

day processed by Roseville Yard could, in theory, translate to approximately \$700,000 in savings per year in per-diem costs. These numbers are unrealistically optimistic, but if even a small fraction of these savings could be realized in practice, the worth of the TRACS program could more than justify its implementation in a yard.

The impact of TRACS on a yard at or near capacity may be different than that experienced at Roseville Yard, which was considerably under capacity and had substantial rehaul traffic. Nevertheless, the results of the Roseville Yard simulation do justify the high expectations for the TRACS program.

CONCLUDING REMARKS

The worth of the concepts underlying the TRACS program has been demonstrated in the Roseville Yard evaluation. Under the sponsorship of the AAR, the program is being installed in SP's Terminal Control Computer (TCC) system. The first yard to use the program will be SP's West Colton Yard; once installed in the TCC, however, the program can readily be made available to other SP yards.

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Labor Productivity in Rail Transport

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Labor productivity is among the central economic issues in the railroad industry. Labor negotiations and federal price-control programs are examples of activities that have involved productivity considerations. Currently, the Interstate Commerce Commission is considering productivity adjustments in the rail cost recovery procedures that were mandated by the Staggers Rail Act of 1980. Historically, productivity has been measured as labor content per ton-mile. Such measures, however, typically have produced productivity gains that appear to be unreasonably large. This may be caused by the changing nature of the ton-mile itself as the railroads increasingly embrace new operating practices such as unit trains, larger freight cars, and so on. An allocation of rail labor inputs among several output measures, including train miles, car miles, and carloads, is proposed. It is shown that rail productivity gains have been modest, at best, and that there has been considerable variation in productivity gains among the major carriers.

Productivity is a perennial issue in rail transport. It arises in commonplace regulatory proceedings involving rail prices, costs, and inflation impacts. Currently, productivity is the central issue in an Interstate Commerce Commission (ICC) consideration of the propriety of its rail cost recovery index.

Productivity is a deceptively simple concept that becomes complex either when econometricians attempt to formulate equations of measurement or when a simple productivity equation is quantified. The literature is highly theoretical, yet claims of measured change are often cited in the trade journals. The railroad industry is no exception; we are regularly treated to numbers of ties laid per man

and coal cars unloaded and, simultaneously, to a literature overloaded with transformation equations and mathematical symbolism—all in disagreement.

In the economic literature, production functions relate outputs and inputs. In measuring productivity, one can hold inputs constant and measure the change in output or hold output constant and measure the change in inputs, but basically the production function is a cost function related to some measure of physical output. Theory attempts to differentiate change related to scale economies from changes due to organizational and technological improvement. Theory can offer many reasons for, and include them in, the theoretical formulation of the production function, but for the practitioner, there is an immediate need for simplicity.

There is another more practical school, which measures single-factor productivity. This is more or less an engineering approach, easier to use in practice. But it is not the measurement of productivity in the theoretical sense. Output per person hour, a single factor, is not the same as productivity of all factors, but it has many advantages. For example, if there is some fixity in other factor input, e.g., capital, or if labor is left constant and a capital change is made, the net effect can be measured. For instance, if a tamping machine replaces labor, there will undoubtedly be a rise in output per person hour, even though total factor productivity may not rise. Such a result would be a function of whether the total cost of the activity

were reduced through the capital substitution. The introduction of the tamper can be looked at in two ways, and the way one looks at it influences distributive shares. A rise in output per person hour when all else is held constant can be used to justify a rise in wages, whereas if the wage is held constant, an increase in productivity would measure the marginal productivity of capital or scale economies. The difficulty in the real world is holding all things constant and varying only one factor at a time. Thus the theoretical concept of the production function would be extremely useful to the management of the firm if it could be quantified, but it has its limitation in practice.

The next most difficult concept is that of homogeneity. The production-function approach glosses over the output homogeneity problem. It is assumed that the railroad industry customarily has two products, freight and passenger service, measured as ton-miles and passenger miles. Real output may be very different, however, because passenger service has all but disappeared. But in studying freight alone, a production function may be thought to include highly distinctive technologies, such as unit-train service for coal as distinct from piggyback service.

Another complexity is nontransportation service. A simple example is the effort expended in running the Greenbrier, a railroad-owned hotel and medical facility. How is the labor of the chief executive officer of the Chessie System divided between rail and nonrail activities? More seriously, most railroads build and repair cars, and not only for their own account. An even greater perturbation in any time series would be maintenance of track, which has a high correlation with earnings. Maintenance can be viewed as either an expense or an investment and treating it as an expense may distort factor input.

If we revert to a simple question of the output unit, freight, and associate it with one variable, which is measurable, such as person hours, perhaps we have a relationship that has utility and can be understood. Perhaps analyzing all change as an attribute of one variable is as useful a method as possible as long as it is understood and other measures are used simultaneously to modify or limit conclusions and recommendations.

Thus, in this paper we start from the measurable and it is hoped that as we understand the data employed, we can expand our knowledge, introduce more variables, and simultaneously interpret so as not to ignore effects of other variables.

Our inputs are person hours only. There is disaggregation in that freight is separated from passenger service. We interpret change over time as it is reflected in this one measure.

For outputs, we reject the methodology most often used to analyze rail labor productivity, which relies on a single measure of output--the ton-mile. This measure generally computes a level of rail labor productivity growth that appears to be unrealistically high.

Though distinctions are often blurred, major categories of rail labor input can be associated with a particular output measure. This exercise was undertaken in this study. Analysis of the data in this framework for several railroads and for the sum of all Class 1 railroads shows that labor productivity growth in recent years has been modest at best and that growth has varied widely among the carriers. These conclusions have serious implications for the railroad industry, its customers, and national transportation policy.

IMPORTANCE OF PROPER PRODUCTIVITY MEASUREMENT

Proper productivity measurement is not a trivial matter. This is emphasized by the current debate over the ICC rail cost recovery index and by the experience of the Federal Price Commission in its control of rail price increases in the early 1970s.

Cost Recovery Index

The Staggers Rail Act of 1980 prohibited the use of general rate increases as a vehicle to compensate the rail industry for inflation-generated cost increases. The act directed the ICC to devise an appropriate cost-adjustment procedure to replace the function of the general rate increase.

General rate increases, which had been presented as periodic petitions to the ICC, had been predicated on revenue needs--a euphemism for cost increases generated, presumably, by inflation. Because the general rate increase was cost based, productivity was not an issue outside the railroad industry itself, because gains in productivity were automatically passed through to the shipping public.

In response to the Staggers Act, the ICC initially has adopted a cost recovery index procedure based on price indexes. Because this procedure involves price--not cost--indexes, productivity gains are not automatically passed through to the shipping public. The ICC is considering the petition for productivity adjustments in this calculation.

Price Commission Experience

In the early 1970s, the federal government undertook the control of rapidly growing inflation through wage and price controls. Of interest here is the Price Commission effort, in which permissible price increases by industry were derived as the net of labor cost increases and industry gains in labor productivity.

For its efforts, the Price Commission computed average productivity gains for all industries for the 1961-1971 decade. The railroad industry productivity standard was calculated to be 6.3 percent per year by using the ton-mile measure for rail output. This result was nearly three times the annual gain for the motor carrier industry and twice the national average for all industries.

These results for the railroad industry were not reasonable. Were the railroad industry to have made a sharp gain in productivity relative to its major competitor, the railroads could have reduced relative prices and enhanced their market share and profitability. In fact, it is clear that the railroad industry did not enjoy a competitive advantage relative to motor carriers.

Problems with use of the ton-mile as a measure of railroad output were not addressed by the Price Commission. These problems include the following:

1. Changes in rail traffic mix at the commodity and subcommodity level can distort output measured by ton-miles. The current version of a full-sized automobile--say, a Chrysler New Yorker--weighs considerably less than its predecessors of a few years past. The marginal productivity of rail labor would be affected by the downsizing of this model Chrysler by using the ton-mile measure. There is ample evidence that such examples are not isolated.

2. Just as commodity mix changes can be responsible for lack of homogeneity in the ton-mile measure, mileage itself can cause distortions. This is evident in freight rates that commonly taper with

increasingly long freight hauls. Furthermore, it is known that diversion of rail traffic to motor carrier has been far more dramatic in the shorter-haul sector of the market. These factors indicate a segmentation of the freight transportation market by length of haul.

SELECTED MEASURES FOR EVALUATION

Like professional baseball, the railroad industry is awash in the statistics it generates. For measures of freight output and labor input, the task is to seek suitable data or data that can be altered to suit the task.

Freight Output

The railroad industry produces several categories of reliable data for freight output measurement. The ton-mile was rejected because it was concluded that car miles, train miles, and carloads were more descriptive. This selection rests on the proposition that carloads, train miles, and car miles are the basic units of transportation output processed by the principal classes of railway workers.

Car miles are assigned to measure output for maintenance of way and equipment and for bridge and building workers and their supervisors.

The train mile is used to measure output for such diverse workers as train dispatchers, telegraphers, train and engine workers, and signal and electrical workers. These functions typically deal with freight output in trainload lots (or, alternatively, are assigned to areas based on trainload activity).

Finally, the carload is used to measure output for two groups of employees: (a) clerks and yard-operations workers and (b) executives, general office workers, and support personnel--railway police and the like.

It is appropriate here to point out a problem with the carload measure. Historic carload data are discontinuous for rail merger partners. That is, the sum of premerger carload counts involves double counting of loads interchanged between the merger partners. The double counting is not present in postmerger data. Merger-related efficiencies in the labor functions, which are associated with carloads here, by merger partners will eliminate some duplication in labor input associated with carload output, and this will ameliorate the impact of the discontinuity in carload counts.

Labor Input

As with freight output data, the railroads generate labor input data in quantity. Labor data are taken here from the ICC Wage Statistics Forms A and B: Annual Report of Employees, Service and Compensation. This report includes total person hours worked for 128 classes of employees.

These rail labor data are not ideal for our purpose here. Three significant difficulties were confronted and only one could be dealt with successfully. These were as follows:

1. The 128 categories of employees are not sufficient to distinguish all the myriad occupations of rail workers. Grouping occurs and this is a detrimental productivity measurement.

2. Railroad workers are involved in numerous activities only incidentally related to the transportation function. The building of freight cars and locomotives is one obvious example of this.

3. Both freight- and passenger-related labor are

mingled in the data. By using data from the railroads' annual reports to the ICC (Form R-1), it was possible to estimate the passenger-related content of the major categories of labor input. This procedure reduced the U.S. total labor hours by 10.9 percent for 1969 and the effect declined steadily to 6.5 percent for 1981.

ANALYSIS AND RESULTS

Analyses of labor productivity were performed for 11 major railroads and all U.S. railroads for the 1969-1981 period. Because of various mergers, the 11 carriers currently are major partners in 7 rail systems. Data for all U.S. railroads less those for Consolidated Rail Corporation (Conrail) and Penn Central were analyzed also to respond to the legitimate concern that there might be bias in U.S. total data caused by the demise and subsequent reconstruction of the former Penn Central properties.

Productivity for each road was calculated for the four component measures: car miles per maintenance hour, train miles per transportation hour, carloads per clerk and yard-operations hour, and carloads per executive and general-office hour. A joint index for each road year was computed from the four component measures by using freight labor hours as weighing factors.

Analysis of these materials results in four important conclusions: (a) For an individual carrier, the four component productivity values used here can exhibit widely divergent trends; (b) when carriers are compared, productivity varies over a wide range; (c) overall labor productivity growth for the U.S. total has been less than 1 percent per year since 1969; and (d) removing the Conrail-Penn Central data does not materially change the growth trend of U.S. rail productivity.

If we look at the four component productivity measures for each carrier over time, it is seen that the growth patterns differ markedly. This is true even for the most efficient carriers. For example, the Southern Railway System has enjoyed sharp productivity growth in the transportation area but some decline in the clerk and yard-operations sector (Figure 1). Union Pacific, on the other hand, has a strong pattern of growth in the clerk and yard-operations area and modest growth in transportation (Figure 2). Clearly, this disparity in productivity trends is a product of management emphasis, geography, physical plant influences, and other factors. This illustrates the potential for error in rail productivity calculations based on sample data sets.

Output per person hour for each of the four component measures varies widely among the carriers. Figures 3-6 display the range of these data for the carriers studied. The figures show U.S. total data and illustrate the high and low ends of the range of productivity values with appropriate carrier data.

1. For maintenance functions (Figure 3), the U.S. total has a slight upward trend. Southern, among the most efficient carriers, has a slight downward trend from about 140 car miles/hr. Chessie, among the least productive, has a downward trend in the range of 60-80 car miles/hr. Chessie has been active in freight car construction and this clearly causes a downward bias in these data.

2. In the transportation area (Figure 4), U.S. total productivity shows little change at just more than 1 train mile/hr. Southern is a strong performer in both level and growth. Conrail, at the bottom of the range, has had little change in output per person hour through 1981.

Figure 1. Productivity components: Southern Railway.

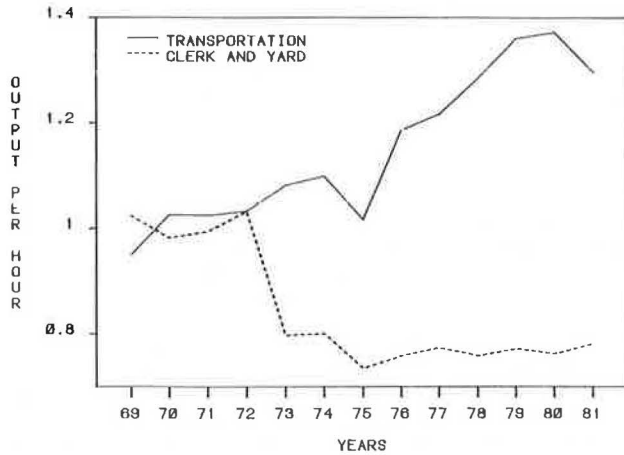


Figure 4. Range of train miles per transportation hour: U.S. total, Southern Railway, Chessie System.

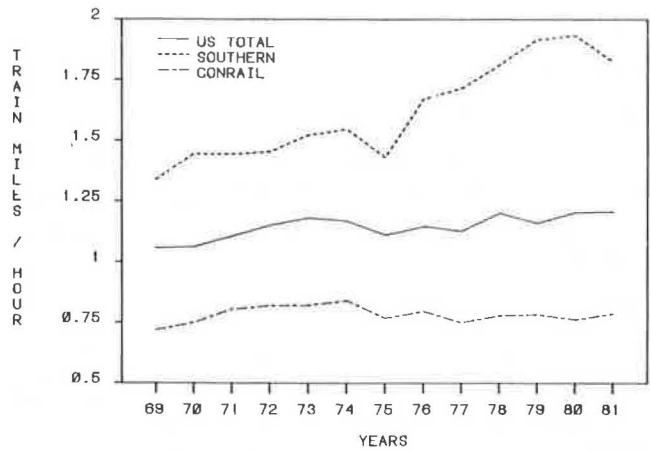


Figure 2. Productivity components: Union Pacific.

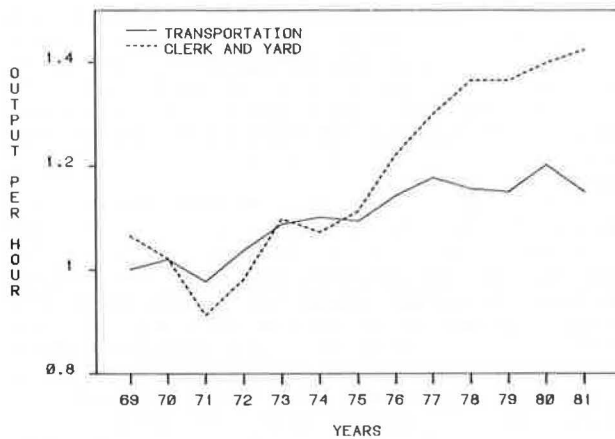


Figure 5. Range of cars per clerk and yard hour: U.S. total, Southern Railway, Union Pacific.

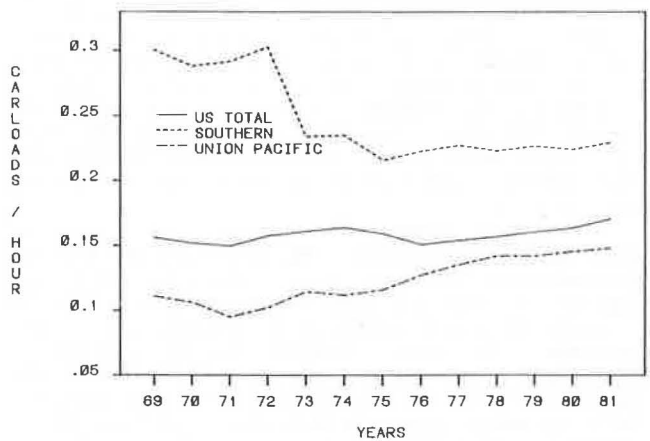


Figure 3. Range of car miles per maintenance hour: U.S. total, Southern Railway, Chessie System.

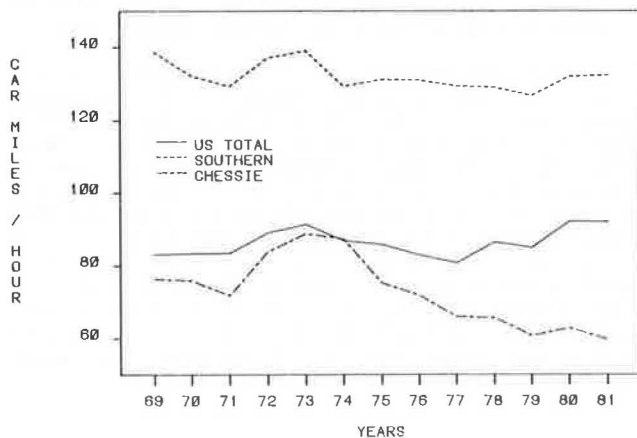


Figure 6. Range of cars per executive and office hour: U.S. total, Southern Railway, Burlington Northern.

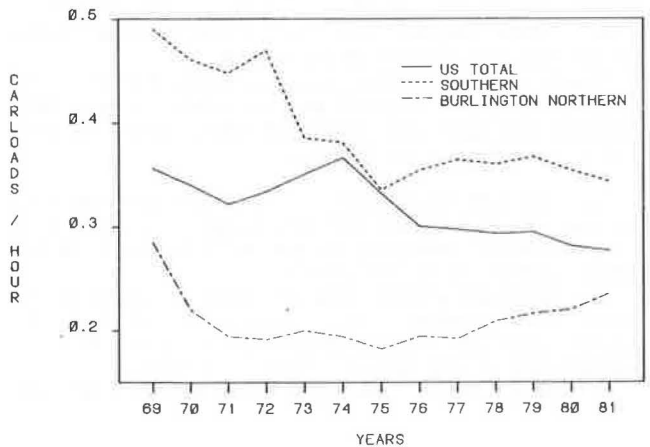
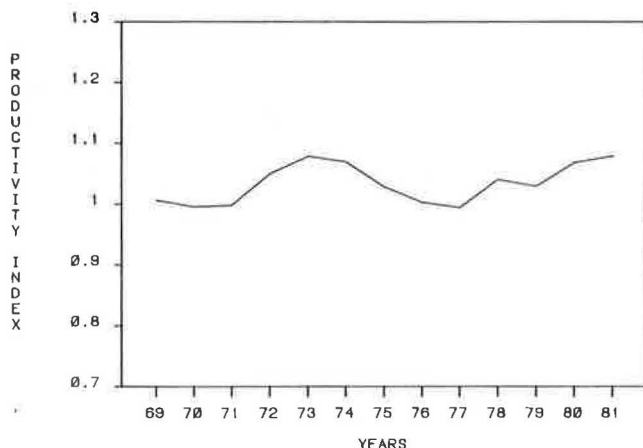


Figure 7. U.S. total rail industry productivity.



3. For clerk and yard operations (Figure 5), U.S. total productivity has a flat trend at just more than 0.15 carload/hr. Southern, again a strong performer, has suffered a steep decline and Union Pacific, a weak performer, has a solid pattern of productivity growth.

4. Executive and general-office output per person hour has declined over the study period (Figure 6). Southern, a strong performer in the early years, has declined sharply and Burlington Northern, at the bottom of the range, has had a solid growth trend since the early 1970s.

Overall labor productivity growth for the rail industry has been less than 0.5 percent/yr for the 1969-1981 period [Figure 7 (1969-1971 = 1.00)]. Rail productivity increased from 1969 to 1973, declined to 1977, and then increased to 1981. By productivity component, the U.S. total has performed as follows from 1969 to 1981 (note the decrease in carloads per executive and general-office hour):

Component	Avg Annual Gain (%)
Car miles per maintenance hour	0.4-0.5
Train miles per transportation hour	0.9-1.0
Carloads per clerk and yard-operations hour	0.5-0.6
Carloads per executive and general office hour	2.0-1.9
Overall productivity growth	0.3-0.4

These data imply that labor productivity in the 1969-1981 period has not made a material contribution to the competitive posture or to the prosperity of the railroad industry.

To add perspective to the overall rail labor productivity found here, it must be compared both with overall U.S. labor productivity as calculated by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor and with rail labor productivity calculated by the conventional ton-mile method (Figure 8). This comparison shows the following:

1. Growth in labor productivity for all industries has averaged 1.5-1.6 percent annually since 1969. This increase is roughly four times the average annual rail productivity growth computed in this study. Over the 12-yr period of this study, this disparity in average growth rates is cumulatively large.

Figure 8. National total and rail industry productivity.

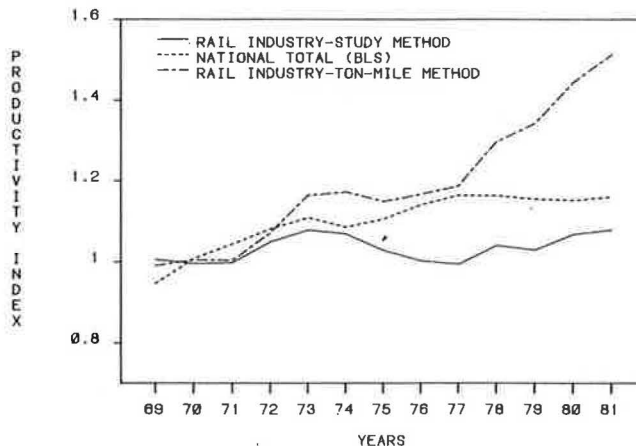
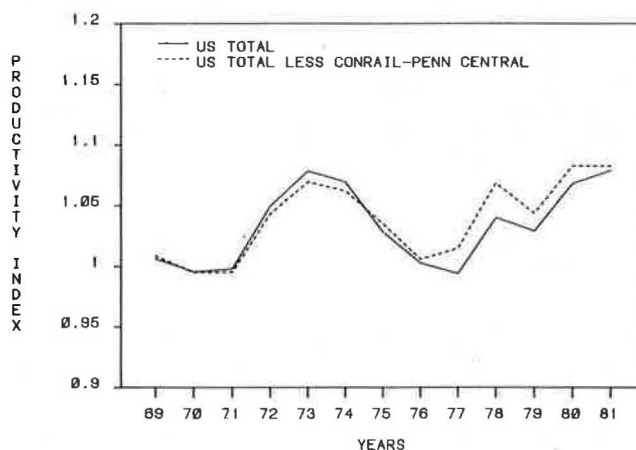


Figure 9. Comparison of U.S. productivity with and without Conrail data.



2. By the ton-mile method, rail productivity has grown 4.0-4.1 percent annually since 1969. This is 2.5 times the growth in productivity for all industries and more than 10 times the growth for the rail industry computed by the methodology of this study.

Because of the Penn Central disaster and the subsequent necessity to rebuild the properties that became the Conrail system, it might be charged that Conrail's presence in the data had a material effect on productivity growth for the rail industry. To respond to this question, Conrail data were removed from the national totals and analyses were repeated. It was found that the productivity growth trend for the United States without Conrail-Penn Central was about 0.2 percentage point/yr higher than that for the U.S. total (Figure 9). This difference is minute on an absolute basis, but since U.S. total productivity growth was small, it is large on a percentage basis. It cannot be charged, however, that Conrail has spoiled the productivity growth record for the railroad industry.

CONCLUSION

We believe that we have demonstrated a simple, understandable methodology for useful labor productivity measurements. These are useful in the sense that a manager can comprehend their message and can react to their implications. The methodology can be

a beneficial planning aid, for example, for estimation of productivity gains from capital investment and for verification of results after the investment has been made. Finally, we present our methodology as a general framework for analyses. Our particular choices of output measures, our groupings of labor inputs, and our choice of relationship of certain outputs to certain inputs are unlikely to suit all circumstances or all users. The general framework allows the manager to tailor the features of the

model with relatively little effort, however, and this is a major advantage.

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Minnesota's Railroad Information System

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The railroad network in Minnesota has undergone major changes in recent years. Knowing the status of the network and being able to predict future changes and directions depend on having a comprehensive and accessible source of rail information. The implementation of a computerized railroad information system in Minnesota in 1981 is helping to ease the information and decision-making needs of the state's transportation planners. A synopsis is given of the system's computer records, data files, and data elements and of uses of the information.

In the late 1970s, the Minnesota Department of Transportation (Mn/DOT) recognized the need to develop a source of comprehensive and readily accessible information about the state railroad network. Major changes were occurring in the rail system in the state, which made it increasingly important to know the status of the transportation network and to be able to predict future deficiencies. To meet these needs, Minnesota's rail data base was developed in 1981.

Having ready access to information about the state's rail system serves a number of important purposes, among them the annual updating of the state rail plan and providing information for systemwide assessment, eligible branch-line analysis, track inspection, and other surveys arising in rail transportation.

Before a rail data base existed, these needs were satisfied by a time-consuming process. A variety of publications and maps served as sources. Simply finding the right sources was often difficult. Once they were found, understanding the terminology and the format of the data could be difficult.

The data base, which is also called the railroad subsystem, is one of six operational subsystems of Mn/DOT's Transportation Information System (TIS). Roadways, accidents, traffic, bridges, and rail grade crossings are the other five subsystems. Together they are a computerized system of data files and programs for reporting and analyzing transportation data.

SYSTEM DESIGN

At the time that a work program for the development of a data base was being prepared, there were no software packages available for a rail data base. Whatever Mn/DOT would be able to use had to be developed. With no package available, the best development option was a data base that would be similar to the roadway subsystem of TIS, which had been developed for Mn/DOT by Montana State University.

The roadway subsystem is based on mileposts. Computer records describe road sections in terms of surface thickness, number of lanes, and so forth, and physically locate these sections by mileposts. Different points along these sections are also described and located, such as county boundaries or intersections. If further information is needed, subordinate tables or files tied to the physically located data item are supplied. For example, a city table tied to the city number stored in the physical data expands that number so that the city name, population, census year, and so forth, can be accessed.

The rail data base as developed by Montana State University and Mn/DOT follows the same general structure as the roadway subsystem. Railroads originated the milepost concept; their track charts show milepost locations on their lines. Sections of rail lines are described in computer records and located in reference to these mileposts. Points along the lines, such as stations or jurisdictional boundaries, are described and located as well. Another similarity is that subordinate tables or files are used for additional information, such as station details.

Each rail computer record must have a unique identification. This key field format is similar to the roadway key, which consists of a route system code, as for a U.S. or state highway; a route number; and a reference point. The key designed for rail lines consists of a railroad system code, a railroad line number assigned by Mn/DOT, and a reference point calculated in relation to the railroad milepost locations.

Because of the relatively small size of the rail data base (7,000 miles of railroads versus 128,000 miles of roads) and because many rail characteristics rarely change, once the initial data have been stored, management of the system is relatively simple.

DATA ELEMENTS

Data elements were developed after in-depth investigation of rail user needs. Mn/DOT units that would be the principal users of the data base were consulted about their needs and about potential data elements, codes, and other requirements. Primary among their needs was a data base of sufficient detail to be used for system analysis and eligible-line analysis. As development progressed, regular meetings were held with a representative rail user committee to keep the units informed of the status