Trunk Route Analyses: A Useful Tool for Statewide and Regional Rail Planning

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The underlying purpose in developing and applying a truck route analysis procedure was to (a) prepare reliable estimates of traffic likely to use the various main lines that make up a rail system and (b) transform resulting traffic flows into estimates of railroad costs and revenue on the basis of links, nodes, corporate systems, and regional rail systems. The objective is to identify the overall effect of proposed changes in facility usage, routings, and corporate ownership through identification of the difference between the current system and alternative plans. The developed procedure used traffic assignment principles applied to rail freight. Key steps involved (a) establishing geographic and physical facility characteristics, (b) obtaining traffic and revenue data, (c) preparing the various inputs (physical characteristics of links, zone-to-zone traffic, and likely routings), and (d) assigning traffic and calculating associated costs and revenues by using a specially prepared computer program. The procedure, developed for the Pennsylvania Department of Transportation, was used to evaluate the United States Railway Association's Preliminary Systems Plan (for reorganizing bankrupt railroads in the Northeast and Midwest) and a simple plan proposed by the commonwealth of Pennsylvania. The resulting procedure helps fill the void for rapid, large-scale tools for policy and systems level planning. Although developed for statewide and regional rail planning purposes, the procedure and supporting computer program are general enough to permit their application to other freight modes of an intercity character.

Government involvement in rail planning at the regional or statewide level is relatively new. Planning differs from regulation, the long-standing government control mechanism over the private sector. It is born of rising interest in comprehensive, intermodal transportation planning on the one hand and the current rail crisis in the Northeast and Midwest on the other. Seven bankrupt railroads, not reorganizable by traditional means (section 77 of the Bankruptcy Act), are being consolidated under the provisions of the Regional Rail Reorganization Act of 1973 as a new private, for-profit carrier backed by large infusions of federal money for start-up expenses, plant rehabilitation, and labor protection. The dominant role in the restructuring process has been assigned to the federal government through the United States Railway Association (USRA) and the Rail Services Planning Office (RSPO) of the Interstate Commerce Commission (ICC). The role envisioned by the act for states and lesser units of government is primarily one of presiding over the ultimate disposition of light-density branch lines not included in the ConRail system, an issue separate from that of trunk route planning.

Since the issuance of the Secretary of Transportation's report (1) giving recommendations with respect to "the geographic zones within the region in and between which rail service should be provided," much public discussion of the potential abandonment of a large number of light-density lines has taken place. Release of the Preliminary System Plan (2) and testimony given at subsequent RSPO hearings on that plan have attested to the great concern being given by state and local governments and shippers to the issue of light-density lines. Although much of this focus has been needed to point out supposed analytical mistakes or data errors made in deciding whether a particular branch line generates sufficient revenue to cover the costs incurred, it has tended to divert the attention of state and local officials away from the more important issues involved with future trunk route service.

Several states (Pennsylvania, New York, Iowa, Wisconsin, and Michigan) have shown interest in the ultimate trunk route system for the Northeast and Midwest. At least one state (Iowa) is deeply concerned over the ultimate disposition of the Chicago Rock Island and Pacific Railroad Company (Rock Island Lines). In practically all cases, the approach has been conceptual or built around suggested restructuring criteria; in most instances, it has not included quantitative analyses. Crises have the by-product of promoting interest and concern where there was none before. Practically no interest has been shown by states not facing actual or threatened railroad bankruptcies, their presumption being that the current method of operation will continue unabated.

Of all the states, Pennsylvania has probably shown the greatest interest in the subject of main-line structure. The reasons for this are numerous: historic interest and involvement with railroads (the commonwealth was an original investor in the Pennsylvania Railroad), industry and natural resource dependency on railroad service, concern over possible loss of railroad employment and

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lowered service levels adversely affecting industrial investment, further loss of interrailroad competition in eastern Pennsylvania through inclusion of the Reading, Lehigh Valley, and Erie-Lackawanna railroads in an even larger and potentially less manageable railroad system blanketing the state, and the possibility of creating an even larger financial fiasco than that involving Penn Central. Governor Milton J. Shapp of Pennsylvania has advanced his own reorganization or system plan as well as a rehabilitation funding proposal through a trust fund similar to that in existence for highways (3). Instead of leaving the problem (which is admittedly regional in scope) solely in federal hands (with only a critique or comments on the output documents), Pennsylvania has chosen the independent course of conducting its own quantitative analysis of the reorganization proposals advanced in the USRA Preliminary System Plan. The method developed for conducting trunk route analyses is the subject of this paper.

WHY UNDERTAKE TRUNK ROUTE ANALYSES?

Why should a state not facing the problems associated with ensuring the continuation of essential rail services become involved in rail planning? Why undertake trunk route analyses? Isn't this the responsibility of the federal government and the private carriers? These are very real and difficult questions.

We must define what we mean by trunk route analysis. The term refers to the systematic process of assigning zone-to-zone traffic flows, expressed as carloads, mass transported in megagrams, and revenues to a "main-line" regional rail network for the purpose of quantitatively estimating overall costs, revenues, car-kilometers, and megagram-kilometers with appreciable detail or precision. Conceptually it is similar to highway traffic assignments but differs in that rail traffic assignments cannot be made solely on time, cost, or distance relationships because of corporate policies, intercorporate relationships, and the like. Portions of it can be computerized; other portions (such as routings) must be done manually. Different levels of analysis are possible. Large-scale planning would be involved with traffic flows over competing trunk route configurations and resulting corporate costs and revenues. Operations studies would be concerned with track capacity, train performance, train delays, and optimizing yard-to-yard movements. These are more typically done by railroad management to improve the efficiency of internal operations. They are generally not of direct concern to government. [USRA, in developing its Preliminary System Plan (2), undertook quite extensive operations planning to derive the costs of operating a ConRail system. The Federal Railroad Administration (FRA) and RSPO participated in several of these studies.]

It is important to understand where railroads stand and where they are headed. Industrywide, the return on investment has been low. Consequently, investment in plant, especially in track and other roadbed improvements, has been low. This has led to large amounts of deferred maintenance of ties and rail. A recent study (4) has estimated that the nation's rail system needs about $5.8 billion just to replace worn-out rail and ties. Roughly 80 percent of this deferred maintenance estimate is for materials. The cost of rail and ties has escalated sharply in recent months. Faced with such capital investments, railroads are increasingly forced to take a hard-nosed stance against the continuation of light-density lines not yielding a sufficient return on past or required future investment. This reassessment will ultimately be extended to routes carrying overhead traffic as well. Route consolidation and reduction in plant are increasingly becoming an economic necessity. The abandonments of the past may seem tame compared to plant rationalization proposals likely over the next decade. There may also be further corporate mergers, facility consolidations through trackage rights, and the like.

States must become prepared to respond intelligently and quickly to such proposals. The main question is, How can a state successfully affect such decisions and what leverage does it enjoy? There are many possible approaches, such as (a) lobbying to change law or regulatory mechanisms, (b) using state financial assistance either for operating expenses or capital investment, and (c) negotiating through a third party with carriers, unions, and shippers to bring about desired change. Such tactics by themselves probably are not adequate over the long term. One of the best ways is to develop an in-house professional capability to perform trunk route and similar technical analyses in order to quantitatively judge the effects of specific plant rationalization proposals. This, of course, would greatly aid and support the aforementioned approaches.

The trunk route analysis procedure developed for the Pennsylvania Department of Transportation and used in assessing the USRA Preliminary System Plan (2) and the Pennsylvania Plan (3) is entirely suitable for application by other states to the variety of rail system proposals likely to occur in the future. The process is applicable to

1. Testing alternative trunk route rail networks;
2. Examining where state money can best be used in supplemental subsidy and capital improvement programs;
3. Assessing the effects of consolidations, mergers, and track abandonments;
4. Studying traffic generation, yards, interchange points, and their effects on the railroad system;
5. Determining rail line profitability;
6. Analyzing rail freight pricing policies; and
7. Studying the traffic distribution patterns of various commodities such as coal or iron ore.

TRUNK ROUTE ANALYSIS PROCEDURE

The underlying purpose of any trunk route analysis procedure is to (a) prepare reliable estimates of traffic likely to use the various main lines that make up a rail system and (b) transform resulting traffic flows into estimates of railroad costs and revenue on the basis of links, nodes, corporate systems, and regional rail systems. The objective is to identify the overall effect of proposed changes in facility usage, routings, and corporate ownership through identification of the difference between the current system and alternative plans. This procedure is an input in the preparation of net railway operating income statements, a commonly used means of comparing alternative rail systems.

Establishing Geographic and Physical Facility Parameters

The four initial steps required in any quantitative analysis procedure are (a) determining the geographic area to be divided in the analysis, (b) establishing a zonal system for aggregating rail traffic originations and terminations, (c) selecting the railroad lines to be included as trunk routes, and (d) developing a link and node system to represent trunk routes and the principal interconnections occurring within the selected geographic area.

Figure 1 shows the geographic area and the zonal system used in the Pennsylvania Department of Transportation study that focused on rail systems located in the northeast and midwest portions of the United States except for the northern New England states. A total of 71 zones (25 zones in Pennsylvania to identify impacts to a greater detail) were used for traffic aggregation purposes. [Zone size may be varied to meet analytical requirements. The "building block" is the standard point location code (SPLC) that identifies geographic areas by means of a six-digit code. In the Pennsylvania Department of Transportation study, zones are aggregations of states or counties within a state. Finer breakdowns are possible, however.] The basic rationale underlying zone delineation is to identify tributary areas for main-line traffic wherever possible while keeping the number of zones (and hence the number of separate interchanges) to a minimum (primarily to minimize the amount of preparatory or setup work).

The selection of rail lines should be based on criteria separating trunk from branch lines. Usually factors such as traffic density; operating characteristics (maximum speeds, number of tracks, train control systems); and connectivity between cities of a certain size and larger enter into such delineation. It is important to realize that discrete categories and firm criteria have not yet been established; therefore judgment must be based in part on a knowledge and feel for the rail system being classified. Criteria can differ according to the purpose of the analysis; often including low-density lines carrying overhead traffic is desirable if such routings offer distance savings over more heavily used routes. However, the addition of substantial kilometers of low-density lines has relatively little effect in terms of increasing the proportion of the total traffic assigned to the trunk route system. A relatively sparse system can still account for a high proportion of the total traffic. The Pennsylvania Department of Transportation study found that about 89 percent of all rail traffic moving on bankrupt railroads was assigned to the base network. Also links on the periphery of a regional system need not be included where alternate routings are not a factor.

Figures 2 and 3 show the schematic network structure used for the base case and for testing the USRA Preliminary System Plan respectively. Approximately 214 links and 67 nodes were coded in the Pennsylvania Department of Transportation study. The basic network included more than 25 750 route km (16 000 route miles) and 15 different railroads.

Obtaining Traffic and Revenue Data

The key to rail system network analysis is assembling suitable traffic and revenue data. Although this information exists, most of it is considered proprietary by railroad companies and has not been made available to public agencies. Until recently, the only public information was the state-to-state and territorial statistics contained in the 1 percent waybill study conducted periodically by the ICC and more recently by the FRA. The waybill sample by itself is unsuitable for detailed network analyses. This lack of detailed information has discouraged public agencies from undertaking rail network analyses in the past (e.g., in preparing a comprehensive statewide transportation plan).

The Pennsylvania Department of Transportation study used portions of two different but overlapping origin-destination (O-D) data sets plus supplementary estimates of the amount of traffic handled by solvent railroads between selected zone pairs. The two primary data sources were the 1972 ICC-FRA waybill study data (a readily available O-D file prepared on a periodic basis from a 1 percent sample of the waybills of all railroads in the U.S.) and a USRA-assembled data file composed of abstract data for interline shipments and waybill data for local shipments representing the full record of traffic over each bankrupt railroad in 1973. Existence of and release of this latter file to states made detailed rail network analysis possible. Information sought included carloads, net mass transported in megagrams, and cor-

Figure 1. Trunk route analysis zones.

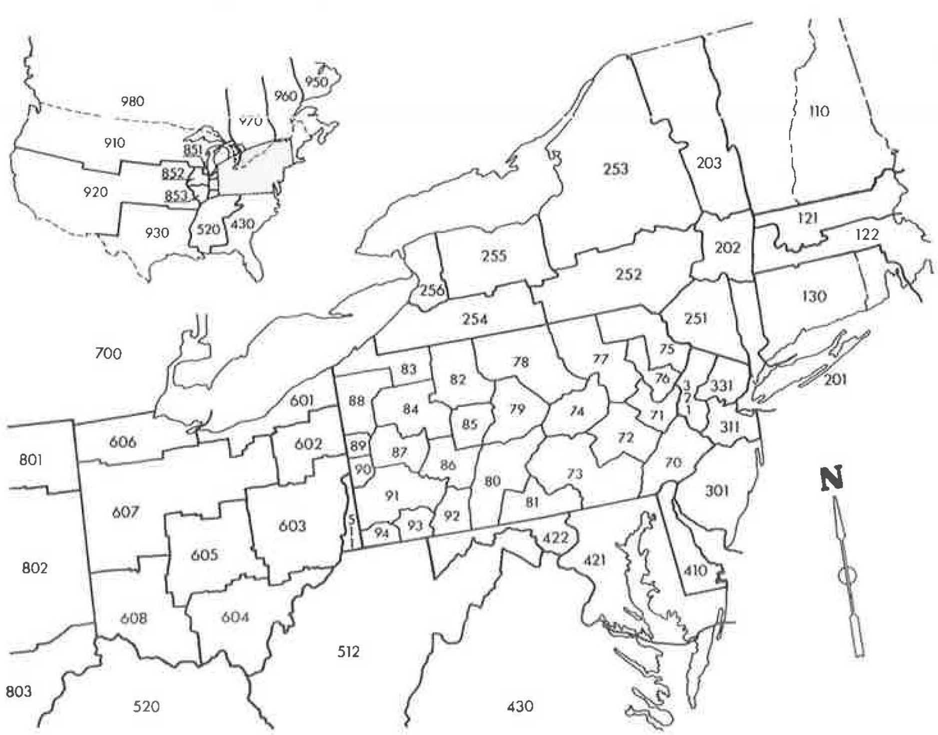


Figure 2. Trunk route analysis for existing system.

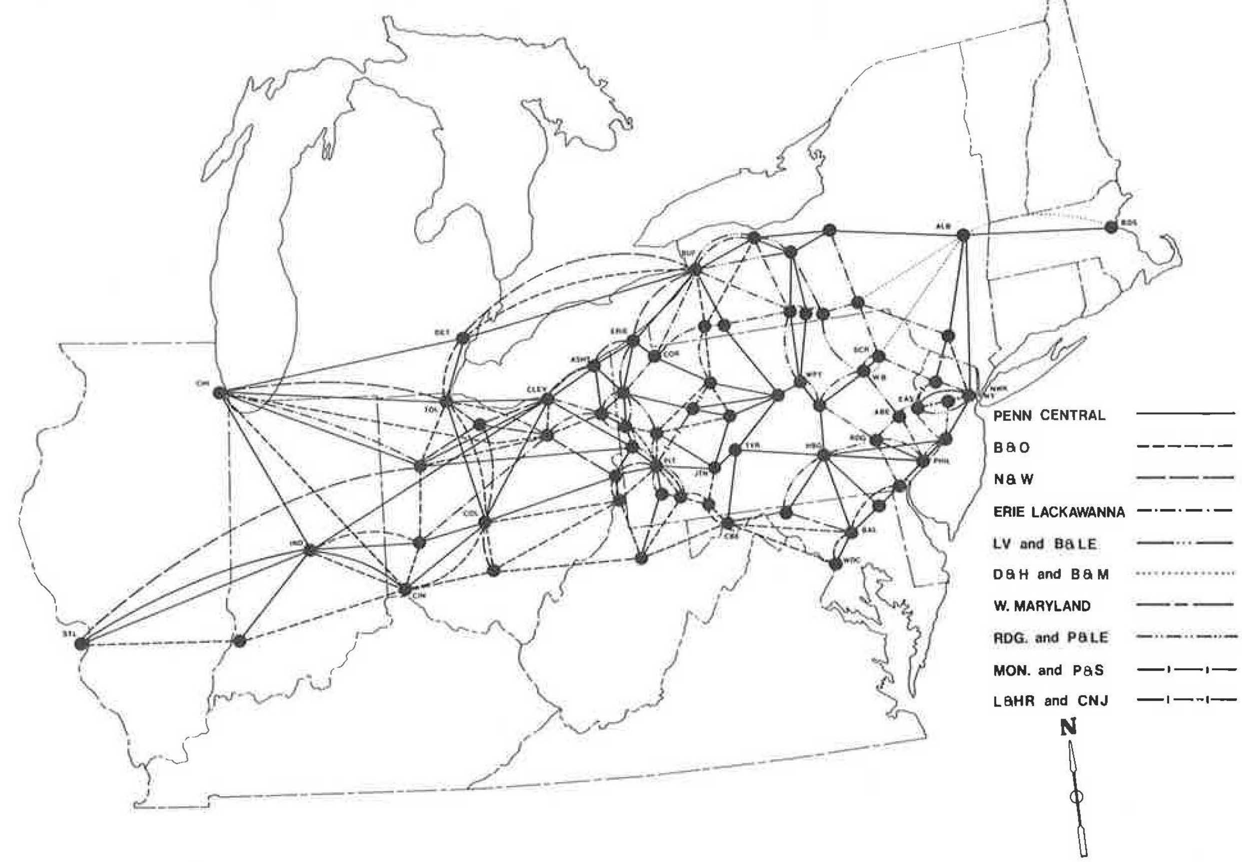
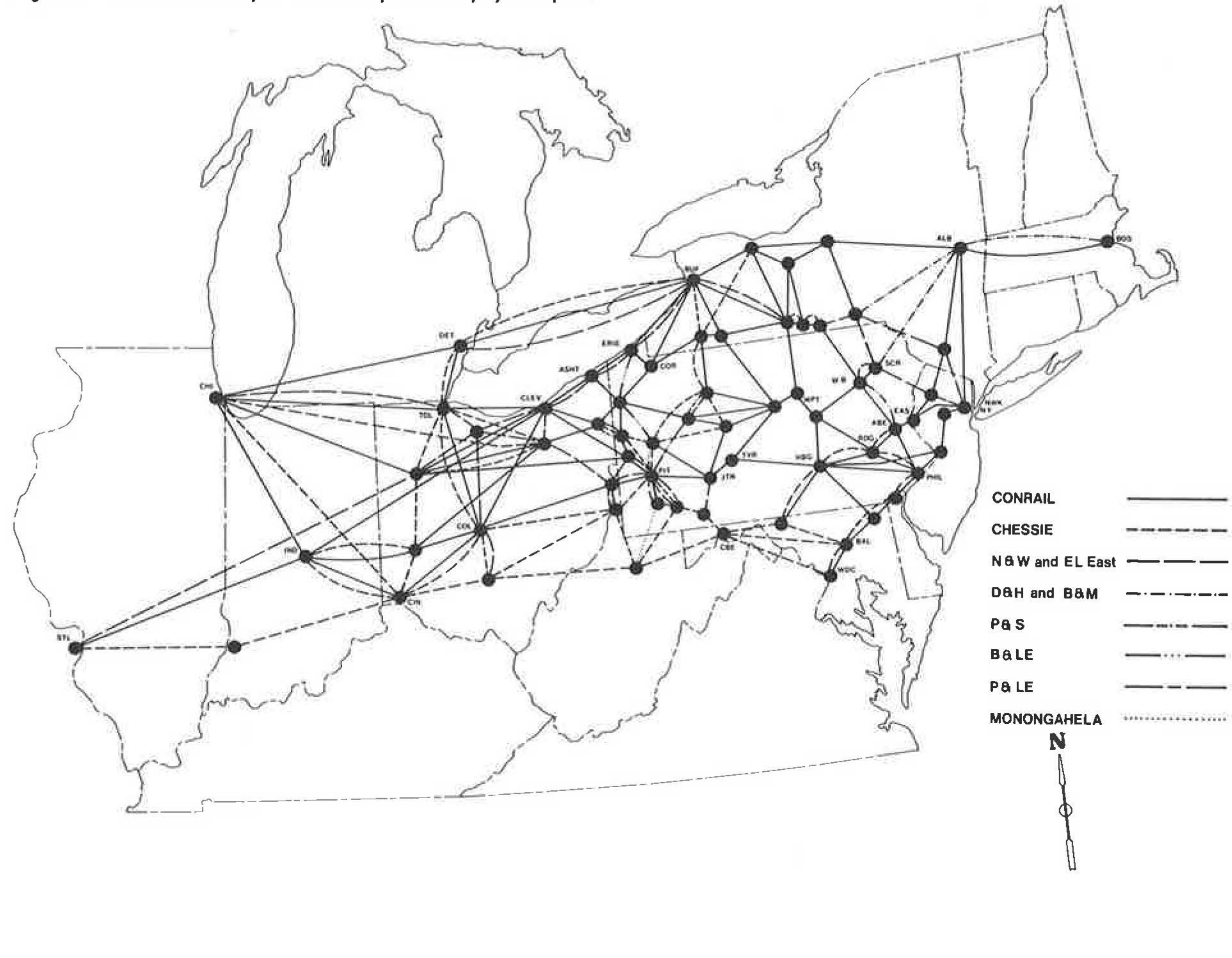


Figure 3. Trunk route analysis for USRA preliminary system plan.



porate and rail system revenues. (ICC waybill sample data also include information on type of commodity, haul distance, type of rate ascribed to the movement, freight car used in the move, and rail carrier.)

Several modifications were necessary to make the two data files usable in the Pennsylvania Department of Transportation study. First, the traffic origination and termination coding in each file had to be converted into the zone coding system previously described. (A conversion table of department zones and SPLC codes was provided to FRA to prepare computer tabulations of the ICC waybill sample.) Second, the ICC-FRA data had to be expanded and adjusted to represent 1973 traffic. Third, the overlap between separate railroad USRA files, such as that which occurs on interline shipments handled by two or more bankrupt railroads, had to be identified and eliminated. After these modifications were completed, the remaining task became one of choosing which portions of the two files should be used in the subsequent network analysis.

Both source files have important limitations. The ICC-FRA data were geographically and corporately complete, although the small sampling rate results in very high statistical variability. On the other hand, the USRA files contain the desired census-type data, but are limited to the seven bankrupt railroads. The solution was to select the strongest portions of the two source files. The USRA data set was used for interchanges between internal Pennsylvania zones and for interchanges with zones outside Pennsylvania. Such movements are characterized by small zone size (in Pennsylvania) and a high incidence of movements over bankrupt railroads. This was supplemented by separate estimates of the traffic using solvent railroads only. The ICC-FRA data set was used for interchanges between zones outside Pennsylvania where the aggregation from using larger zones reduced the variability resulting from the small sampling rate. The resulting data base was representative of the traffic originating in, terminating in, or passing through the defined geographic area.

Both source files have revenue data, although in the ICC-FRA file the amounts shown were total revenues and in the USRA file were revenues attributable to the reporting railroad. In the Pennsylvania Department of Transportation application, the revenue data from the USRA file were used because the revenues earned by railroads outside the region were not of concern. This was supplemented by ICC-FRA data for zonal movements not served solely by bankrupt carriers. Revenue data were extracted as an average dollar figure per carload for specific zone-to-zone interchanges.

Preparing Inputs

There are three basic inputs to the computerized trunk route analysis procedure: (a) a "link" record describing the physical characteristics of different segments of the rail system, (b) a zone-to-zone "traffic" record, and (c) a "routing" record identifying the commonly used sets of links for movements between zone pairs.

Coding Route Physical Characteristics

The link record provided the mechanism for inputting needed transport and cost characteristics. Basic physical characteristics are length (route- and track-kilometers) and unit operating costs; other characteristics can be included for more sophisticated analyses. Included for information purposes was a numeric and geographic identification of the delimiting nodes and its corporate association (the railroad company owning and operating the link). Link records can be added or deleted at any point to represent trunk route system changes or the granting of trackage rights. Similarly, the corporate association identified can be changed to represent the different reorganization proposals. Thus the link record contains the control characteristics that shape the program outputs.

Inputting Traffic Data

Total zone-to-zone traffic volumes, expressed as total carloads, net mass transported in megagrams, and average revenue per carload, are input directionally for each zone-to-zone pair. As previously stated in the Pennsylvania Department of Transportation study, these data were derived from computer tabulations of the ICC-FRA and USRA files supplemented occasionally by independent estimates of traffic handled solely by solvents within, to, or from Pennsylvania. Traffic data would normally remain constant unless different time periods were being analyzed.

Determining Likely Routings

The step involving the greatest amount of preparation is that of directionally delineating interzonal routings and estimating market shares by competing routings. These judgments are based on such factors as competitive relationships, past "friendly" connections (or antirelationships), comparative access to zonal originating traffic, physical and operational characteristics of the alternative trunk line routes, and the common practice of maximizing the length of haul by the controlling (originating) carrier. Routings are created by sequentially listing the links traversed in moving traffic from one zone to another. The number of routings to be designated depends on the amount of interrailroad competition between the two zones and the volume of traffic involved. Only the principal routings should be considered, because of the time involved in manually making assignments. It makes little sense to hypothesize an alternative routing if only a handful of carloads would ultimately be assigned to such a routing.

The work involved in designating routings is best done by analysts having railroad traffic department experience. Only in this way is there a reasonable guarantee that the routings reflect what is indeed happening or likely to occur under alternative corporate arrangements. [Additional information on route choice theory and behavioral considerations underlying rail freight route choice is available elsewhere (5).]

Assigning Traffic and Calculating Associated Costs and Revenues

The trunk route analysis procedure used a specially prepared computer program to accomplish the accounting work required. The program itself consisted of three major phases. The first phase was to set up the several arrays in which carload, mass transported, revenue, and cost data could be aggregated on the basis of links, nodes, and corporate systems. In the second phase, traffic and associated routing records were read by the computer, which then prorated the traffic and revenue data to available routings on the basis of market share estimates for each routing and then allocated it to the affected links, nodes, and corporate systems. After all traffic and routing records had been read, the third phase computed traffic (megagram-kilometers and car-kilometers), revenue, and cost for each of the arrays and printout summaries.

The program is dependent on a number of unit costs used in the computation of total costs. Among these are a series of variable costs for carload origination or termination, carload interchange, mass transported origination or termination, and revenue-car-kilometer and megagram-kilometer charges and a fixed cost per kilometer of route operated. [Unit cost data were developed by R. L. Banks and Associates by using information contained in annual reports to the ICC. The variable unit costs were $60.80/carload origination or termination, $20.74/carload interchange, $0.1061 for origination or termination/Mg ($0.0963/ton), $0.170 818/revenue·car·km ($0.274 906/revenue-car-mile) and $0.001 88/Mg·km ($0.002 74/ton-mile) respectively. The fixed cost was $12 698/km ($20 436/mile) of route operated.] The car-kilometer and megagram-kilometer costs are system averages. Some segments have higher or lower costs because of the physical characteristics (such as grades) of the route segment. These costs were adjusted in the program proportionally to fuel consumption, which was found by analyzing the outputs from RSPO train operating simulations, which took into account the topographic features of various lines.

The program also depends on proportioning the revenue received among the participating carriers. Replication of actual revenue divisions was beyond the capabilities of the Pennsylvania Department of Transportation study. As a substitute for this, 10 percent of the revenue was assigned to the originating and terminating carriers and the remainder was apportioned on the basis of revenue-megagram-kilometers. In many cases, the originating or terminating carrier is located outside the region; in these cases, the arbitrary (10 percent) origination or termination charge would not be assigned to the network.

Checking the Results

Most traffic assignment processes include a checking phase in which the resulting link volumes are compared against independently obtained traffic counts to see how closely the simulated system replicates the actual. If there are major differences, the characteristics of selected links of the simulated network are refined to produce a closer match. Checking is required mainly because of imperfections in the data or because of extraneous behavior patterns.

Such a check is possible and indeed is recommended with rail analyses. Although the routings may appear to be obvious, the market penetration or proportional split of the traffic in a zone among competing routings is not. Thus a comparison of assigned traffic with reported link densities is desirable. The latter is usually expressed as millions of gross megagrams per year; the net mass assigned to the network must be expanded to reflect the mass of locomotives, cabooses, empties, and nonrevenue freight traffic. Railroad annual reports to the ICC (from R-1) can be used for this purpose. The results of this comparison will quickly show where there are major differences requiring reconciliation.

The adjustment process can be cumbersome, tedious, and time consuming. To reduce the manual searching, an option was included in the computer program (sometimes called a select link option) to list out, in order, all the zone-to-zone traffic movements using a particular link. Thus the analyst can readily identify the principal movements using the link and make any adjustments desired by changing the routing percentage or adding or deleting routings.

How well did the process work in the Pennsylvania Department of Transportation study? The following tabulation gives the mass transported across Pennsylvania borders in 1973 (1 Mg - 1.1 ton):

State Border	Actual Railroad Density Records (millions of Mg)	Simulated Base Case (millions of Mg)
West	152.5	152.6
South	76.5	74.8
North	68.4	68.3
East	29.9	30.0
Total	327.3	325.7

As can be seen, the agreement between railroad data and the simulated base case is extremely close.

A further comparison was made on an individual link basis. Although there was appreciable variation on some links between railroad data and that simulated, there was reasonably good agreement overall. For example, in Pennsylvania the sum of gross megagrams on links came to 2276 million (2509 million tons) for simulated traffic versus 2291 million (2526 million tons) reported by the railroads. The high volume links generally were within 10 percent of reported densities.

Analyzing Alternative Plans

The same basic process described above can be used for testing alternative plans. In such analysis, the zone system, the traffic inputs, and the unit costs remain constant. Link records can be deleted to reflect proposals for consolidating service from existing parallel routes or the elimination of low-density routes currently carrying overhead traffic. Link records also might be added to reflect trackage rights. The corporate designation can be modified to reflect a change in ownership. The routing records can be changed to reflect different patterns brought about by changed corporate relationships.

The overall effect of an alternative plan is obtained only by determining the resulting differences in car-kilometers, megragram-kilometers, costs, and revenues between a base case and the alternative being tested.

Using the Procedure Results in Preparing Net Railway Operating Income Statements

The traffic estimates cover railroad operations for those portions of the system included on the network. To prepare total system estimates, off-network revenues and expenses must be estimated and added to the totals obtained earlier. Adjusting traffic and revenues to reflect what is anticipated to happen at some future point in time (short-term projections) may also be necessary. This can usually be done as a multiplier applied to the basic results.

ARE THERE OTHER ANALYTICAL TOOLS?

FRA has also developed a network model to assist railroad planners in developing and analyzing traffic loadings on a link-by-link basis. Basically, the model is a modified version of the Federal Highway Administration's highway assignment package. This program is being made available to states for rail planning purposes. The FRA model (6) can produce graphic displays of various data items (such as line plots of network configurations). Its principal virtue is its potential as a repository for detailed network information stemming from the size and extensiveness of the network already coded. (The U.S. rail network consists of almost 20 000 links and 16 000 nodes). The model has three major drawbacks. First, the use of minimum path routings resulting from the use of an internal algorithm probably does not depict real-world rail routings, which are often quite circuitous because they are influenced by corporate management policies. Second, multiple routings between two points are not possible, even though such interrailroad competition is frequent. Third, the size of the FRA-developed network and computer program is large and quite complex, which makes its application relatively time consuming and costly.

The trunk route analysis model developed for the Pennsylvania Department of Transportation (a) permits multiple and circuitous routings, (b) is flexible, (c) produces full output including node interactions and corporate system summaries, (d) has extensive internal data editing capabilities, and (e) requires relatively little computer time. It does depend on manually prepared routings that are time consuming to develop. In its current form, it does not have all the niceties that ultimately would be desirable such as real time network and routing updating, parameter card input of unit costs and other constants, and inclusion of coordinates for computer prepared graphic displays. These can be readily added, however.

SUMMARY

We feel that the trunk route analysis procedure described in this paper helps fill the void for rapid, large-scale tools for policy and systems level planning. Although developed for statewide and regional rail planning purposes, the procedure and supporting computer program are general enough to permit their application to other freight modes of an intercity character.

In short, the procedure is a simple, straightforward, pragmatic adaptation of computer-based accounting in support of manual estimates of the distribution of traffic among competing carriers made by experienced analysts. The procedure does not rely on theory or algorithms for routing decision making. The process can be influenced by subjective biases, although the checking process is included to uncover major distortions. The computer program is relatively quick and inexpensive to operate. The interaction process between the analyst and computer can and should be further refined to reduce the efforts involved in changing data entries. The procedure is a start; further improvements will come as the process is applied to similar freight transport problems.

The field of freight transport planning is nearly a virgin territory in terms of availability of analytical planning techniques. What has been presented is only a start. Indeed, it is only through beginning with relatively simple tools, such as the one described in this paper, that advances in technology emerge over time.

ACKNOWLEDGMENTS

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REFERENCES

1. Rail Service in the Midwest and Northeast Region. U.S. Department of Transportation, Vols. 1 and 2, 1974.
2. Preliminary System Plan. U.S. Railway Association, Vols. 1 and 2, Feb. 1975.
3. Pennsylvania's Plan for a Balanced Eastern Rail System. Commonwealth of Pennsylvania, March 1975.
4. Estimate of Deferred Maintenance in Track Materials for Twenty-five Railroads. Thomas K. Dyer, Inc., 1974.
5. J. Drake. Rail Merger Evaluation and Rail Freight Route Choice: A Study in Quantitative Impact Analysis, University Microfilms, Univ. of Michigan, Ann Arbor, PhD dissertation, 1972.
6. W. E. Canty and T. T. Bouve. The Use of Analytical Models and Related Data in State Rail Planning Process. Paper presented at National Rail Planning Commission Meeting, New Orleans, May 1975.