Service Management in the Railroad Industry

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Many elements must be included in an overall effort to improve railroad freight service management. An understanding of the nature and causes of railroad unreliability is essential to gain an understanding of the dimensions of the problem and the opportunities for improvement. There are many different approaches to improving railroad service, and coordinated efforts will be required in many different areas.

This paper was prepared for the joint Transportation Research Board (TRB), Association of American Railroads (AAR), and Federal Railroad Administration (FRA) Conference on Railroad Freight Transportation Research Needs, the first such conference held in nearly 20 years. Many changes have taken place since the previous conference (*1*), as suggested in the accompanying text box.

Papers presented at the previous conference in 1975 provide useful background on service management in the rail industry. Sussman addressed service measurement, terminal performance as a major determinant of service reliability, and shippers' requirements. He commented on the need for demand models that could, on a commodity- and level-of-service-specific basis, predict what types of demand would occur as a function of changes in service quality. The relationship between service reliability and shipper behavior was identified as an important research need, including concerns with shippers' car detention, car ordering, and regularization of demand by shippers as it would relate to the quality of service provided (*2*).

Sussman also addressed the supply side of service reliability, demonstrating how various operating policies would lead to different levels of service. Operating practices, information systems, and cost models were highlighted, along with capital investment decisions and their relationship to service. Finally, institutional change as a mechanism to achieve better service was outlined with particular focus on work rules, network shape, fractional per diem (soon thereafter implemented as "hourly car hire") and organization structure. The dichotomy between operations and marketing staffs on railroads was emphasized—the former being concerned primarily with cost control, the latter primarily with service—with adjudication of their differences often occurring at the level of the chief executive officer (*2*).

A number of other papers touched on concepts related to service management. Briggs (*3*) commented that holding down rates as a mechanism for avoiding large traffic losses may lead to a railroad's inability "to spend sufficient amounts of money to assure that the physical plant is regenerated." This ties service quality, indirectly through revenue generation, to the ability to refurbish the physical plant. Ostrow focused on the need to develop traffic flow data that can be

Significant Changes Since 1975 in Service Management and the Environment for Service Management

Service Management

- General recognition of the importance of equipment utilization;
- Greater senior management concern for service;
- Better coordination of operations and marketing;
- Higher level of professional education among railroad managers; and
- Greater interest in intermodal transportation.

Environment

- Resolution of the Northeast rail crisis;
- Railroad rationalization (mergers, line abandonments, and line consolidation);
- Deregulation of the rail and trucking industries;
- Technological revolution in computers and communications;
- Technological advances in railroad equipment and line operations, allowing heavier axle loads and higher traffic densities;
- Vastly improved rail infrastructure; and
- Significant progress in labor-management cooperation.

the foundation for market research (*4*). This essentially addresses customer needs as well as the needs of the operating department in optimizing their performance. Davies (*5*) noted, "The railroad industry must implement costing procedures that will enable more effective planning, control and pricing of its production." Implicit within this notion is the ability to provide highly reliable service at a reasonable operating cost.

Dingle (*6*) concluded that the "design of operation management organizations is a basic research need." In other words, the ability of the railroad to produce high-quality service is directly tied to the organizational structures designed to produce this service. Williamson (*7*) bemoaned the lack of research and understanding of railroad terminals and stated, "The United States railroad terminal has only started receiving serious attention in the past 10 years. This attention needs expansion." Finally, Hoppe (*8*) added, "It is in the dynamic planning of operations where yard design needs considerably more effort."

In summary, the previous conference identified many themes relevant to service and service management: recognition of customer needs is critical; providing cost-effective, high-quality service is important; data systems and dynamic planning models are essential; and performance within terminals is a major determinant of service quality.

The first section of this paper, Customer Requirements and Logistics Costs, indicates which aspects of freight service are important and why. The section on Origin-Destination Analysis presents an overview of typical service levels, which shows that there does seem to be considerable opportunity for improving service. In the section on Systems Analysis, the basics of service and capacity management are outlined. Broad options for improving service management are identified in the section on Improvement Strategies. The section on Cross-Cutting Themes includes a discussion of five themes: future market requirements, productivity, advanced technology, human factors, and safety. Summary and Conclusions is the last section.

Customer Requirements and Logistics Costs

The freight transportation market is complex, competitive, and constantly evolving. Freight flows depend on the types of commodities that are produced and consumed, where they are produced and consumed, and the options available for transportation. A particular mode or carrier may prosper or fail because of changes in any of these three areas. Many a rail line has failed because of the movement of the industry away from the line (and consolidation of production in larger, more efficient facilities). The emergence of vibrant export economies in

Asia led to rapid rise in container shipments across the Pacific and across the United States; clipper ships, the Erie canal, and the 40-ft boxcar succumbed to better technology.

There are three broad categories of freight traffic. Basic raw materials, such as coal and mineral ores, almost always move in large shipments by rail unit train or by water. Intermediate goods, such as cement, fertilizer, edible oils, food-grains, bulk chemicals, bulk steel goods, oil products, and automobile parts, are subject to intense intermodal competition. The share of railroads depends on the degree of concentration of flows and the degree of adaptation of rail service, equipment, and infrastructure to the particular requirements of this traffic. For general agriculture and manufactured products, flexible, rapid, dock-to-dock truck service is ideal. Increasing regional and local production implies smaller shipment sizes and shorter hauls. Increasing product differentiation and higher value imply smaller shipment size and greater demand for quality service.

Customers base their transportation decisions on logistics costs. From this perspective, the most important characteristics of freight service are the ones that have the greatest impact on logistics costs. Expressing each element of logistics in terms of customer characteristics, commodity characteristics, and carrier characteristics highlights the importance of average trip time and reliability, along with price and loss and damage (*9*).

For some commodities, the value of inventory or the needs of the production process lead shippers to demand short trip times with little or no variation in the trips (such as just-in-time processes). For other commodities, most notably bulk goods, the value of the commodity may be considerably lower than the equipment in which it moves; consequently, shippers do not object to holding inventories and safety stocks and require only that a certain volume is moved within a relatively long window (*10*). The prices customers are willing to pay also vary. Some customers may be willing to pay a substantial premium to ensure high-quality service, whereas others may not. In both cases, customers' decisions are based on the logistics costs that they face. If the service provided is matched to a customer's desires and is consistent with expectations, the service may be considered reliable, even if that service would not be acceptable to a different customer.

Origin-Destination Analysis

The basic elements of the origin-destination (O-D) trip are described in this section, existing levels of reliability are examined, and some of the best opportunities for improving service are identified.

Trip Plan

The trip plan, or car schedule, describes how a shipment is supposed to move from its origin to its destination. The trip plan lists the pickup time, the sequence of trains that the shipment will move on, the yards where it will be classified, and the estimated time of arrival (ETA) at the destination. For a typical boxcar movement, the trip plan might be as follows:

- Pickup at 1600 on Day 0 by Local 1,
- Arrive Class Yard A at 2100 on Day 0,
- Depart Class Yard A at 1200 on Day 1 on Train AB,
- Arrive Class Yard B at 0200 on Day 2,
- Depart Class Yard B at 0100 on Day 3 on Train BC,
- Arrive Class Yard C at 1500 on Day 3,
- Depart Class Yard C at 1200 on Day 4 on Train CD,
- Arrive Class Yard D at 0800 on Day 5,
- Depart Class Yard D at 0500 on Day 6 on Local 2, and
- Place at Siding at 1000 on Day 6.

For an intermodal shipment, the trip plan is likely to involve only a single train. The plan would be much simpler than for a boxcar, as the following list suggests:

- Arrive origin terminal before 2200 cutoff for Train A,
- Depart at 0100 on Day 1 on Train A,
- Arrive destination terminal at 1200 on Day 2 on Train A, and
- Available for pickup at 1500 on Day 2.

A unit train movement would have a plan similar to that of the intermodal shipment:

- Empty train arrives for loading at 0700 on Day 0,
- Loading completed by 1500 on Day 0,
- Unit Train 101 departs at 1600 on Day 0,
- Unit Train 101 arrives at 0400 on Day 2, and
- Unit Train 101 available for unloading by 0700 on Day 2.

Trip plans can be derived from the operating plan. Local train schedules determine when cars can be picked up and delivered, and the blocking plan determines the route through the network, including the classification yards. Block-to-train assignments and train connection standards determine the specific trains that will be used.

A fundamental question concerns the minimum time that must be provided in a trip plan for a car to make a connection at a class yard. In some cases, connections are scheduled to be made in just a few hours; more commonly, 8 to 12 hr is the minimum time scheduled for a connection. In extreme cases, 20 hr or more might be the minimum time for scheduling a connection. If the minimum time is 12 hr, the scheduled yard time required for a connection to a train that departs daily is between 12 and 36 hr. Longer scheduled delays are required for trains that operate less frequently.

Customer Commitments

The trip plan is not the same thing as the commitment to the customer, and many shipments are made without a specific commitment to the customer. In general, the trip plan may be faster or slower than the commitment, but a realistic commitment usually adds a buffer to protect against potential delays. In any case, the trip plan becomes the goal for the operating department in implementing the plan. If the operating plan produces unacceptable trip plans, the operating plan should be changed or the customer commitment renegotiated.

Measurements are an important aspect of service management. Both absolute and relative measures are needed. Absolute measures include the average trip time, trip time distribution, standard deviation, and *N*-day percent (the percentage of shipments arriving within a window of *N* days); carriers frequently use such measures in their control systems. However, shippers are likely to be much more concerned with measuring performance relative to commitments.

Railroads must therefore be able to monitor customer commitments at the level of the individual customer and the individual shipment. Closely related to this is the need for service measures to be structured in a way that leads carriers to detect and diagnose service failures (*11*). Railroads must develop mechanisms for determining whether variation from the trip plan is sufficiently significant to require active intervention (such as running extra service or notifying the customer). Some shipments may have to be "sacrificed" for others of a higher priority during times of resource shortages or under severe operating difficulties. Even greater than these concerns, however, is that a customer-focused service plan requires that railroads carefully negotiate service commitments with customers to ensure that the service offered meets customers' needs, is achievable, and is profitable.

Origin-Destination Reliability

The levels of rail service vary by market segment. As part of a study conducted for AAR, the AAR Affiliated Laboratory at the Massachusetts Institute of Technology (MIT) analyzed performance for 10 percent samples of boxcar, double-stack train movements and covered hopper unit train movements during a 12-month period beginning in December 1990 (*12,13*, Kwon, unpublished data). For each car type, the average trip time and the reliability of trip times were calculated for the highest volume movements. The data in Table 1 show that the service provided to boxcar traffic was significantly slower and less reliable than that provided to the other two classes. The 2-day percent for a typical boxcar movement was only 49 percent, which means that only half of the cars arrived within 2 days. Although weekends, holidays, and the possibility of alternative routings may have caused some of the variation in trip times, it is clear that the service provided to general merchandise shippers was unreliable. Shippers who use double-stack services between some cities, on the other hand, are able to take advantage of faster and more reliable service.

Causes of Unreliability

The AAR Affiliated Laboratory at MIT recently reviewed previous work on railroad reliability (*14*). After a brief summary of some of the most important results of this earlier work, some recent results are presented.

Early Studies

FRA sponsored a series of studies on railroad reliability in the early 1970s. These studies were focused primarily on general merchandise freight service. A general conclusion was that reliability is closely related to the operating plan and the ability to carry out that plan. Terminal reliability was identified as a major problem because 10 to 30 percent of the cars studied missed connections at each yard as a result of inbound train delays, yard congestion, or inadequate outbound train capacity. Delays related to track failures or equipment failures (including bad orders and locomotive failures) were not found to be major factors for either train or O-D reliability. Meets and passes and other operating problems accounted for a much higher percentage of line delay time than did engineering failures.

In 1975, the Freight Car Utilization Program (FCUP) was initiated by the industry with support from FRA and AAR. Through a series of studies related to various aspects of rail service management, FCUP showed that service problems reflected underlying institutional and organizational problems. FCUP's Industry Task Force on Reliability Studies concluded that railroads lacked the desire, organization, data, and resources to provide reliable service (*15*). The task force recommended that senior management take the lead in providing a commitment to better service, developing an operation and service plan, and providing the necessary resources to implement the plan. On the basis of these recommendations, FCUP then sponsored case studies of operation and service planning on the Boston & Maine and Santa Fe

TABLE 1 Service Characteristics of Rail Freight Service

MOVEMENT TYPE	MEAN TYPE (DAYS)	2-DAY (%)
Boxcar (average)	7.2	49
Unit train	5.3	61
Double-stack train	3.3	86

NOTE: Ten percent sample of Train II data, December 1990 through November 1991.

railroads. The MIT Service Planning Model (*16*), which was developed in these case studies, is still in use today and supported by an industry users group.

Additional research, particularly in the areas of meets and passes and other operational improvements, was conducted by carriers and other interested parties in the 1980s. This effort was driven in large measure by the desire to assess the value of large-scale line control systems such as advanced train control systems (ATCS) and Advanced Railroad Electronics System (*17*). These studies, focused almost entirely on line operations, found that most train delays were due to dispatching and operations and not the reliability of the underlying hardware (track, signals, or equipment).

Recent Results

Recent research by the authors addressed the current causes of unreliable service on the basis of rail industry data (*18*). Three types of data were analyzed. A Class I railroad provided customer service data showing the nominal reasons for delays to individual shipments relative to customer commitments. Two other Class I railroads provided detailed root cause analyses of train delays. Finally, TTX Company provided detailed mechanical data for double-stack cars that experienced delays.

The customer service data reflected more than 93,000 cars handled in 4 selected months in 1991 and 1992. Causes of delay were grouped into the following six categories:

1. Power availability delays, which include delays to trains caused by power not being in position to move the requisite tonnage (24.4 percent of all train delays);
2. Terminal delays, which include yard congestion, cars not switched in time, cars moved on other than scheduled trains, and so forth (20.2 percent of all delays);
3. Train delays, which reflect management decisions about which trains to run and with what resources, including maximum tonnage, annulment due to lack of traffic, train consolidations, and the like (20 percent of all delays);
4. Mechanical delays, which include bad orders of cars or locomotives (16 percent of delays);
5. Line delays, which reflect delays en route, such as track work, curfew, train meets, and so forth (13.3 percent of delays); and
6. Other delays, which include derailments, unknown causes, no bills, and the like (6.1 percent of all delays).

As can be seen, power availability was a significant problem for this railroad. What is even more striking, however, is that terminal and train delays were almost as large and together accounted for more than 40 percent of the delays to shipments. It is noteworthy that even if the railroad had "perfect" technology, only 30 percent of the delays would disappear; 65 percent of the delays required better management of resources (terminal management, train management, and power distribution).

Two railroads provided train delay data. One of the railroads undertakes an annual study of train operations in detail in order to understand the root causes of failures to maintain the schedule. The other railroad has recently begun to monitor train performance on a continuing basis. The results of the root cause analysis results are summarized in Figures 1 and 2. Figure 1 shows the department within the railroad that assumed responsibility for delays; Figure 2 provides more detail for the Transportation Department, which was responsible for the largest number of train delays. The largest single cause of delays was train meets, which is consistent with the results of earlier studies reported previously. The second largest cause was yard congestion. This is surprising because the study was focused on delays to trains (i.e., cars that had already made connections) and not individual shipments or cars. It seems likely that if the study were focused on individual cars, the share of delays due to yard and terminal problems would be even greater. The third and fifth largest causes of delays, crew rest and crew shortage, further highlight the concerns raised by the customer service study.

Data from the second carrier are presented in Table 2. Although not identical to the root cause data, the results are generally consistent. Transportation operations account for approx-

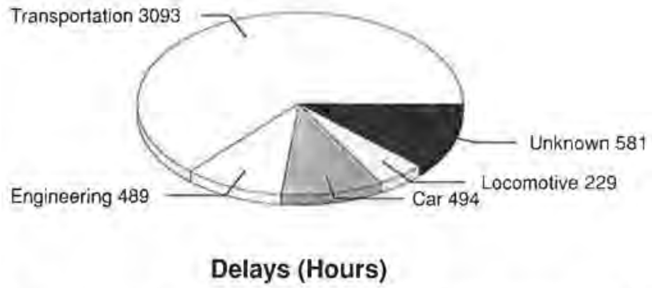

FIGURE 1 Train delays by department (source: MIT Affiliated Laboratory).

imately one-half of the delays to trains, and yard delays to road trains are substantial enough to raise questions regarding the impact of terminals on service to shippers.

Finally, managers from TTX Company assisted in determining the extent to which mechanical problems had affected double-stack cars that had experienced delays on a set of highly reliable corridors. Of 5,539 loaded trips in the overall sample, 195 were delayed 1 to 5 days beyond the mean travel time. Of these delayed trips, 31 were holiday trips, representing 15.9 percent of the delayed shipments, 39 cars (20 percent) had mechanical events during their trips, but only 8 cars (4.1 percent) had mechanical events that required that equipment be sent to the repair shop.

In other words, 80 percent of the delays to high priority, high quality shipments were left unexplained after accounting for mechanical delays and holiday disruptions. This suggests that mechanical reliability is not the root cause of unreliability, even for cars that are only rarely in terminals.

All the recent work, then, suggests that freight reliability appears to be more a matter of management than of railroad technology. The delays to cars and the delays to trains that may be attributed to failed equipment, track, or technology are modest, whereas those due to the management of resources constitute a clear majority. This finding suggests that the focus of research to improve service reliability must be shifted in a manner that will provide tools to manage the railroad and not to technologies and hardware.

SYSTEMS ANALYSIS

A small number of extremely important systems management issues do much to determine the levels of service reliability. These issues include long-term decisions concerning capacity, the annual budgeting process, and the incentive system set up for rewarding operating and marketing officials. Recent studies have reiterated the tight links among capacity, line perfor-

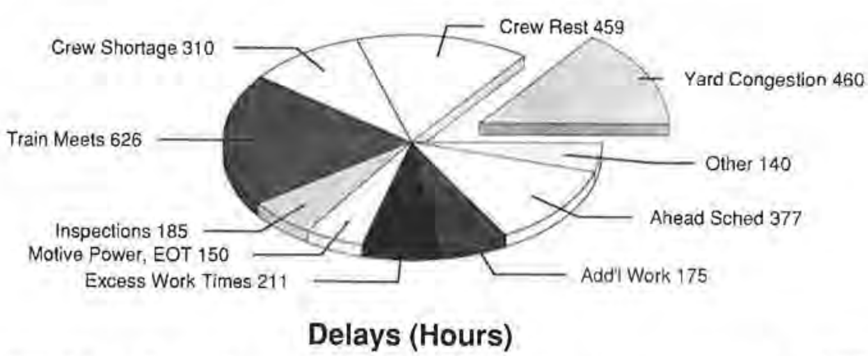

FIGURE 2 Train delays caused by transportation department (source: MIT Affiliated Laboratory).

TABLE 2 Functional Areas Responsible for Train Delays

	PERCENTAGE OF TRAIN DELAYS	
FUNCTIONAL AREA	NOV. 1992	FEB. 1993
Road (transportation)	30	39
Yard (transportation)	15	13
Maintenance of way	2	2
Communications and signals	1	1
Maintenance of equipment	4	8
Foreign (interchange)	13	16
Passenger train delays	0	0
Other	35	21

NOTE: Data are from a Class I Railroad.

mance, and terminal performance. Modest adjustments in train arrival times and connection times can compensate for capacity problems in terminals.

A fundamental concern is how to handle the peaks and valleys of demand. Because of the importance of cost control and the lack of a reservation system, railroads do not attempt to provide capacity to handle peak demands. Instead, there are various ways in which priority shipments can be handled expeditiously at all times and empty cars and low-priority freight can be handled when capacity is available. In fact, a major opportunity for the industry is to achieve a better understanding of the true costs and potential benefits of market segmentation and service differentiation.

Another fundamental concern is how to adjust capacity to what is required for current service levels. The fixed plant is often taken as a given in service design, but significant changes may be made over time. The most visible breakdowns in service are related to situations in which demand exceeds supply, as when extraordinary delays resulted from attempts to ship too much grain to Gulf Coast ports during Russian wheat deals during the 1970s.

A third fundamental concern is related to the constraints imposed by the infrastructure. Limits on axle loads and dimensions are likely the most important. During the past 20 years, the industry has reduced the cost of bulk operations by creating a track structure capable of handling first 100-ton and then 112-ton loads (i.e., axle loads of 33,000 to 36,000 lb). The most rapidly growing segment of rail business, double-stack container traffic, was made possible by technical innovations in equipment and by investments in raising clearances on major routes across the country.

Service Management

Given the existing physical plant and equipment, what service should a railroad offer? Service design, implementation, and monitoring and evaluation are three critical aspects of service management discussed in this section.

The basic elements of service design are as follows:

1. Service philosophy and objectives
2. Potential demand
   a. Market segmentation
   b. Potential traffic (based on historical flows, customer information, or demand models)
   c. Sensitivity of traffic to service parameters
3. Service requirements
4. Operating or service plan
   a. Service planning algorithms and models

   b. Capacity planning and trade-offs—locomotives and crews
   c. Achievable terminal work plans
   d. Marginal costing of service options and plans
5. Equipment plan: capacity planning and trade-offs—freight cars
6. Infrastructure plan: capacity planning and trade-offs—line and terminal
7. Pricing strategy

The whole process of service management is driven by a railroad's basic service philosophy and the objectives pursued by senior managers. The importance of service relative to costs, which may show up in the relative weights given to budget adherence and service measures in the annual reviews of operating officials, will permeate all of the decisions related to service management, particularly service design. Senior managers also determine whether the operating plan provides realistic goals to all managers.

Assuming that senior managers intend the plan to provide the basis for all operations, several important steps should be followed. The first steps are to assess the potential demand and customer requirements for specific market segments that may be defined in terms of commodity, customer, or geographic characteristics. A knowledge of the elasticity of demand in various markets to service parameters will be helpful in trading off trip times, reliability, price, equipment, and other elements of rail service (*19*). Railroads generally rely on their marketing and sales departments to identify opportunities for attracting new traffic or for improving the profitability of service to existing traffic.

The next step is the development of the operating or service plan. Since service levels result from the implementation of the operating plan, the development of an operating plan is, in effect, also the development of a service plan. Although academics may argue that the service requirements come first, as a practical matter, the operating plan is a more useful starting point. The operating plan exists, and it leads to a predictable level of service. A railroad seldom redefines its entire plan but frequently modifies the plan to take advantage of marketing opportunities or to adjust the plan to current traffic flows. The marketing department can identify (using surveys, models, or intuition) where service is inadequate, and the plan can then be adjusted as needed.

A notable weakness in service design is the normal treatment of terminal operations as a "black box." As discussed previously, trip plans (i.e., car schedules) must specify train connections at classification yards. These connections are normally based on cutoffs, which are negotiated by headquarters and field personnel; they are seldom, if ever, based on terminal plans or detailed studies of yard performance. Although detailed simulation models may be used to study terminal capacity, the authors know of no models that are used routinely to assist managers in moving cars through terminals. Hence, terminal managers do not have well-defined terminal operating plans, nor do they have tools to assist them in creating better plans or in estimating the incremental costs of different strategies for operating terminals. It is clear from the summary of boxcar service presented previously that rail carload service is often unreliable; cars seldom follow their trip plans, in large part because of problems in moving reliably through terminals.

The next steps in service design are the development of plans for equipment and infrastructure that provide adequate capacity for implementing the plan. As noted previously, failure to provide adequate resources for implementing the plan will lead to significant service problems. FCUP published a useful series of reports on various aspects of fleet management (*20*).

The final aspect of service design is pricing. The objective is to provide a service at a price sufficient to attract customers and also earn a profit. The ability to estimate true incremental costs is critical because so many shared and allocated costs are associated with railroad operations. It is beyond the scope of this paper to address pricing strategy, except to emphasize that prices are based on market conditions (willingness to pay), with incremental costs as a floor.

Implementation

The key elements in successful implementation of a service plan are as follows:

1. Well-documented operating or service plan
2. Coordination among control center, officers, and crews
   a. Precision execution of planned operations
   b. Work order generation and feedback
3. Near-term estimates of traffic and operating conditions
   a. Car status data base (terminals and trains)
   b. Freight car scheduling
   c. Interline Service Management
   d. Near-term forecasting strategies and methods
   e. Customer orders
   f. Customer-provided information on planned shipments
4. Capacity management (short-term supply and demand)
   a. Train departure planning (what time, what traffic)
   b. Train annulment, consolidation, and extra trains
   c. Emergency response to incidents
   d. Recovery from unplanned events
5. Track time allocation
   a. Train priorities, meet and pass planning, and ETAs
   b. Maintenance-of-way windows
6. Customer support
   a. Customer service center technology
   b. Trip plans, car location, and delay notification
   c. Logistics information systems (e.g., pipeline)
   d. Billing systems (electronic data interchange, computerized rates)

The first of these elements is a well-documented service plan. Although this might seem to be a truism, some of the AAR/FCUP studies of the late 1970s and early 1980s found that the operating plan being implemented in the field did not correspond with the operating plan as developed by senior staff, or with the service plan being offered to customers by the marketing department.

Attention must be paid to keeping the plan current as it is modified in response to changing conditions. This requires that information systems be put in place that allow line and staff managers to determine the current plan and be alerted when significant changes occur.

Closely allied with this is the need for coordination between those parts of the organization responsible for exercising control (e.g., dispatch centers, operations control centers, and so forth) and the field staff who carry out the plan. Many railroads are currently focusing attention on this problem. Burlington Northern, for example, is moving strongly in the direction of "precision execution," under which central management assumes responsibility for developing an achievable plan to provide service and field personnel are responsible for carrying out the plan (*21*). Other developments in this area include the development of sophisticated work order systems that allow for virtually real-time direction and monitoring of individual train crews using aspects of ATCS.

The causality studies cited earlier highlighted the importance of management of resources instead of development of new technologies as the key to improving service reliability. Central to the successful management of resources is the need for accurate information regarding traffic levels, operating conditions, and resource levels. This has led railroads to begin large investments in information technology. Some of these systems are industry wide (at least at the standards level), such as Interline Service Management, whereas others are specific to individual railroads, such as terminal inventory systems. The development of some of these systems is expected to take several years.

Railroads face a difficult problem in matching transportation supply with customer demand. It is necessary to provide adequate capacity during peak periods while avoiding idle resources during nonpeak periods. Capacity in this sense includes not only available space in yards or on lines, but also train and terminal schedules, decisions on annulments and consolidations and other modifications to plans, and responses to emergency conditions. Given the high costs of expanding facilities, this task of matching supply and demand has a direct effect on the ability to profitably implement the operating or service plan.

Although much of the focus of implementing an operating plan is necessarily short-term in nature, long-term functions of the system must still be realized. Track and equipment must be maintained on an ongoing basis. The operating plan must allow adequate time for track crews to inspect, repair, and upgrade the track while permitting the service commitments to be met. Equipment inspection, repair, and maintenance cycles must be met so that locomotives are available to operate scheduled trains, cars are available in acceptable condition for customers, and overall safety requirements are met.

Finally, there is a need for mechanisms to ensure that customers are provided information regarding the status of their shipments, structured to both report on current movements and encourage additional shipments. Railroads are beginning to centralize these responsibilities, which allows for economies of scale in information technology and permits customers to have a single point of contact with the railroad (or even several railroads for interline moves). This centralization is not without its risks, however, as the customer's source of information regarding the shipment is now divorced from the actual provider of the service. This makes the carrier as dependent on the quality of the information systems as is the customer.

Monitoring and Review

The major steps in monitoring and reviewing service, the third continuing component of service management, are as follows:

1. Comparison of actual with planned performance
    a. Service measures
        (1) Line, terminal, O-D, and system
        (2) Trip times and reliability
        (3) Cost
    b. Service goals
    c. Root cause analysis of service failures
2. Budget process
    a. Inclusion of equipment costs
    b. Link between service and budgetary performance—inclusion of service penalties
    c. Incentive systems (bonuses, pay, promotion)
3. Strategic planning
    a. Service philosophies and strategies
    b. Long-term evolution of market
        (1) Customer requirements
        (2) Demand elasticities
        (3) Additional logistics services
        (4) Competitor capabilities
        (5) Technological advances

The first step is to compare actual to planned performance for line, terminal, O-D, and system performance. Performance must include consideration of trip times, reliability, and cost. Service should ideally be measured against customer commitments in terms that are meaningful to the shipper. Service must also be measured relative to the operating plan, at all levels of operation. Information systems need to be able to support root cause analysis of service failures on a routine basis.

The second element of monitoring and review is the budget process. If budgeting focuses on only a portion of costs, suboptimization and misdirection of effort may result. The change to hourly car hire in 1976 helped make hourly car costs more tangible, which led to the inclusion of car costs in most terminal reporting systems, thereby allowing terminal managers to trade off car costs and switch engine costs.

The third element of monitoring and review is the feedback to the strategic planning process. Do opportunities exist for entering new markets? Are customer requirements or competitor capabilities changing? How will technological advances affect operating capabilities?

Summary

In summary, service management is constrained by several factors:

- Overall objectives of the company concerning service, market share, cost, and profitability;
- Capacity of the existing physical plant;
- Capacity of the car and locomotive fleets;
- Performance capabilities of terminals;
- Ability to forecast traffic volumes;
- Ability to formulate efficient and effective plans; and
- Ability to implement plans.

Improvement Strategies

Several broad strategies may be used to improve service reliability:

- Improve the overall objectives to give more appropriate priority to service relative to costs. Senior managers can quickly change the relative incentives for providing good service, meeting budgets, or operating according to plan.
- Improve the operating or service plan. The existing plan may be inefficient in the use of resources; it may be infeasible in terms of current terminal or line capabilities or capacity. It may be ineffective in providing appropriate levels of service for different market segments; it may be inflexible in response to variable traffic and operating conditions.
- Reduce the constraints on operations. Increase the capacity of the physical plant in order to reduce delays related to congestion. Improve track quality to allow higher speeds or heavier axle loads. Since labor agreements have been negotiated that reduce the size and costs of crews, seek improvement concerning work rules. Invest in more reliable equipment that can be used more flexibly in operations.
- Improve implementation of the plan. Operations officers may disrupt service by continuously adjusting the plan in order to cut costs. Train reliability may be low because of poor discipline in originating and in dispatching trains or because of frequent maintenance-of-way activities. Terminal operations may be out of control, causing connections to be missed frequently. There may not be adequate power to implement the plan, and there may be no way to recover once cars fall behind schedule.
- Improve the review process. It is essential to identify problems before they become unmanageable and to correct them before customers are lost. Both the short-term and long-term perspectives are relevant—what's happening to my shipment today and why can't you provide more consistent service this year?

Note that strategies for improving reliability are not the same as those for reducing costs. Whereas improving locomotive reliability may have only a minor effect on O-D reliability, it may have a major effect on locomotive cost.

Cross-Cutting Themes

Service management can be related to five cross-cutting themes that apply to all aspects of rail research. These themes are discussed in the following paragraphs.

Future Market Requirements

Service reliability and service management are important primarily because of the need to compete successfully within the freight transportation market. What customers require and what they are willing to pay for are perhaps the most critical elements in determining how best to improve railroad reliability.

Productivity

At some level, there is a fundamental trade-off between productivity and reliability. To the extent that productivity is emphasized over schedule adherence, managers will diverge from the service plan in order to reduce costs, and they will defer investing in additional capacity.

Advanced Technology

Although technology cannot be viewed as a "silver bullet" to solve all problems, there are areas in which advanced technology can make a difference:

- *ATCS* allow railroads to keep customers informed regarding the status of shipments vis-a-vis their trip plans and can allow the carrier to determine if any special action will be required to meet customer commitments.
- *Automatic vehicle identification and location techniques* could have tremendous impacts on operations in yards, lines, and customer sidings, especially for large shippers for whom shipments by rail constitute an important element in a well-managed inventory.
- *Advanced sensors* that may be used to predict failures of rolling stock and right-of-way and thus ensure improved maintenance could be useful in reducing the effects of in-service failures and improving the scheduling of maintenance activities.
- The development and adoption of *advanced materials* offer opportunities for increasing the mean time between failures and extending the maintenance cycle of both track and equipment.
- Advanced methodologies in the areas of *risk assessment, simulation, and network analysis* may be used to allocate resources and design operating plans to optimize reliability.

Human Factors

The management of resources is at the center of improving reliability for many types of shipments studied. Key areas include the operations control center, terminal operations, and crew management. Although not traditionally considered an aspect of human factors, institutional and organizational issues concerned with the implementation of plans may be critical. Railroads must foster an environment in which the human concerns associated with organizational change are addressed in a positive way. In general, all the railroad's control systems must provide the information needed by people to make better decisions, and must do so with interfaces that encourage them to use the best information possible.

Safety

Safety is an ultimate constraint on railroad operations. Areas related to safety and reliability include the distinction between engineering and performance specifications in establishing safe practices and equipment and whether federal and state safety requirements unnecessarily limit railroads in their attempts to compete in the marketplace. Another important consideration related to safety is the robustness of the rail operation in recovering from accidents or other serious events.

SUMMARY AND CONCLUSIONS

A framework for considering the many varied approaches for improving railroad reliability has been presented. Customers will base their transportation choices on their logistics costs, which means that different customers will have different requirements. Reliability means knowing those requirements and meeting them. Evidence suggests that railroads are capable of offering different levels of service when demanded, but there is an opportunity to provide the promised levels of service much more consistently. At the heart of the rail industry's service problems is a need for better management of resources and system performance, including operations and service planning, power distribution, train management, and terminal management. Railroads have improved component reliability to a level at which it is a minor part of the overall reliability issue, largely through investment in research and cooperative programs with suppliers. It remains a vital challenge for the rail industry to do the same thing for the managerial problems that currently limit the quality of service.

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