commission's (ICC) control over certain domestic water transportation and also formally recognized that the major problem facing transportation was one of intermodal competition, not monopoly. Also, with federal funding, state and local nonprofit institutions are operating rail services that would otherwise be abandoned.

The energy (fuel) crises suggested a more essential role for rail, because trains often use less fuel than other modes for comparable transportation productivity. However, modal energy comparisons can rightfully be made only on a true point-to-point basis.

The status of the industry can be summarized in one statement: The costs of reliably operating and maintaining railroads and replacing worn-out facilities have been increasing and continue to increase at a much faster rate than revenues increase. Furthermore, regulated revenue increases create a lag in cost increases that are traditionally necessary to justify rate increases. Thus all facilities cannot continue to exist. Even the $600 million made available for government-purchased railroad preference stock and the $1 billion made available for government loan guarantees by Title V (Railroad Rehabilitation and Improvement Financing) of the transportation act will not renovate most of the "tired" rail plants existing on many railroads. While some railroads are able to cover debt service and fixed charges plus return an income profit, many railroads are less fortunate. Such weak links hurt the entire interdependent national rail system and rail transportation capability.

Many suggestions have been made to improve the industry in areas such as labor, technology, deregulation, equipment and asset utilization planning. For each such area the possibilities are complex and substantial but beyond the scope of this paper. However, reduction in the size and shape of the (claimed) excess-capacity rail network has been a major subject of suggested improvement. The term applied to this concept is "network rationalization." In our context, it refers to consolidation into fewer and larger railroad systems with fewer total route kilometers than now exist. The term should not be confused with other types of rail rationalizations. Operating rationalization generally refers to different ways of operating over a network (train sizes, blocking yardings, routes, schedules); system rationalization generally encompasses both operating rationalization and network rationalization. The transportation act specifically encourages consolidations and network rationalization in Title IV (Mergers and Consolidations) by providing for more streamlined proposals and decisions concerning them. In fact, the U.S. Department of Transportation (DOT) is authorized to act as a catalyst in bringing potential consolidation and rationalization partners together and is also authorized to acquire any railroad data toward that end. DOT may also advance its own proposals, although ultimate regulatory authority for consolidation approval remains with the ICC.

NEED FOR RATIONALIZATION

Considering overall rail transportation demands and economics today, if a rail network were to be built from scratch, it would be different and smaller than the one that has taken over a century to evolve. This point is, of course, academic. The degree to which the existing network can and should be modified to accomplish rationalization is a highly controversial social and business question that touches distribution costs, intermodal competition, railroad creditors and stockholders, and the general future of American transportation and commerce. First some of the benefits and claimed advantages and then some of the difficulties of network rationalization are presented in what follows.

Advantages of Network Rationalization

1. More single-line shipment control. Today, 70 percent of all rail freight shipments are interchanged and carried by more than one railroad, although most do not travel through "run-through" interrailroad trains. This presents problems of responsibility and jurisdic-

tion insofar as more than one carrier participates in the complete transportation service rendered. Under rationalization, a greater proportion of shipments would be single line, providing generally better and more reliable transit times, which can also be achieved between lines that have good physical and information interchanges.

2. Better car utilization. Today, freight-car ownership influences whether a car is restricted to being loaded for movement only in specified directions. With fewer freight-car owners and fewer such restrictions (which rationalization would provide through fewer railroad companies), the number of effective freight cars would increase. The recent formation of intercompany freight-car clearinghouses, under guidelines issued by the Association of American Railroads (AAR), allows cooperating railroads to ignore ownership direction restrictions and has actually caused some of these restrictions between certain companies to be lifted.

3. Elimination of redundant facilities. Under rationalization, certain lines could be eliminated or at least be downgraded to lower service and maintenance standards. A clearer understanding of the true role and needs of each line should increase overall system performance reliability and reduce maintenance costs.

4. Improved efficiency. In certain areas, larger railroad companies should be able to accomplish more for a given price than smaller railroad companies. For example, favorable conditions probably exist for training, computer systems development, general administrative overhead, and so forth. These advantages may be less discernible in pure operating areas.

5. Better balancing of traffic. In a larger system, there is a greater likelihood that if certain commodity revenues are "soft" (because of strikes or seasonal or weather conditions), revenues from the system's other commodities will permit the system to better sustain reduced but still reliable operation.

6. Better financial power. All of the above should provide financially sounder performance and therefore make larger railroad companies more attractive to the financial community.

Difficulties of Network Rationalization

1. Disturbance of institutional conditions. Individual railroads and their managements have their own personalities, histories, motivations, and abilities to tolerate substantial changes. Depending upon how well the altered railroads would then fit into any rationalized network structure, their comprehensive roles in U.S. rail transportation would increase or decrease.

2. Too large a span of management control. The ability of a management team to effectively control a system larger than the largest current systems remains untested. Although large systems today range from roughly 16 000 to 40 000 km (10 000 to 25 000 miles) of lines operated, by 15 000 to 40 000 employees, they are not as large as some of the proposed transcontinental systems could be. Even with new information and operating technologies, which should permit more plant to be managed by fewer, managing such a large organization could prove extremely challenging.

3. Less competition. Single-line service under rationalization could diminish competition, but it could also accommodate at least two-carrier service between major traffic centers.

4. Labor considerations. A railroad career is regarded as desirable by most railroad employees, both unionized and nonunionized, who feel loyal attachment to the industry. Because of this, railroad planners, management, and employee representatives must carefully assess the impact of rationalization on employment and labor savings.

From a customer service and marketing standpoint, which should be considered critical in determining what a national rail system should be, the advantages of network rationalization seem to clearly outweigh the difficulties.

THE SURVEY

Cited below are some modern, relatively well-known past network rationalization proposals and plans made since 1958. In order to qualify for inclusion in the survey, a proposal must be an explicit plan in terms of number of rail systems (management) and a specific network and resulting kilometers of line, or both, but not a mere suggestion. Deliberately excluded are various historical proposals for overcoming different national and railroad crises during the first half of this century. Also excluded are the myriad restructuring proposals for the northeastern railroads or those considered by the U.S. Railway Association (USRA) in response to a specific congressional mandate to plan the Consolidated Rail Corporation (Conrail). Undoubtedly there have been numerous other proposals discussed in private transportation circles, and more will be discussed in the future. It is expected that the new rail consolidation opportunities invited by Title IV of the transportation act will stimulate future proposals by DOT and the railroads themselves.

This survey focuses on the emphasis of each proposal, the extent of its specificity with respect to proposed number of rail systems, and the criteria leading to the proposed plan. Table 1 compares the key characteristics of each proposal.

Burck's Plan to Save the Railroads

In a very revealing 1958 Fortune article, Gilbert Burck (2) predicted that the prosperity of the railroads would diminish and advocated that "large scale consolidation is probably the only measure that will enable the railroad industry to make enough money to survive as private enterprise." He suggested that railroads should "consolidate into three or four non-competitive, integrated, regional systems that would absorb every one of the 634 existing companies." He discussed at length the opportunities for savings, improved service, and increased profitability that consolidation would presumably offer.

Four systems Burck proposed are (a) a northeastern system of 94 770 line km (58 900 miles), (b) a southern system of 59 500 line km (37 000 miles), and (c) a northwestern and a southwestern system of 202 700 line km (126 000 miles). These were not described in detail, nor was the desirability of rail competition within the regions considered.

Bixler's Railroad Map of the Future

In 1966, Herbert Bixler (3) presented a "provocative merger map" that he described not as a plan but as a set of carriers grouped according to three criteria: intramodal competition everywhere, single management control over wide areas, and balance. The map showed six systems, each more or less regionally oriented. Competition was well maintained in that west of the Mississippi River, for example, only 2 of the 47 cities with populations over 130 000 would have fewer than two railroads. One of the proposed systems did combine railroads that actually were eventually consolidated in the Burlington Northern merger. The presentation was qualified by concerns for unaddressed but relevant matters such as efficiency of traffic flow, financial issues, and unproved manageability of large systems.

Gallamore's Thesis

In 1968, Robert Gallamore (4) studied the national rail system and the extent to which large systems should be encouraged. In analyzing problems suggesting the future organization of the U.S. railroad industry, he concluded that "all of this leads to development, in the future, of truly 'transcontinental railroads', transcontinental systems which would preserve vestiges of intermodal competition and that are as small and simple as truly transcontinental systems can be."

Gallamore proposed the following criteria for a national plan for transcontinental railroads.

1. Maintain intraregional, interregional, and transcontinental competition among systems to the maximum possible extent.
2. Eliminate excess capacity wherever possible and consistent with maintaining competition.
3. Make each system viable.
4. Each system should have ample points of contact between its eastern and western portions.
5. The plan should conform to existing realities in the merger picture.
6. Accept Professor Healy's conclusion (5) on desirable line densities of 2.3 to 2.8 million kg/m per year in the direction of heaviest traffic flow.

Using these criteria, three successive plans for transcontinental systems were proposed: plan A consisted of six systems; plan B also consisted of six systems; and plan C, the "preferred" plan, consisted of five systems. Maps were provided for each system.

DOT's Western Railroad Mergers

In January of 1969, DOT's Office of the Assistant Secretary for Policy Development and the Federal Railroad Administration defined criteria that the ICC might adopt as merger policy goals for establishing an efficient rail network west of Chicago (6). These criteria were maintenance of competition, strong carriers as the bases for western systems, preservation of essential rail connections and service levels, and strong supportive evidence for trade-offs among objectives. Six plans, each containing four or five systems and labeled A to F, were identified with tables and maps. Each plan proposed the consolidation of the Great Northern Railway Company, Northern Pacific Railway Company, and the Burlington Northern Railroad, which did in fact occur in 1971. Within each plan, the systems were compared in terms of 1967 data for revenues, net railway operating income, net income, and freight traffic density.

Table 1. Key characteristics of 15 rationalization proposals.

Proposal	Territory Considered	Specific Criteria	No. of Systems	Specific System Networks Proposed	Map Included
Burck's Plan to Save the Railroads	Entire nation	Regionalization	4	Roughly	Yes
Bixler's Railroad Map of the Future	Entire nation	Competition, single management control, and balance	6	Yes	Yes
Gallamore's Thesis	Entire nation	Maintenance of competition Elimination of excess capacity Viability East-west points of contact Recognized merger realities Desirable rail densities	Plan A = 6 Plan B = 6 Plan C = 5	Yes	Yes
DOT's Western Railroad Mergers	Entire nation	Competition Strong carrier Preservation of connections and service Strong supportive evidence for trade-offs	Plan A = 4 Plan B = 4 Plan C = 4 Plan D = 4 Plan E = 4 Plan F = 5	Yes	Yes
Miller's Single National U.S. Railroad Proposal	Entire nation	End of destructive competition between railroads	1	No	No
DOT's 1972 Circuity Versus Density Network Analysis	Entire nation	Least-distance routings over consolidated network with trade-offs between increased circuity and increased density	Not proposed	No	Yes
Modern Railroads Magazine and Livingston Plan	Entire nation	End-to-end transcontinental systems	4	Partially	Yes, but very rough
Task Force on Railroad Productivity Suggestion	Entire nation	Making rail systems more congruent with markets they best serve	4 to 7	No	No
Simon's Single System Proposal	Entire nation	Not specifically proposed	1	No	No
Whitten and Carman Suggestion	Entire nation	Not specifically proposed	2	Yes	Yes, but very rough
Klitenic's Restructuring Proposal	West of Chicago	Based upon petitions of railroads desiring to acquire portions of Rock Island	4	Yes, with some options	Yes
Tennyson Plan	Entire nation	Recognition of past research that railroads were most efficient having between 15 000 and 30 000 employees	20	Yes	No
Zlatkovich's Interstate Rail System	Entire nation	Gravity model, line distances, and intermediate population centers between major population centers	Not addressed	No	Available
Quinn Proposal	West of Chicago	Financially strong lines to be "strong" lines	4	No	No
New York State DOT Suggestion	Entire nation	Proposed types of criteria not specific criteria for developing a plan	Not Specified	No	No

Miller's Single National U.S. Railroad Proposal

In 1972, Spencer Miller (7), President of the Maine Central Railroad Company, proposed the creation of a single U.S. national railroad (the American Railroad Corporation) under private ownership that would be not unlike AT&T. His proposal claimed seven main virtues:

1. Treatment for railroad employees equal to that accorded employees of the nation's more prosperous industries;
2. Addition of great strength to American free enterprise, in contrast to the alternative of nationalization;
3. Various savings and efficiencies, avoidance of intraindustry competition, and better transportation service;
4. Feasible return of light rail traffic to the railroads;
5. Preservation of the ICC to regulate a railroad monopoly, but elimination of many ICC functions that would become unnecessary;
6. Vast economies from elimination of interroad junctions, terminals, inspections, and accountings; and
7. Easier return to intercity rail passenger service.

In summary, Miller claimed that his plan "has all the merits of nationalization and none of the drawbacks." To overcome the problem of assessing values and satisfying stockholders, Miller suggested that Congress pass a compulsory statute for railroad mergers and then appoint a commission to find values. Feasibility of the concept would, of course, have been totally dependent upon mandatory legislation that would undoubtedly have had many political difficulties.

DOT's 1972 Rail Circuity Versus Density Network Analysis

The 1972 National Transportation Report (8) published by DOT included a rail network analysis that used estimates of 1980 freight traffic flows for over 500 areas in this country, including 225 standard metropolitan statistical areas (SMSA). Through a heavily computerized process and starting with a base network of 217 200 route km (135 000 miles) of rail arterials with least-distance flows from origin to destination areas, traffic flows were iteratively consolidated onto more circuitous routes and denser lines to analyze trade-offs between increased circuity and increased density. It was concluded that "circuity was increased by consolidation, but not greatly," and that, based upon such findings, approximately 125 500 km (78 000 miles) of today's system might be subject to abandonment. Branch lines feeding the arterials were excluded from the analysis.

While no specific number of rail systems was advocated, the analysis implied that a substantially smaller national rail network could handle arterial traffic demands without unacceptable increases in circuity. Maps resulting from the analysis are part of the study's working papers.

Modern Railroads Magazine and Livingston Plan

In September of 1972, a Modern Railroads magazine (9) editorial stated that "This magazine believes the railroad industry should restructure itself into a small number of nationwide systems that can better compete with the interstate highway system." Its thesis was specified by Henry Livingston, Vice President of the investment banking firm of Clark, Dodge and Company, who said that "the root cause of the industry problems is its corporate structure." Livingston's plan included "four competitive systems reaching all the major metropolitan centers, many secondary ones, and even third class ones so that the shipper at every point has entry into the railroad network with a choice." Continuing, Livingston advocated that "only through a nationwide network concentrating on a maximum number of single line, end-to-end city-pair services, without continual intermediate interchanges, can the railroad operator ever hope to retain what he still has of high value.... Such a network would eliminate the fractured product offered by several separate railroads, each struggling to maximize its long haul."

The plan included rough maps for the four recommended transcontinental systems, including north-south service routes. Four systems in sequence west of Chicago would form the nucleus for the plan. Two southern systems would then negotiate long-term service contracts with the western systems, permitting the latter to operate on southern-owned and southern-developed routes and rights-of-way. Finally, in the east, liquidated bankrupt railroads would fall between two balanced eastern systems under the Norfolk and Western Railway Company and the Chessie System, and these systems would then become extensions of the western railroads in a manner similar to that of the southern systems.

Task Force on Railroad Productivity Suggestion

The Task Force on Railroad Productivity, established in 1972 by two White House agencies and by the National Commission on Productivity, recommended (10, 11) industry reorganization, with connecting railroads merging end-to-end to form from four to seven independent, competitive transcontinental systems. Such end-to-end mergers would presumably make rail systems more nearly congruent with the markets they serve best. Some of these systems would be truly transcontinental; some would be oriented along a north-south axis; but each would reach every major market in its area. Avoiding interlining of traffic was claimed as the most significant continental road benefit and would include a breakup of the bankrupt Penn Central system into at least two pieces from the Mississippi River to the East Coast. Also, more piggybacking for long hauls was promoted to permit each carrier to serve a region and to compete for most of the traffic in that market, thus encouraging interrailroad competition to become almost as pervasive as present truck and rail competition. No maps or specific systems were proposed.

Simon's Single System Proposal

On November 8, 1973, industrialist Norton Simon (12) hired a hall at the Waldorf Astoria Hotel in New York City to discuss fundamental problems confronting America's railroads. He proposed that the nation's railroads be merged into a single, publicly owned (but not nationalized) national corporation. This, he claimed, would lead to better system management and efficiency and would avoid controversies over divisions of rates.

Whitten and Carman Solution

In December 1973, H. Whitten and J. Carman (13) proposed two privately owned transcontinental systems, two being the minimum number that could afford nationwide competition. Accompanying the proposal were claims that such consolidations should permit a 100 percent increase in car utilization and at least a 50 percent reduction in the number of terminals. A map was presented identifying two reasonably balanced systems of 163 600 and 167 300 km (101 700 and 104 000 miles) of lines respectively. In terms of freight revenues, the systems showed $5.6 billion and $6.1 billion respectively at 1971 freight rate levels.

Klitenic's Restructuring Proposal

Incidental to the long and complex Rock Island merger case before the ICC, Administrative Law Judge Nathan Klitenic (14) proposed a western railroad restructuring creating four large systems. In the opinion of some observers, the restructuring proposal exceeded the scope of the merger case itself, and the commission's ultimate decision was influenced by, although different from, the proposal. However, the proposal did represent the ICC's most significant recent venture into reshaping railroad operations.

The Klitenic proposal is the only one tnat considered evidence from the affected parties and therefore must be considered more acceptable than the others. Each of the four systems would have a current strong carrier as its nucleus, and some options were left open as to which of the systems a few specific railroads would join. The proposal was characterized by transactions railroads would have to agree upon within a specified time limit and other transactions that were unspecified as to time. Of all maps prepared for any proposal in this survey, the Klitenic maps were the most informative.

Tennyson Plan

A 1975 plan by E. L. Tennyson, Deputy Secretary, Local and Area Transportation, Pennsylvania Department of Transportation, offered a middle-of-the road approach to restructuring. Tennyson proposed that there be about 20 surviving railroads that could emerge strong and healthy with minimum duplication and maximum competition. The Tennyson consolidation plan is the only recent one known to advocate as many as 20 systems ranging in size from 5000 to 38 000 employees, and from $150 to $1140 million of 1973 annual gross revenues. No maps were provided.

Zlatkovich's Interstate Rail System

In April 1975, Charles Zlatkovich (15) of the University of Texas Bureau of Business Research proposed an interstate rail system similar in scope and function to the Interstate highway system and based on the best route segments of the existing railroad system.

Route selection was based on the "gravity model" (derived in name from its similarity to Newton's theory), which estimates the volume of interaction (or traffic) between two points on the basis of their relative size and the distance between them. For the size of a point, Zlatkovich used the population of the SMSA as representative of economic activities that generate freight traffic. The methodology selects a best route in terms of line distance and intermediate population centers between each of the 1000 SMSA pairs with the strongest gravity model interaction. These routes are then adjusted, applying considerations such as grades and curves, signal control, state of maintenance, and combinations of connected rail lines between two points where connections would improve the route between the points. The resulting system contains tracks of 40 existing railroads and 63 323 line km (39 331 miles), and is offered not as a final recommendation but as a starting point for further discussion and study of the concept. A map was provided.

Quinn Proposal

In mid-1975, W. Quinn (16, p. 11), Chairman of the Milwaukee Road, proposed a method of western railroad restructuring, and claimed that "large scale merger is the only feasible way of the over-built western railroad plan." The goal of his proposal was to reduce the number of systems in the west, thus concentrating traffic and revenues on fewer main lines. While the proposal did not identify specific systems or maps, it significantly identified necessary legislative changes to facilitate establishment of four systems.

New York State DOT Proposal

In mid-1975, the New York State Department of Transportation (DOT) issued a report (17) to Congress suggesting that the 3R Act of 1973 would be inadequate as a solution to recognized national railroad problems. Specifically, the report recommended that "the nation must be served by a small number of competitive, efficient, modern railroad companies, each with a network extending across the country and should be both east-west and north-south transcontinental systems." The report also discussed the mechanisms for developing transcontinental systems, namely a national railway reorganization act.

A key focus of the report was that certain branch lines may be unprofitable to a specified railroad but would make a net profit for a national system and therefore should not be eliminated from service. In advocating a system that allows efficient single-line movement of the greatest amount of traffic but preserves competition in major markets, the report enumerated specific areas in which guidelines needed establishment with respect to the number of systems, efficient market sizes, and both line importance and route selection criteria. Although no specific maps or systems were proposed in the report, a proposed act represented a very clear procedure for arriving at it.

OBSERVATIONS

It is not surprising, because of the complexity of the subjects, that the proposals differ widely with respect to emphasis, number of proposed rail systems, and (to the extent addressed at all) how a better rationalized rail network might be realized. Most of the proposals were not the result of detailed transportation systems planning analysis based on origin-destination flows, presumably because of the difficulty of projecting them for the future and because of the time and effort necessary for such analyses. (Only the Klitenic, the DOT circuity-density analysis, the Zlatkovich, and the Gallamore proposals recognized origin-destination traffic flow demands.)

None of the proposals mentions the thought that network rationalization planning might best and perhaps should be done by representatives of the railroad companies themselves. Implementation is generally the most difficult successor to planning, so those who must make the results of rationalization work should ideally plan it. However, whether railroads will voluntarily and seriously undertake such planning remains to be seen. The opportunities presented by Title IV certainly present more desirable environments for such planning and resulting rationalization than have existed in the past.

CONCLUSION

The proposals represented by the survey above represent much thinking and effort about railroad network rationalization. Each of them may be said to be a contribution to a very complex subject and should be recognized (with specifics possibly utilized) by future rail network rationalization planning efforts.

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The views expressed in this article are those of the various authors cited and my own and should not be considered as representing policies of the U.S. Department of Transportation.

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Impacts of Light Density Rail Line Abandonment

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Estimates of the extent of potentially uneconomic light density railroad lines in 31 states outside the Northeast and of the amount and type of traffic on these lines were developed. The analysis utilized the Federal Railroad Administration network model, the 1 percent waybill sample, and a decision rule, derived from U.S. Railway Association planning, of 43.5 annual carloads per kilometer (70 carloads per mile) of line. It was estimated that approximately 41 000 kilometers (25 500 miles) of line, or 18 percent of the route length, in the 31 states are uneconomic. Only 2.4 percent of total traffic originates or terminates on these lines. Only for agriculture is the traffic on these lines significant, but mitigating factors indicate that adjustments after terminating service can be made with relatively little adverse effect. The effects of termination on the highway system, energy consumption, and the environment were also analyzed and found to be generally minor.

The nation's railroad system is currently undergoing considerable restructuring of facilities and services, largely caused by economic effects from shifts in product demand, industry location, competing modes of transportation, and government policies. The low rate of investment return over several decades has plagued the railroad industry as a whole and has brought a number of important railroads, particularly in the Northeast, to bankruptcy.

In an effort to restore vitality to the industry, Congress passed the Regional Rail Reorganization (3R) Act of 1973 and the Railroad Revitalization and Regulatory Reform (4R) Act of 1976. These two acts demonstrate the importance of a strong private railroad industry to the economic well-being of the nation.

The 3R and 4R acts are proof that the private railroad industry is no longer expected to provide deficit services. The 3R Act, in dealing with light density freight lines in the Northeast, indicated that, if it is in the public interest to continue such services, then the government must underwrite part of the losses. A subsidy program was established to provide for the continuation of essential local rail services on a temporary

Figure 1. Regions and states included in the light density line analysis.

basis, until workable alternatives could be implemented. The 4R Act extended government subsidies for essential services to the entire nation and expanded the options for use of subsidy funds to include nonrailroad alternatives when such alternatives are more cost effective.

Congress has, however, clearly indicated that service continuation subsidies are a short-term, transitional measure, not a permanent solution to the problem of light density railroad freight service. The potential cost of the subsidy program, the large capital needs of the mainline railroad system, and the nonaccountability of operational subsidies underscore the importance of analyzing these programs and alternative policies to ensure that public funds are spent effectively. The U.S. Department of Transportation (DOT) is now sponsoring research into whether alternate programs for local freight assistance would be more cost effective and would provide more positive solutions for stabilized freight service than railroad subsidies.

In addressing the matter of light density lines, it is important to estimate (a) the amount of uneconomic light density lines in the railroad system as a whole, and (b) the portion of traffic of the various commodities that originates or terminates on these lines.

The railroad system of the Northeast, especially the bankrupt railroads, has been studied extensively. The United States Railway Association (USRA), in a careful case-by-case analysis, found that 9263 km (5757 miles) of line were uneconomic to operate. These lines accounted for 23 percent of the system's lines but originated or terminated only 2.2 percent of the total system traffic (1). However, the extent of uneconomic light density line distance in the rest of the nation must also be estimated.

Section 904 of the 4R Act, accordingly, mandated that the Secretary of Transportation

> shall submit to the Congress, within 90 days after the date of enactment of this Act, a comprehensive report on the anticipated effect, including the environmental impact, of any abandonment of lines of railroad and any discontinuance of rail service in the States outside the region.

Section 904 deals with the 31 southern and western states (excluding Alaska and Hawaii) shown in Figure 1. This paper summarizes the findings of a research report on abandonment and alternatives submitted to Congress (2). The study responded to the Congress's request for a macroview of current uneconomic service in the 31-state area and a discussion of anticipated effects of relieving the railroad industry of the associated financial burden. The purpose of this study, however, was not to identify or recommend specific line segments for abandonment.

Section 803 of the 4R Act calls for a comprehensive federal, state, and local rail planning process to deal with the problem of uneconomic light density lines. This process will be responsible for detailed line-by-line estimates of viability. In addition, Section 804 requires that each carrier prepare, submit to the Interstate Commerce Commission (ICC), and publish a diagram of its system that includes a description of lines potentially subject to abandonment.

ESTIMATING THE EXTENT OF UNECONOMIC LIGHT DENSITY LINES

Because major new research was not possible within the 90-d limitation imposed by the 4R Act, our study relied heavily on available information and findings, particularly the studies of the reorganization of the bankrupt railroads of the Northeast. However, a new computerized network analysis was undertaken to estimate the rail traffic and route length of potentially uneconomic light density railroad service within the 31 southern and western states.

The analysis was performed in three steps. First, the Federal Railroad Administration's (FRA) preliminary network model (3, 4) of the nation's railroad system was used to select a set of light density line segments and to obtain the length of each segment. The segments selected for analysis were those that are directly represented in the network model, are served by a single carrier, and carry just under a million megagrams or less per year. There are no data on terminating traffic for railroads with average annual operating revenues of less than $3 million, so their lines were excluded from the analysis.

Next, estimates of the total traffic originating and terminating on each light density segment were obtained from the FRA waybill files for 1972, 1973, and 1974. These data represent a systematic 1 percent sample of audited revenue waybills for all domestic shipments terminated by railroads with annual operating revenues of $3 million or more. The 3-year period increased the sample size and reduced the effects of the business cycle, weather, and other ephemeral influences on traffic volume.

Finally, each segment was tested for economic viability according to the volume of traffic generated and its importance to the mainline. USRA published data summarizing the results of detailed financial analyses of the economic viability of 344 former Penn Central Transportation Company lines were reviewed (5). Slightly less than half of these lines passed USRA's viability requirement of generating sufficient revenue to cover at least 90 percent of avoidable costs. From these data, a simple viability criterion was developed: Did the line originate or terminate or both an annual average of at least 43.5 carloads/km (70 carloads per mile)?

This criterion classified approximately 90 percent of the individual line segments in the same way as USRA's detailed financial analyses did. Moreover, the criterion produced an almost perfect estimate of the total number of segments found uneconomic by USRA. Of 344 segments tested, the 43.5-carload/km criterion classified 166 as viable, 143 as not viable, 18 incorrectly as viable, and 17 incorrectly as not viable. Although the 43.5-carload/km criterion is in no way an accurate substitute for a careful financial analysis of individual line segments, it did give a good indication of the total number of unprofitable segments and was therefore used in developing estimates of apparently uneconomic lines.

EXTENT OF POTENTIALLY UNECONOMIC LIGHT DENSITY LINES

The computerized network analysis estimated that some 41 000 km (25 500 miles), or 18 percent, of the total route length in the 31 states are potentially uneconomic light density (PULD) lines. However, these lines account for only 2.4 percent of total carloads. These percentages are comparable to those found by the USRA in the Northeast, where 23 percent of route length accounted for only 2.2 percent of the total traffic.

The overall traffic data were grouped into six regions generally conforming to the boundaries shown in Figure 1; tabulations of affected route length and traffic are given in Tables 1 and 2. These regions have varying amounts of PULD lines, ranging from 6 percent of the system in the East South Central region to a high of 28 percent in the West North Central region. Estimated affected traffic on uneconomic lines in these two regions is 0.6 percent and 5.3 percent, respectively.

The commodities originating and terminating on PULD lines are shown in both absolute and relative terms in Table 3. It should be noted that, except for agriculture, the traffic originating and terminating on these lines is quite limited.

Table 1. Route length of PULD lines outside the Northeast.

Region	Existing Lines[a] (km)	Potentially Uneconomic Light Density Lines: No. of Kilometers	Percentage of Existing Kilometers
South Atlantic	26 851	1 800	6.7
East South Central	23 992	1 400	5.8
West South Central	41 153	5 800	14.1
West North Central	77 774	22 000	28.3
Mountain	32 608	5 900	18.1
Pacific	24 430	4 100	16.8
Total	226 808	41 000	18.1

Note: 1 km = 0.62 mile.

[a] From the 1974 Yearbook of Railroad Facts (6).

PRIMARY ECONOMIC EFFECTS

The Railroad Industry

One estimate of financial relief to the railroad industry in the 31 states set the reduction in the affected railroads' annual operating losses at approximately $150 million. In addition, the capital committed to this portion of the system has a value of at least $640 million in track facilities alone, exclusive of the value of rights-of-way. Equipment and labor resources devoted to these lines could also be utilized more effectively on the profitable parts of the rail system. Capital formation is a major problem for the industry, and this committed capital is therefore of great importance.

Manufacturing, Retailing, Mining

The effect of a cutback of PULD service on the productive sectors of our economy would be quite small in scale with the exception of agriculture. Petroleum, pulp and paper products, machinery and equipment, metal products, waste and scrap, metallic ore, and coal use well

Table 2. Shipments originating or terminating on PULD lines outside the Northeast.

Region	Originating Carloads (000s): Total[a]	On PULD Lines	Percentage on PULD Lines	Terminating Carloads (000s): Total[a]	On PULD Lines	Percentage on PULD Lines	Overall Percentage of Carloads Affected[b]
South Atlantic	2 188	21	1.0	2 724	10	0.4	0.6
East South Central	2 490	15	0.6	1 810	10	0.6	0.6
West South Central	2 045	49	2.4	2 344	35	1.5	1.9
West North Central	3 427	260	7.6	3 184	90	2.8	5.3
Mountain	1 296	55	4.2	1 045	17	1.6	3.1
Pacific	1 651	53	3.2	1 665	18	1.1	2.1
Total	13 097	452	3.5	12 772	179	1.4	2.4

[a] Derived from FRA waybill files for 1972-1974.

[b] Carloads originating or terminating on potentially uneconomic light density lines are taken as a percentage of all originations and terminations in the 31 states.

Table 3. Commodity shipment originating or terminating on PULD lines outside the Northeast.

Product Description	Originating Carloads (000s): 31-State Total[a]	On PULD Lines	Percentage on PULD Lines	Terminating Carloads (000s): 31-State Total[a]	On PULD Lines	Percentage on PULD Lines	Overall Percentage of Carloads Affected[b]
Farm products	1 389	249	17.9	1 278	17	1.3	10.0
Coal	752	6	0.8	560	6	1.1	0.9
Nonmetallic minerals	808	18	2.2	773	16	2.1	2.2
Food products	1 390	43	3.1	1 200	26	2.2	2.7
Lumber and wood products	1 691	78	4.6	1 491	18	1.2	3.0
Pulp and paper products	765	4	0.5	582	9	1.6	1.0
Chemicals	900	8	0.9	806	33	4.1	2.4
Petroleum and related products	550	7	1.3	527	12	2.3	1.8
Clay and concrete products	642	16	2.5	635	13	2.0	2.3
Metal products	364	4	1.1	541	12	2.2	1.8
Machinery and equipment	424	7	1.6	854	9	1.1	1.3
Waste and scrap	308	6	1.9	269	2	0.7	1.4
All others	588	6	1.0	757	6	0.8	0.9
Total	10 571	452	4.3	10 273	179	1.7	3.0

[a] Derived from FRA waybill files for 1972-1974.

[b] Carloads originating or terminating on potentially uneconomic light density lines as a percentage of all originations and terminations in the 31 states.

Table 4. Estimated agricultural shipments sent on PULD lines.

Commodity	Rail Shipments[a,b] (Mg 000 000s) National Total	31-State Total[c]	On PULD Lines	Percentage of 31-State Total on PULD Lines	Percentage of National Production Shipped on PULD Lines
Wheat	40.3	37.1	7.9	21.3	17
Corn	28.6	16.3	2.7	16.6	2
Barley	4.5	4.4	1.0	22.7	12
Sorghum grains	6.2	5.8	0.8	13.8	4
Oats, rye, and other grains	3.5	3.0	0.6	20.0	3
Soybeans	8.5	5.8	0.9	15.5	2
Other field crops	11.9	4.8	0.5	10.4	—
Other farm products	4.4	4.0	0.3	7.5	—

Note: 1 Mg = 1.1 short ton.

[a] All production figures are national estimates; figures given for rail shipments on PULD lines are restricted to lines in the 31 southern and western states.
[b] Total shipments may exceed total production because of reshipment.
[c] Derived from FRA waybill files for 1972-1974.

under 2 percent of all carload originations and terminations in the 31 states on PULD lines; manufacturing, retailing, and mining, use much less than 1 percent. Lumber and wood products originate and terminate approximately 3 percent of total carloads on these lines. For food processors, the figure is 2.7 percent.

Agriculture

Most light density lines are located in rural areas, and, as shown in Table 3, agricultural products account for a significant share of the traffic outside of the Northeast.

While many agricultural supplies and products are moved by truck, certain products, particularly grain, fertilizer, and feed, are commonly transported by railroad. The issue is whether discontinuing service on some railroad lines in agricultural areas will force farmers, suppliers, and marketing cooperatives to shift to alternate, perhaps more expensive modes.

The agricultural traffic originating and terminating on PULD lines has been analyzed in some detail and is shown in Table 4. All production and consumption figures are national estimates; figures given for rail shipments and receipts on PULD lines are restricted to lines in the 31 southern and western states.

When the traffic moving over PULD lines is compared to total national production, only wheat and barley are substantially affected. However, even though 17 percent of wheat and 12 percent of barley move over these lines, light density lines could be selectively abandoned with only a slightly adverse effect on grain shipments, because much of the potentially affected distance is located in areas with comparatively dense rail networks and because grain shipments are initially moved by truck from the farm to the elevator, leaving some flexibility as to which elevator might be used.

Another component of agricultural railroad traffic is the inbound shipment of agricultural supplies. Table 5 shows that abandoning unprofitable light density lines would have only a minor effect on receipts of fertilizer, feed, and farm machinery and equipment.

The effects of reduced service are most acute locally. Here the problem can best be approached by separately assessing the impacts of abandonment on several distinct types of agricultural users: grain elevator operators, feed and fertilizer producers and distributors, and the farmer.

Grain Elevators

Numerous country elevators that serve as collection, storage, and shipping facilities for local farmers are situated on light density lines. Complicating the matter is the fact that poor track conditions frequently prevent these elevators from using modern 91-Mg (100-short ton) covered hopper cars. Many of them still ship in one-to-three boxcar quantities. Larger subterminal elevators, those that receive most or all of their grain from country elevators, typically receive and ship grain in sufficient volume to raise the rail line on which they are located out of the light density category.

The best alternative, which would avoid the problems associated with the collection of grain from country elevators, would be to construct larger grain subterminals on nearby high density rail lines that could handle 91-Mg (100-short ton) cars in unit-train service. Grain could be trucked from the country elevators to the subterminals and shipped in unit trains of 50 or more cars at a time. Studies have indicated that, in corn-growing areas, the resulting saving in rail freight charges would more than pay for the construction costs of the new facility as well as for the additional handling and trucking costs (7, 8, 9).

Shipments to terminals or subterminals no more than 300 to 600 km (200 to 400 miles) away would generally be made completely by truck. Baumel (7, 8, 10) and a USDA study (11) indicate using 28-m^3 (800-bushel) tractor-trailers would increase the costs about 0.25 to 0.60 cents/m^3-km (0.015 to 0.035 cents/bushel-mile). This would be about \$0.75 to \$1.80/m^3 for a 300-km shipment (or 3 to 7 cents/bushel for a 200-mile shipment).

Other transport alternatives to country elevators include truck and rail (without the use of subterminals) and truck and barge. Previous abandonments, incidentally, have not prevented the continued expansion of country elevators (7, pp. 138-144).

Feed Producers and Distributors

Feed producers and distributors in grain surplus areas (more grain is grown than is used locally) also frequently use grain elevators. Feed sold in these areas is grown, ground, and mixed locally and is rarely shipped by rail. There should be no adverse effects from abandonment here.

Feed producers and distributors in grain deficit areas, on the other hand, might be adversely affected. The most likely transportation alternative for receiving feed and feed grains would be a combination of rail and truck. Simat, Helliesen, and Eichner (12) found three firms that reported increases in costs of \$0.80 and \$3.30/Mg (\$0.75 and \$3.00/short ton) that resulted from abandonment.

Most increased costs in these areas will be passed on to the firm's customers. In areas where competitors are unaffected by the loss of rail service and the increased cost of trucking cannot be passed along, firms

Table 5. Estimated agricultural shipments received on PULD lines.

Commodity	Rail Receipts[a] (Mg 000 000s)				Percentage of National Consumption Received on PULD Lines
	National Total	31-State Total[b]	On PULD Lines	Percentage of 31-State Total on PULD Lines	
Phosphate fertilizers	9.6	6.1	0.8	13.1	2.0
All other fertilizers	6.0	4.6	0.3	6.5	0.7
Grain feeds	83.1	68.7	0.7[c]	1.0	–
Oil kernel, nut, and seed feeds	9.3	6.6	0.1[c]	1.5	–
All feeds	10.1	6.4	0.2	3.1	0.8
Farm machinery and equipment	0.8	0.6	0.1	16.7	–

Note: 1 Mg = 1.1 short ton.

[a] All consumption figures are national estimates; figures given for rail receipts on PULD lines are restricted to lines in the 31 southern and western states.

[b] Derived from FRA waybill files for 1972-1974.

[c] A significant portion of these commodities are made into feed for local agricultural use.

may be forced to close their feed operations. One study disclosed that of ten feed distributors who lost direct rail service, four closed, and a fifth reported a substantial decline in feed sales (12).

Fertilizer Distributors

Loss of rail service is likely to result in rail and truck transshipment of virtually all potash and most phosphate fertilizer destined for stations on the line. A nitrogen fertilizer producer is likely to be close enough to make direct shipment by truck feasible.

Estimates obtained by Bunker and Hill (13) of increased costs resulting from transshipment by rail and truck were approximately \$1.65/Mg (\$1.50/short ton) for transloading and 2 to 6 cents/Mg/km (4 to 8 cents/short ton-mile) for trucking. Compare these increases in costs to retail prices of \$110 to \$220/Mg (\$100 to \$200/short ton) for common forms of concentrated fertilizers and \$9/Mg (\$8/short ton) for agricultural limestone. This increase will probably make retailing agricultural limestone impractical. It could also cause a loss of sales of other types of fertilizers to nearby distributors who do not lose rail service.

Farmers

Only a relatively small number of farmers will encounter major increases in production and marketing costs for most crops, if local direct rail service is lost.

Data on feed and fertilizer presented previously indicate that the cost increase for these two commodities would generally be less than 2 percent and somewhat more for the cheaper fertilizers. Fertilizers account for only a small portion of the costs of growing crops, so the overall effect on crop production costs should be quite small. The effect of increased feed costs on livestock production costs will be relatively larger but still generally no greater than 0.5 percent of total costs.

The effect on farm incomes of increased shipping costs for grain could be significant. As discussed previously, a system of grain subterminals might allow many light density lines to be abandoned without any effect on shipping costs and perhaps even a reduction in costs. Otherwise, increased shipping costs of \$1.50 to \$3.00/m^3 (5 to 10 cents/bushel) might result. Such increased costs would be absorbed by farmers as lower net on grain sales, although in some cases some portion could be passed on to the consumer. Subterminals, therefore, might play an important role in minimizing or avoiding the adverse effects that the loss of rail service could have on the farmers served by light density lines.

ENERGY, ENVIRONMENTAL, AND OTHER COMMUNITY EFFECTS

Highway Effects

Freight now moving on unprofitable light density lines could be moved by other modes, chiefly motor freight. On-going research sponsored by DOT is focusing on developing reliable estimates of the extent of the modal shifts and the impact on the highway system. One preliminary examination suggests that the worst possible result would be 6 to 7 billion Mg/km (4 to 5 billion short ton-miles) of additional truck traffic on the highway systems of the 31 states, and between 650 and 800 million truck km (55 billion truck miles) of travel by combination trucks (14, Table VM-1). Thus, the shift from 41 000 km (25 500 miles) of light density railroad lines, assuming diversion to truck, would result in an increase in truck traffic of less than 1 percent.

Energy Consumption

On the basis of estimates of fuel use for the alternate transport modes and preliminary estimates of the use of these modes, the potential effect of abandonment on fuel consumption should be between 75 and 150 million L (20 to 40 million gallons) annually; compare this with the 413 billion L (109 billion gallons) of fuel consumed annually by railroads and highway vehicles (15, pp. 194-197). Thus, it can be seen that even under the worst circumstances abandonment will result in less than a 0.04 percent increase in rail and highway fuel consumption.

Air Pollution

Air pollution emission factors have been developed by the Environmental Protection Agency for trucks, locomotives, and riverboats (16). However, although trucks and railroads are both usually diesel powered, trains frequently use a lower grade of diesel fuel, which generates higher emissions. This is particularly true for the four-stroke switch engines commonly used for branch-line operations. As a result, a change in mode would increase emissions of carbon monoxide and nitrogen oxides. Even for these two pollutants, preliminary estimates indicate that the increases would be only about 0.004 percent and 0.04 percent respectively, of the estimated national total emissions for all transportation sources.

Local railroad operations are particularly energy intensive, and the locomotives used in these operations have generally high emission levels, so the individual communities most affected by abandonment would see a small overall improvement in air quality.

Water Pollution

In general, abandoning a light density rail line can produce some minute improvements in local water quality by eliminating herbicide leaching and runoff, oil and lubricating fluid leakage, and the possibility of accidental spills. However, any overall improvement in water quality will probably be negligible.

Noise

A shift from rail to truck for part or all of a haul will have some effect on noise generated and perceived. Railroads normally generate somewhat more noise than trucks do, and railroad train noise levels also decline less with increasing distance. On the other hand, since two to four trucks are normally required to transport the contents of a single freight car, more trucks will produce more noise events.

Noise, and particularly the impact of noise on the population, is a very involved phenomenon, meaningful only at a particular locale under particular conditions, and cannot be judged overall. A review of various retrospective studies of railroad abandonments did not reveal complaints of increased noise levels, but generally speaking the effects of abandonment will be minor.

Other Effects

Other effects of abandonment, including those on safety, land use, and aesthetics, were also seen as being minor overall. At the local level there can be expected economic adjustments. Of particular concern to local interests is the effect of abandonment on population. Therefore, the demographic histories of a number of communities included in retrospective abandonment studies were tabulated. It was found that after abandonment almost as many communities gained population as lost.

ALTERNATIVES FOR FREIGHT TRANSPORTATION NOW PROVIDED BY LIGHT DENSITY LINES

Rail users and communities who face the possible loss of railroad service have a number of possible responses. The alternatives fall under the following:

1. Subsidization of railroad service,
2. Alternatives for cost reduction,
3. Alternatives for increased revenue,
4. Substitution of alternate freight transportation service,
5. Nontransportation alternatives, and
6. Combinations of the above alternatives.

These alternatives are discussed in some depth in another report (2). Rail users and government officials charged with the responsibility of dealing with rail line abandonment are encouraged to consider the full range of alternatives in their planning. The state railroad planning procedure established by Section 803 of the 4R Act is very appropriate to dealing with the analysis of alternatives throughout the transition period and to achieving stabilized local freight services in areas apt to experience abandonment.

CONCLUSIONS

The research reported here indicates that the matter of uneconomic light density railroad lines, when scaled to the perspective of the total railroad freight system, is of relatively little consequence. The agricultural sector merits special attention insofar as significant portions of the nation's agricultural traffic originate on uneconomic lines. However, there are a number of indications that the effects on agriculture can be satisfactorily diminished by minor adjustments in the logistics of transporting those products affected, particularly grain.

While the effects of light density line abandonments are small on a nationwide perspective, they may be important at the local level, where detailed analysis of various alternatives is needed to produce creative solutions and stabilized local freight services for the future. The state railroad planning established in Section 803 of the 4R Act provides the mechanism for such creative local planning and presents a challenge to state and local railroad planning officials.

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Analysis of Rail Line Abandonment Priorities

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Recent reorganization of railroads in the Northeast faced many kilometers of rail lines with service abandonment. The cost to the taxpayer of rail service continuation subsidies was judged to be "less than the cost of abandonment of rail service in terms of lost jobs, energy shortages, and degradation of the environment." Legislation provided federal funds and left the decision to individual states, who were required to submit state rail plans. This paper explains the process used by the New York State Department of Transportation to select analysis variables, importance weights, and impact indexes for establishing line abandonment priorities. Sensitivity testing and interpretations of the analysis are reported.

In 1970 the Penn Central Transportation Company declared bankruptcy. This failure, along with that of four other railroads in the Northeast and Midwest, created a unique and potentially dangerous economic situation, possibly affecting the entire country. To minimize the impact of these bankruptcies, Congress enacted the Regional Rail Reorganization (3R) Act of 1973. The act's major purpose was to reorganize the bankrupt railroads into one or more rail system(s) capable of meeting the rail service needs of the 17-state region at the lowest possible cost to the taxpayer.

Congress recognized from the outset that any attempt to reorganize existing railroads into a self-supporting system would mean large-scale abandonment of light density branch lines. To ease the impact of abandonment, Title IV of the 3R Act provided federal subsidies for a 2-year period to assist state and local governments either in financing the continuation of essential rail services for that period or in systematically phasing out services on lines not selected for reorganization.

Section 401 of the 3R Act emphasized that "under certain circumstances the cost to the taxpayer of rail service continuation subsidies would be less than the cost of abandonment of rail service in terms of lost jobs, energy shortages, and degradation of the environment." The act, however, left to the individual 17 states the decision of whether avoiding the negative social impacts of discontinuing rail service justified continuation subsidies. In December 1975 the New York State Department of Transportation's (NYSDOT) preliminary rail plan was presented, and, after a series of public hearings throughout the state, the final state rail plan was adopted.

As part of the planning process, it was essential that a procedure be developed for quantitatively comparing the potential social impacts—on lines, rail shippers, and communities—of lines threatened with discontinued rail service. Of the long list of variables suggested, five were ultimately selected—consumer costs, employment, tax effects, sales effects, and environmental effects—according to the variable's perceived importance by members of the rail planning staff and local officials, its ability to be quantified, and the availability of relevant data. Scaling and weighting techniques were then developed to pool the measures of satisfaction of the variables. Linear scaling was done by using statistical measures (mean and variance) of independent variables. A small sample survey was conducted to derive weights for pooling scaled values.

This paper briefly explains the process employed by the NYSDOT in selecting their variables, assigning the level of importance weights to them, computing a single "impact index" for each line, and ultimately ranking the lines by their respective impacts. Several hypothetical importance weights are then applied, and the resulting line priority implications are observed and discussed. Conclusions about this decision-assisting process, its sensitivity to values, and the proper interpretation of results are presented.

SOCIAL IMPACT ANALYSIS

When a rail line is abandoned, each of its users must choose one of three courses: using alternate means of transportation for commodities previously carried by the line, relocating to another site having rail service, or ceasing at least that portion of business involving use of rail service. Each user is influenced by many variables such as the availability and cost of the alternative compared to rail service at the user's original site, the availability of suitable alternate sites, the user's market area, the amount of investment required at a new site, and the profitability of the business (1).

Few commodities carried by rail could not in theory be transported by other modes. There are some notable exceptions, such as very large electric generators, transformers, and so forth, but movement of such commodities is relatively infrequent. Usually when a firm says they depend on rail for some portion of their transport needs, they really mean that the cost of using an alternative is prohibitively high.

In general, abandoning rail lines will leave former users with no direct transport facilities other than highways. In the past, some shippers faced with such a situation have elected to use trucks between the plant and an alternate rail station; others have diverted their traffic entirely to trucks for the full haul. In the former the added costs of the transfer between modes in terms of both time and money is an essential consideration.

It is the so-called rail-dependent firms that will either shut down or relocate in the event of rail service abandonment. A certain amount of managerial judgment is necessary in determining whether the costs of alternatives are tolerable for a given firm or not.

The method used to determine and analyze the impact of particular rail abandonments was based on individual rail customers' selecting of one of the three courses of action: going out of business, relocating, or switching to alternate modes. Each was asked for a probable decision, and the impacts of their replies were evaluated. No attempt was made to verify or second guess the actual decision or to screen out "survey sophisticated" responses.

Assumptions and Standards

Several assumptions were made to allow for consistent estimates and statewide comparison of the impact of alternate actions on each line.

1. Team Tracking. All rail users who indicated that they would use an alternate means such as trucking over the entire haul, piggybacking, or team tracking were grouped into the team tracking category. The location selected as the proposed team tracking facility was the nearest station on a rail line not threatened with service discontinuance.
2. Types of Commodities. For the analysis, several of the factors, such as shipping costs and transfer facilities, required an indication of the type of commodity being shipped. A general breakdown of bulk and nonbulk was selected. Bulk commodities include such materials as coal, stone, grain, and fertilizer; nonbulk commodities include lumber, furniture, and grocery goods.
3. Direct Versus Secondary Impacts. Local firms supplying materials or services to a plant that curtails operations or shuts down as a result of an abandonment will be affected according to the proportion of their business derived from the defunct firm. If such suppliers suffer significant enough losses, they may be forced to reduce the sizes of their work forces. This phenomenon is sometimes called the "multiplier effect" of business closings. Because time and reliable information did not allow for more than the development of a single typical multiplier, which would have entailed factoring each line in the analysis by the same value, quantifying this effect was not pursued.

Selection of Social Impact Factors

Many sources were used to initially draft the list of factors for consideration in the analysis. One such guide (2) was published by the Rail Services Planning Office (RSPO) of the Interstate Commerce Commission (ICC) on June 9, 1975. The criteria contained in the guide were only advisory and were not intended to be all inclusive or necessarily appropriate in all cases. Three general subject-oriented categories of factors—economic, social, and environmental—were presented for consideration. Under each of these three major factors, several basic factors and one or more elements for analysis or measurement were suggested.

Some of the factors in the guide were readily identifiable and measurable in generally accepted quantitative terms, while others would have been impractical, if not impossible, to satisfactorily define or identify, in quantitative terms. Although some of these factors and elements were redundant and lacked definite means of identification and measurement, RSPO's recommended factors provided a logical starting point for establishing a working set of criteria.

In developing the final set of criteria to be utilized in the state rail plan, the RSPO list of factors was screened to eliminate marginally significant factors and overlapping categories. Next, a second RSPO report (3) and another report (4) were used to identify those factors for which broadly accepted definitions and measures were available. The proposed criteria, impacts, and appropriate (and available) measures shown below are the result of this screening process.

Criterion	Impacts and Measures
Employment	Railroad employees
	Shipper employees
	Related service employees
Consumer costs	Transportation costs
	Competition effects
Taxes and community economics	Income tax
	Sales tax
	Property tax
	Corporate tax
Pollution	Energy use
	Air quality
	Aesthetics
	Traffic congestion
Community cohesiveness	Population shifts
	Urban and rural composition
	Land use or zoning disruption
	Public investment

Opinion Survey

The perspectives from which individuals would view these suggested criteria and the values they would assign to them were expected to vary considerably. For this reason, a survey of the planning staff and local officials was undertaken to gather opinions on (a) the relative importance of each type of criterion, (b) the definition of criteria or factors within a social benefit index, and (c) the most descriptive and feasible measures to use in quantifying those factors.

Each survey participant was asked to consider the nature and probable application of each of the five social impact factors and to assign it a percentage weight. The weights indicated how important they judged one factor to be in relation to the others. Zero weights were acceptable, and additional factors could be defined and added to the list. The sum of the weights assigned was to equal 100 percent.

Sixty-seven survey forms were returned, of which all but one contained usable responses. Of the 66 usable returns, 19 were from downstate (New York City area) and 47 from upstate. Forty-six forms were returned by state officials (both main office and regional); the remaining 20 were completed by local officials, people in industry, or members of various special interest groups. Importance weights as calculated for the entire survey group are presented below.

Factor	Weight (%)
Employment	31
Consumer costs	19
Tax effects (property and sales)	18
Environmental effects	12
Community cohesiveness	13
Other	7

The number of returns in the survey was quite small, and the sampling procedure was not controlled, so the statistical significance of the results could not be ascertained. Individual responses did vary, however, and there appeared to be patterns. For instance, downstate residents seemed to be more concerned with air pollution than upstate residents.

Quantification of Social Impact Factors

The five factors quantified in the analyses are consumer costs, employment, taxes, sales, and environment. The following is the formulation of the impact for each factor.

Consumer Costs

Those firms required by rail service termination to use an alternate means of transport will generally have to pay more for their raw materials and for shipping their goods. In all likelihood, this increase will be passed on to the consumer. This, then, must be considered a negative impact of rail service discontinuance.

To estimate the increased transport costs for firms switching to team tracking, three sources were utilized (4, 5, 6). The first report contained and referenced the basic operating and transfer costs per megagram by commodities; the second report related costs and distance to the team tracking facility; and the third contained information on shipping and transfer of bulk commodities. The application of these three reports yields the procedure shown below.

Case I. Change from private siding to team tracking facility

For bulk commodities the added cost is \$6.78 per Mg (\$6.15 per ton) times T plus \$0.12 per Mg-km (\$0.18 per ton-mile) times T times d, where T is the number of megagrams shipped, and d is the over-the-road distance difference between old and new loading location, in excess of 8 km (5 miles).

For nonbulk commodities the added cost is \$4.57 per Mg (\$4.15 per ton) times T plus \$0.05 per Mg-km (\$0.08 per ton-mile) times T times d.

Case II. Change of team tracking location

For all commodities the added cost is \$2.37 per Mg (\$2.15 per ton) times T plus \$0.05 per Mg-km (\$0.08 per ton-mile) times T times d.

Employment

Before predicting increases in unemployment, one must first predict the impacts of abandonment on rail users and probable action they will take. The numbers of employees in those firms going out of business were determined from the inventories cited. For those businesses that indicated reduced activity, a reduced number of employees was estimated.

Current rail users who indicated that they would use team tracking or trucking as a substitute for rail service (without a decrease in employment) might in fact create new jobs for truck drivers and truck helpers. Although this number is quite small, an estimate of these created jobs was made and included as a positive attribute, canceling some of the unemployment effects of closed businesses.

Local railroad job loss was determined to be insignificant in view of the dispersion of potentially affected lines and the labor protection provisions of the reorganization process. Estimating the number of jobs created by a switch to team tracking was based on the same references used in estimating the consumer costs (5, 6). The computation procedure follows.

Case I. Change from private siding to team tracking facility

For bulk commodities the added jobs are 0.170 jobs per 1000 Mg (0.154 jobs per 100 tons) times T plus 0.0014 jobs per 1000 Mg-km (0.002 jobs per 1000 ton-miles) times T times d, where T is the number of megagrams shipped annually, and d is the over-the-road distance differential between old and new loading location, in excess of 8 km (5 miles).

For nonbulk commodities the added jobs are 0.115 jobs per 1000 Mg (0.104 jobs per 1000 tons) times T plus 0.0014 jobs per 1000 Mg-km (0.002 jobs per 1000 ton-miles) times T times d.

Case II. Change of team tracking location

For all commodities the added jobs are 0.060 jobs per 1000 Mg (0.054 jobs per 1000 tons) times T plus 0.0014 jobs per 1000 Mg-km (0.002 jobs per 1000 ton-miles) times T times d.

Community Economics

The loss of business caused by discontinued rail service could affect revenue resources at all levels: reduced sales taxes from reduced buying, lost property taxes and corporate taxes from firms closing or relocating, lost income tax and higher unemployment in the area, and so on. A wide variety of types of variables could represent community economics. However, in view of the fact that the respondents in the opinion survey emphasized the importance of impact on community property and sales taxes (together with the various difficulties in creating reasonable estimates for other measures), only these two factors were included in the analysis.

For most communities, the most important and frequently the only significant source of tax revenue is the property tax. Any reduction in this tax base is likely to require a compensating increase in the property tax rate, which affects the entire community. The two direct tax sources affected by rail abandonment are property owned by the railroad and that owned by a present rail user who will close or relocate. Only the latter was considered in the analysis because of the varied status of rail lines relative to tax relief and debt accrual and because of the uncertain outlook for the future. Although federal subsidy could cover taxes, the state rail plan recommended that taxes be waived.

Lost property tax from rail discontinuance was estimated by identifying those current rail customers who would close or relocate out of state. For those firms, the assessed property value was recorded and multiplied by the local tax rate (7, Table 1). For each rail line the tax effects of these firms were then totaled.

In addition to effects on property tax, survey respondents indicated a desire to include a factor that would reflect the impacts of community sales lost as a result of losing local industries. The dollar value of potentially affected annual sales was selected as a substitute for the many and varied effects of industry on local economics that go beyond direct payroll and property taxes.

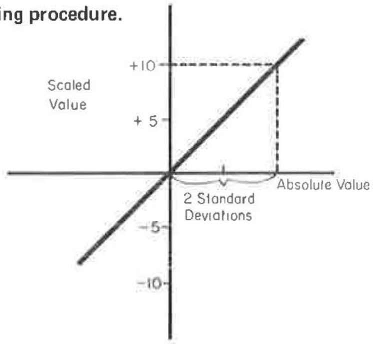
Lack of shipper information on annual sales made it necessary to approximate the measure from statewide relations among sales, type of industry, and number of employees (8, Table D-8). Sales losses were calculated by multiplying the payroll value of firms closing or leaving the state by the sales per payroll ratio as developed from the Statistical Yearbook. For each rail line the sales effects of these firms were then totaled.

Table 1. Statistics of measures for all lines compared with composite index for a single line.

Factor	All Sample Lines Combined		Composite Index for Single Sample Line		
	Mean	Standard Deviation	Actual Social Impact Value	Social Impact Value Scaled by Standard Deviations	Final Weighted Impacts
Consumer costs, $	81 650	77 000	4 968	0.32	0.06
Employment, no. of jobs	87	274	114	2.08	0.64
Tax effects, $	27 200	50 700	140 385	13.85	1.22
Sales effects, $	11 900	19 600	62 745	15.96	1.42
Environmental effects, kg	-2 082	2 159	1 607	-3.75	-0.42
Composite index					2.92

Note: 1 kg = 2.2 lb.

Figure 1. Scaling procedure.



Environmental Effects

Other impacts quantified in connection with a change in mode were energy use and environmental effects. The appropriate energy use measure is fuel consumption of rail versus the alternative. The environmental factors normally include air, noise, and water pollution. However, because noise and water pollution vary widely with project details, only air pollution was quantified. The amount of pollutants emitted is a direct function of the amount of fuel consumed; therefore air pollution from rail service versus team tracking was substituted for energy and environmental factors.

An estimate of the amount of fuel consumed by truck and by rail was obviously needed to calculate pollution. Truck fuel consumption was estimated by taking the number of rail cars needed to be team tracked from the existing station to the proposed team tracking facility multiplied by the number of kilometers between the two locations, multiplied by conversion factors of four trucks per rail car (9, Table 6) and 0.47 L/km (0.2 gal/mile) (10). The fuel consumed by rail was estimated by using the number of hours needed to service the rail line under existing conditions, the proposed future number of annual trips, and the factor of 45.4 L/h (12.0 gal/h) of fuel consumed by a locomotive (5). The following calculations for the round-trip, over-the-road distance (d) between the private siding and the new loading location were made.

1. Truck loads per year equal carloads (rail) per year times d times 4 trucks per carload (rail) times 0.47 L per truck-km (0.2 gal per truck-mile).
2. Locomotive loads per year equal hours per trip times trips per year times 45.4 L per locomotive hour (12.0 gal per locomotive hour).

Because the amount of air pollution is a direct result of the amount of fuel consumed, the difference between rail and truck emissions was also selected to indicate energy use from rail discontinuance. Pollution rates were taken from an Environmental Protection Agency (EPA) publication (10) using the locomotive sizes (3). The rates for trucks were taken from a supplement to the above EPA publication (11).

Other Factors

Other factors, such as community cohesiveness, were collectively assigned a weight of 20 percent, but no reasonable or available measures were proposed. As a result, these factors did not enter the impact index but remained important subjective input.

Development of a Single Impact Index

The computation of the impacts for each factor for each line resulted in the measures and statistics shown in Table 1. Since the measures are not similar, it is impossible to directly total them to determine a single net impact for each line. Therefore, it was necessary to first convert the measures to a common unit.

To arrive at a single index, we scaled each factor of each line according to the magnitude of its impact as compared to the impacts of all other lines. The means and standard deviations of all the impacts were calculated for each factor. Because of the enormous differences among impacts for each line, the standard deviations for each factor were atypically large—for example, that for tax effects among the various lines was approximately twice the mean. A relation was then established by which an impact of one standard deviation was equivalent to five units on the scale; a standard deviation of two, then, was given a scale value of 10. A zero impact read as zero on the scale, and the values on the scale were allowed to be both positive (social disadvantage from abandonment) and negative (social advantage from abandonment). Figure 1 shows the scaling relation, and Table 1 shows an example of how the scaled values of the variables are pooled into an impact index by using importance factors.

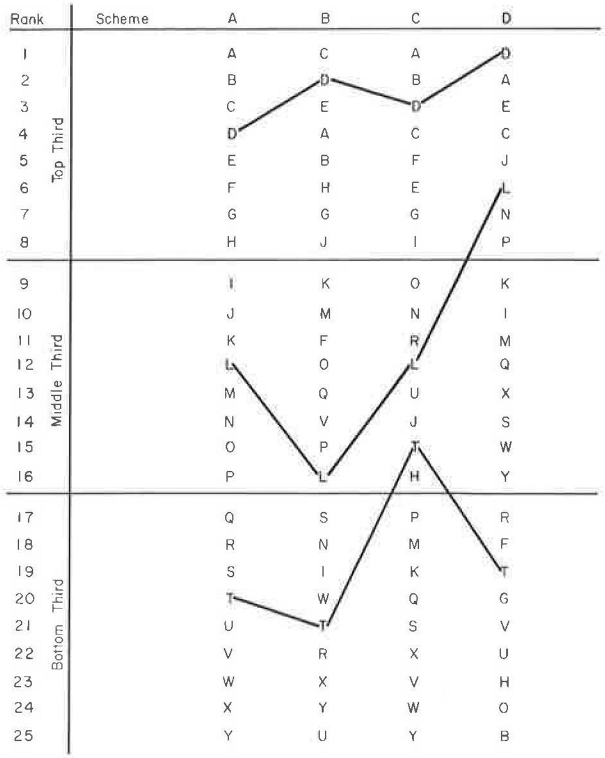
Applications

The results of the social impact analysis of rail line abandonment can be utilized in a number of ways. For example, we identified those rail lines whose abandonments would have no net negative social effects on the rail users and communities along the lines. This result might be useful in decisions on light density rail lines by the recent rail reorganization in the Northeast or in analyzing rail lines faced with service abandonment as a result of normal abandonment cases before the ICC.

A second result of the analysis is an indicator of the social benefits of each rail line relative to the others—an importance ranking. The lines with significant impacts can then be distinguished from other lines and ranked according to their perceived levels of importance based on the social impact factors and criteria weights used in the analysis.

A third significant and useful result of our work is the use of the social impact index to construct a benefit-cost index for each line. This index would include not only the

Figure 2. Ranking under various weighting schemes.



social impacts associated with each line but also an indication of the cost of maintaining the line. As used in the New York State rail plan, the benefit portion of the benefit-cost index was the index of avoidable social impacts. The cost factor was the operating subsidies needed to continue the line plus the rehabilitation costs for restoring the line to proper operating condition. For those analyses where only a short-term relation is desired, the long-term rehabilitation costs could be excluded. Selecting appropriate costs and time periods, however, is quite important and will obviously directly affect the benefit-cost index and consequently vary the ultimate priority ranking of the lines.

The benefit-cost index ranking will present a more cost-effective measure for using limited funding sources. For example, an investment into those lines with the highest benefit-cost index would be expected to yield the greatest return in avoiding social impacts per dollar invested. This guidance is particularly useful when money is not available for continuing rail service on all lines in question or for rehabilitating lines to higher standards or when manpower or equipment shortages reduce the ability to serve all lines.

TEST OF SENSITIVITY TO IMPORTANCE WEIGHTS

As previously mentioned, the results of the social impact survey tended to indicate but could not establish significant differences in category weights among the several subgroups of survey participants. Distribution of the survey was limited, and statistical conclusions were not possible. In all likelihood, however, a more rigorously controlled survey of special interest groups, such as environmentalists or rail users, would result in significantly different sets of weights. We tested the sensitivity of the ranking procedure, which utilized several different hypothetical weighting schemes, along with the actual results of the opinion survey.

The table below shows four distinct sets of hypothetical weights and their percentages of importance.

Factor	A	B	C	D
Employment	31	10	10	10
Consumer costs	19	50	10	10
Community economics	18	10	50	10
Environment	12	10	10	50

Set A contains the weights that were actually developed by a small survey and applied in the state rail plan. The others were chosen to emphasize individual factors. Twenty-five rail lines faced with possible service discontinuance as a result of the recent railroad reorganization process provided the data for the sensitivity analysis. For each line the composite social impact index was calculated from each of the four importance sets. Figure 2 depicts the results by comparing each hypothetical ranking with the survey-based ranking. To provide a perspective on the results, the list is broken into thirds, and the changing relative locations of several lines are traced.

RESULTS AND DISCUSSION

The results of the sensitivity tests showed that variations in the weights assigned to various factors can produce changes in the relative ordering of the actions or projects being considered. To what extent these changes are important depends on the intended application of the resulting list order. At one extreme, such a list might be used simply for administrative priority determination on a single action decision; at the other, each ranking on the list might indicate a different type or degree of action. It is not uncommon for an analyst to decide how to use the list and how to select appropriate critical rankings before actually applying the model to developing the list. One selected set of factor weights would then be developed and applied and the results accepted. However, the results of this particular research effort tend to imply that a slightly different, more cautious approach might be prudent.

Caution is necessary both in developing the factor weights and in viewing the resulting rank-ordered list. First, in order to properly define the importance weights, the analyst must have a good feel for the affected parties. This is particularly important if actual weights are to be ascertained by an opinion survey. If a decision on whether or not to subsidize rail freight services is actually going to be made, the analyst could choose to survey the shipper who would benefit from the subsidy, or the taxpayer who will have to share the burden of the subsidy program and who is generally conditioned to react negatively to added public burden and is not interested in or able to make trade-offs for the general welfare, or the responsible public officials who theoretically represent the consensus and appropriate balances.

With the participants chosen, an opinion survey can be administered, although it may be necessary to employ sampling techniques. Careful selection of participants and survey strategy is advisable. It is recommended that, for awareness and appreciation of the abilities and limitations of this type of structured decision-assisting process, the analyst take the time to create and analyze sensitivity tests for specific applications. Statistics on the distribution of responses observed in the opinion survey will prove useful here in selecting test input.

Finally, in addition to the ranking of potential actions or projects, the numerical value of the measure the ranking is based on can provide useful guidance and should not be disregarded. It would be difficult to defend cut-off points or subdivisions of the list based solely on ranks, particularly when it turns out that the cut-off point discriminates between actions that differ very little in terms of the numerical measure that forms the basis of the ranking. Moreover, the actual distribution of numerical values can provide support for the selection of cut-off points.

In this regard one should recognize the mode or modes of the distribution; their presence and location might assist the analyst in selecting the number of different treatments or types of actions, and the troughs between modes might prove convenient and defensible cut-off points for assigning treatments.

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Optimum Fleet Sizing in the Northeast Corridor

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The Regional Railroad Reorganization Act of 1973 mandated the U.S. Department of Transportation to undertake engineering and planning studies for improved passenger rail service in the Northeast Corridor. In order to obtain fleet estimates and to analyze the effects of management strategies a calculation of the optimum number of cars required for a design day service in the Northeast Corridor was undertaken. A linear programing model that determines fleet requirements for several different formulations of the objective function was formulated. Minimum fleet size was then calculated from a demand forecast based on the service standards prescribed in the Railroad Revitalization and Regulatory Reform Act of 1976. Minimum car-kilometers per day and maximum load factor were also found. The analysis indicated that the most heavily traveled portion of the corridor, Philadelphia to New York, might be better served by adding trains between these two cities.

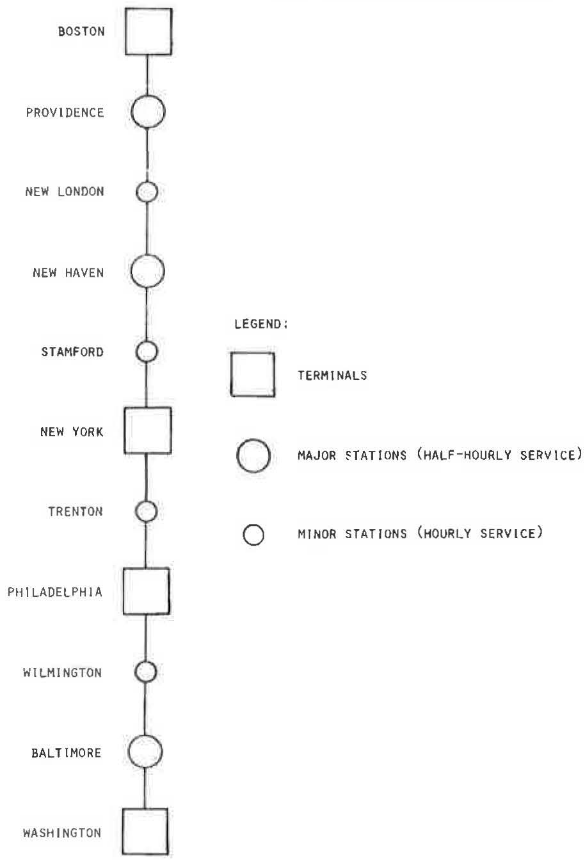
In 1973, Congress passed the Regional Railroad Reorganization (3R) Act. This complex piece of legislation dealt with passenger as well as freight operations and called for the U.S. Department of Transportation (DOT) to improve passenger rail service in the Northeast Corridor (NEC) as recommended in the 1971 Northeast Corridor Report. The NEC is defined as the rail line extending from Boston to Washington. It is 734 km (456 miles) long and crosses eight states and the District of Columbia. Included in the corridor are four major metropolitan areas: Washington, Philadelphia, New York, and Boston.

With the mandate of Congress, the Federal Railroad Administration (FRA) undertook several major studies to examine in detail

1. Ridership that might be expected with high-speed service,
2. Investment required to achieve high-speed service, and
3. Financial viability of the improvement project.

The Transportation Systems Center, supporting the Office of Northeast Corridor Development in FRA, provided the major analytical effort in the areas of financial analysis and demand forecasting. The results of these efforts, as well as those of the engineering studies, provided the necessary background for passage of the Railroad Revitalization and Regulatory Reform (4R) Act that was signed into law in February 1976. This legislation provides $1.9 billion for improving rail service between Boston and Washington and requires the following trip times by February 1981.

Figure 1. Terminals and major and minor stations in the NEC.



Time	Trip
1 h	Philadelphia to New York
2 h 40 min	Washington to New York
3 h 40 min	Boston to New York

In order to meet these deadlines, extensive improvement of the right-of-way will be undertaken. Track will be realigned and upgraded; bridge and tunnel structures will be modified. The New Haven to Boston segment of the right-of-way will be electrified, and the electrification system in the remainder of the corridor will be improved. Fifteen stations will be extensively renovated, and new equipment service facilities will be constructed. Finally, new rolling stock will be required for corridor service.

Financial analysis of the improved service required an estimate of the fleet size for each year of operation. It was assumed, for purposes of the financial analysis, that the required fleet was

$$\text{Number of cars in fleet} = (\text{annual passenger-kilometers})/[(\text{seats per car})(\text{load factor})(\text{annual car utilization in kilometers})] \quad (1)$$

There were two major shortcomings to this approach. It required an estimate of system load factor, and it did not consider the variation in patronage at different hours of the day, or on different days. It could therefore not determine if the proposed system would have enough equipment to meet demand peaks, nor was there a way to determine if certain trains would be filled to capacity, causing travelers to be turned away. The need for a more careful analysis of scheduling and fleet sizing led to the work described in this paper.

FLEET MANAGEMENT STRATEGIES

Proper fleet management results in reduced fleet size, lower operating costs, and increased ridership and deals with scheduling both of trains and of the units that make up these trains.

At present only conventional diesel trains operate on the nonelectrified portion of the corridor north of New Haven, while two types of service operate south of New Haven on the electrified portion: conventional trains and Metroliners. However, since conventional trains and Metroliners offer very different levels of service, the users are deprived of the benefits from the actual frequency of the trains over this northernmost portion of the corridor. Also, because the north is not electrified, travel between the southern and northern portions of the corridor often requires a time-consuming transfer at New York.

When electrification of the entire corridor is completed, a more integrated schedule will be possible, and more options will be available for fleet management. The following are some possibilities:

1. All cities can be treated alike, for example, the current situation in which conventional trains stop at all the cities along their routes;
2. More frequent service can be given to major cities, for example, half-hourly service to Washington, Baltimore, Philadelphia, New York, New Haven, Providence, and Boston and hourly service to Wilmington, Trenton, Stamford, and New London; and
3. Express and feeder systems can be established whereby local trains would stop at all stations along a segment of the corridor and transfer passengers to an express train at the first major corridor city.

All three strategies can be subdivided into those requiring a constant train length and those permitting cars to be added and deleted at one or more intermediate stops.

For the purposes of this study it was decided to begin by modeling the fleet management strategy that provides more frequent service to major cities and allows for modification of the train length at selected stops.

SYSTEM DESCRIPTION

Eleven cities along the NEC rail line are assumed to have improved service. Seven of these cities receive half-hourly service and the remaining four, hourly service. Figure 1 identifies the 11 cities and the level of service at each. In addition, it is assumed that train length can be modified at Philadelphia and New York as well as at the two end points, Washington and Boston. The switching points are referred to as terminals. The trip times required by the 4R Act include intermediate stopping times. Because the time gained by not stopping at a station is negligible (estimated at 1.25 min by the Engineering Division of the NEC Project Office), it is assumed that the skip-stop service has the same running time as the local service trains. There is a 20-min time requirement for reversing the direction of a car, which can be done at any of the four terminals.

The assumed uniform fleet with an average car capacity of 75 passengers corresponds to Amfleet equipment and allows one snackbar car for every four cars. Parlor car service is not considered.

All equipment is locomotive hauled with a maximum train length of 14 cars, not including the locomotive. Maximum train length is determined by the platform lengths planned for the improved system. If more than 14 cars are required to satisfy the projected demand, a second section will be added to the schedule. All deadheading is accommodated through the existing schedule.

MODEL FORMULATION

The system described above can be modeled by a transshipment network whose unit of flow is one car. In its simplest form, the network has one node for each potential arrival or departure time at each city. These nodes are connected by two types of directed arcs, storage arcs and train arcs.

Storage arcs connect each time node for each city to the immediately following time node; flow along one of these arcs represents storage of cars at a city during the interval between two times. Train arcs connect a time node in one city to a subsequent time node in a different city; flows along these arcs represent movement of cars in scheduled trains from one city to another.

Network flows must satisfy constraints of several sorts: flow must be conserved at every node (cars do not enter or leave the system); flows along train arcs must be great enough to meet demands; and all flows must be integer and nonnegative.

This network system may be transformed to an equivalent set of linear programing (LP) constraints. (LP is an efficient technique for computing an optimum solution.) In more precise terms, this is done as follows. First, define the relevant sets as

C = set of cities;

$T = \{0, \ldots, \tau - 1\}$ = set of time intervals into which the day (or other schedule period) is divided; and

$S \subset \{(c, t, c', t') \in C \times T \times C \times T \mid c \neq c'\}$ = schedule for which each element ($\in$ is "element of") represents a train that leaves city c at time t and arrives at city c′ at time t′.

Then represent the demands by

$d_{cc'}[t, t'] > 0$ = smallest (integral) number of cars required to meet demand for train $(c, t, c', t') \in S$.

Express the nodes of the network as

$A_c[t]$ for all $c \in C$, $t \in T$.

The directed arcs representing storage of unused cars (U) are then

$U_c[t]$: $A_c[t] \rightarrow A_c[(t+1) \bmod \tau]$ for all $c \in C$, $t \in T$.

The arcs representing movement of cars in trains (X) are

$X_{cc'}[t, t']$: $A_c[t] \rightarrow A_{c'}[t']$ for all $(c, t, c', t') \in S$.

The LP structural variables corresponding to each arc represent the flow over the arc as

$u_c[t]$ flow over $U_c[t]$ for all $c \in C$, $t \in T$, and
$x_{cc'}[t, t']$ flow over $X_{cc'}[t, t']$ for all $(c, c', t, t') \in S$.

The constraints on network flow are then expressed as in the following table.

Constraint	Expression
Conservation of flow	$u_c[(t-1) \bmod \tau] + \sum_{\{(c_1,t_1,c,t) \in S\}} x_{c_1c}[t_1,t] = u_c[t] + \sum_{\{(c,t,c_2,t_2) \in S\}} x_{cc_2}[t,t_2]$ for all $c \in C$, $t \in T$;
Satisfaction of demand	$x_{cc'}[t,t'] \geq d_{cc'}[t,t']$ for all $(c,t,c',t') \in S$
Nonnegativity	$u_c[t] \geq 0$ for all $c \in C$, $t \in T$
Integrality	$u_c[t]$ integer for all $c \in C$, $t \in T$; $x_{cc'}[t,t']$ integer for all $(c,t,c',t') \in S$

Satisfaction of demand ensures nonnegativity of the x variables.

Given that all $d_{cc'}[t, t']$ are integers, a fundamental property of transshipment problems guarantees that every basic solution to the above LP is an integral solution. Consequently, a feasible solution to the above problem—and hence a feasible allocation of cars to trains—may be determined directly by application of the (phase 1) simplex method. Given any linear objective function, the simplex method will also find the most feasible allocation. Objectives of special interest follow.

Capital Cost

The daily cost of amortizing the passenger-car fleet, here referred to as the capital cost, may be considered proportional to the number of cars in the fleet. Hence, minimizing fleet size is equivalent to minimizing capital cost. A linear expression for this objective is

$$Z_{CAR} = \sum_{c \in C} u_c[\tau - 1] + \sum_{\substack{(c,t,c',t') \in S \\ t' < t}} x_{cc'}[t,t'] \qquad (2)$$

This expression counts the number of cars in the system during the last interval of the day. The first sum represents the number of cars in storage during the interval, while the second represents the number in trains that are running at that time.

Operating Cost

Cost proportional to the number of car-kilometers run in a day, here called operating cost, is another logical candidate for minimization. Letting the distance from c to c′ be $m_{cc'}$, total car-kilometers per day equal the linear form

$$Z_{KM} = \sum_{(c,t,c',t') \in S} m_{cc'} x_{cc'}[t,t'] \qquad (3)$$

Load Factor

Given fixed demands, it is reasonable to try to maximize system load factor in order to minimize the cost of providing service. By definition, system load factor is Z_{LF} = (passenger-kilometers/day)/(seat-kilometers/day) = [(passenger-kilometers/day)/(seats/car)]/(car-kilometers/day). Since both passenger-kilometers per day and seats per car are fixed by the problem, Z_{LF} is inversely proportional to car-kilometers per day equals Z_{KM}. Hence, minimizing operating costs is equivalent to maximizing the system load factor.

Many desirable extensions and refinements of this model are presented in full detail in Fourer (1). Variations on the network permit the number of nodes to be greatly reduced and make possible a distinction between northbound and southbound trains. Techniques for optimizing two or more objectives sequentially or in combination are also developed.

BASE RUN DATA

A hypothetical case representing service on a busy day in 1982, the first full year of improved service, was chosen for analysis. Annual patronage for 1982 was calculated by using a computer-based model (2) developed by Peat, Marwick, Mitchell and Company (PMM). The input data were those derived from PMM's base assumptions, with the exception of trip times, which were increased to reflect trip times required by the 1976 4R Act.

PMM's model estimated annual two-way patronage for individual station pairs in the NEC. Annual one-way patronage was computed by halving the two-way figures. A few possible station pairs were omitted, either because they could not be separated from other pairs or because competitive commuter service is available for their travelers. All of these excluded pairs are short in distance and are deemed relatively insignificant to corridor service.

The base run modeled patronage for a design day calculated as 1/270 of the annual amount. This concept of design day, representing approximately the tenth busiest day of the year, has been employed before in engineering studies of the NEC. Note that the fleet size determined by the model represents only those vehicles required for scheduled service. Additional units will be needed to accommodate maintenance requirements.

To derive the patterns of demand between station pairs over a day, the base run employed a set of cumulative demand functions. Following a PMM study method (3, pp. C.7-C.14), demand for service from a larger station to a smaller one was taken to be departure based (that is, dependent on the time of departure), while demand for service from a smaller to a larger station was arrival based (dependent on time of arrival). Demand between cities of comparable size was determined by averaging arrival-based and departure-based distribution functions. The demand distributions employed in the base run were bimodal Gaussian-like probability distributions fit to actual arrival and departure counts for Tuesday, May 21, 1974.

SOLUTION

The base run formulation was solved and analyzed by using the SESAME interactive linear programing system and supporting computer routines. The values of the objectives at their optimums for the base data were found to be min Z_{CAR} = 164 cars, min Z_{KM} = 211 400 car-km/day, and max Z_{LF} = 74.15 percent.

The next step was to minimize total operating and capital cost of the base model, expressed as

$$P_{CAR} Z_{CAR} + P_{KM} Z_{KM} \quad (4)$$

where

P_{CAR} = capital cost per car/day,
Z_{CAR} = number of cars in the system,
P_{KM} = operating cost/car-km, and
Z_{KM} = car-km/day.

The properties of an optimum solution depend on the value of P_{CAR}/P_{KM}, the ratio of capital cost per day to operating cost per kilometer. For the base data, there are three significantly different regions into which this ratio may fall.

1. Capital cost per day ≥ 724 (operating cost per kilometer). Here capital cost dominates; in any optimum solution the number of cars is at its absolute minimum, 164. The minimum number of car-kilometers per day, given 164 cars, is 218 800; the system load factor (which is inversely proportional to total car-kilometers) is 71.65 percent.

2. 724 (operating cost per kilometer) ≥ capital cost per day ≥ 290 (operating cost per kilometer). At this level the influence of capital cost declines somewhat. The number of cars in an optimum solution increases to 167; car-kilometers per day decline to 216 700 (system load factor is 72.37 percent).

3. Capital cost per day ≤ 290 (operating cost per kilometer). Here operating cost dominates. In an optimum solution, car-kilometers per day is at its absolute minimum, 211 400 (system load factor is 74.15 percent), while the number of cars in the system increases to 185.

The results are shown graphically in Figure 2. Clearly, the biggest jump is at the critical ratio P_{CAR}/P_{KM} = 290, the round-trip distance between New York and Philadelphia. At ratios below this point, buying an extra car is economical even if it saves just one New York to Philadelphia run. At higher ratios it pays to buy a smaller fleet, running each car (on the average) more kilometers every day. The magnitude of the jump—about a 10 percent difference in fleet size—is not surprising. Demand is heaviest along the New York to Philadelphia segment and is highly unbalanced: northbound travel peaks in the morning; southbound demand is highest in the afternoon. Consequently, a fair amount of deadheading can be avoided if a larger fleet is available. An examination of the passenger load on the three links in the network revealed that modifying the schedule to have some trains run only between Philadelphia and New York would accommodate projected demand and eliminate excessive switching at these points.

The other jump, at P_{CAR}/P_{KM} = 724, represents a point at which the cost of a car equals the cost of running it from New York to Washington and back. This is a fairly insignificant critical ratio, however, as the optimum at ratios below 724 requires only three cars more than the optimum above 724.

Several estimates of the actual P_{CAR}/P_{KM} are plotted against the critical ratios in Figure 3. The estimates suggest that P_{CAR}/P_{KM} probably falls into region 1 and, hence, that capital cost probably predominates. Moreover, if the ratio is not in region 1 it would very likely be in region 2, where the optimum solution is not very different.

OTHER ANALYSES

A number of additional analyses were conducted by using the base model and data. These have been described fully elsewhere (1) and can be summarized as follows.

Sensitivity to Demand

Alternative estimates of demand were derived through scaling the base patronage estimates by a constant factor; nine factors, ranging from 0.7 to 1.3, were chosen. Optimum solutions were calculated for each alternative demand estimate. It was found that both the minimum fleet size and the minimum number of car-kilometers that must be run with a minimum fleet were roughly proportional to total patronage over the range of factors chosen: min $Z_{CAR} \approx 0.0000103$ (total annual patronage); min $Z_{KM} | Z_{CAR} \approx 0.0138$ (total annual patronage).

Minimizing Turnaround

Using an expanded version of the model that distinguished northbound and southbound trains, we could minimize turnaround (changing car directions at terminal stations). Analysis of the optimum solution suggested that many cars are needed only for the Philadelphia to New York segment to satisfy peak demand northbound in the morning and southbound in the afternoon. This suggests a revised schedule in which New York to Philadelphia shuttle trains, in addition to the usual through trains, are run at peak hours.

Locomotive Requirements

Operating under simple assumptions, the model may be adapted to analyzing requirements for locomotives as well as for cars. We determined for the base data that a single solution minimized both the number of locomotives (31) required and the number of locomotive-kilometers (54 840) run.

FUTURE WORK

Many more sophisticated sensitivity analyses are conceivable if one allows patronage between different station pairs to vary at different rates. Other parametric studies include changing car capacity, altering turnaround time, and modifying train size limitations. Schedules can also be modified.

In addition, other fleet management strategies (several have been mentioned above) should be investigated in similar fashion and comparisons drawn. The present linear programing formulation is not capable of handling the more sophisticated express-feeder arrangement. It is likely that there is a suitable integer programing formulation that would, however, require different optimization techniques.

Finally, it should be noted that, although the model has been formulated for NEC operations, the same technique could be applied to other portions of the Amtrak system.

Figure 2. Cars and car-kilometers when total cost is minimized.

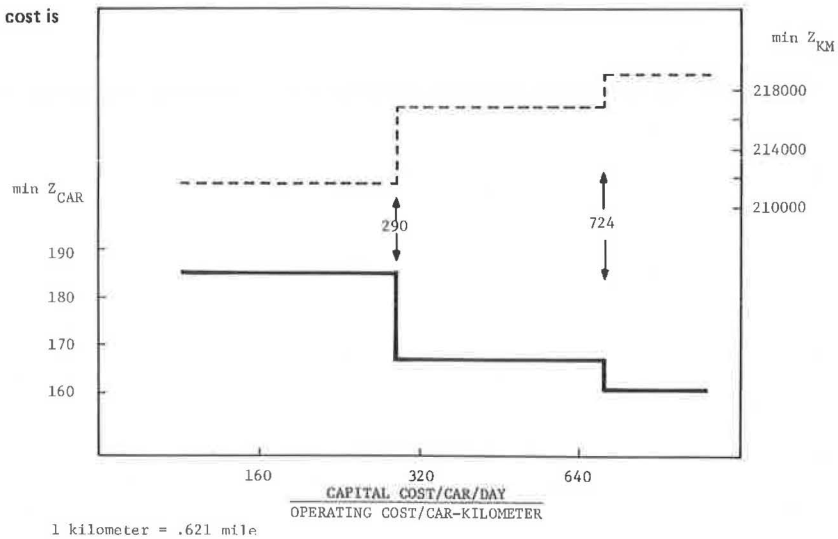
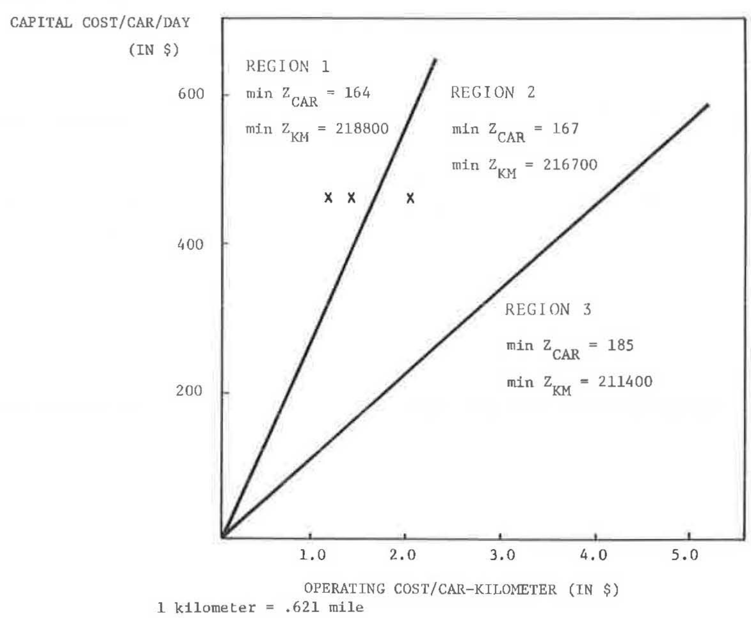


Figure 3. Three solution regions plotted as a function of capital cost per day and operating cost per kilometer.



ACKNOWLEDGMENTS

This study was performed under the Transportation Systems Center's Northeast Corridor Passenger Project Support Program, sponsored by the Northeast Corridor Project Office. A detailed description of the formulation of the linear programing model is contained in Fourer (1), whose second volume is a User's Guide for the model. The model formulation and programing were performed at the National Bureau of Economic Research. Walter Messcher and Alan Wellington of the Transportation Systems Center derived and estimated the demand distributions.

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Computer Methods in Blocking and Train Operations Strategies

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This paper presents a set of computer-aided methods for developing blocking and train operations strategies for railroad networks. These methods are iterative processes in which complex, judgmental decisions are made by experienced railroad operators and extensive, repetitive calculations are performed by a computer. By using these methods, railroad operators can compare the consequences of various blocking and train operations strategies in terms of such measures as car switching, yard loading, block size, car-kilometers, ton kilometers, train-kilometers, and the like, which are calculated by the computer; operators can then develop efficient blocking and train operations strategies.

The blocking and train operations strategies currently used by various railroad companies have taken years of professional experience, judgment, and knowledge to develop. However, because of mergers, railroad networks have become increasingly extended and complex, and network conditions and demand patterns have been changing continuously. Blocking strategies thus tend to lag behind the real-world situation by even a year or two and create a need to be constantly reviewed and revised.

One outstanding example of such a need occurred recently when Congress charged the U.S. Railway Association (USRA) with the responsibility of developing a systemwide operating and management plan for the rail operations of the Consolidated Rail Corporation (Conrail). A key element of USRA's approach to this problem was to develop detailed schemes for blocking railroad cars and forming trains, as well as for routing and scheduling these trains within the network both on rail lines and through the yards.

To get some idea of the magnitude of the problem, consider the following statistics about the Conrail network. It has about 32 200 km (20 000 miles) of track, part of which is double; it handles approximately 40 000 cars per day, including both loaded and empty cars; and it has 500 to 600 distinct origins and destinations (actually many more when considered in detail). With such a large network and so much activity, it is obviously exceedingly difficult and laborious to analyze and develop blocking and train operations strategies purely manually.

On the other hand, the interrelations among the demand patterns, the car blocking, the train routing, and the constraints on rail tracks and yards are inherently so complex that the logic of forming blocks and trains cannot realistically be stated in sufficiently concrete steps for purely automatic generation of blocking and train operations strategies. Consequently, USRA needed a method by which complex judgmental decisions could be made by experienced railroad operators but the extensive and tedious calculations would be performed by a computer.

The resulting method, the subject of this paper, was developed by a team of researchers from USRA and Stanford Research Institute (SRI) and was used extensively in developing both the preliminary and the final plans for the Conrail system. However, because the method and the computer programs described in this paper are so general, they have also successfully been used to analyze and develop suitable blocking and train operations strategies for other railroad networks.

STATEMENT OF THE PROBLEM

In its basic form, our blocking and train operation problem can be stated as follows: Given a railroad network in terms of the origin-destination (O-D) nodes (yards) and the connecting links (tracks) and given the O-D demand data on railroad cars, we wanted to develop an efficient blocking and operations strategy for the movement of railroad cars.

Unfortunately, no single criterion of efficiency can be realistically defined for comparing various alternatives. However, operators used the following typical attributes of blocking and train operations strategies to compare various alternatives:

1. Total number of car handlings the system has;
2. Number of times cars are switched before reaching their destinations;
3. Number of cars that are switched at various nodes;
4. Number and sizes of the blocks that are made at various yards;
5. Total train-kilometers, car-kilometers, train hours, car hours, and ton kilometers there are on a per day basis; and
6. Number of trains per day, cars per day, tons per day there are on various links.

By studying such measures as those noted above, experienced operators can develop an efficient blocking and train operations strategy after a few iterations. It is, of course, possible to translate the above attributes into a common set of units, for instance, delays or costs. However, defining suitable equivalent delays or costs for various attributes is quite a difficult task and may even be misleading, because certain attributes cannot realistically be treated on an equivalent basis. We therefore calculated the various measures individually and used them as a set of criteria for comparing various alternatives.

METHODOLOGY

For a given network and O-D data, there are two approaches for developing blocking and train operations strategies: (a) the blocking strategies are developed for all nodes simultaneously, and the resulting blocks are then combined to form trains; (b) the blocking strategies are first developed for the extremity nodes, which generally do not have any transit traffic, and then trains from these nodes are designed to carry the developed blocks to the various destination nodes. Blocking strategies are then developed for the set of nodes next to the extremity nodes.

The blocking strategies for this second set account for any cars sent to these nodes from the extremity nodes for further movement. Trains are then developed from this next set of nodes to carry the designed blocks to the respective destination nodes. This process of developing blocks and then trains at a small set of nodes at each stage is continued until all the cars have been moved to their destinations.

The advantage of the first approach is that a significant amount of information related to system car handlings, block sizes, and yard loadings becomes available during the first stage. The second stage then provides the information related to train-kilometers, ton kilometers, and the like (although our program was based on the mile). In the second approach this information becomes available in partial steps, and the whole process has to be completed before systemwide data can be established.

In view of the advantage mentioned above and the ease with which the process can be computerized, the first approach was selected by the SRI-USRA team to develop the strategies. Figure 1 indicates the overall logic and interrelationship of the blocking strategy analysis and development process. Figure 2 indicates the overall logic and interrelationship of the train operations analysis and development process. The following steps are associated with the development of blocking and train operations strategies. (It should be noted here that all the calculations were carried out in customary, rather than metric units; these have not, then, been converted, but metric equivalents have been noted where applicable.)

1. A suitable representation of the railroad network was prepared. For example, to develop the preliminary system plans, the bankrupt railroad network in the Northeast and Midwest was represented by 147 nodes, 23 junction points, and 246 links. Later, a more detailed representation with 494 nodes and 650 links was developed to conduct more detailed analyses and to develop the final system plan.
2. An O-D table giving average daily traffic between pairs was prepared.
3. The designer manually prepared a preliminary blocking strategy, based on experience and on study of the network and the O-D table, for each node. In a later version of the program, a preliminary blocking strategy, based on some heuristic rules, was generated automatically. Specifying the blocking strategy for each node includes (a) the destinations of various blocks to be made at the node and (b) the destinations of other groups of cars to be included in each block. For example, the designer may specify that at node 1 he or she wishes to make a block destined for node 53, containing cars for nodes 53, 54, 74, and 89; another block destined for node 87, containing cars for destination nodes 87, 90, 91, and so forth. All destinations are to be accounted for. Note that the designer need only specify the destination of the nodes included in each block. The actual number of cars in each block is automatically calculated by a program based on the O-D table, as discussed below. The details of the exact format for specifying blocking strategy are explained elsewhere (1, 2).
4. The specified blocking strategies for all the nodes are put into the blocking strategy analysis program, which uses the specified strategies along with the O-D file stored in the computer. The program is designed to calculate the number of cars in each block by adding not only all cars originating at the node for the destinations included in the block but also all the cars sent to the node by other nodes through the specified strategy. The specifications of blocking strategies for each node in combination with the O-D table uniquely determine several operating characteristics through simple mathematical relationships, such as number of car switchings at each node, number of cars switched how many times, block sizes made at each node, and total system switchings. These data are used to analyze the proposed blocking strategy. The program also generates and stores a block file in the computer to be used with train formation and a road statistics analysis program. The designer can modify the blocking strategy by using an editing program and can rerun the program many times to accomplish a satisfactory strategy.
5. After a few iterations, when the blocking strategy has been refined to the satisfaction of the designer (the yard loadings are satisfactory; the number of car switchings is acceptable; and the block sizes are satisfactory), he or she manually combines various blocks generated by the proposed blocking strategy into trains and specifies a route for each train. The designer may also specify the departure time of each train. The formats for specifying these data are included in our other papers (1, 2).
6. These manually generated routing and departure time data are then applied to the train formation and road statistics generation program. Specification of the train composition (blocks in each train) and routing in combination with network details (link length in miles or travel times) uniquely determines several operational characteristics through simple mathematical relationships, for example train-miles, car-miles, ton miles, and trains per link. These operational characteristics are used to analyze the proposed train formation and routing strategies. The designer can modify the composition, routing,

and scheduling of trains and can rerun the program many times to accomplish a satisfactory set of trains.

Completion of the above steps results in a set of blocking tables and trains for each yard that is realistic because it has been defined by experienced designers and is efficient because the various performance attributes calculated by the computer have been used by the designers to select the strategies. In a related effort, a detailed yard simulation program (1, 3) was also developed and used to study the yard operations in finer detail; this ensured that the loadings imposed on various yards as a result of the selected blocking strategies were feasible.

EXAMPLES OF PROGRAM OUTPUTS

As indicated earlier, the computer programs associated with blocking and train operations strategies calculate several performance attributes for these strategies specified by the designer. Examples of several outputs are presented for content and format, and those discussed under car handling and blocks and block sizes below are produced by the blocking analysis program; those discussed under block routing and train and link statistics are produced by the train analysis program.

Systemwide Car-Handling Output

Systemwide car-handling output gives the total number of cars switched and how many times. It also gives the total number of system switchings and the total number of switchings in all intermediate yards. These systemwide figures are very helpful in comparing blocking strategies quickly on a systemwide basis. A sample output is shown in Figure 3.

According to this figure 6774 cars were handled once (either once at the origin or once at the destination); 13 176 cars were handled twice (once at the origin and once at the destination); 13 752 cars were handled three

Figure 1. Blocking strategy analysis and development process.

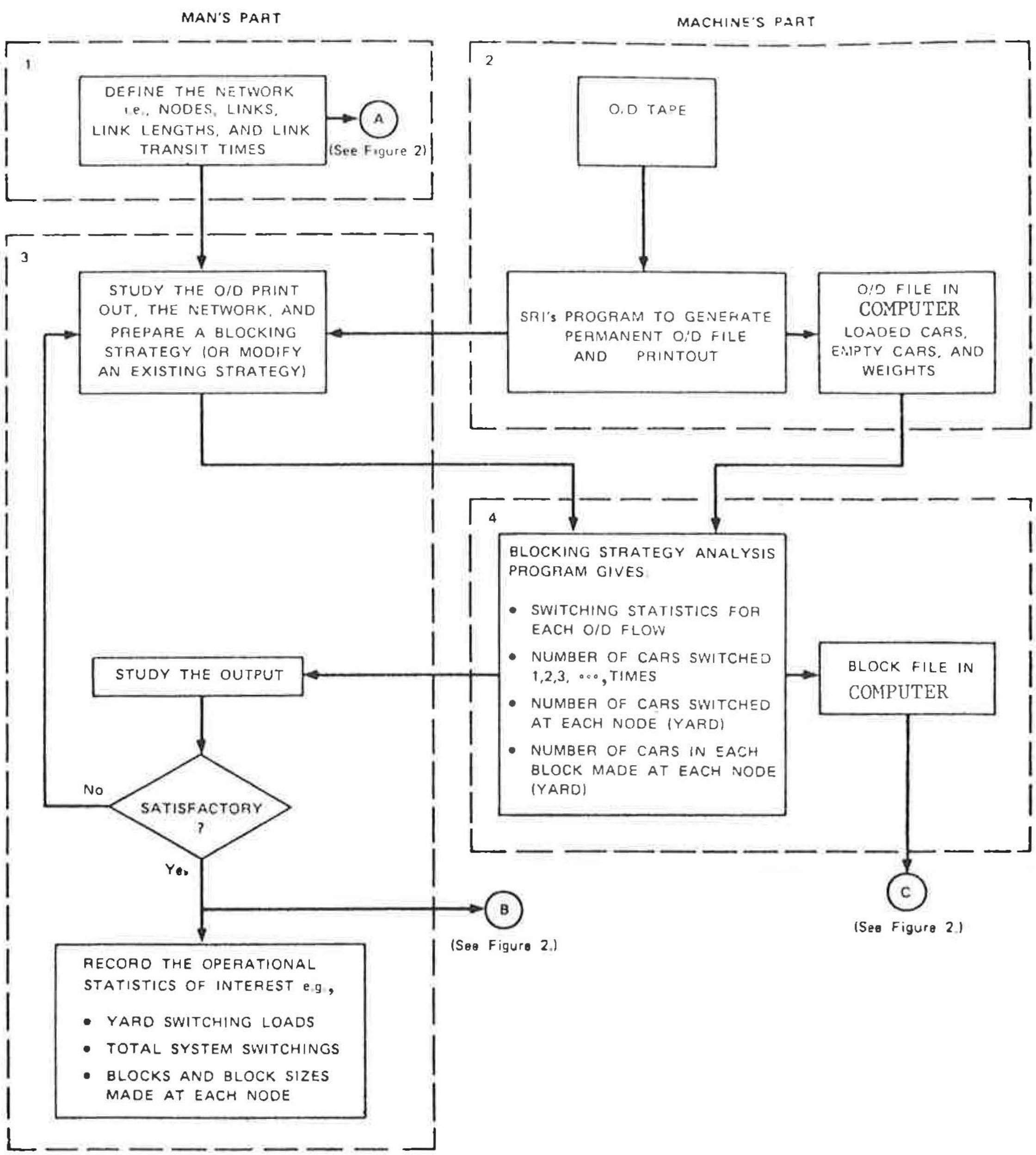
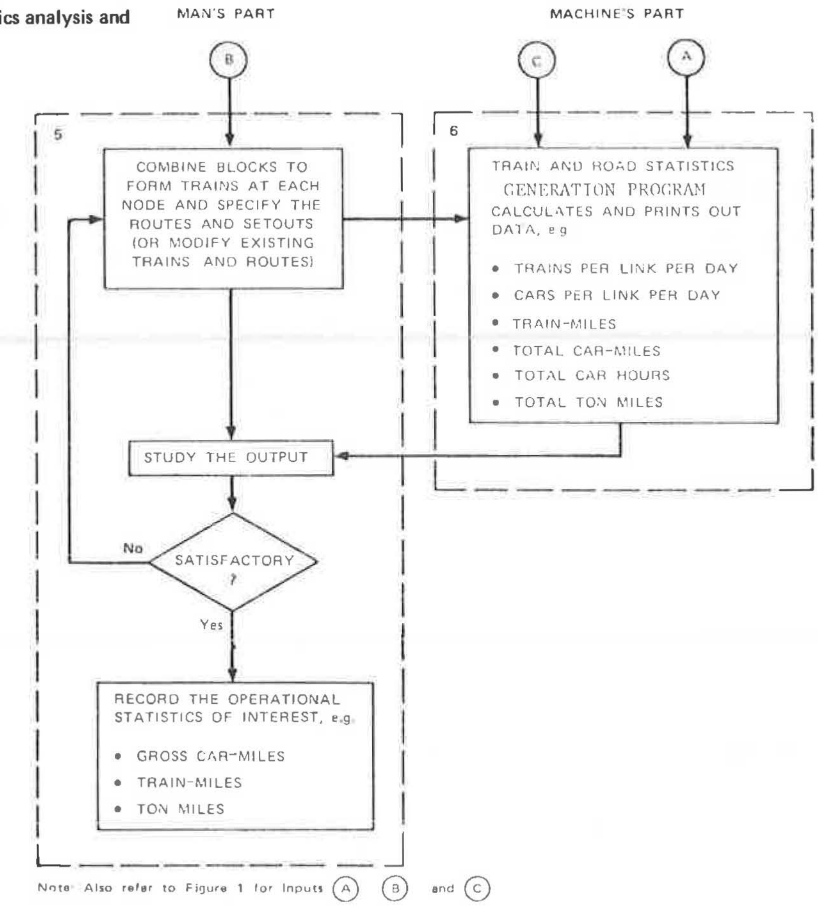


Figure 2. Train and road statistics analysis and development process.



times (once at the origin, once at an intermediate yard, and once at the destination), and so on. The total handlings, 90 576, is the sum of 6774 + 2 (13 176) + 3 (13 752) + 4 (3730) + 5 (250) + 6 (4). The total excess handlings, 21 978, is the sum of 13 752 + 2 (3730) + 3 (250) + 4 (4) and gives the total number of intermediate yard car handlings not including the handlings at the origin or destination.

Individual Flow-Handling Output

This output gives the number of times cars are handled (switched) before reaching a destination from various origins. The program is designed to print any selected data specified by the designer. Figure 4 shows a portion of the flow-handling output associated with destination nodes 32, 33, 34, 35, 36, and 37. It is assumed that cars are handled once at the origin node, once at the destination node, and once at each intermediate node (yard). Thus, considering the flows associated with destination node 35 (Grandview), all cars from node 3 destined for node 35 are handled once at node 3, once at intermediate node 34, and once at destination node 35. The numbers (Figure 4) in the columns give the products of the numbers of cars times the number of handlings. The 21 cars from nodes 3 to 35 are handled three times; therefore, the number of car handlings from this flow is 63, as indicated. Similar remarks apply to other flows.

From this output, the designer can spot flows that are handled too many times. For example, referring again to Figure 4, the flows from node 58 to node 35 are switched at three intermediate nodes, at nodes 57, 49, and 34, before reaching node 35. The designer may wish to improve his or her strategy by checking the blocking strategies for nodes 34, 49, and 57.

If the designer does not want a switching count at certain yards (in case the block is being delivered to an interchange yard to be switched by other railroads), he or she may specify the node numbers of all such yards as inputs to the program. The program will not count switchings at all these specified yards. Exact details of this feature are explained in the user's manual for network analysis computer programs (2).

Yard-Loadings Output

This output gives the number of cars handled at each yard as a result of the prepared blocking strategy. Displayed are the numbers of inbound cars, outbound cars, local cars, and cars in transit, and the total number of cars switched at every yard. A breakdown of loaded and empty cars is also indicated, as well as the weight in tons. A sample output showing the loadings for some selected yards is given in Figure 5.

Blocks and Block Sizes Output

This output is one of the most useful. It gives a list of all the blocks made at each node, together with the number of loaded and empty cars and total weights. A sample output showing blocks made at nodes 1 through 5 is given in Figure 6. This output gives the designer a complete picture of block sizes, contents, and weights for each node resulting from his or her proposed strategy. Some blocks may be found to contain too many or too few cars. If so, the designer can then revise his or her strategy on the basis of this information and rerun the program until satisfactory block sizes have been formed.

Block-Routing Review Outputs

These outputs are intended basically to help the designer find out if the complete movement of each block has been specified correctly (for instance, if some blocks were overlooked or some were set out but not picked up). Because of the large number of blocks involved, say, around 2000 blocks in the network under consideration, and the hundreds of trains to be specified, it almost always happens, particularly in the first go round, that

Figure 3. Sample output of systemwide car handling.

CAR HANDLINGS FOR STRATEGY CONRAIL 2A-85			12 FEB 75			
TOTAL CARS HANDLED 1,2,3 TIMES	6774	13176	13752	3730	250	4
TOTAL HANDLINGS =	90576					
TOTAL EXCESS HANDLINGS =	21978					

Figure 4. Sample output of flow handling.

FLOW HANDLINGS FOR STRATEGY CONRAIL 2A-85 12 FEB 75 75/05/08. 10.10.12.

DESTINATION	ORIGIN	LOADS	EMPTIES	CARS	CARS*HANDLINGS	---INTERMEDIATE YARDS---
32 DAYTON	32 DAYTON	1	15	16	16	
33 SPRINGFIEL	30 SHARONVILL	29	54	83	166	
	33 SPRINGFIEL	0	3	3	3	
34 BUCKEYE	34 BUCKEYE	0	5	5	5	
35 GRANDVIEW	3 FXERMONT	10	11	21	63	34
	12 CHICAGO	38	8	46	138	34
	14 COLHOUR	5	17	22	44	
	30 SHARONVILL	22	18	40	80	
	35 GRANDVIEW	53	28	81	81	
	39 STANLEY	4	34	38	76	
	50 FAIRLANE	1	25	26	52	
	58 GATEWAY	5	0	5	25	57 49 34
	61 ASHTABULA	1	14	15	45	51
	62 ERIE	1	11	12	48	60 51

Figure 5. Sample output of yard loadings.

YARD LOADING FOR STRATEGY CONRAIL 2A-85 12 FEB 75 75/05/08. 10.10.12.

		INBOUND				OUTBOUND				LOCAL				TRANSIT				TOTAL			
		LOAD	EMTY	CARS	TONS	LOAD	EMTY	CARS	TONS	LOAD	EMTY	CARS	TONS	LOAD	EMTY	CARS	TONS	LOAD	EMTY	CARS	TONS
1	ROSFLAKE	285	112	397	24475	134	93	227	15009	3	9	12	581	165	124	289	18969	587	338	925	59034
4	PARIS	21	64	85	4115	35	19	54	4011	2	17	19	648	65	115	180	9669	123	215	338	18703
5	TERREHAUTE	35	58	93	5220	56	51	107	6023	1	20	21	722	7	1	8	624	99	130	229	12594
10	AVON	53	150	203	9036	89	74	163	8730	1	5	6	232	1362	1135	2497	134052	1505	1364	2869	157050
11	HAWTHORNE	172	230	402	23385	177	255	432	20673	27	207	234	9962	89	67	156	9399	465	759	1224	63419
12	CHICAGO	167	196	363	27722	1529	662	2191	142330	3	85	88	2832	90	62	152	13244	1789	1005	2794	181128
13	CHICAGO59	189	268	457	24028	99	130	229	10979	0	56	56	1680	1	3	4	214	289	457	746	36901
14	COLHOUR	159	117	276	16616	151	153	304	19293	0	82	82	2464	0	0	0	8	310	352	662	38381
16	ELKHART	108	95	203	12924	86	181	267	11661	1	22	23	756	1160	1297	2457	126822	1355	1595	2950	152163
19	LOGANSPORT	63	62	125	7815	46	74	120	7029	3	32	35	1166	28	6	34	2605	140	174	314	18617
20	MARION	53	97	150	8881	128	44	172	8659	2	12	14	560	48	41	89	5284	231	194	425	23384
21	ANDERSON	73	57	130	8488	69	59	128	6274	4	5	9	604	5	4	9	659	151	125	276	16025
23	KALAMAZOO	72	53	125	8605	75	65	140	6691	1	20	21	684	37	26	63	3617	185	164	349	19597
25	JACKSON	119	64	183	10358	66	96	162	7442	2	50	52	1633	81	127	208	10208	268	337	605	29641
27	FT.WAYNE	80	81	161	9090	87	77	164	10338	8	56	64	2368	0	1	1	30	175	215	390	21826

Figure 6. Sample output of blocks and block sizes.

BLOCKS AT EACH ORIGIN FOR STRATEGY CONRAIL 2A-85 12 FEB 75 75/05/08. 10.10.12.

ORIGIN	DESTINATION	CARS	TONS	LOADS	EMPTIES
1 ROSFLAKE	1 ROSFLAKE	409	25061	288	121
	2 MADISON	4	138	0	4
	3 EXERMONT	5	206	1	4
	4 PARIS	13	615	4	9
	5 TERREHAUTE	38	2481	17	21
	10 AVON	50	2820	24	26
	11 HAWTHORNE	82	3511	21	61
	12 CHICAGO	51	5783	41	10
	16 ELKHART	40	2403	20	20
	34 BUCKEYE	19	1054	7	12
	39 STANLEY	16	691	9	7
	51 CLEVELAND	10	428	4	6
	66 CONWAY	80	5142	54	26
	98 ALLENTOWN	44	3325	41	3
	124 DEWITT	36	3589	30	6
	130 SELKIRK	27	1781	25	2
2 MADISON	1 ROSELAKE	155	8195	66	89
	2 MADISON	319	12184	74	245
	10 AVON	65	2662	14	51
	34 BUCKEYE	35	1668	10	25
	39 STANLEY	45	1587	5	40
	66 CONWAY	31	1709	18	13

Figure 7. Sample output of block routing review.

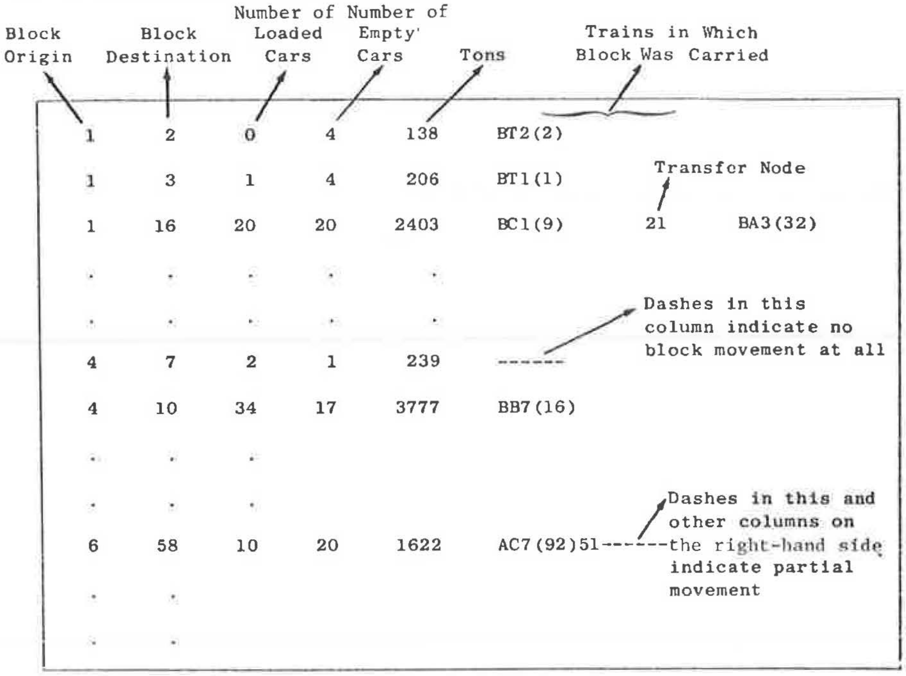


Figure 8. Sample output of beginning portion of train statistics.

TRAIN	COUNT	TRAIN MILES	CAR MILES L	CAR MILES E	CAR MILES T	TON MILES	TRAIN HOURS	CAR HOURS L	CAR HOURS E	CAR HOURS T
BT1	1	0	0	0	0	0	1.25	66.25	90.00	156.25
BT2	1	0	0	0	0	0	1.25	25.00	24.75	49.75
BB2	1	224	13440	12768	26208	1577632	6.67	400.00	380.00	780.00
BB3	1	224	12674	21539	34213	1784184	7.42	377.92	667.00	1044.92
BF1	1	982	99164	5444	104608	8273724	31.75	3153.83	171.67	3325.50
BA1	1	310	18975	9766	28741	2894988	16.58	1108.92	610.33	1719.25
BB1	1	236	4956	14396	19352	826596	7.42	155.75	452.42	608.17
BB4	1	236	10010	10670	20680	1161288	8.92	380.92	405.25	786.17
BC1	1	454	20029	36057	56086	2576300	15.83	663.75	1207.58	1871.33
BC2	1	417	21684	33777	55461	3185880	15.25	777.50	1204.75	1982.25
BD1	1	589	45942	10602	56544	4634512	17.92	1397.50	322.50	1720.00
BD2	1	589	48768	24243	73011	4563967	18.67	1486.25	741.25	2227.50
BE1	1	953	46363	3588	49951	3691418	30.42	1487.08	115.25	1602.33
BB5	1	90	910	7318	8228	291276	11.00	111.00	893.00	1004.00
BB6	1	90	4770	1080	5850	710370	11.00	583.00	132.00	715.00
BB7	1	146	9932	3867	13799	1055759	7.75	488.25	272.83	711.08
BB8	1	146	9393	5917	15310	1062871	7.75	530.92	241.25	772.17
AB1	1	310	8506	11840	20346	1205280	16.08	414.25	614.17	1028.42
AB50	1	152	5676	5552	11228	739418	11.42	415.17	404.50	819.67
BB9	1	224	1753	5141	6894	281900	7.42	53.83	164.83	218.67
BB10	1	131	16113	1572	17685	1791556	10.08	1240.25	121.00	1361.25
BB11	1	131	1048	16637	17685	589107	10.08	80.67	1280.58	1361.25
BB12	2	234	17433	12870	30303	1663506	13.33	993.33	733.33	1726.67
BB13	2	234	14274	14859	29133	1626300	13.33	813.33	846.67	1660.00
BB14	3	672	55328	16128	71456	4482240	19.25	1584.92	462.00	2046.92
BB15	2	448	13888	40768	54656	2126656	14.83	459.83	1349.83	1809.67
BB16	5	1120	76384	40544	116928	6054072	33.33	2273.33	1206.67	3480.00
BT3	2	24	1236	1548	2784	172440	2.00	103.00	129.00	232.00
BT4	2	24	1536	2520	4056	184416	2.00	128.00	210.00	338.00
BA2	1	167	19918	10832	30750	1960272	14.50	1680.50	910.17	2590.67
AB2	1	179	14355	5286	19641	1431623	15.50	1185.50	434.50	1620.00
BA3	1	167	9432	7285	16717	1110293	8.92	499.50	391.25	890.75
BA4	1	119	5503	2659	8162	574378	6.17	284.67	150.33	435.00
AB3	1	119	4410	3417	7827	447348	6.17	241.17	170.33	411.50
BA5	1	244	15293	4234	19527	1124253	11.92	730.50	190.17	920.67
AB4	1	221	7538	6089	13627	591406	11.25	373.33	295.42	668.75
BC3	1	119	3699	2756	6455	323229	5.50	166.17	128.17	294.33
CB1	1	119	2500	5670	8170	388153	5.50	125.00	262.50	387.50
BC4	2	350	9386	25891	35277	1534067	16.17	434.67	1196.42	1631.08
BB50	1	77	953	1704	2657	151041	3.00	35.00	60.00	95.00
BC5	1	187	13263	8290	21553	1319019	9.08	645.33	402.92	1048.25
BE2	1	727	47882	15057	62939	3968523	25.42	1657.67	531.67	2189.33
BC40	1	158	6122	6132	12254	698972	6.75	278.25	274.50	552.75
BF3	1	296	15045	18629	33674	1766942	9.67	487.67	603.33	1091.00
BC6	1	292	9589	8549	18138	950316	11.42	341.25	315.75	657.00
CB2	1	142	5271	1526	6797	405429	5.67	226.92	79.17	306.08
BD3	1	365	13505	8030	21535	1320935	11.25	416.25	247.50	663.75
AT1	1	0	0	0	0	0	2.50	19.00	143.00	162.00
AT2	1	0	0	0	0	0	2.50	58.50	104.50	163.00
AA1	1	22	1034	1034	2068	163328	3.50	140.00	124.50	264.50
AA2	1	22	1188	902	2090	143726	3.00	136.00	61.00	197.00
AB5	2	334	9352	34569	43921	1865724	28.00	784.00	2898.00	3682.00
AA3	2	174	14790	7221	22011	1454292	11.00	888.00	433.50	1321.50
AA4	1	87	3915	4263	8178	513300	3.00	135.00	147.00	282.00

Figure 9. Sample output of beginning portion of link statistics.

LINKS

LINK	MILES	TRAINS	CARS L	CARS E	CARS T	TONS TRAIN ALL	TRAIN MILES	CAR MILES L	CAR MILES E	CAR MILES T	TRAIN HOURS	CAR HOURS L	CAR HOURS E	CAR HOURS T
14 - 15	22	21	1413	409	1822	126773	462	31086	8998	40084	21.00	1413.00	409.00	1822.00
15 - 14	22	18	770	1078	1848	86493	396	16940	23716	40656	18.00	770.00	1078.00	1848.00
15 - 16	65	21	1427	458	1885	128547	1365	92755	29770	122525	42.00	2854.00	916.00	3770.00
16 - 15	65	18	808	1084	1892	93201	1170	52520	70460	122980	36.00	1616.00	2168.00	3784.00
16 - 169	42	17	1217	392	1609	107469	714	51114	16464	67578	19.83	1419.83	457.33	1877.17
169 - 16	42	15	715	843	1558	79442	630	30030	35406	65436	17.50	834.17	983.50	1817.67
26 - 169	51	16	722	852	1574	80301	816	36822	43452	80274	25.33	1143.17	1349.00	2492.17
169 - 26	51	18	1229	399	1628	108787	918	62679	20349	83028	26.50	1945.92	631.75	2577.67
26 - 40	42	18	1239	408	1647	109194	756	52038	17136	69174	24.00	1652.00	544.00	2196.00
40 - 26	42	16	720	856	1576	80657	672	30240	35952	66192	21.33	960.00	1141.33	2101.33
40 - 50	70	21	1576	434	2010	132410	1470	110320	30380	140700	42.00	3152.00	868.00	4020.00
50 - 40	70	20	819	1116	1935	95848	1400	57330	78120	135450	40.00	1638.00	2232.00	3870.00
50 - 51	34	22	1596	531	2127	135647	748	54264	18054	72318	22.00	1596.00	531.00	2127.00
51 - 50	34	21	867	1124	1991	101967	714	29478	38216	67694	21.00	867.00	1124.00	1991.00
51 - 60	29	18	1187	299	1486	104663	522	34423	8671	43094	22.50	1483.75	373.75	1857.50
60 - 51	29	17	517	991	1508	66630	493	14993	28739	43732	21.25	646.25	1238.75	1885.00
60 - 61	26	18	1153	324	1477	100671	468	29978	8424	38402	13.50	864.75	243.00	1107.75
61 - 60	26	17	537	978	1515	71058	442	13962	25428	39390	12.75	402.75	731.50	1136.25
61 - 62	42	19	1306	364	1670	121168	798	54852	15288	70140	22.17	1523.67	424.67	1948.33
62 - 61	42	19	623	1101	1724	81328	798	26166	46242	72408	22.17	726.83	1284.50	2011.33
62 - 81	80	19	1271	348	1619	116052	1520	101680	27840	129520	41.17	2753.83	754.00	3507.83
81 - 62	80	19	609	1041	1650	79417	1520	48720	83280	132000	41.17	1319.50	2255.50	3575.00
81 - 82	8	24	1346	492	1838	125747	192	10768	3936	14704	12.00	673.00	246.00	919.00
82 - 81	8	24	665	1139	1804	86902	192	5320	9112	14432	12.00	332.50	569.50	902.00
1 - 160	147	11	583	500	1083	66472	1617	85701	73500	159201	43.08	2283.42	1958.33	4241.75
160 - 1	147	12	707	503	1210	62518	1764	103929	73941	177870	47.00	2769.08	1970.08	4739.17
5 - 160	18	12	712	535	1247	63877	216	12816	9630	22446	8.00	474.67	356.67	831.33
160 - 5	18	11	583	500	1083	66472	198	10494	9000	19494	7.33	388.67	333.33	722.00
5 - 10	59	12	697	529	1226	77274	708	41123	31211	72334	22.00	1277.83	969.83	2247.67
10 - 5	59	13	773	609	1382	71531	767	45607	35931	81538	23.83	1417.17	1116.50	2533.67
10 - 21	46	19	986	732	1718	105538	874	45356	33672	79028	38.00	1972.00	1464.00	3436.00
21 - 10	46	18	872	847	1719	88020	828	40112	38962	79074	36.00	1744.00	1694.00	3438.00
21 - 170	49	16	851	659	1510	91017	784	41699	32291	73990	21.33	1134.67	878.67	2013.33
170 - 21	49	15	763	775	1538	79260	735	37387	37975	75362	20.00	1017.33	1033.33	2050.67
170 - 172	57	6	341	216	557	35105	342	19437	12312	31749	14.00	795.67	504.00	1299.67
172 - 170	57	6	259	295	554	30702	342	14763	16815	31578	14.00	604.33	688.33	1292.67
34 - 172	41	7	291	355	646	35277	287	11931	14555	26486	11.67	485.00	591.67	1076.67
172 - 34	41	7	372	242	614	38248	287	15252	9922	25174	11.67	620.00	403.33	1023.33
34 - 67	61	8	443	241	684	45032	488	27023	14701	41724	14.00	775.25	421.75	1197.00
67 - 34	61	7	367	442	809	49096	427	22387	26962	49349	12.25	642.25	773.50	1415.75
67 - 68	90	8	435	241	676	44235	720	39150	21690	60840	20.00	1087.50	602.50	1690.00
68 - 67	90	7	363	430	793	48451	630	32670	38700	71370	17.50	907.50	1075.00	1982.50
65 - 68	34	7	235	474	709	36045	238	7990	16116	24106	8.17	274.17	553.00	827.17
68 - 65	34	6	339	227	566	39885	204	11526	7718	19244	7.00	395.50	264.83	660.33
65 - 66	11	6	367	237	604	43008	66	4037	2607	6644	3.50	214.08	138.25	352.33
66 - 65	11	6	256	346	602	34597	66	2816	3806	6622	3.50	149.33	201.83	351.17
38 - 170	58	10	415	521	936	44083	580	24070	30218	54268	18.33	760.83	955.17	1716.00
170 - 38	58	10	576	311	887	57432	580	33408	18038	51446	18.33	1056.00	570.17	1626.17
38 - 49	49	9	580	252	832	57605	441	28420	12348	40768	13.50	870.00	378.00	1248.00
49 - 38	49	11	381	634	1015	44876	539	18669	31066	49735	16.50	571.50	951.00	1522.50
49 - 51	75	8	447	180	627	45266	600	33525	13500	47025	16.00	894.00	360.00	1254.00
51 - 49	75	8	245	536	781	32180	600	18375	40200	58575	16.00	490.00	1072.00	1562.00
34 - 49	66	3	213	64	277	21597	198	14058	4224	18282	5.75	408.25	122.67	530.92

some blocks are overlooked, set out but not picked up, or assigned to more than one train simultaneously. The program checks each block in the blocking table, follows its movement in accordance with the specified trains and their routes, and flags whenever there is an incomplete journey of a block or a block has been assigned to more than one train. Figure 7 shows a sample of this output.

Train and Link Statistics Outputs

The specification of blocks for various trains, together with routing of the trains—in combination with link tables, link lengths, and link transit times—uniquely defines many statistics associated with trains and links: train-miles, car-miles, ton miles, train hours, car hours, trains per link per day, cars per link, and car-miles per link. The program has been designed to calculate several of these values, which are printed in two sets of tables. The first set is arranged with reference to trains and the second with reference to links. Figure 8 shows a portion of the output with reference to trains. The symbols L, E, and T under the headings of cars or car-miles refer to loaded, empty, and total cars. Figure 9 shows the beginning portion of the output, referring to each link.

USEFULNESS OF THE METHOD

The method and computer programs discussed in this paper can be used for the following purposes:

1. Development of efficient blocking strategies so that systemwide and individual car handlings are not excessive;
2. Appropriate distribution of the switching load at various system yards so that each yard's share in the switching load is consistent with its capabilities; and
3. Development of suitable train compositions and routings so that link loadings are not excessive.

In addition to the above purposes, the method could, for example, be used to study overall system effects of closing yards, downgrading or upgrading mainlines, and opening yards. It is also possible to test the systemwide effects of major changes in operating philosophy on yard and mainlines, such as the effects of short and long trains.

AREAS FOR FURTHER RESEARCH

The methods and the computer programs in their present forms are valuable for analyzing and developing systemwide operating plans, but there is room for modification and improvement. Under an extended research contract, SRI is currently adding a feature to trace the movement of selected traffic flows from origin to destination in terms of time spent in waiting in the origin yard, in transit on road, in intermediate yards for switching, and in waiting to be set out and picked up, until arrival at the destination. This will give the designer additional information regarding the individual and systemwide travel times of various cars. These data will also be helpful in comparing various blocking and train formation strategies in terms of car hours and delivery times.

Some other possible improvements in the present program are as follows:

1. Developing an improved automatic blocking strategy process;
2. Developing a technique to combine blocks and form trains automatically;
3. Developing a cost model to compare various strategies on a cost basis; and
4. Converting the whole system to time sharing with interacting blocking strategy and train editing capabilities.

The above is only a partial list, and several other features have been suggested during the course of the project. We hope that the present programs can eventually be augmented, by incorporating all the significant features, so that a highly efficient and useful tool will be available for railroad operators.

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Inventory Model of the Railroad Empty-Car Distribution Process

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Techniques to improve freight-car fleet use are of considerable interest to the railroad industry. One potentially high improvement area is the disposition of empty cars within the network. This paper reports the first results of inventory control applied to one aspect of the process, namely the sizing of empty-car inventories at points in the network. First we evaluate existing techniques for distributing empty cars on a rail network. These techniques deal primarily with optimizing empty-car movements from areas of surplus to areas of deficit. To account for variations in supply and demand, we designed a discrete event simulation model that can determine optimum inventory level, for a single terminal area, as a function of (a) daily supply variations, (b) daily demand variations, and (c) cost of holding a car in a terminal awaiting loading compared to cost of having no car available to satisfy shipper demand. A first attempt to use the model to evaluate the performance of an actual railroad terminal area indicates that excessive inventories are maintained in surplus terminal areas. The applicability of the model to a real railroad operating situation is also demonstrated.

Empty-car distribution is an unavoidable problem for most railroads, because demand and supply are typically unbalanced in any given region. Thus, surpluses and deficits at terminal areas are inevitable, and some mechanism must be employed to move cars from points where they are not needed to points where they are.

Shippers feel the impact of the distribution mechanism directly. Car availability will largely be determined by the ability of the railroad to efficiently move cars from surplus to deficit areas.

This recurring need to manage and monitor car movement has come to dominate current empty-car distribution processes. The techniques used to allocate cars usually employ standard static optimization methods and thus rely on the hypothesis that levels of supply and demand will not vary significantly. Variations, however, do exist, and one of them is periodic shortages caused by railroads unreliably routing cars from surplus to deficit areas.

Some empty-car distribution practices have evolved to cope with this problem; individual terminal distributors, for example, often maintain an inventory of empty cars to protect against the uncertainties of supply and demand. Still, since distribution mechanisms seldom consider inventory levels, no strategy for determining appropriate inventory levels has yet been proposed, and costs to the railroad incurred by wasted car days or lost loads due to shortage can be directly related to these levels.

This report evaluates the theoretical implications and tests the methodology of one strategy for determining inventory level in a railroad operating environment. The proposed strategy grew naturally from our reexamination of the empty-car distribution process from the perspective of the local or terminal decision maker. Several theoretical solutions to the empty-car distribution problem, such as existing network models that determine flow rules, are contrasted with a theoretical construct of the need for empty-car inventories.

A discrete event simulation model of empty-car distribution determines the best target inventory level for a particular terminal area given the supply and demand characteristics of that terminal.

Finally, the results of sensitivity analyses of the impact of changes in railroad and shipper behavior on the optimum inventory level are presented, and the results of our first attempt to use the model to predict the best inventory level in a railroad terminal area, based on the actual flows into and out of the terminal, are given.

The results of this research effort have, to date, been encouraging. The model of freight-car distribution we tested accounts for the relationship between service reliability and freight-car utilization, and it may prove to be a useful tool when applied parallel to a traditional flow model to improve car distribution strategies. Much of what follows has been founded on the work of Philip (1).

THEORETICAL APPROACHES TO EMPTY-CAR DISTRIBUTION

Efficient empty-car distribution satisfies shipper demands at the lowest possible cost. There are two necessary and related approaches to empty-car distribution. The first, with its emphasis on empty-car movements to balance surplus and deficit areas, has been adopted in some form by most railroads. The second, which focuses on variable car supply to satisfy variable demand, has not been systematically analyzed. A theoretical base for such an analysis is the subject of what follows.

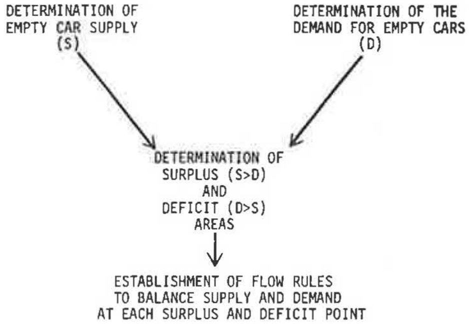
Traditional System Focus of Empty-Car Distribution

"The essence of car distribution and assignment is the process of providing destinations to empty cars and monitoring their movements towards those destinations" (2, case iv. 1). This definition embodies a rather appealing philosophical approach to the car distribution process when it is viewed from the system perspective. A car emptied at a point on the railroad where it is not needed for reloading must be moved to a potential reloading point. The process of deciding where to send which cars, then, becomes the essence of car distribution.

This process is further delineated in Figure 1, which highlights the three subsystems in all traditional car distribution systems:

1. Identification or prediction of empty-car supply,
2. Identification or prediction of the demand for empty cars, and
3. Allocation or control or both of car movements

Figure 1. Four-part traditional empty-car distribution process.



from surplus to deficit areas.

Demand and supply estimations define surplus and deficit areas, which themselves are only the inputs into the flow rule decision process; the quality of these flow rule decisions is necessarily limited by the accuracy of the demand and supply estimates. A recent report prepared for the Federal Railroad Administration (FRA) concluded that shipper demand varies a great deal (3, p. iii). Of even greater importance, it was found, is that demand level is not measured adequately by railroads and, with a few exceptions, is not even formally forecast.

Car supply itself is subject to at least as much variation as demand, because the receipt of unloaded cars from industry is the principal source of empty cars. In fact, empty-car supply is likely to vary even more than demand because of the variations introduced by unreliable movement of the cars by the railroads themselves.

Car Distribution as a Classical Transportation Problem

If certain simplifying assumptions are made, the problem of distributing empty cars from surplus to deficit points fits nicely into the form of what Dantzig (4, p. 299) and others have called the "classical transportation problem." This empty-car distribution problem as perceived in the classical sense is precisely one of determining a set of flow rules governing the movement of cars from surplus directly to deficit points; the objective function is to "minimize the cost of moving the cars into position [for loading] from the locations where they become available" (5, p. 147).

As one might expect, this has not been overlooked by theorists or practitioners. Models using either linear programing techniques or some other network optimization algorithm have been proposed repeatedly in the literature. One model for distributing wood rack-cars, was implemented with good results on the Louisville and Nashville Railroad Company, and the Missouri Pacific Lines periodically use a linear programing model to establish empty-car distribution guidelines. Dan Berman of the Southern Railway Company reports that a linear program is at the core of a system that manages the movement of the entire free-running fleet.

Shortcomings of the Traditional Approach

At first blush, the linear programing technique would seem to be an ideal solution to the problem of empty-car distribution, because it is offered as an optimum allocation of the empty-car fleet and thus minimizes the costs of allocation. Unfortunately, the solution is only optimum if the simplifying assumptions required to yield the solution are in fact correct, and in this case critical assumptions at odds with the realities of railroading have been made. For example, quality and uniformity of demand and supply forecasts are needed to define surplus areas, and the solution is optimum only when these forecasts are accurate and demand is stable.

A second, more subtle assumption has been made in forming the objective function. Here it is assumed that the only cost important to the distribution process is the penalty cost of moving cars from surplus to deficit areas. If the first assumption were true and the situation were in fact deterministic, then this second assumption might be plausible. The real costs associated with the stochastic nature of the process, however, should not be ignored in the solution strategy.

It is not the purpose of this study to indict existing car distribution practices because of the tremendous variations inherent in the levels of supply and demand. The system view of the problem, with its emphasis on flow rules and car movements, is an absolutely necessary component of any car distribution mechanism. Nevertheless, variations in supply and demand as well as forecasting difficulties need to be accounted for in any car distribution procedure.

Inventory Approach to Car Distribution: Terminal Perspective

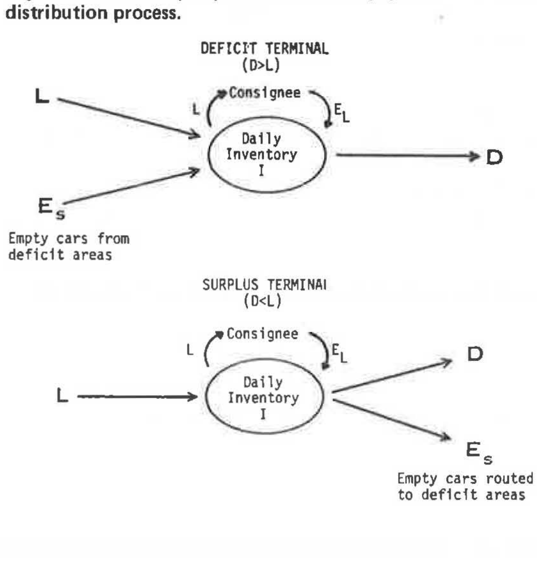
The model described in this section evolved naturally from what has been called the traditional or system perspective on empty-car distribution. The typical proposed definition of the process resulted in network solutions to the problem. An alternative definition, however, suggested by Johnson (6) demands a new perspective and different solution strategies: "The main function of railway freight car distribution systems is to control the inventories of empty cars held to buffer the supply and demand at the loading points." This definition shifts the focus from the movement between areas to the surplus and deficit areas themselves.

Figure 2 (where L = loaded cars as supply, E_L = emptied cars, and D = demand) shows the terminal perspective appropriate for car distributors at both surplus and deficit areas. The process involves less network optimization and more inventory control. This conceptual framework suggests that the variable nature of empty-car supply and demand is related to the inventory maintained in terminal areas. A methodology to formally specify this relation is proposed in the next section.

SIMULATION MODEL OF TERMINAL EMPTY-CAR CONTROL

To provide a new perspective on the empty-car distribution problem, we have sought a technique that would clarify the operation of a small part of the existing railroad environment and, if appropriate, would give us a simple tool for managing this environment more effectively. To this end, the elements of a discrete event simulation model that represents the empty-car inventory decisions of a surplus or deficit terminal area are described.

Figure 2. Terminal perspective on the empty-car distribution process.



Basic Structure of the Model

As illustrated in Figure 2, most railroad terminal areas can be classified as being either "sources" (surplus) or "sinks" (deficit) for empty cars.

In a surplus terminal situation, empty-car supply normally exceeds demand. Each day consignor demand for empties will first be satisfied; then any empty cars remaining will be used to replenish the inventory (Figure 2). The model determines the number of cars, called the "target" inventory level, that should be in the inventory after replenishment. The following daily decision structure ranking is followed: (a) all daily demands are satisfied by the daily supply; (b) any empty cars not needed to satisfy the daily demands are used to bring inventory up to the target level; and (c), finally, any remaining empties are sent to a deficit area according to the flow rules.

In a deficit terminal area, demand for empty cars is generally greater than the number of loads terminated. Additional empties will be transshipped to the terminal area according to system flow rules, so that in the long run demand and supply will be in balance. Given this balance, the terminal decision maker cannot rely upon the daily flow of cars to establish or replenish his inventory, and additional cars will periodically be sent to the terminal to replenish the inventory. The model determines how large this inventory (initial inventory) should be at the beginning of each simulation period. Empty cars never flow out of the terminal area in this formulation, so a very simple decision structure is possible: All current demands are satisfied if possible, and any remaining empty cars are placed in the inventory.

For both surplus and deficit situations, the inventory level on a given day i will be determined by the day's new supply of and demand for empties, by the previous day's inventory, and by the prespecified target or initial inventory level (I°):

$$I_i = f(I_{i-1}, E_i^S, E_i^D, I^\circ) \qquad (1)$$

where

I_i = inventory level at the end of day i;
E_i^S = arrival of empty cars on day i;
E_i^D = demand for empty cars on day i;
I° = prespecified target or initial inventory level for the simulation.

I° is implicitly a part of the decision structure, because it effectively increases the supply of cars every day by an amount I°. Thus, for a day during the simulation period when supply exceeds demand, the result will be to increase the day's remaining inventory by I° cars. Likewise, on days when demand exceeds supply, the added cars will reduce the number of unsatisfied demands by an amount I°.

An optimum initial inventory level will be one that balances the costs of increasing the inventory level on surplus days against the costs of reducing the unsatisfied demand costs if shortages occur. The next section presents the method used to arrive at such a solution.

Determining Optimum Inventory Level

The terminal decision structures for both surplus and deficit situations have been specified. While they differ in several important ways, the daily inventory levels in both cases depend on the same set of four independent variables shown in Equation 1, of which only I° is specified by the decision maker. The other three depend on the external environment. For each I^o, a different set of daily inventory levels I_t will emerge from the decision structure. The problem becomes one of selection from among different sets of daily inventory levels.

Terminal Cost Function

The principal function of an inventory of empty cars in a terminal is to diminish the impact of variations in

Figure 3. Using cost function to determine terminal cost.

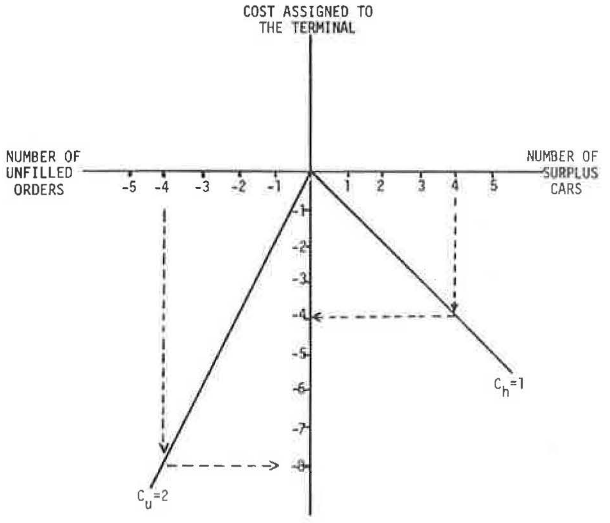


Figure 4. Example of the optimization process.

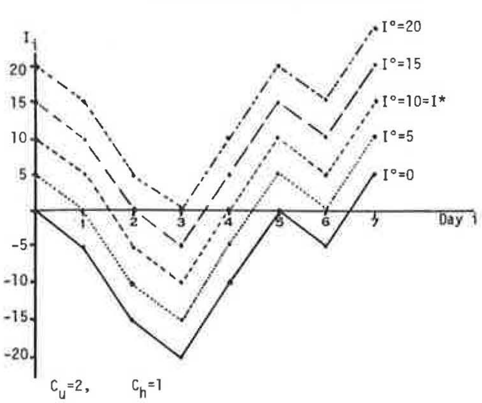
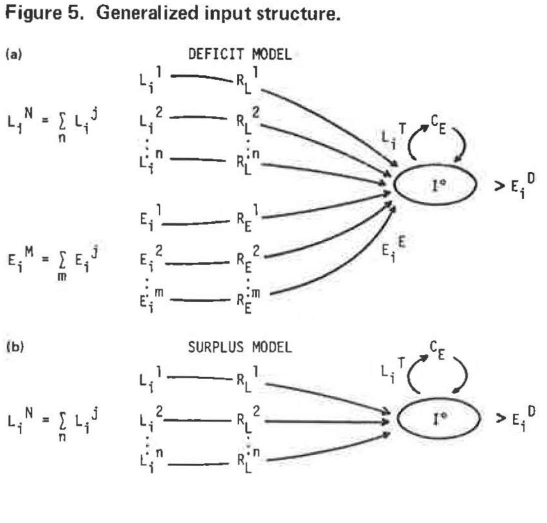


Figure 5. Generalized input structure.



demand and supply levels on the area's ability to satisfy empty-car demand. Each car added to the inventory decreases the risk of a shortage, but increases empty-car inventory cost. Incurring some cost is an inevitable consequence of demand and supply variability, so the objective should be to minimize the expected total shortage plus inventory cost.

We can define a terminal cost function that accounts for this. For any inventory level (positive or negative), the cost function defines the cost to the system, and a simple piecewise linear function can be denoted as follows:

$$C(I_i) = \begin{cases} C_u(I_i) & \text{if } I_i < 0 \\ -C_h(I_i) & \text{if } I_i \geq 0 \end{cases} \tag{2}$$

Figure 3 illustrates the case where unsatisfied demand cost C_u equals 1 and holding cost C_h equals 2. If the inventory level is $I_t = 4$, then $C(4) = -1(4) = -4$; and if $T_t = -4$, then $C(-4) = +2(-4) = -8$. In a similar fashion, calculating the cost of a sequence of daily inventory levels is a simple matter of totaling individual costs for each day:

$$C^T = \sum_{i=q}^{Z} C(I_i) \tag{3}$$

where

q = first day of the simulation period;
Z = final day of the simulation period;
$C(I_t)$ = cost for the inventory level I_t; and
C^T = total cost for the period.

Recalling that the daily inventory level is itself a function of $I_t = f(I^o)$, it is also possible to conclude that cost is a function of I^o. Each value of I^o implies the unique sequence of daily inventory levels that follow (Figure 4).

	Daily Cost				
Day	I° = 0	I° = 5	I° = 10	I° = 15	I° = 20
0	0	-5	-10	-15	-20
1	-10	0	-5	-10	-15
2	-30	-20	-10	0	-5
3	-40	-30	-20	-10	-15
4	-20	-10	0	-5	-10
5	0	-5	-10	-15	-20
6	-10	0	-5	-10	-15
7	-10	-10	-15	-20	-25
Total	-120	-80	-75	-85	-125

Each has a certain value of C^T associated with it. The remaining task is to find the I^o value that defines the sequence of inventory levels with the lowest C^T.

Finding Minimum Cost Inventory Level

The nature of the decision and cost structures in the empty-car inventory problem defined here will ensure a well-behaved situation. As initial inventory increases, the number of demands not satisfied can diminish, but the daily inventory level can only increase. The piecewise linear cost structure equates fewer demands with lower cost and a larger inventory with increased cost over its entire range, so increasing I^o may at first reduce C^T, but, if large enough, it will eventually increase C^T. Thus, the value of the C^T function will fall to the point where increased inventory cost exceeds decreased unfilled demand cost associated with an increase in I^o. (The piecewise linear cost structure is not required to create the conditions described; however, any function whose slope is always positive for inventory levels less than zero and always negative for the inventory levels greater than zero will lead to the same optimality conditions.)

Given this functional relationship between C^T and I^o, it is possible to define a very simple search routine to determine the optimum inventory level (I^*). By successively testing $C^T(I^o)$ for increasing values of I^o, the optimum value of I^o will be found when $C^T(I^o)$ stops decreasing. This process is illustrated in a sample problem in Figure 4, in which the holding cost is 1 and the unsatisfied demand cost is 2; each day's individual cost for each I^o is recorded along with the C^T. For instance, the cost on day three for $I^o = 0$ is the inventory level (-20) multiplied by $C_u(2)$, which equals -40. As the results indicate, the optimum I^o is 10.

Components of the Input Subprogram

The previous section's inputs were parameters defining the utility function (C_u and C_h), the daily empty-car supply (E_i^S), and the daily demand for empties (E_i^D). Much of the simulation model is given over to the process of determining these values, as is described in the following sections.

Cost Function Parameters

The cost function parameters are easily specified for our model's purposes because they are treated deterministically. However, they prove difficult to determine accurately in any particular inventory or railroad situation. Buffa (7) suggests that "though it is not difficult to develop a model for buffer stock based on the concept of balancing inventory and stockout cost, more often than not it is difficult, if not impossible, for management to isolate a realistic stockout cost."

In the railroad environment also, neither inventory cost nor cost of delayed or unfulfilled demand for cars is well defined. We therefore ran the model repeatedly using the same car supply and demand inputs but different cost ratios in order to reduce the importance of the cost specifications. It is the linear nature of the cost function that makes this possible, because the actual optimization routine is sensitive only to the cost ratio C_u/C_h and not to the absolute values of C_u and C_h themselves.

Daily Empty-Car Supply

One principal goal of this modeling effort was to determine the impact of rail network operations on the need for empty-car inventories in terminal areas. The input structure we established gives the model user a wide range of options with respect to the specifications of rail service and shipper behavior. This structure for surplus and deficit terminal areas is depicted in Figure 5.

For both surplus and deficit, the model assumes that loaded cars are destined for the terminal area in question. On each simulation day i, n groups of loaded cars (L_i^j) are generated. The number of cars in an individual L_i^j will vary from day to day according to the specified distribution, which can be different for each group. A Monte Carlo sampling procedure from each distribution was employed to determine the values of the L_i^js each day. This ensures that each L_i^j will have some known expected average value that keeps total daily number of loaded cars generated each day (L_i^N) constant over the simulation period.

At a deficit area, empty cars are also routed to the terminal. The same rules that apply to L_i^j and L_i^N also apply to E_i^M and E_i^n.

Trip-time distributions (R_E^j, R_L^j), which indicate how often a trip takes a particular number of days, are used to describe the railroad operating environment. The Monte Carlo procedure for appropriate trip-time distribution is used to determine the travel time for each group of cars, L_i^j or E_i^j. The trip-time distribution may be different for each group of cars, $R_E^1 = R_E^2$, for instance, but a particular group's trip time will be governed by one distribution during the entire simulation. Having selected the trip times, the arrival day for each group of cars at the terminal is determined; therefore arrival day equals departure day plus trip time.

Knowing the arrival day of each group of cars and the number of cars in each group, it is possible to determine the total number of loaded, L_i^T, and empty, E_i^E, cars arriving on day i. Empty cars immediately become part of the supply, but the loaded cars must first be unloaded and then returned to the terminal according to a "time to empty" distribution.

The two components of the daily new empty-car supply are now well defined. The E_i^L, added to the E_i^T, defines the total number of new empty cars each day (E_i^S):

$$E_i^S = E_i^T + E_i^L \qquad (4)$$

From the terminal's perspective, a rather complicated network, characterized by numerous points of loaded and empty-car generation and equally numerous trip-time distributions, is reflected in the variation of a single input variable, E_i^S.

Daily Demand for Empty Cars

Daily empty-car demand is simpler to define than empty-car supply. The model user specifies a daily shipper demand distribution, which is sampled to determine a daily demand for cars (E_i^D), just as the loaded and empty group size distributions were sampled. The model in its present form also assumes that E_i^D and supply (E_i^S) are not correlated with one another. Use of a more complicated demand structure that assumes numerous independent sources of empty-car demand is possible but was not pursued in this study, because the behavior of a group of sources can be adequately represented for our purposes by a simple demand source.

Results of both a theoretical and an applied study using the model are presented in the next section.

EXPERIMENTAL RESULTS

Verification of our simulation model is a multifaceted problem, but, as it is based on theories of inventory control, its results should be consistent with theory. Also, as a model of rail terminal operations, it should be capable of evaluating current operation realistically. Since the core of the model is independent of the input subprograms, the model can be used to test both cases.

Theoretical Results Based on Hypothetical Input Data

This model can be used to show how rail operations, shipper behavior, and perceived operating costs affect optimum inventory level. Of the many possible relationships that can be analyzed, three of the most relevant concern the impact of

1. Improving trip-time reliability,
2. Lowering the cost of unfilled demand relative to the cost of holding a freight car, and

3. Decreasing variability in the number of loaded and empty freight cars generated.

The initial hypothesis, based on common sense and the classical theories of inventory control, is that each change should lower the optimum inventory level. Inputs that isolate these relationships in the deficit case are described and utilized in the following analysis.

To eliminate some sources of potential variation in the inputs, we created a simplified input structure that can be readily modified to isolate the three relationships outlined above. The demand for empty cars (E_1^0) is assumed to be constant each day and equal to 200 cars. Exactly 100 loaded cars in four equal groups of 25 and 100 empty cars in five equal groups of 20 cars are generated each day. The time required to empty each loaded car is always a day.

In addition, for a particular run, the trip-time distributions for all groups are modeled identically. This does not mean that the trip time for each group will be the same on a particular day, because it is independently selected from the underlying distribution. Finally, the ratio of the late load to inventory holding cost is assumed to be 2:1, and we used a simulation period of 7 d, based on a general railroad official's consensus that a weekly planning horizon for many car distribution decisions seems reasonable.

Impact of Trip-Time Reliability

With these inputs, the only source of variability comes from the trip-time distribution, which allows study of the first relationship between trip-time reliability and the optimum inventory level by repeatedly running the model using different distributions.

The trip-time distribution defines both expected trip time (the mean) and the reliability of the trip. The variance is a conventional measure of a distribution's dispersion. The "n-day-%," developed by Martland (8), is also a measure of a distribution's central tendency and is derived as the maximum percentage of cars with trip times in a single n-day interval. Martland also proposes use of the measure "%-n-days-late," which is defined as the percentage of cars arriving n or more days later than the mean. As reliability improves (indicated by a smaller variance or a larger 2-day-%), predictability of trip time also increases.

Typical railroad trip-time distributions were selected from a compilation of actual trip times reported by a large shipper between seven origin-destination pairs. These distributions are listed in Table 1.

Two hundred 1-week simulations were performed with each of the trip-time distributions; the results are graphically presented in Figure 6, which shows that improvements in rail reliability (according to any of the three measures) are generally accompanied by smaller optimum inventory levels.

This imperfection reflects our inability to precisely define the variance of an actual distribution by using a single measure. Combining several of the measures, however, does provide a more adequate explanation of the results. The second distribution (2-day-% = 79) appears to have a higher inventory than can be explained by the 2-day-%, but if its %-2-days-late is also considered, it becomes clear that the higher inventory is caused by the extreme values of the distribution.

These seven trip-time distributions are used in the remainder of the analysis, and the seven runs of the model made with the inputs as specified for this first analysis will be referred to as the base case.

Impact of Cost Ratio

Simple changes in the base case permit testing of the second relationship for the impact of changes in the ratio of unfilled demand cost to holding cost. The base case is modified by first increasing the ratio from 2:1 to 3:1 and then decreasing it to 1:1. As before, 200 1-week simulations were run for each of the seven trip-time distributions, and in each case an optimum inventory level was determined. The results are illustrated in Figure 7.

When the penalty cost of not satisfying a shipper's demand increases relative to the empty-car holding cost (an increase in ratio), the optimum inventory required to minimize the terminal decision maker's cost increases regardless of the level of trip-time reliability. If the penalty is small, the decision maker will keep an inventory only if service is very unreliable.

These results are also consistent with those found in classical inventory theory. Safety stock is only justified when the cost of not maintaining it exceeds that of maintenance. When the cost is the same (per car in this case), a car supply must be very unreliable before the cost of the inventory justifies the reduction in the risk of stockout associated with it.

Impact of a Stochastic Car Generation Rate

The base case was designed so that trip times would vary while number of cars generated each day was constant. To consider the impact of variability in the number of loaded and empty cars generated, the base case is twice modified so that the number of cars generated is normally distributed, with means still equal to 25 and 20 for the five loaded and four empty moves respectively, and standard deviations of 25 and 50 percent of the respective means in the two cases tested.

Again, 200 1-week simulations were run for each trip-time distribution and standard deviation combination. Note also that an additional trip-time distribution, one with perfect reliability, was tested in order to isolate the impact of variation in the car generation rate on the inventory level.

The results are presented in Figure 8 and show that variability in the car generation rate does in fact increase the needed inventory for all levels of trip-time reliability.

It is difficult to make a direct comparison between the relative impacts of trip-time unreliability and generation variation, because there are no directly comparable measures of variance. The results do support the hypothesis, however, that each source of additional uncertainty increases the required inventory level.

Summary of Theoretical Results

To isolate and evaluate certain critical relationships between inputs to the terminal model and optimum inventory level, the model was exercised by using an appropriately designed set of inputs. Each of the tested sources of supply and demand variation increased the required inventory level both individually and when combined together. In addition, increases in the cost ratio, representing a larger stockout cost, also raised the optimum inventory. Each of these results is consistent with inventory control theory, the basis for the modeling structure. Although these results have no direct applicability to a particular railroad operating situation, we shall use the model to evaluate performance of an actual terminal area in the next section.

Table 1. Trip-time distributions for seven origin-destination pairs.

	Percentage of Cars per Trip						
No. Trip Days	Pair 1	Pair 2	Pair 3	Pair 4	Pair 5	Pair 6	Pair 7
1	0	0	0	0	0	0	0
2	0	2	6	0	0	0	0
3	0	2	45	0	17	0	0
4	4	64	33	11	41	0	4
5	12	15	14	26	19	0	15
6	57	10	2	43	8	15	27
7	27	1	—	16	15	28	13
8	1	2	—	0	—	30	12
9	—	1	—	0	—	11	9
10	—	0	—	0	—	2	6
11	—	2	—	2	—	7	4
12	—	0	—	0	—	5	4
13	—	1	—	2	—	0	5
14	—	—	—	—	—	2	1
Mean no. trip days	6.1	4.6	3.6	5.9	4.6	8.1	7.5
Percentage of cars 2 d late	84	79	78	69	61	59	42
Percentage of cars more than 2 d late	0	8	2	4	15	14	20
Variance	0.55	2.66	0.77	1.94	1.65	2.24	5.58

Figure 6. Impact of trip-time reliability on optimum inventory level.

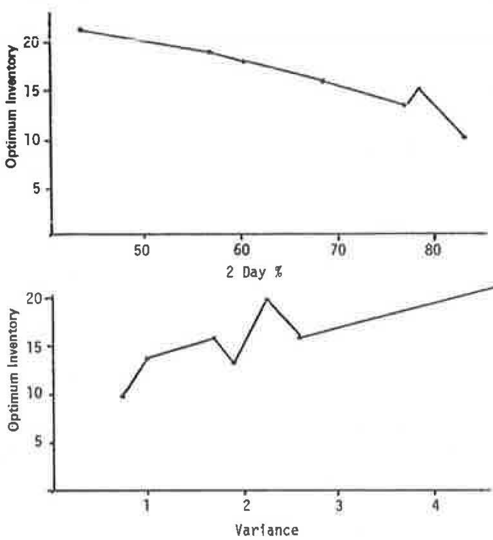


Figure 7. Impact of changes in cost ratio.

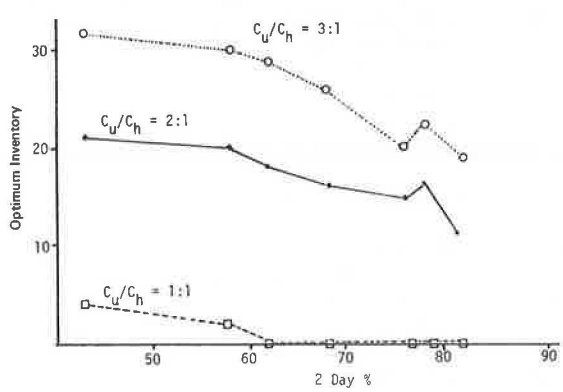
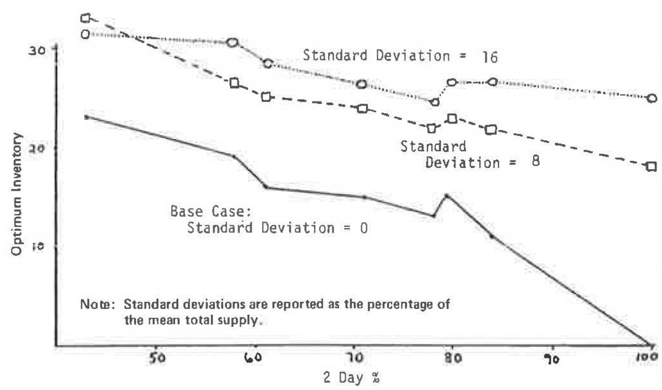


Figure 8. Impact of supply variability on optimum inventory level.



Applying the Model to a Real Terminal Area

The theoretical results suggest that an appropriately specified inventory model structure can be used to determine the empty-car inventory that should be maintained in each terminal or area of a railroad. If the model can be verified, then the inventory information, along with data on total available empties and empty repositioning costs, might become part of a method to better allocate empty cars.

Currently, no railroad attempts to quantitatively determine an optimum empty-car inventory level. Several large class I railroads were contacted during the course of this study: we found one both willing and able to provide daily data on empty-car movements for each car type and major terminal area. In concert with this particular railroad, we attempted to apply the model.

Our railroad has a traditional but sophisticated car distribution process that relies on flow rules to balance system surpluses and shortages. The number of cars maintained in a terminal area's inventory is determined by the terminal manager himself. The system decision maker can define a route for all surplus cars, but the local decision maker is largely responsible for determining how many cars are surplus.

Available Data

For each terminal area and car type, daily disaggregated data (each car is identified) are available showing (a) number of empty cars on hand and (b) number of empty cars out to industry. While these two categories do not in themselves define the inputs required by the model, the disaggregate nature of the data makes it possible to calculate empty inventory, empties loaded, empty arrivals, and empty cars routed to another terminal. One key variable is obviously missing—the number of empty cars demanded but not provided—and without this information it is impossible to balance the inventory cost against the cost associated with lost or delayed loads.

Table 2. Model results for the case study.

Ratio of Unfilled Demand to Holding Cost	Target Inventory		Average Daily Inventory		Average Daily Flow to Deficit Areas		Total Late Loads	
	Actual	Generated[a]	Actual	Generated[a]	Actual	Generated[a]	Actual	Generated[a]
Existing situation	—	—	49	—	9	—	0	—
1:1	0	0	0	0	9	9	71	33
2:1	0	0	0	0	9	9	71	33
5:1	4	2	3	1	9	9	47	22
10:1	16	5	13	4	9	9	10	11
100:1	22	14	19	12	9	9	0	0

[a] Results generated by using the stochastic input data.

Figure 9. Analysis of mean and standard deviation for area.

While this problem is perhaps unavoidable in any deficit area, the characteristics of this railroad's decision-making structure permit and perhaps encourage a different problem in surplus areas. The surplus terminal manager is not penalized for maintaining an excessive inventory of empty cars (in the model's terminology, his holding cost, C_h, is very low), leading him, as the theoretical results suggest, to maintain a large inventory. If surplus areas do maintain excessive inventories, then a precise measure of demand is available in the "number of empties loaded," since we assume that loads are seldom lost and empty cars are always available. A surplus area was therefore selected for analysis.

Characteristics of the Selected Surplus Area

Data listing the empty cars on hand and out to industry at the terminal each day for the selected car type were collected for a 1-month period in 1976.

It was possible to create a complete history of the empty-car decisions at the terminal from these data. On the average, 14 cars arrived each day; 5 cars were damaged; 9 cars were routed to the appropriate deficit area. An average inventory of 50 cars was maintained over the period, and at no point did the inventory level drop below 20 cars, which supports the assumption that loads were never lost. These characteristics are schematically summarized in Figure 9.

Using the Model to Evaluate the Terminal's Performance

The historical data, provided by the railroad, record variations in supply and demand as they actually occurred. Thus, instead of repeatedly simulating the situation using hypothetical inputs, the model was run by using the actual supply and demand data.

With these inputs, the optimum empty-car inventory was calculated for different ratios of delayed load to holding costs. The results, reported in Table 2, reveal that the average inventory required to avoid any lost or late loads was only 19 cars; average daily flow was 14 cars; average daily demand for empties was 5 cars; and the maximum inventory was 91 cars.

For the purposes of comparison, the stochastic model form was also run. Both supply and demand were assumed to be normally distributed with means and standard errors equal to those found in the actual demand and supply data. These results were also reported in Table 2 and are similar to those determined by using the actual data.

For the 1-month period examined, both sets of results suggest that the inventory level maintained during the period is oversized regardless of the cost hypothesis used. The average inventory of cars needed to ensure that no load be lost is only 19 cars; the average of 30 additional cars sitting in the inventory were not needed and were of no value to the terminal operator. Of course, even a superficial, qualitative examination of the daily supply and demand characteristics indicates that an inventory of 50 cars is excessive. The model is useful to the extent that it can quantify the degree of excess inventory, given the unique characteristics of the flows into and out of the area.

The cost of maintaining this excess inventory will depend on a number of factors, including car type, time of year, and age of the fleet. The particular car type analyzed was in short supply when the data for this study were collected, but during times of car shortage inventory cost will approach the opportunity cost associated with loads lost or delayed elsewhere on the railroad.

SUMMARY AND CONCLUSIONS

This paper reports the first results of applying an inventory control theory to one aspect of the empty-car decision-making process. The empty-car distribution process and its importance to overall railroad performance were first reviewed. Then the theory of inventory control and its applicability to empty-car distribution were outlined and a simulation model based on this theory presented. Theoretical results were discussed, and, finally, the model applied to an actual railroad situation.

The theoretical results are consistent with classical inventory control theory. A positive correlation has been discovered between variability in the supply or demand and the number of cars needed in the inventory.

The model has also been successfully utilized to evaluate the performance of an actual railroad terminal area, and the results in this case are consistent with railroad thinking. The model data required that a surplus area be analyzed; data needed to evaluate a deficit area were not available. During the 1-month period while data were being collected, the inventory level in that surplus area was found to be oversized. This conclusion corroborated opinions voiced by several individuals at the railroad. Application of the model to deficit areas should prove useful in the long run, but data on lost or late loadings are not presently available.

It should be recognized that these results are preliminary in nature. While the single case study performed does seem to verify the theoretical results, more terminal areas will be investigated. The model itself should be looked upon as part of a more comprehensive set of models for use as a tool for managers seeking to balance empty-car inventories over an entire network.

ACKNOWLEDGMENTS

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Part 3
Intermodal Transport Planning

Abridgment

Intermodal Freight Transport

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In describing the role of intermodal transport research, the Transportation Research Board's Special Committee on Rail Transport Activities said that

> Unfortunately, there has been relatively little research with respect to intermodal transport since much of what has been done has been modally oriented. There is a real opportunity for research approaching intermodal transport from a systems viewpoint. Analysis of the role of intermodal transport can set the state (sic) for more effective modal interface planning, including, for example, study of terminal design and location. Work on these intermodal issues is of continuing interest to the railroad industry.

If this is to be a mandate for the newly formed Intermodal Transport Committee, then definitions, for instance of intermodal traffic, must be formulated and agreed upon.

There are two elements characteristic of intermodal transport. The first is the through movement from origin to destination with no intermediate storage. With the exception of truck transport, movements by all other modes are made largely in conjunction with a second form of carriage. But it is not clear whether all such instances are typical of what is called intermodal transport.

The committee, in one of its earliest discussions, felt that intermodality implied something specific. Intermediate storage was one aspect that helped exclude certain shipments from being defined as intermodal. The committee did not attempt to provide a time dimension, although a transfer should take place within days, more likely hours.

The second element is an interchange or transfer between two or more modes, because so many shipments require more than one mode. It is the ease with which these transfers occur that brings them under the intermodal umbrella. In committee discussions, this type of transfer was not defined. By general agreement, however, some form of containerized handling, rather than piece-by-piece interchange of the components of a shipment will be involved. In fact, it is containerization, or some variation on it, that has popularized the concept of intermodal transport. Today's sophisticated techniques for rapidly transfering bulk materials also qualify as intermodal.

These transfers involve fairly high-volume shipping levels—at least 32 kg (70 lb) but likely to run 9 to 18 Mg (20 000 to 40 000 lb) or as high or higher than 91 Mg (200 000 lb).

Perhaps the single most important advantage to intermodal operations is the superior cost and service tradeoff it offers compared with the use of a single form of carriage or with two modes employed but not in an integrated fashion. The dollar savings are well known and may exist because an intermodal system uses a lower cost line haul means of transportation and still provides the needed flexibility for the short haul or destination handling to the shipper's dock. Moreover, service is improved, because there is more efficient transfer at the interchange point, in terms of both transit time and reliability.

In addition, handling or transport damage decreases and thievery drops off sharply. For any one component the cost or service comparison of an intermodal operation can be better or worse than a conventional system, but it is the existence of a real option to the shipping public that enhances its importance.

Robert Redding, formerly a Department of Transportation official, recently alluded to another advantage when he observed that many of this country's transportation facilities will not grow much during the next 15 years but that there will be a need to increase transport capacity (1). One way to expand capacity is to design intermodal operations that use the existing infrastructure, which, where the potential exists, can be done at a very reasonable cost.

If intermodal operations cost less and use the existing plant more efficiently, additional likely benefits are preserving scarce resources, minimizing pollution, and using land more efficiently. From several perspectives, then, intermodal transport offers distinct opportunities.

It is very difficult to establish how much intermodal transport there is compared with the various other forms of transport services. Through container shipments are made by air, but discovering how many containers are loaded by shippers at an off-airport location is very difficult. Estimates are available, but they vary greatly depending upon the person questioned. Out of the 2.740 billion Mg/km (4 billion ton miles) of air freight, or two-tenths of 1 percent of the total intercity freight movement for 1975, maybe 20 to 30 percent could be considered intermodal.

TRUCKING

For truck, one would have to do a good deal of arithmetic to develop an estimate of its involvement in intermodal transport. Although trucking is a major partner in the intermodal movement, it is infrequently the dominant partner. Of the trucking industry's 22 percent share of the market, it would seem that only a modest portion—say less than 3 percent—has been a part of an intermodal service. However, one important fact must be borne in mind: for selected truckers this business can be extremely important and may even be their entire operation.

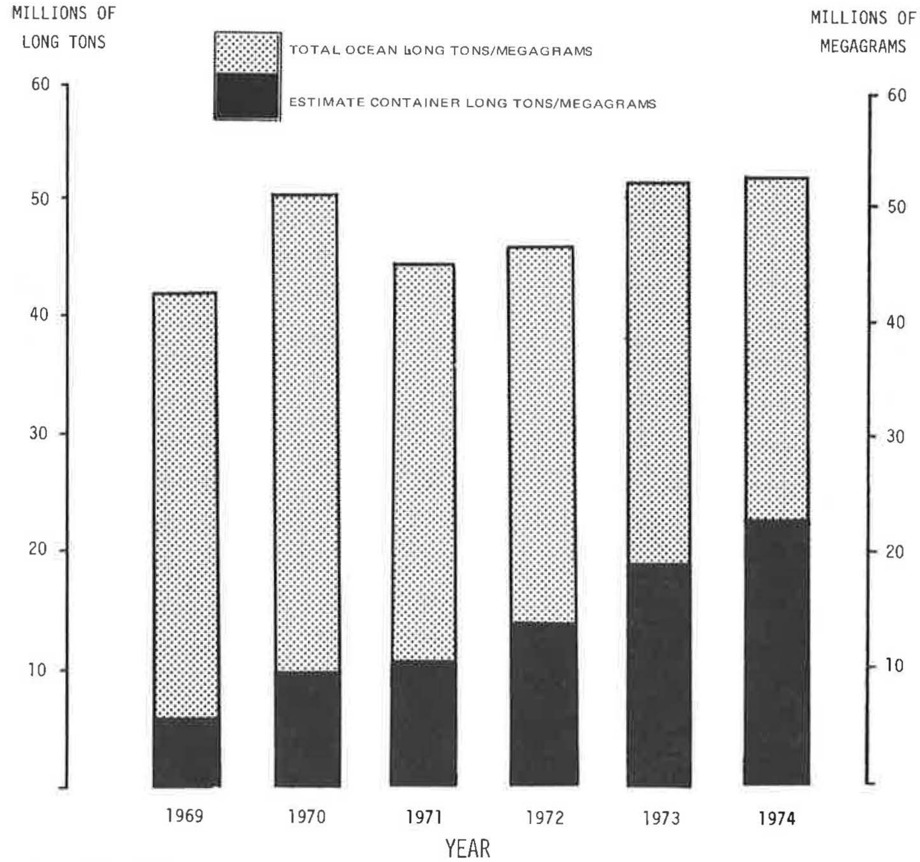
WATER TRANSPORT

In water transport there are three distinct issues. Domestic water carriage suffers from problems of definition and data availability. Any assessment of intermodal operation is therefore difficult. In foreign trade, data on Lash and Seabee operations are lacking, although there is wide agreement that these barge and ocean vessel operations are clearly intermodal in character.

In marine containerization, however, intermodal has been a major success. There have been problems, but many of them have been overcome. This form of transport has revolutionized the steamship business, which has shown a clear, steady increase in intermodal containerization (Figure 1). In the 5 years since statistics began to be collected, there has been a quadrupling of container tonnage. A significant portion of this is only port to port; nevertheless this type of intermodal operation has made major progress. For confirmation one would have only to review the massive investment in container and Ro-Ro ships, in containers and trailers, and in terminals.

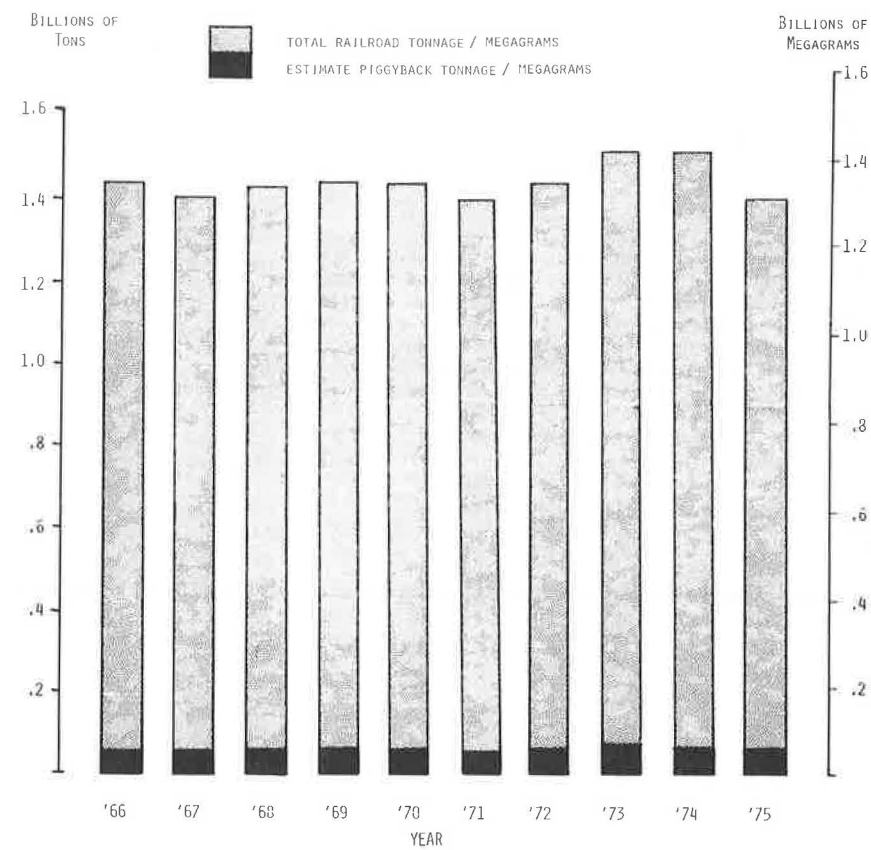
In 1974, the most recent year for which data are available, container freight amounted to over 43 percent of total liner cargo. And for U.S. flag carriers alone this percentage would be almost 52 percent. In terms of

Figure 1. Containerization and total U.S. ocean intermodal.



Note: 1 Mg = 1.02 long tons.

Figure 2. Piggyback and total U.S. rail intermodal.



Note: 1 Mg = 1.1 tons.

consistent growth and in percentage of total cargo carried, intermodal operations now transport a major portion of this business.

RAIL TRANSPORT

The rail picture is something else again. Piggyback has been around for quite some time now, and many have looked to it as a way of maintaining railroad participation in the merchandise traffic business. Progress, however, has been less than exciting. As can be seen from Figure 2, rail and truck intermodal has grown only modestly. Disregarding the major slump in 1975, which returned piggyback carload volume to its 1967 level, the growth from 1966 to 1974 is only about 3 percent per year. And in terms of the total rail market, tonnage has been between 3 and 4 percent. Yet, in its defense, in terms of megagram kilometers this percentage would be closer to 4 percent. As a proportion of freight revenue, piggyback might run as high as 9 percent. And, if present piggyback service volume were to be compared with the domestic containerizable freight market, the figure might be 5 percent. In fact in some individual origin and destination markets it might even be as high as 30 percent. But, to quote an editorial in Traffic World (1) a few months ago, "the possible maximizing of efficiency of freight markets that shippers for years have envisioned in their dreams about intermodalism is still far from being realized."

What is holding things back? More study has been suggested, although this may not be immediately necessary. Considerable analysis has been completed in the past 5 years, but much of this information has not been communicated or fully evaluated. Unfortunately, intermodalism has been discussed with people in planning positions and with operating authority who have been unwilling to consider the fundamental changes required of their businesses.

Agents of change for an entrenched institution often have to come from the outside. Consider, for example, the innovation of Malcolm McLean of Sea Land. His plans for marine containerization certainly were not accepted by the traditional steamship operator, but ultimately they turned the business upside down.

The members of the Intermodal Transport Committee must look beyond traditional statements and solutions if the issues are to be identified and resolved. The barriers and problems that have prevented intermodal operations from achieving their potential must be overcome.

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Intermodal Issues in Transport Planning

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Economic and institutional aspects of intermodalism are discussed from the viewpoint of a fully integrated Canadian multimodal transport owner and operator. The development of Canadian Pacific Ltd. into the world's only fully intermodal transport enterprise and the Canadian institutional and regulatory environment in which it operates are described. Intermodal ownership has not been destructive to transportation competition in Canada, and intermodal ownership was of considerable importance in the early achievement of intermodal handling of traffic there. The organization of an intermodal transport enterprise is discussed, the most workable format apparently being a fairly loosely structured company with all modes represented by self-standing profit centers that operate and market independently. Corporate management only sets overall policies and guidelines, allocates capital and personnel, and sorts out serious conflicts. This type of organization, with all its inherent conflicts, is to be preferred with a tightly structured and highly centralized system. Neither intermodalism nor multimodal ownership offers easy answers to the very serious problems facing the investor-owned transport industry.

This paper is about economic and institutional issues from the viewpoint of the private sector, specifically of a fully integrated multimodal Canadian transport owner and operator. I emphasize Canadian because, although the countries are close geographically and similar in many ways, one must also recognize the many differences.

HISTORICAL BACKGROUND

Canadian Pacific Ltd., now called CP Rail, began as a railway but from the outset had a very strong intermodal bias. The main line of the railway across Canada was completed in 1886 and was the first transcontinental line in Canada. It had something over $1 billion in total revenues in 1976, and was profitable, but only marginally, with a return on invested capital of slightly more than 6 percent, after taxes. This may not look bad compared with some other railways, but it certainly does not look good compared with most other businesses.

In the year the railway was completed, CP began chartering ships on the Pacific Ocean to connect with the railway. In fact, within three weeks of commencing transcontinental operations, a chartered ship was unloading 45 000 kg of tea at Vancouver for rail delivery in eastern North America. Intermodalism is almost as old as the railway itself.

Then came the acquisition of an interest in shipping in the Atlantic to connect with the eastern terminal of the railway. Before the end of the last century, CP offered an integrated through service between Western Europe and the Orient. Over the years, the company's ocean shipping interests developed in their own right, reflected changes in trade patterns and technology, and adapted to the consequences of two wars that each wiped out most of the fleet. Today, CP is represented in this field by two wholly owned subsidiaries—CP Ships, which operates a fully containerized service between Quebec City and the U.K. and the Continent, and CP Bermuda, which was formed in 1964 to engage in all aspects of international shipping. CP Bermuda today has a fleet of some 27 vessels of about 2 million Mg operated under various types of charter and freight arrangements.

The company's involvement in the trucking industry really began while the railway was being built, in 1884, when it purchased an express company, which later became CP Express. From its beginning as a stagecoach, this operation developed into an integrated local trucking and intercity rail, small shipment service. Our involvement in intercity trucking began immediately after World War II, when it became clear that this mode would become a major part of the domestic transportation scene. The development in Canada of intercity trucking lagged behind U.S. development, because of lower population density, longer lengths of haul, and the later development of adequate highways.

Beginning in 1946, CP engaged in a series of acquisitions that, coupled with growth from within, have made CP today, with the various subsidiary companies, the largest intercity trucker in Canada. With a market share of something under 10 percent, it is one of the largest in North America.

In 1919, CP obtained statutory authority to own and operate aircraft within and outside Canada. If nothing else, CP was long on foresight. From 1939, a series of acquisitions of small regional airlines, mostly bush lines operating north to south, were made and resulted in the formation in 1942 of Canadian Pacific Airlines Ltd., now called CP Air. From these beginnings, CP Air has evolved into a major domestic and international air carrier.

The only major sector of the transportation industry in which CP has no operating involvement at present is the pipeline sector. Our involvement in pipelining is limited to a research program in the field of solids pipelining and to a significant share ownership position in TransCanada PipeLines, the major west-east trunk gas pipeline in Canada.

To round out the picture, CanPac International Freight Services Ltd. was incorporated in 1972 as a wholly owned subsidiary that provides various transportation-related services. These include customs brokerage, sufferance and dry cargo warehouses, freight forwarding, and various agency services.

Thus, CP, which began as a railway, has followed the evolution of markets and technology to develop into an intermodal transportation enterprise. Certainly, we can and do claim the distinction of being the only fully intermodal transportation enterprise in the world.

Transportation, nevertheless, represents only one facet, albeit a major one, of CP's interests. The company also has very substantial operating and investment interests in telecommunications and hotels and in all aspects of the resource industry and certain areas of manufacturing. Over the past 20 years or so, these nontransportation interests have come to constitute the larger share of CP's development.

The consolidated sales of the company are of the order of $4 billion, of which some 45 percent is in the transportation sector and 55 percent in other industries. In the transportation sector, the railway accounts for some 55 percent of sales. In 1976, CP's transportation interests earned approximately 6 percent on capital employed, while the nontransportation sector earned about 12 percent.

CANADIAN CONTEXT

As background, a few words about the Canadian context in which we operate might be helpful, as this may be somewhat unfamiliar to many readers and is important to understanding more substantive comments.

Until 1967, there were no restrictions on intermodal ownership in transportation in Canada. The only restrictions were the standard antitrust restrictions, and Canada compared to the United States has had a tradition of some tolerance in this area. Since 1967, there has been a legislative provision for review of acquisitions of one transport entity by another. Such acquisitions may be disallowed on the grounds that they "will unduly restrict competition or otherwise be prejudicial to the public interest." This has not significantly affected CP's development, because almost all our transportation acquisitions predated the provision.

In general, the regulatory framework in transportation within Canada has historically been much less burdensome than that here. There are no federal regulations on the intercity trucking industry, only provincial regulation. There is a generally more permissive attitude toward railway pricing than in the United States, since the 1967 transportation legislation, which very much limited the scope for price regulation. There are no economic regulations on international shipping in Canada. One important regulatory provision, however, that applies particularly to railroads, is that the same tariffs be applied to subsidiary or associated companies as are to third parties.

Finally, CP is a shareholder-owned company, listed on the major stock exchanges, which operates in parallel and in competition with Crown Corporations owned by the federal government of Canada. The Canadian National Railways (CN), which is federally owned and some 50 percent larger than CP Rail, has lagged far behind CP in intermodal development. Over the past 10 to 15 years, CN has developed a major trucking subsidiary, largely by acquisition, and has more recently purchased a major interest in a North Atlantic container shipping operation. But CN has very much less intermodal diversification than CP. Air Canada is nominally owned by CN but is really an independent government-owned airline. It is Canada's major domestic and international flag carrier and much larger than CP Air.

This strange institutional relationship, wherein a shareholder-owned company coexists and competes with government-owned enterprises, is perhaps somewhat unique to Canada. The story of the beginnings and development of this relationship and an explanation of how and why it persists would be another very interesting story.

ADVANTAGES OF INTERMODAL OWNERSHIP

Intermodal ownership has not been destructive to competition or to anything else in Canada. Two very large intermodal firms operate here, and no one would seriously suggest that competition within the transport sector has suffered as a result, or that any other dire consequences have resulted. A more interesting question is if intermodal ownership helps to better achieve intermodal handling of traffic.

Some 10 years ago I argued that intermodal ownership did make a significant difference and did significantly assist in making intermodal handling happen. The earlier introduction and growth of piggyback services in Canada, the greater use of piggyback services here, and the earlier development of an integrated international container service in Canada, were all compared with the U.S. experience. I argued that as long as the regulatory process significantly interfered with market pricing and impacted the various modes differently, a multimodal transport owner would do better than the marketplace in making intermodalism happen, since he or she could internalize the economies that would not be reflected in the market prices. I also argued that multimodal ownership would help in overcoming the initial inertia in achieving intermodal handling and the natural and historic antagonisms that existed between the various modes.

I still believe what I said then, but perhaps not quite as strongly, because in Canada market pricing is generally prevalent in the transport sector. I would still maintain, though, that multimodal ownership was of considerable importance to overcoming inertia and the antagonisms among the various modes and that it eased the birth pangs attending the emergence of intermodalism. But, intermodal's growth does not reflect its easy birth.

When CP first took a significant position in intercity trucking, it operated its subsidiary trucking companies as adjuncts to the railway. There were instructions to use piggyback services for specified hauls and to limit the marketing effort in those areas where the railway was the dominant carrier and the traffic was attractive to the railway. It did not take long to discover that this was simply not workable. It distorted incentives, yielded meaningless managerial control documents, and destroyed any type of managerial accountability and responsibility. We found that our trucking companies were not being efficiently operated, that their service level was inferior to that of their competitors, and that limiting the marketing thrust of our own trucking companies to protect the railway did not really help the railway. There was no lack of other truckers waiting to attack, which they did with considerable success.

Today, CP Transport is very much a self-standing trucking company, able to choose where it should concentrate its marketing efforts, where and when it uses piggyback services, and how it should price them. Quite naturally, we expect it to use CP Rail piggyback services not those of our competitor, other things being equal, and to use the services of CP Air and CP Ships, other things again being equal. But they pay tariffs, either standard or objectively negotiated, for these services. Anybody else could make the same deal with the other arms of CP as CP Transport does, given the same volume and other conditions surrounding the movement of the traffic.

In general, CP is convinced that the concept of self-standing profit centers for each transport mode is the only workable organizational structure for an intermodal transport enterprise because

1. Generally, intermodal traffic still makes up a fairly small portion of the overall business of any single modal entity, with the exception of CP Ships. Therefore, it makes no sense to let the tail wag the dog by organizing around intermodalism.

2. There is an overwhelming need to give local authority and responsibility to each of the modal profit centers and to let their managements operate their own businesses as they see fit. Each mode is different from the others and requires dedicated and specialized management, able to respond to situations quickly and effectively.

3. No one is smart enough to sit at the center of the web and direct the various modes. Perhaps this is possible in certain industries, but the dynamics, constant change, and need for immediate decisions in transportation make this, in our view, totally impractical.

4. We believe that our overall degree of market penetration is improved through modal marketing, with all its overlap and conflicts, as compared with centralized multimodal marketing, and that the extra costs resulting from the overlap are easily covered by higher market shares.

The result is a fairly loosely structured transportation company. There are independent profit centers, each judged on its performance and its own profit and loss statement. Each one operates, markets, and prices independently. Each uses the services of other arms of the company when it chooses at prices in published tariffs or negotiated directly; each is allowed to use services provided by third party transportation companies when it is clearly to their advantage and there is no need, on a day-by-day basis, to justify such decisions to corporate management. This is not an empty freedom that no one utilizes.

As can be easily predicted, there is scope for considerable overlap in such an arrangement and for conflict among profit centers. CP Rail, for instance, offers a piggyback service that competes directly with the trailer-load service offered by CP Transport, which, in many cases, has piggyback service on the very same train as the CP Rail trailer. CP Transport aggressively markets a less-than-trailer load service that competes directly with the service offered by freight forwarders, who are very important and profitable customers of CP Rail. CP Rail markets its domestic container service to foreign shipping companies, who themselves pursued the very same traffic being pursued by CP Ships in continental Europe. CP Air markets an air express service, as does CP Transport. The list could also be extended.

We have been told by many people that we are going the wrong way and that what is needed is a central marketing group and a centralized control system to eliminate wasteful competition and overlap between our subsidiaries, and to rationally plan our marketing posture and operating patterns. Our answer is very simple: Maybe you are smart enough to do this, but we know that we are not. The transportation market is too complex, too changing, too volatile, and too localized to be managed centrally.

Lest you be left with the impression that all is chaos with CP, we do have a corporate management that sets overall policies and guidelines, allocates capital and people, and sorts out any conflicts. And we do put considerable stress on fostering the flow of people between corporate management and the profit centers and among the profit centers themselves. Our people, of course, do come to know each other, and there is an esprit de corps about working for CP. But emphasis is on modal autonomy, not on head office centralization.

To the question of whether the various CP transportation entities are different because they are part of an intermodal company, one could answer that the only instance of a very marked difference might be in the case of CP Ships. Essentially they only sell intermodal door-to-door service. CP Ships maintain that being part of the CP and being able to offer a single company door-to-door service very much improves their marketing posture.

CP Transport would probably make the same use of piggyback services whether they were part of CP or not, although choice of carrier might change somewhat. The only significant difference for CP Transport relates to certain regulatory obligations that were shuffled into CP Transport when CP Rail withdrew from services some time ago. CP Air would not look different if it were in the hands of an independent owner, and CP Bermuda might as well be owned by Greeks or Swedes.

Our intermodal experience and our transfer of people among the modes themselves and within the management have benefited the general level of management at CP.

CONCLUSIONS

One conclusion that can be drawn from the CP experience is that intermodalism, while clearly becoming a more significant part of the transport sector, is not a magic answer to the problems surrounding that sector. These problems are grounded in public policy, history, technology, markets, industrial location, and so on. Intermodalism is the result of fairly recent technological, economic, and market changes, and those engaged in transport obviously have yet to exploit it.

Second, multimodal ownership can help intermodal handling develop. But, once again, this is not the magic answer to the ills besetting our transport industry.

Third, we believe that there are very real, extensive diseconomies of scale and complexity in the management of multimodal transportation enterprises. This is a problem with which we have struggled for some time, and we have concluded that intermodalism does not warrant the development of a highly centralized, closely integrated management structure. Perhaps this is because we are not clever enough or because our computers are too small.

The last remark is that transportation, even in a fully multimodal fashion, has basic difficulties from the investor's viewpoint. For many years, CP pursued a very aggressive expansion policy toward transportation—very broadly defined—to develop a multimodal transport enterprise. Over the past 15 to 20 years, our major development effort has steadily and continuously shifted from transportation to other endeavors, until today transportation represents only 45 percent of our consolidated sales, compared to 90 percent 20 years ago. The ratio is more likely to decrease than to increase in the future. This only emphasizes the need to right some of the basic ills plaguing the industry; this goes far beyond the challenges of intermodalism.

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Intermodal Realities

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The current decline in the market share of U.S. railways for merchandise traffic has led the Federal Railroad Administration to initiate a major study of the shortcomings and potential of rail piggyback and intermodal operations. The study examines merchandise movements, transport services' modal and economic capabilities, and shipper needs and practices. A model of rail intermodal services over a hypothetical 52 000-km (32 500-mile) route structure serving 120 cities was developed. Results indicate that the current piggyback market share of total containerizable freight in the U.S. is about 4 percent and that the principal impediments to the shipper of rail intermodal services were costs and service. The study recommends cost reductions in rail operations and service improvements. The rail network modeled could handle three times the current trailer-on-flatcar volume by 1980, and transport cost might be reduced by an estimated $200 million a year. The Federal Railroad Administration and cooperating railroads have begun a series of demonstrations to test the practicability of the study results and rail intermodalism.

Secretary Coleman, in his September 17, 1976, statement of national transportation policy, said that

> Underlying comprehensive transportation policy is the recognition that diversity and intermodal competition are essential to an effective transportation system.... The strength of our transportation system has in its diversity with each mode contributing its unique and inherent advantages.... A priority for reform is to encourage intermodal joint use of facilities... the potential of intermodal services remains for the most part unrealized.

He concluded that a transportation system based on the policy outlined in his statement would provide "new, more cost-effective, energy-efficient and intermodal technology."

This statement carries forward the policy of his three predecessors—Boyd, Volpe, and Brinegar. Early statements of Secretary Adams indicate a continuation and even a strengthening of this policy. Enunciating a policy, nevertheless, is a great deal easier than implementing it.

In 1972 it was apparent that intermodalism was not, in fact, working in the marketplace. The railroad share of merchandise traffic was declining. Piggyback, the great hope of the railroad industry, was until recently in a decline. Several major northeastern carriers either teetered near or had toppled over the edge of bankruptcy.

It became apparent that a major effort of disciplined research was necessary both to document previous shortcomings and to outline future potential for intermodal business.

In cooperation with a liaison committee made of railroad intermodal officers, the Federal Railroad Administration (FRA) designed and launched the National Intermodal Network Feasibility Study (1).

This study was divided into four major areas. The first task was to gather material on market flows of merchandise traffic, the second to estimate carrier service and economic capabilities, the third to identify shipper needs and practices, and the fourth to design a series of models.

The models defined a probable market split and then proceeded through a complex train scheduling exercise. They finally estimated financial, environmental, energy, and employment impacts of the network.

The method is laid out in detail in the study's more than 700 pages. A more digestible summary of it, however, is presented elsewhere (2). The methods used by the study team are both fascinating and complex and have been discussed on a number of previous occasions. I would like, therefore, to deal with the findings of the study.

One caveat is in order before we start. The network structure on which the study was based was designed with two things in mind: to be structurally and analytically simple and to stimulate discussion on potential rail market strategies both within and outside the rail industry. The FRA did not intend to imply that the network concept was either an optimum or the preferred option.

STUDY NETWORK

In terms of the description that was developed, there were roughly 500 trains/d in the network, the majority of them nonstop, over 52 000 km (32 500 miles) of route, serving 120 cities. The route density was 10 or more trains per day on 60 percent of the network links, and many cities required new terminals to handle up to 2600 transfers a day. A total of 120 highly improved mechanized terminals were required—fewer than today's 1400 piggyback terminals, 90 percent of which are ramp-style operations. Traffic growth on the network was projected at 6.6 million loads a year by 1980, three times the current piggyback traffic level. The revenue was projected to be $2.5 billion by 1980, and the net return projected was roughly $1 billion before taxes.

The study contained some very conservative biases. It was assumed, for example, that traffic would be diverted only when network service itself matched or could exceed all highway service. External financing required for all new terminals, additional equipment, and some line upgrading was to range between $300 million and $3 billion, depending on the amount of upgrading to be done.

CONCLUSIONS OF THE FRA STUDY

Perhaps the most startling conclusion of the study was that all-highway carriage is much more cost competitive with either current all-rail or piggyback service than was previously suspected. To become competitive for merchandise traffic in any form, railroads will have to substantially sharpen their operations. The study's major findings were that

1. Piggyback service currently has about 4 percent of the total containerizable freight market (this definition of total market does not include bulk materials such as coal);
2. Piggyback growth in real terms has declined or stopped over the recent years; and
3. Profitability of a substantial portion of piggyback service is, at best, questionable.

The study also outlines what is needed for developing viable intermodal service from both a rail and a customer standpoint: more speed dock-to-dock and reliability, costs competitive with all-highway operations, high standards of equipment and facility maintenance, upgraded trackage and roadway along certain routes, proper pricing and selective selling for directional balance, and better management control through an improved terminal control and management information system.

The study also found that shippers would benefit from additional competitive service as well as savings of almost $200 million a year. Public benefits include possible reduction of future aid to the railroad industry, which, as we have seen from recent legislation, could be substantial. In addition, fuel savings of about 284 million dm^3 (75 million gal) a year and reduced air emissions were projected. Current results of FRA's Office of Research and Development indicate that these savings may, in fact, be much larger. For highway carriers, both increased traffic and drayage activity and drayage jobs are anticipated. For the railroads, increased profits through network operations and more and better quality rail jobs are obvious benefits.

The study found that improved intermodal service is feasible; now we must test the theories in practice, which FRA is in the process of doing. Several rail carriers and their labor organizations are jointly investigating putting demonstrations on specific route segments together.

PROGRAM OBJECTIVES

The objectives of their program include measuring intermodal traffic growth to determine whether the industry, if it does the things that the study pointed out, can in fact increase intermodal traffic growth and improve return on investment for railroads. Many chief executive officers looked at intermodal and concluded, even before our study, that today's intermodal business is not producing investment returns for their firms.

Another objective is to see whether the shippers would view the new services as a new service option. This relates to one of the U.S. Department of Transportation's (DOT's) experiences with the Metroliner demonstration, in which it was found that many passengers, particularly the new ones, did not consider Metroliners as rail service but as a new mode. DOT wants to see if this intermodal experience will result in something similar.

DEMONSTRATION SPECIFICATION

Specifications for the demonstration itself include piggyback trains handling no other freight and being free from classification yard handling en route or at end points. Next, multiple frequency train operation at a level of service competitive with all highway operations will be offered. As an example, if three current market carriers all have 10:30 cut off, 11:00 departure, and little in terms of an alternative time frequency choice to shippers, DOT will try to spread the frequencies to departure throughout the day. Next, a balancing of loads in and out of terminals for optimum car and locomotive use, increased labor productivity, and a limitation on trains in terms of the amount of empty trailers and empty cars will all be required to keep costs in line. Simplified terminal operation for rapid and less costly transfers, including intermediate points, and a real-time car and trailer control system and management information system complete the demonstration specifications.

There are several carriers and their labor organizations currently prepared to participate in the demonstration in the Midwest and West in cooperation with shippers and truckers. DOT hopes to be able to turn the first wheel of the demonstration shortly. In the meantime there is a substantial amount of supporting work going on within FRA and elsewhere.

SUPPORT STUDIES

This work includes the development of a management information system and gateway terminal consolidation and improvement. The FRA R&D people are also conducting light-weight car evaluations, car vibration testing, fuel consumption testing, and aerodynamics drag studies; reports are due soon.

In addition, a total systems engineering study of all hardware aspects of intermodal and their interfaces is about to begin. These studies should produce hardware innovations over the next decade. DOT and FRA look forward to an exciting and nationally significant series of experiments in implementing intermodal policy.

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Pennsylvania Commonwealth Piggyback Demonstration

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In the belief that a prototype intermodal service is crucial to the development of a national intermodal network, the Bureau of Science and Technology of the Pennsylvania Department of Commerce has been planning the Transcommonwealth Piggyback Demonstration Project. This has been developed to the point where it can be brought to operating status relatively quickly with a modest investment and will be of substantial value to federal rail planners. This paper presents the need for such a project, plans for providing a reasonable approximation of network-type service, potential value in terms of operating data obtained and momentum created for the development of a national network, and costs of carrying out the demonstration.

In 1973 the Bureau of Science and Technology of Pennsylvania's Department of Commerce became interested in intermodal transportation and in using rail as the line-haul mode. The Bureau asked James Romualdi to gather empirical data for the purpose of determining whether an intrastate piggyback service in Pennsylvania was warranted. Concurrently, the Pennsylvania Department of Commerce organized a seminar on the subject, attended by representatives of the American Association of Railroads, the Penn Central Transportation Company, then still a railroad, the Pennsylvania Department of Transportation (PennDOT), and at least one motor carrier, the New York Motor Freight.

The idea of a piggyback demonstration project between Philadelphia and Pittsburgh was generated in the course of the 1973 meeting. Convinced that such a demonstration would be crucial to the development of a national intermodal network, the Bureau of Science and Technology began planning one, which became known as the Commonwealth Piggyback Demonstration.

This project has now been developed to the point where we believe it can be of substantial value to federal rail planners. It can also be brought into operation relatively quickly and at a modest cost. In terms of the valuable information and momentum it can lend to network development, the potential returns far exceed the level of investment that would be required to bring it into being.

Also, Governor Shapp's long-standing interest in railroad transportation has probably had a good deal to do with the enthusiasm of the department of commerce; this is in keeping with Pennsylvania's historical interest in railroading. The largest railroad in the free world carried its name for some time.

A prospectus for this piggyback demonstration project was therefore developed by Gellman Research Associates. Despite widespread acceptance of the importance of resuscitating the railroads and of improving transport and labor and capital productivity and of effecting meaningful fuel conservation, there is still a great deal of inertia affecting the development of a national intermodal network.

DEMONSTRATION ADVANTAGES

Even though the Federal Railroad Administration (FRA) study indicates the feasibility of such an intermodal network, an operating piggyback demonstration is essential to overcoming this inertia. Performing the type of service at the actual price level if the entire network were in operation would also provide the operating data necessary to handling many of the crucial questions now inhibiting network development. Further, it would serve as a test facility, providing the opportunity to experiment, under operating conditions, with innovative line-haul and terminal equipment techniques. It would also facilitate pricing experimentation and the trial of various intermodal interface arrangements. Not least, the experiment could provide a test bed to help settle such old, but still burning issues as the relative efficiency of container on flatcar versus trailer on flatcar.

It is a measure of our intellectual deficiencies in transport that such issues have not yet been decided. The demonstration project could aid in the identification and measurement of the benefits that would accrue to railroads and shippers, were such a network to be introduced on a national scale. The benefits to highway users and to the public at large would also be identified and measured.

DEMONSTRATION PROBLEMS

To be sure, substantial problems will have to be overcome in developing a demonstration that approximates network-type service and operates within the parameters of the current national intermodal transportation scheme. First, the speed and reliability of the network line-haul trains will be difficult to duplicate with existing equipment under the track conditions existing throughout much of the nation.

Another problem is that information on fully automated intermodal terminals is lacking. No such terminals are even in the prototype stage at this time. A third problem is that, because of existing labor rules, the labor cost component of a demonstration service will be substantially above what can be expected in network service, with modified labor rules within our grasp.

A further problem is that the prices of network services probably could not be duplicated without incurring a loss. The prices of intermodal network service in the intrastate Pennsylvania context could not be introduced without incurring a loss because of the demonstration's limited scope, which would necessitate spreading terminal capacity costs and overhead over a relatively small traffic volume. That is, it is doubtful that the set of rates introduced in Pennsylvania would reflect the rate structure if the system were to be profitable. Because some initial losses would be incurred, supporters of this project should enter it with the understanding that some losses must be borne now in order to gain the knowledge that will later offset these losses.

Another problem is that the desired cost-based rates would likely be at odds with the bulk of the current rate structure, which is heavily commodity oriented. Finally, pricing the service at a loss, because of the inability of the project to duplicate network economy in scale, would be in conflict with most price and regulatory policies and practices. Yet, the Bureau of Science and Technology has formulated a plan for a demonstration service, designed to circumvent these difficulties well enough to allow a reasonable approximation of network-type service.

DEMONSTRATION ROUTE

At present, service is planned to run between Philadelphia and Pittsburgh, paralleling the heavily traveled Pennsylvania Turnpike. Preliminary work done for the FRA has shown that the volume of traffic between these two cities that is potentially divertible to an intermodal-type service is among the highest in the nation. Consolidated Rail Corporation's (Conrail's) Pitcairn Yard, east of Pittsburgh, and a site at Plymouth Meeting, just northwest of Philadelphia, have been identified as possible terminal locations for this service.

Each evening, from Sunday through Friday, a fixed-length train would depart from Philadelphia to Pittsburgh, and another from Pittsburgh to Philadelphia. The service would be designed to allow shippers to drop trailers off at the terminal after normal business hours, with the assurance that these trailers would be available for pickup at the opposite terminal before the opening of business the following day. Because this service coincides with peak shipping and receiving periods, it duplicates service offered by overnight trucking.

At the inception of the service, both the Penn Central Transportation Company and the Reading Company became competitively interested, but now Conrail remains as the sole potential supplier of complete line-haul service between Philadelphia and Pittsburgh. It presently provides some intermodal service over longer routes but appears interested in the demonstration of this particular service over a shorter route of about 500 km (300 miles). Conrail cannot independently institute such an intermodal service because of lack of capital funds to build the necessary terminals with rapid-loading equipment. However, it has indicated a willingness to provide dedicated trains with high quality, well-maintained motor power and suitable flatcar equipment for the initial part of the project.

ROLE OF THE ICC

According to its normal practice, the Interstate Commerce Commission (ICC) could be expected to object to an arrangement that was not fully remunerative. Moreover, pricing would initially employ a "freight-all-kinds" rate technique that is generally in conflict with the commodity-based rate system used by ICC-regulated truck and rail carriers. Although there are exceptions, the commodity-based rate system dominates.

It is hoped that the intrastate nature of this demonstration service will remove it from the ICC purview to allow more flexibility in rate experimentation. The ICC, nonetheless, probably will attempt to extend its authority, at least to shipments using the demonstration system, if such shipments originate or terminate outside Pennsylvania, for example, shipments from Camden, New Jersey, to Akron, Ohio, traveling on this service between Philadelphia and Pittsburgh. International traffic would be a topic of particular interest to lawyers.

SHIPPERS, RATES, AND POLITICS

The initial technologically conventional demonstration service can, in fact, break even, although at projected rates it would require a utilization rate or load factor of approximately 90 percent to do so. Given a national intermodal network in place, it seems reasonable to assume that a 50 to 70 percent utilization rate could eventually be achieved. Starting at about 50 percent, it would climb to about 70 percent in the course of the project, and the levels of utilization in this service would result in annual losses of between $1 and $2 million annually. Although a considerable sum per se, it is insignificant when compared with the potential value that the demonstration service could have in aiding the development of a national intermodal network. It is, however, a substantial cost for Pennsylvania to bear alone. The development of the proposed demonstration service has been conducted thus far solely with the modest financial resources of the Bureau.

Modal choice simulation work done for the FRA gives evidence that a substantial portion of shippers would rather use an intermodal network than either common or private motor carriage, if speed and reliability were equal and the costs the same or lower. Even more surprising perhaps is that shippers providing their own transport state that they would be eager to get out of the transportation business if the carrier could provide them with service of equal quality at the same cost. In addition, reliability has been shown to be by far the most important service quality to shippers.

Much of the intermodal traffic that Conrail now carries between Philadelphia and points west of Pittsburgh comes from freight forwarders' and shippers' associations that were established primarily if not solely to take advantage of the freight-all-kinds piggyback rates that have been published to date in such a limited way. It is likely that a substantial portion of these same users would be interested in the proposed demonstration service; several prominent carriers have expressed substantial willingness to shift some of their freight to the projected service.

Clearly, there are limits to what carriers, especially common carriers, can do in this regard. Not the least of these limits relating to the Teamsters' constraints on the common carriers' ability to serve is the unions' potential functioning as a catalyst in the development of the national intermodal network; they could focus public attention on the concept. This type of interest is the basis for the broad political support that the development of the national network will require. There is a tendency to underestimate the importance of political support for this kind of an operation—political support that transcends the support of railroads, truckers, proprietors, Teamsters, and shippers.

A program carried out well in Pennsylvania could galvanize public opinion on the side of this sort of a proposition, not only in Pennsylvania, but, if properly broadcast, nationally. There is no reason why demonstration projects of this nature cannot be carried out simultaneously throughout the country.

PROJECT FUNDING

The proposed piggyback demonstration project is uniquely suited to the role of providing a demonstration of the level of service that would exist under a national intermodal network. Since July 1973, the Bureau has attempted to cull advice and suggestions from the various groups that would be affected by such service. The overwhelmingly positive reactions of those consulted have been quite encouraging.

The remaining tasks are a marketing study and the development of final plans for the construction of the two terminals, estimated to cost about $2 million. This sum is beyond the limited resources of the Bureau alone, but it is possible that low interest loans, either through the Pennsylvania Industrial Authority or the Revenue Bond and Mortgage Plan in the state, will be made available to cover substantial portions of terminal construction costs. Because of the temporary nature of the service and its questionable ability to be economically self-sustaining, some sort of guarantee is likely to be required from the FRA. It is also possible that the highway department will be able to aid in building some of the terminal areas.

Funding needs during the service period will be limited to the initial working capital and expected operating deficits. At this point, these can only be estimated. However, the level of demand necessary to realize the objectives of the demonstration should also prevent the operating deficit from exceeding $2 million annually. If demand is not great enough to keep the deficit below this, the project should not be launched. Lack of demand, however, should not be a problem.

The analysis suggests the conclusion that losses can be limited to well under $2 million. The trial period of the service should be of substantial length, in order that shippers may be induced to alter their present routing patterns. For planning purposes, this period has arbitrarily been set at 5 years. If the entire cost of the demonstration project reaches $10 million ($2 million a year for 5 years), it represents a very small investment compared with the project's massive potential value. The project might be the prototype of a national network.

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Intermodal Transport and Containerization

Howard W. Jones, General Foods Corporation

Shippers' associations began the development of intermodal operations about 10 years ago. Growth has been steady since that time because of improved transit times that make intermodal more competitive with truck and boxcar service. Containers also cost relatively little compared with boxcars. These capital considerations must be weighed by carrier management in future investing strategies. Many shippers are hopeful that intermodal will grow by using the flexibility of motor carrier deliveries with the economics of long-haul rail transportation. Private business must assist in the development of new concepts in intermodal transportation by cooperating with carriers, government, and shipper communities.

General Foods (GF) is a diversified processor and marketer of packaged grocery products, with worldwide operations and distribution capabilities. GF's net sales for fiscal year 1976 totaled almost $4 billion.

The transportation scheme within GF is designed basically to support our distribution and to provide our customers with the best service available at acceptable cost. Until recently, GF was primarily rail oriented; that is, most of our raw and packaging materials were received at our plants by rail, finished products shipped to our distribution centers by rail, and approximately 50 percent of the volume moved from our distribution centers to customers by rail. In the last few years, however, GF has tended to shift more toward truck, and for 1976 our volume split about evenly between rail and truck. Transportation dollars are also divided equally.

To implement our transportation strategies, we have made extensive use of the grocery car developed about 15 years ago in cooperation with railroads and car equipment manufacturers. These cars are made available to us by about 20 major rail carriers.

GF'S INTERMODAL HISTORY

To give a user's or customer's perspective on the transportation industry, one must go back about 10 years to the time when GF began developing intermodal transport. Intermodal in this context refers primarily to land transport within the United States, of the truck-on-flatcar, container-on-flatcar, or piggyback type.

In our international operations, we have used containerization for a number of years, because it was developed both by the container people and by the steamship lines. Many of the advantages of containerization have been exploited by water carriers, but there appears to be a great deal still to be done with containerization as applied to land transport.

In 1967, when we began our intermodal operation, we used shippers' associations primarily. We shipped several hundred trailers that year and realized favorable cost reductions and reduced transit times. In 1976, GF shipped products in more than 2000 trailers, or about 10 times as much as in 1967, and continued to use our membership in shippers' associations.

In the following I shall discuss the use of shippers' associations, the growth in containerization use, how GF views the future as customers or users of containerization, and what some of the difficulties in the development of containerization are.

SHIPPERS AND PIGGYBACK

Many shippers and customers began to use shippers' associations because of costs. The mixture rules and other pricing devices imposed by carriers in the last few decades to protect carload freight turned customers toward shippers' associations. The net result of this pricing strategy has been phenomenal growth of these associations in the last 10 to 15 years. In hindsight, at least, it appears that carriers' desire to protect the carload freight made them miss a good marketing opportunity.

The need for consolidators to perform so-called "marriage" arrangements because of mixture restrictions has eased in recent years, because the mixture rules themselves have been liberalized or eliminated. On the other hand, volume trains (10 trailers or more) increase the need for the consolidators to those shippers who cannot make the necessary minimums.

The growth in GF's piggyback traffic has developed because transit times are more competitive with existing truck service and much more dependable than carload service. For example, our experience with piggyback service has been excellent—in some cases, equal to or better than truck. Shipments from our Chicago plants to a distribution center in Dallas, for instance, have shown that transit times and dependability are comparable to or better than those of motor carriers.

The importance of dependability and competitive transit times does not relate particularly to the transport business factors but is measured in reduced inventory in transit. We estimate that, at any one time, there may be 1 week's production in transit. This is inventory that has a measurable value, but it is also inventory that cannot be sold, or disposed of, or touched, or in any way managed until it is delivered.

In that Chicago to Dallas example, the best schedule by rail is 5 d. Experience, however, shows that the range of any individual shipment could be from 4 to 12 d, depending on the carriers used, their experience, the volume moving at any one time, and the weather. On one particular move, the 90th percentile—9 out of every 10 cars—would arrive on perhaps the eighth day; that is, there is a 3-d miss on the schedule. The 90th percentile tends to skew itself toward the high end of the range, and there is no assurance that any specific shipment will meet the 90th percentile or the schedule.

The difficulty for a customer is to maintain volume on the rail carriers and to develop competition with the existing motor carriers. One answer is piggyback or trailer-on-flatcar. This is one and perhaps the only way a customer can maintain some competition between existing modes of transport. Volume increases and a desire to maintain competition have led to the major intermodal growth in GF.

FUTURE OF INTERMODAL

In 1962 a grocery car cost about $19 000; today that same car costs well over $40 000. My company uses that car about 1.8 loaded trips per month, which is higher than the national average for free-running, railroad-owned boxcars. It is not surprising, then, that most carriers experience considerable difficulties in meeting established investment criteria, particularly at high interest rates on an investment in excess of $40 000, and that their profitability is under continuing pressure.

The cost of a trailer, on the other hand, is much closer to $8000 or $9000, and the utilization factor is considerably higher—five times that of a boxcar. These are compelling considerations for carriers trying to maintain a competitive position in the market, to attract high margin traffic, and to increase their market share.

One method that rail carriers can use to increase their share of the market is to develop their trailer-on-flatcar capabilities. The technology we have today no doubt needs improvement, but the equipment is there, as are the basic devices—the trailers, the cars, and the power. This is not the technology we would necessarily like to see in tomorrow's environment, but neither were the DC-3s we all rode. The 13.7-m (45-ft) trailers could be intermodal's answer to the 707.

What is needed is top management's attention and commitment to the development of intermodal capabilities, and their attention to organizing for maximum profits from these investments. Carriers can also benefit from some of the pricing errors of the past and can maximize their profitability with this new marketing tool.

Of course, there are definite capital implications that must be cost-benefit analyzed. Some of the hurdles can be foreseen if the carriers move forward in exploiting intermodal capability. Intermodal calls for increased marketing skill, and a proper blend of existing equipment and technology with flexible pricing philosophies and strategies is essential to making this a flexible, competitive mode of transport. One pricing approach to be closely scrutinized is the continued use of the mixture rules that have become so ingrained in some marketing philosophies and pricing strategies.

Another problem is the need for the high degree of dependability that would attract volume to intermodal. This could take the form of a guaranteed service at a premium price, which would permit the customer to choose between paying a higher price for a guaranteed service or running the risks of a less dependable service and trade-offs in his internal economics.

Equipment design also has to be reviewed and evaluated, particularly as it relates to efficient energy use. Consideration should be given to the use of containers over trailers on flatcars. Several studies have indicated that a container creates much less air resistance than a trailer on a flatcar and is therefore more energy efficient. In addition, the design of the flatcar is essential to improved equipment design. From the customer's viewpoint, the shipper should be able to switch the entire flatcar and container into the facility, just as a boxcar is handled today.

With proper flatcar design, containers could be moved onto the loading dock and loaded or unloaded as a truck trailer is today. This method would have two advantages. One is that many plants are designed for handling or shipping by rail. To increase shipments by motor or container would require a considerable capital investment on the part of the manufacturers. However, if the carriers themselves developed intermodal, the shipper would have the option of taking his shipment by trailer, that is on rubber, or having it switched into his plant as a boxcar. This flexibility would certainly open up avenues to shipper acceptability. GF has done considerable work in this area and has proved its feasibility.

CONCLUSION

Manufacturers are cautiously optimistic. We are extremely hopeful intermodal applied to land transportation will begin to accelerate soon. This would provide the best of both worlds: the economics of long-haul rail transportation plus the flexibility of motor carrier deliveries and operations on either end.

Creativity on the part of both motor carriers and railroads is necessary to giving them an opportunity to share the volume of traffic in intercity transportation. Both should become beneficiaries of this volume rather than out-and-out competitors.

The vigor, commitment, and management skills with which carrier management develops and exploits this mode will determine how well the public in general and the shipping public in particular will benefit from the advantages of intermodal land transport.

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