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Determination of the Effectiveness of Railroad-Car-Distribution Decision Making

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Most railroad organizations have defined and divided functions narrowly—around their visible physical activities such as moving trains, switching cars, and setting prices—because it appeared to be the most efficient way to manage such a complex production process. Unfortunately, adoption of such a structure has meant that the level of service provided to shippers and the use of the railroad's capital assets are the indirect result of numerous and often unrelated decisions rather than the focus of managerial activity. To understand this problem, a single function—car distribution—has been chosen for detailed investigation because it is an important determinant of both level of service and use of the freight-car fleet. Numerous operations research studies of car distribution have been conducted in recent years, but most have defined car distribution narrowly and ignored the broader organizational context within which car distribution actually functions. A framework is developed that is used to structure the analysis in a manner that permits consideration of both the physical elements of the production process and the managerial elements required to control it. Car-distribution organization, information, and decision structures are described and analyzed. Eight major areas in which improvement appears to be necessary are identified, and the direction of future research in this area is briefly discussed.

The railroads pioneered the development of organizational structures and practices to permit the management of large industrial concerns (1, p. 87), yet today there is a growing awareness that these decision-making and organizational structures (which have been used by the railroad industry for the last 100 years) may require change if the industry is to remain competitive with other transportation modes. This is no small task. Drucker, in his most recent text on the problems of management (2, pp. 590-591), cites railroads as one of the few businesses "for which we do not possess an adequate principle of organization"; he notes in particular the dilemma that faces managers responsible for the major capital assets--cars and locomotives--who must decentralize to attain efficiency but centralize to ensure effectiveness.

The solutions to this problem that have surfaced most recently focus principally on the form and structure of the organization as a whole (3, p. 176). While useful, such prescriptions may not address the problem at the level of the individual decision maker, whose behavior requires change. This study demonstrates that a focus on individual decision making is helpful in understanding the relevant organizational, information, and decision support systems of the transportation firm where the production process itself is complex.

To illustrate the proposed methodology, a single function--car distribution--has been selected as the subject of this decision-making diagnosis and design study. Car distribution was selected because

1. It is a function that has high leverage; even small improvements will have a major financial impact due to the rapidly increasing value of the freight-car fleet;
2. It is a relatively well-defined activity in the organization that has identifiable actors and procedures;
3. It has been the subject of numerous studies by operations researchers, who have adopted a traditional engineering view of the problem;
4. Institutional changes within the industry, which include the Clearinghouse (a mechanism to allocate equipment between railroads), hourly car hire, and the dramatic increase in the number of cars provided by third-party investors, have a significant impact on car distribution; and
5. Change is likely to be forced on it by external pressures--significant deregulation will remove many of the barriers that now constrain distribution activities and force a reassessment of policies and practices.

Car-distribution activity concerns the transfer of emptied cars from their unloading points to the next prospective shipper. Usually defined as an operating function, it is a support task to the primary productive activity of the railroad, which is to move loaded freight cars from shippers to receivers.

Car distribution is defined by car distributors themselves to be the process of identifying destination points for empty cars, given an available supply and potential demands, in a manner that minimizes cost. Defined in this way, the only problem faced by the car distributor is the matching of a given set of available empty cars with a given set of specified destinations. Most operations research studies have focused on the problem as defined in this way, since solutions can be generated by a variety of mathematical programming techniques. A review of attempts to apply mathematical programming to the car-distribution problem may be found elsewhere (4).

A main tenet of this study is that it is more fruitful to investigate the role of car distribution in the context of the railroad's total production function. This requires that the focus be not on a narrow interpretation of what car distribution produces--the movements of empty cars--but on the interdependencies that necessarily exist between car distribution and the rest of the railroad organization. From this perspective it is clear that (a) the choice of the empty cars to be distributed from those available and (b) the selection of which demands are to be satisfied are themselves problematic and interdependent decisions that must also be considered, and extensive observation of car distributors at work confirms that they are actively involved in these decisions. Thus, an operational definition must account for all the roles actually played by car distributors in the organization.

Part of the reason for this incongruity between definition and action can be explained by the constraints that have historically impinged on the car-distribution activity. From a political perspective, a narrow definition of the car-distribution activity provides insulation from the Interstate Commerce Commission (ICC) and from other departments of the railroad. The ICC's Common Carrier Obligation is usually interpreted to require equitable treatment of all shippers, so car distributors may be réluctant to admit that their actions have a substantive impact on shipper car supply.

More fundamentally, this difference in definition is a reflection of a problem that many consider to be at the heart of the industry's current difficulties. The organizational structure adopted by most railroads has tended to define positions narrowly--around visible physical activities such as moving trains, switching cars, repairing track, and setting rates--and not around the coordinated control of these interdependent activities to produce profitable transportation service. The established decision-making structure often does not acknowledge these coordinating functions and so obscures the interdependencies between decisions.

It is thus not sufficient to examine the present organization in terms of the acknowledged decisions and decision processes employed. To effectively assess or change any of these activities requires a framework that relates the function or functions that are being investigated to the relevant organizational context.

A framework that can be used to analyze the management processes at work within a transportation firm is described in the next section. The framework selected is based on ideas found in control theory.

In the second section, the car-distribution process will be formulated as a control problem, and in the third section the car-distribution management process found on several railroads examined during the study will be described by using the framework to organize the description.

Finally, a preliminary diagnosis of the management process will be described in terms of major areas of potential improvement to the organizational, information, and decision-making structures relevant to car distribution.

FRAMEWORK FOR ANALYSIS

In this section a framework will be described that can be used to guide an assessment of a transportation organization's decision processes and structure. The framework developed is similar to that used to analyze control problems in physical systems in that it explicitly distinguishes between state and control variables. It differs to the extent that explicit consideration is given to the fact that constraints and objectives for each part of the organization are usually derived in a complex fashion from the entire organization's constraints and objectives. Feedback and evaluation are also considered separate definable processes, since these too often present problems.

What Are We Trying to Analyze?

Analysts of transportation systems are often seduced by the complexity of the technology employed. In analyzing the car-distribution activity, for example, it is possible to look only at what might be called the physics of the problem, searching for a mathematical representation of the equipment flows and trying to find optimal solutions to the problem. Such approaches assume a single decision maker, who has complete information about the problem and an unambiguous objective. While each assumption may represent an appropriate normative ideal, none is reasonable as a description of the actual problem-solving environment.

The context within which the decisions are actually made almost always involves more than one decision maker; each has a limited amount of information that concerns both the environment and the activities of others, and each responds to multiple and conflicting objectives or constraints. To understand why decisions are made as they are and to prescribe changes that are likely to be feasible and effective, the analysis must account for this organizational context.

But what is an organization and how can it best be analyzed? Schein provides a definition that is typical of those found in the literature (5, p. 9):

> An organization is the rational coordination of the activities of a number of people for the achievement of some common explicit purpose or goal, through the division of labor and function, and through the hierarchy of authority and responsibility.

The specifics of this definition are less important than its identification of the essential elements of an organization: a group of people, some of whom are responsible for the coordination of work by others, who have divided a task to achieve some objective. Our study of the car-distribution function will therefore focus not only on the task itself but also on how that task has been divided, how each subtask is performed, and how they are coordinated to achieve a desired result. A framework based on control theory in physical systems is proposed in the remainder of this section to relate these organizational aspects of the problem to its physical structure.

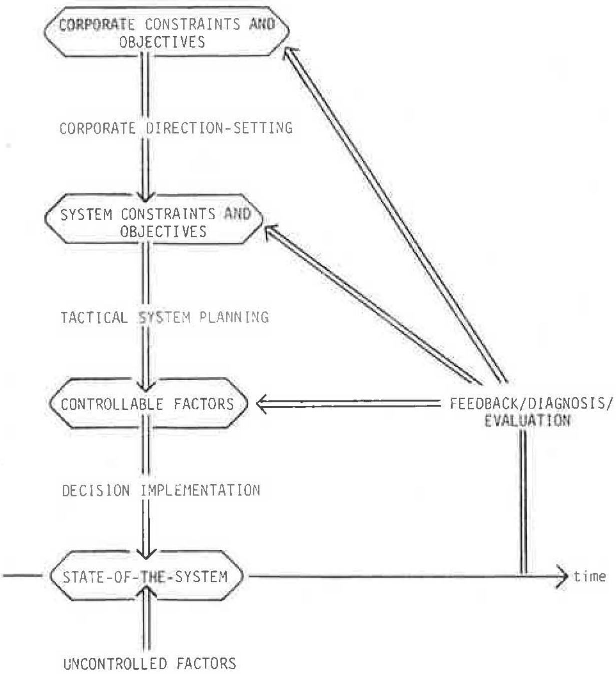
Defining the Concept of Control

The word "control" is one of those terms used in a wide variety of contexts. Anthony defines management control as "the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives" (6, p. 14). From this definition it is clear that most managerial activities (organizing, analyzing, and communicating) are undertaken to achieve control, but the word is often used in a much more limited context. For example, Tricker (7) states that "the purpose of any management control system is to establish criteria of performance for units in an organization." Control is often equated with budgets and performance measures, as though these activities alone would be sufficient to achieve control.

We are primarily interested in the control of managerial systems, but the term finds its most precise meaning and usage when applied to physical problems. In this context, the control system has four elements:

1. State variables, which characterize the attributes of the system believed to be most relevant;
2. Control variables, which characterize the

Figure 1. Management analysis framework.



known choices or decisions that can be made to alter the system;

3. Equations of motion, which describe the impact that control variables are believed to have on state variables; and

4. Objective function, which describes the desired state of the system.

For those engineering problems that can be so characterized (e.g., setting a missile's trajectory), the solution process is devoted to the formal specification of the equations of motion, which, when combined with an appropriately defined objective function, can often be solved for the optimal setting of the control variables. Although it is unlikely that problems of control in social or managerial systems could be formally modeled or solved in this way, it is interesting to note that the physical control problem implied by the structure above is similar to the definition of management control proposed by Anthony.

The framework used for physical systems analysis provides a useful point of departure for a framework to analyze managerial systems. Most important is the explicit distinction made between the state variables, which characterize the system, and the control variables, which represent those activities about which managers make choices to influence the state of the system. Explicit consideration of the relationships among these variables establishes the most important link between the physical and the managerial structures of the problem.

The Framework Defined

The main dimension of this framework for managerial analysis is based on the hypothesis that control is a principal task of management. The structure described below and illustrated in Figure 1 is motivated by that used to assess physical systems but modified to reflect the important differences between physical and social systems.

The physical-system framework focuses on the variables that characterize a system and the equations that characterize the relationships between variables. In an equivalent fashion, we will distinguish between elements and processes that act on the elements.

Control Elements

Control elements are defined as follows:

1. The state of the system is defined by a set of selected state variables. "System" refers here to that portion of the organization's productive activity that is the responsibility of the functional area or areas being analyzed. For example, in analyzing the car-distribution function, the state of the system will be defined by variables that relate to the location and status of the empty fleet.
2. Controllable factors are those variables that can be altered by managers to change the state of the system. Car distributors, for example, can decide which cars should be kept for reloading.
3. Uncontrollable factors are those variables that influence the state of the system but are controlled by others in the organization or by forces outside the organization. Shipper orders, for example, cannot be controlled by the car distributors in the short run.
4. System constraints and objectives are the limits and goals that restrict and motivate the actions taken relevant to the system. For example, car distribution may have as an objective to maximize filled orders but may also be constrained by the ICC to allocate the available fleet equitably.
5. Corporate constraints and objectives are the organization's constraints and objectives that are relevant to the system. A railroad, for example, may have an objective to maximize the profit contribution of its car fleet.

Control Processes

Control processes are defined as follows:

1. Decision implementation is the application of decisions made with respect to control variables. For example, car distributors may decide to reload foreign equipment (cars from other railroads) and must see that their decisions are actually executed.
2. Tactical system planning is the translation of system constraints and objectives into plans that specify how controllable factors are to be manipulated. Car distribution, for example, translates car service orders into rules that govern the selection of foreign cars for reloading.
3. Corporate direction setting is the translation of corporate constraints and objectives into constraints and objectives relevant to the system. For example, a corporate objective to reduce the number of cars owned may be translated into a system objective to increase foreign-car reloading.
4. Feedback, evaluation, and diagnosis is the comparison of actual system behavior over time with expected behavior. For example, a system objective to use all available foreign cars could be evaluated by measuring the foreign cars actually reloaded.

The relationships between control elements and processes are shown graphically in Figure 1. The most important difference between this structure and the one described for physical systems is the explicit recognition that the definition of constraints and objectives in a social organization and the translation of these into specific ones that can guide actions in any single part of the organization is a potentially complicated and problematic area.

Managerial Dimensions

The managerial activities (e.g., tactical system planning) required to control a particular physical process (e.g., moving empty cars) were identified in the previous section. The ability of the firm to execute these activities is determined by the organizational, information, and decision structures adopted by the firm. Key elements of each will now be described.

Organizational Structure

The most important distinguishing characteristics of any organization are the divisions of labor and responsibility used to achieve its objective or purpose. In this context, four characterizations of the structure are possible:

1. Personnel authority relationships: Individuals are grouped together under other individuals who have authority over their actions.
2. Task authority relationships: Individuals are given the right to carry out certain tasks.
3. Accountability relationships: Individuals are held responsible for the performance of tasks, for the activities of specific individuals, or for both; this requires that a manager's actions be accompanied by a prediction or expectation of the outcome and that the actual outcome be measured and subsequently compared with this prediction.
4. Motivational relationships: Within the context of their authorities and responsibilities, managerial behavior is prompted by inducements or incentives structured by the organization.

The traditional organization chart, which specifies reporting relationships among positions, partly reveals the first two relationships. To understand the task authority and accountability relationships, however, the individual activities of managers should be related to the control processes identified earlier.

Motivational relationships need to be examined, because social systems are largely volitional: Individuals must be motivated to choose the behavior thought to be appropriate by the organization. In some cases, parts of the motivational structure may be explicitly stated in terms of incentive pay systems, performance evaluation schemes, etc. Often, however, implicit codes of individual behavior and performance will exist that may or may not be tied to organizational objectives.

Information Structure

One popular approach to organizational analysis begins with the assumption that organizations can be characterized and understood as information-processing networks. This approach focuses on the channels of communication that exist between senders and receivers of information, in which the sender selects, encodes, and transmits information to a receiver who detects and decodes the message. Based on this framework, three issues are relevant: (a) who originates what information relevant to the elements of the system, (b) how the information is packaged and transmitted, and (c) who receives what information and in what form.

The analysis of the information structure must embody both the formal management information system and the informal communication channels that exist among members of the organization. The former is likely to be highly structured and documented, and the latter may be informal and discovered only through observation of participants.

Decision Structure

Decision making may be said to occur whenever a choice among different potential actions is required. The individual or group that is to make the choice (and to some degree their motivation in the selection process) will be determined by the organizing structure. The information system will define the data available to support the decision.

The process used will be determined by the tools available to synthesize the information, which may be informal and involve training appropriate individuals or structured in the form of computer programs and systems. In either case, the decision structure can be broken down and analyzed in terms of the way it supports the three stages of decision making (8, p. 47):

1. Knowledge: Searching the environment for conditions that call for a decision;
2. Design: Inventing, developing, and analyzing possible courses of action; and
3. Choice: Selecting a course of action from those available.

In many cases, it may be difficult to identify precisely the decisions that are made or the three phases of decision making noted above. In fact, there is substantial evidence from behavioral studies of decision making that the more important the decision, the less structured the process. In such cases, a principal benefit of the analysis may be to reveal the structure implied by the actual decision-making process.

Use of the Framework for Analysis of Managerial Systems

This framework makes it possible to systematically analyze the management of a particular function or set of functions performed by a transportation firm. The function is first formulated as a control process that reveals the essential managerial activities and their relationships to each other. The execution of these activities can then be assessed in terms of the organizational, information, and decision structures adopted. Car distribution will now be analyzed in this manner.

CAR DISTRIBUTION AS A CONTROL PROCESS

The framework described in the previous section will be used to define the control elements and processes required by the physical characteristics of car distribution and its role within the organization. Particular emphasis is given here to the interdependencies involved.

System-State Variables

The primary productive activity of a railroad is, of course, to move loaded freight cars from shippers to receivers. An additional task is usually necessary if this productive activity is to be accomplished, namely, the movement of emptied cars from the unloading point to the next prospective shipper. The state of the car-distribution system may thus be described by equations defining three variables:

$$E^t = \sum_i (I_i^t + P_i^t) \quad (1)$$

where

E^t = empty cars in the sytem to be used for loading,

I_i^t = cars waiting at supply point (any point where they can enter or exit from the distribution system), and

P_i^t = cars moving from one supply point to another.

$$D^t = \sum_i D_i^t \quad (2)$$

where D^t = cars applied to orders.

$$U^t = \sum_i (0_i^t - D_i^t) \quad (3)$$

where U^t = unfilled demand and 0_i^t = empty-car orders at point i.

Controllable and Uncontrollable Factors

The system as defined by Equations 1-3 is determined by both controllable and uncontrollable factors, which are listed below:

1. Controllable Factors

   F_i^t = empty cars sent to other system supply points from i,

   J_i^t = empty cars sent off line from i, and

   D_i^t = empty cars applied to orders at i.

2. Partly Controllable Factors

   A_i^t = empty cars arriving at i from other system supply points,

   P_i^t = empty cars in the pipeline to i from other supply points (arrivals and pipeline volume are in the part determined by operating-department decisions that determine travel time), and

   R_i^t = empty cars received from interchange at point i (empty interchange receipts will be determined in part by foreign-carrier decisions).

3. Uncontrollable Factors

   S_i^t = empty cars released from industry at point i and

   0_i^t = empty car orders at point i (both. these factors are determined by marketing decisions).

The state variable in Equation 1 (E^t) is a function of controllable, partly controllable, and uncontrollable factors:

$$I_i^t = I_i^{t-1} - F_i^{t-1} - J_i^{t-1} - D_i^{t-1} + A_i^{t-1} + R_i^{t-1} + S_i^{t-1} \quad (4)$$

$$P_i^t = P_i^{t-1} + \sum_j F_{ji}^{t-1} - A_i^{t-1} \quad (5)$$

Both state variables in Equations 2 and 3 are a function of D_i^t, a controllable variable, but the degree of control is constrained by uncontrollable factors, since $I_i^t \geq D_i^t \leq 0_i^t$. In other words, it is obvious the number of cars applied to orders cannot be greater than the order but, which is more important, it cannot be larger than the number of cars available (I_i^t). This reflects the high degree of interdependence caused by the fact that controllable and uncontrollable factors simultaneously affect all the state variables.

Corporate Direction Setting

Car-distribution decisions determine the car orders actually satisfied, which directly affects the railroad's revenue level, and these same decisions determine the empty-car and movement costs required to support this revenue.

Yet car distribution cannot possibly determine the best revenue and cost levels. For its decisions to be made in a manner consistent with corporate objectives, the other departments with more direct control and responsibility for revenue and cost levels must define the set of corporate objectives and constraints relevant to car distribution. Marketing should provide a market plan that includes anticipated levels of loaded movement (0_i and S_i for all i) and a priority ranking of these demands, operations should provide an operating plan that includes level-of-service expectations, and finance should provide a car plan that projects the system fleet size.

These plans must be translated into a set of specific plans for car distribution, which specify realizable performance targets and guidelines for action. The two most important of these are the loading plan and the empty movement plan, both of which are described below.

The loading plan specifies expectations with respect to the car placement activity:

$$D_i = \begin{cases} 0_i & \text{if } E > E^* \\ \alpha_i 0_i & \text{if } E < E^* \end{cases} \quad (6)$$

where

$E^* = \sum_i [0_i * (I_i + P_i)/L_i]$,

α_i = shortage allocation factor (between 0 and 1), and

E^* = number of empty cars required to satisfy all orders, given the movement plan, which is represented here by $(I_i + P_i)/L_i$ (car days/load).

When available car supply E_i is less than E^*, the shortage allocation factors (α_i) determine which supply points will receive the largest percentage of available supply.

The empty movement plan translates the car supply and demand forecasts into expected movement patterns. J_i, A_i, and F_i are determined such that

$$(D_i + J_i) - (S_i + R_i) + (A_i - F_i) = 0 \quad (7)$$

$$(F_{ij} C_{ij}) + (J_i C_i') \quad (8)$$

is minimized where

C_{ij} = movement cost for empty car from i to j,

C_i' = movement cost for empty car from i to interchange, and

$F_i = \sum_j F_{ij} + A_i = \sum_j F_{ji}$.

Equation 7 expresses the requirement that distribution pick a plan that balances network car supply (through J_i) and local car supply (through A_i and F_i) with demand. Equation 8 reflects the desire to achieve this in a manner that minimizes cost.

It is important to recognize the interdependence between the two plans. The loading plan depends on both demand forecasts and the movement plan, while the movement plan depends on the car plan, the market plan, and the level of demand specified in the loading plan. It is this interdependence between activities within car distribution and between car distribution and the other departments on the railroad that makes this direction-setting process necessary and makes a simple mathematical programming approach to car-distribution planning untenable.

Tactical Direction Setting

The loading and movement plans set overall goals for the car-distribution function. To be effective, these goals must be made operational in terms of specific sets of rules for the control variables that can be manipulated.

Order application rules should be derived directly from the loading plan so that, on a daily basis, the percentage of orders to be satisfied at an individual supply point (i) is determined by the level of car supply compared with that needed by the system.

Foreign-reloading rules are derived from both the loading and the movement plans; i.e., if $D_i^t = 0_i^t$ for all i, set J_i's to minimize movement expenses; if $D_i^t < 0_i^t$, set J_i's so that $D_i = \alpha_i 0_i$. Thus, when there is a car surplus, foreign cars should be used rather than being sent off line only if this reduces empty costs, but when there is a car shortage, foreign cars should be used to satisfy marketing targets.

Finally, movement flow rules are developed from the movement plan:

$$F_i^t = (0_i^t + J_i^t + A_i^t) - (S_i^t + R_i^t) \quad (9)$$

with F_{ij} calculated to satisfy

$$F_i^t = \sum_j F_{ij} \qquad E(A_j) = \sum_i F_{ij} \quad (10)$$

These three sets of rules make the system car-distribution plans operational by relating them directly to the control variables. They are designed to guide decision implementation.

In summary, car distribution is a necessary and complicated part of the railroad production process. Based on an understanding of the car-distribution activity and of its relationship to the rest of the organization, a description structured by the framework for analysis has been presented. Figure 2 displays the relationship of these elements and processes to each other. This figure identifies the variables that characterize the state of the system, the controllable and uncontrollable factors that determine the state of the system, and the corporate and system direction-setting processes necessary to guide car distribution. By using this description, it is possible to analyze a railroad's car-distribution activities.

CAR-DISTRIBUTION MANAGEMENT PRACTICES

The framework for analysis already presented was developed so that the managerial activities related to car distribution could be understood and analyzed. During the past year, several major U.S. railroads have been visited and interviews have been conducted with personnel responsible for the car-distribution activity. In addition, the results of a survey of industry car-distribution practices conducted by the Association of American Railroad's Freight Car Utilization Program have been reviewed and the results have been synthesized. Although practices differ, there is a substantial degree of commonality. The following description is based on a composite view of the characteristics found most often on the carriers studied.

As suggested in the preceding, the description that follows will focus on the organizational, information, and decision structures used to carry out the car-distribution activities already defined.

Organizational Structure

In analyzing the division of tasks among individuals, we will focus on three important structural characteristics: (a) the division of personnel authority (who reports to whom), (b) the division of task authority (who carries out which tasks), and (c) the division of task accountability (who is responsible for the outcome of specific tasks). The first is embodied in the departmental structure adopted by the organization; the second and third are revealed through an analysis of organizational behavior.

Personnel Authority Structure

Most major railroads in the United States today are functionally organized; Figure 3 illustrates the division of the major functions relevant to car distribution.

The operations department is divided functionally: The mechanical, engineering, and transportation departments have tended toward centralization, whereas most operating organizations have remained geographically decentralized. Car distribution is typically one of the functions of the transportation department.

The traffic department is also organized along functional lines; the principal division is between sales and marketing. Within marketing, pricing, equipment and service planning, and market development are the main subdivisions. All are centralized.

The organization of the transportation department itself differs somewhat from one railroad to another. Some have district or division superintendents responsible for particular regions of the railroad to whom regional car distributors report. Others have system car distributors who are responsible for the entire railroad.

Also in the operations department, the local agency personnel play a major role in the car-distribution function. The agents report through the operations organization to the district general managers.

In addition to the functional relationships described above, one or more car committees often exist to coordinate some car decisions, particularly those concerned with acquisitions. Members of each of the major functional areas are represented and, although the committees usually do not have staff or budgets of their own, they do facilitate communication between functional areas affected by car decisions.

Task Authority Structure

The tasks carried out by individuals in the organization are not specifically identified by the organizational chart or the personnel relationships shown in it. The major managerial activities associated with car distribution have been identified; it is possible to identify the individuals who have authority to carry out each activity shown in Figure 4.

The car distributors are largely concerned with the day-to-day implementation of car distribution.

Figure 2. Car-distribution control task hierarchy.

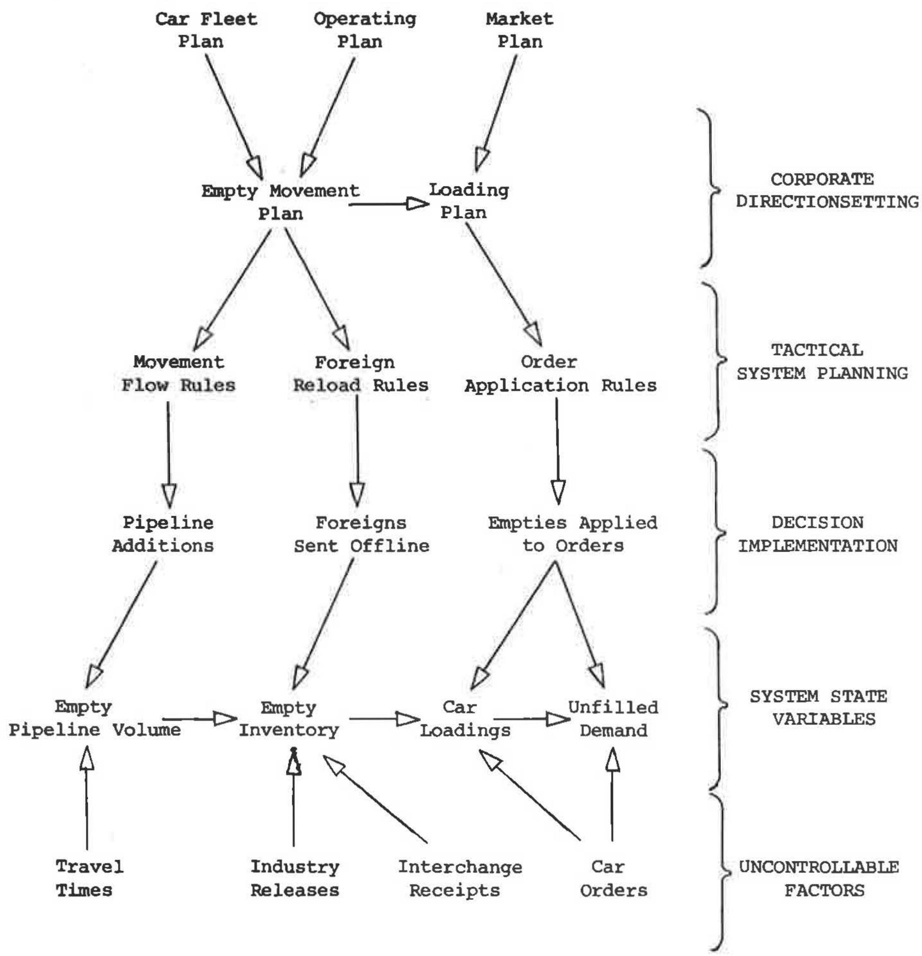


Figure 3. Departmental organization relevant to car distribution.

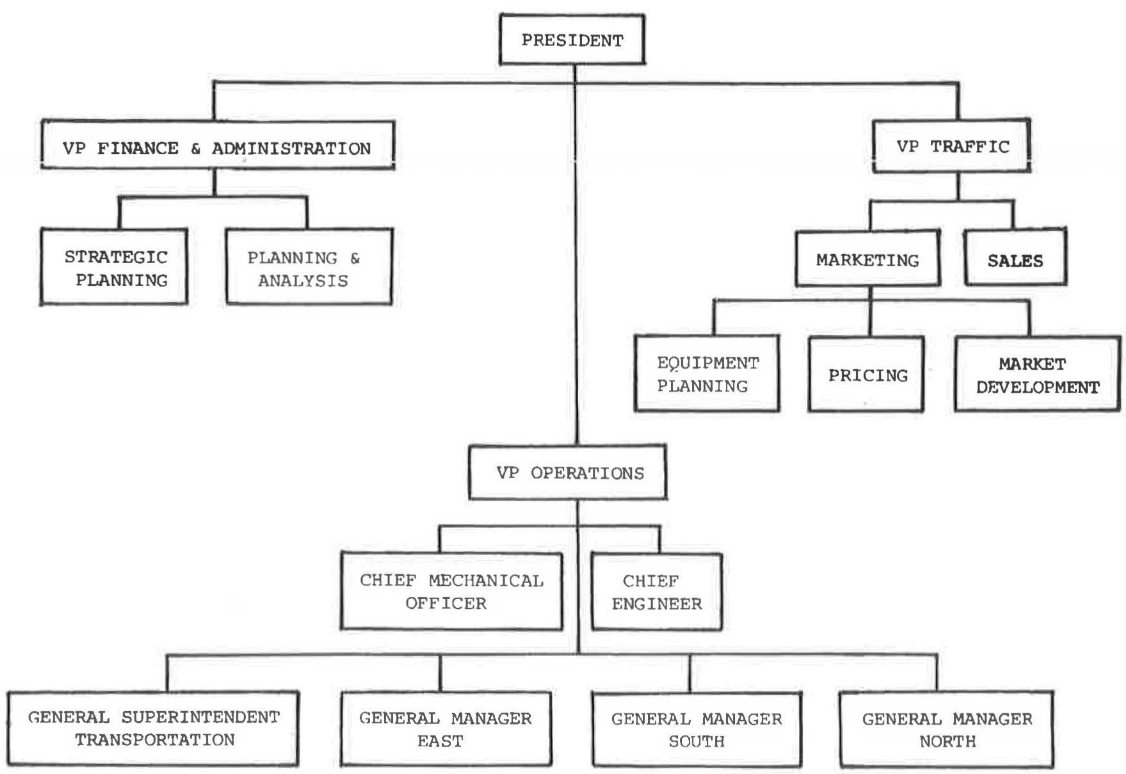
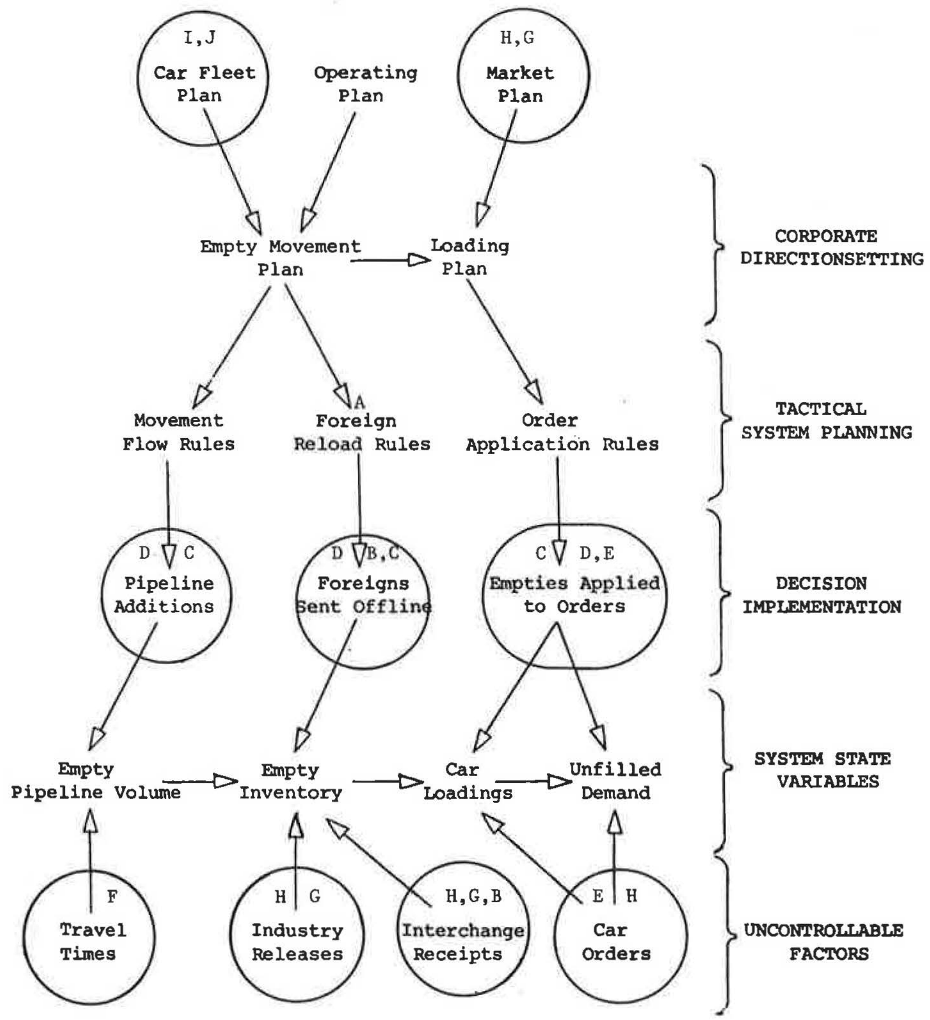


Figure 4. Task authority structure.



A = General Superintendent of Transportation

B = Director of Transportation Services

C = Director of Freight Car Utilization

D = Car-Distribution Managers

E = Local Agents

F = Operating Department

G = Market Managers

H = Sales Department

I = Equipment Planning

J = Planning and Analysis

They are the first line of defense between the railroad operating organization and both the customer and the commercial departments on the railroad. When problems arise with respect to equipment availability (even when the problems are caused by events not controllable by car distribution), the car distributors must respond to the crisis.

There is no one to perform the activities necessary to assure that these actions taken by the car distributor are consistent with the objectives of the firm. There is no regular preparation of movement or loading plans or of the movement, foreign-reload, or order-application rules necessary to guide car-distribution implementation decisions. Car fleet and market plans are prepared by other groups in the organization, but no one is formally authorized to translate these plans into constraints and objectives for the car-distribution activity. Tactical planning to guide daily implementation decisions is not evident.

Task Accountability Structure

Authority, accountability, and responsibility are often considered interchangeable, but we have defined accountability more precisely to refer to those actions where the result or impact is measured and explicitly compared with the result predicted. Thus, a manager may have authority to undertake some task but not be accountable and likewise may be accountable even though not authorized to take the action. Task accountability defined in this way requires that a manager's actions associated with the task be accompanied by a prediction of the outcome and that the actual outcome be measured and subsequently compared with this prediction.

Given this definition, no one is typically accountable for car-distribution decisions. The general superintendent may be responsible for net car hire, but an estimate of what net car hire ought to be is seldom made and in any case it is only indirectly related to car-distribution performance.

To some degree the implementation decisions of the car-distribution managers can be deduced from historical data on their decisions, but these decisions are not evaluated against the resulting empty flows in any formal way.

In general, the motivational philosophy that is relevant to the major actors in car distribution has tended to be behavioral rather than quantitative. In other words, judgments about the performance of the car-distribution managers are related primarily to their ability to behave like car distributors and are not based on any formal measure of output.

Information Structure

The proliferation of sophisticated computer-based information systems complicates the task of understanding what information actually supports decision making in any area of the railroad organization. Car distribution is particularly affected because it must use car data from both the real-time operating system and shipper information from the local agencies.

An enormous amount of car-location and status data are collected and manipulated by a railroad's management information system, and much of this information is potentially relevant to the car-distribution activity since distribution decisions are based on the number and location of available empty cars. In addition to this car- oriented information, shipper-order data are also gathered, usually by local agents in the field, and periodically transmitted to the car distributors.

The collection, manipulation, and reporting of these data about the system-state, controllable, and uncontrollable variables were different on each of the railroads investigated. Yet, although the format of the specific reports differed, the type of information available to the car distributors was similar. Car distributors typically do a substantial amount of manual data manipulation to supplement that provided by the computer system. This is particularly true of data concerned with car orders, which are often telephoned to the car distributor by agents in the field and not entered into the computer directly.

The types of information most often found in the car-distribution reports and the relevant time frames within which the reporting occurs are shown below. The tabulation does not show whether the report formats are useful, but it provides an indication of what coverage is available for the factors relevant to car distribution.

Type of Information	Time Frame: Real Time	Time Frame: Historical
State variables		
Empty inventory	x	
Empty pipeline	x	x
Cars loaded	x	x
Unfilled demand		
Controllable factors		
Pipeline additions	x	
Empties off line	x	x
Orders filled		
Uncontrollable factors		
Industry releases	x	x
Interchange receipts	x	x
Car orders	x	
Travel time		

Decision Structure

The organizational structure describes who will make which decisions, and the information structure determines what data will be available about the problem. Here, the processes used by the decision maker about car distribution will be described. As proposed earlier in the paper, the description will examine three aspects of each decision process: knowledge, design, and choice.

In analyzing the organizational structure, it was discovered that car distribution is involved in three areas of decision: pipeline additions, foreign empties sent off line, and empties applied to orders. In practice, the first two of these are handled as part of the same decision process. We will thus focus on two major decisions--establishing empty-car disposition instructions and applying cars to orders.

Establishing Empty-Car Disposition Instructions

Knowledge

When car distributors were asked what event or events caused them to make disposition decisions, the most common response was a customer order for cars or an unanticipated problem on the railroad. These events were, in fact, found to trigger the decision-making process in many cases.

However, it often appeared that decisions were made whenever cars became available. This might be called origin- or car-oriented behavior, and it seemed especially typical in times of car shortage. This is a logical approach because, of course, even if there are many car orders, it is impossible to make disposition decisions if there are no cars available.

Design and Choice

Despite extensive observation of car distributors at work, in general it was not possible to distinguish between the process used to find alternatives and the process of criteria used in selection. The literature on the behavior of decision makers supports this finding (9, p. 32). It has been hypothesized that decision making involves an often-undirected search, which stops once a feasible solution has been found. The aspects of design and choice will therefore be treated together.

Before adoption of real-time management information systems on railroads, freight-car distribution was accomplished on a disaggregate basis. Local car distributors would make an assignment decision for every car that became empty within their territory; this process could not possibly account for the interdependencies among disposition decisions.

As their information systems have improved, most railroads have, to some degree, centralized the car-distribution activity and attempted to develop mechanisms that would allow car distributors to make decisions about groups of cars and to leave to the computer the application of the decision to specific cars. The car distributors use a set of well-defined computer instructions that specify the desired pattern of empty-car movements, and the computer determines which instruction is relevant for each car. Two types of typical instructions are (a) movement instructions (MI's), which are used to assign destinations to a specific number of cars of a particular type from a specific origin, and (b) control orders (CO's), which assign a destination to cars at a specific origin that are not covered by any operative movement instruction.

There may also be an option to specify either instruction as absolute (the car is to be assigned as indicated by the instructions whether it is needed locally or not) or permissive (local needs are satisfied first). By making the instructions absolute, the car distributor can attempt to control local inventories as well as flows between points.

These instructions are used by the car-distribution managers to make disposition decisions such as the following: (a) when a car becomes empty on the system, the computer scans the MI and CO files and matches the car's specifications with those contained in one of the control orders; and (b) if the car is a foreign car and is not to be reloaded (or if car service rules prohibit reloading), the computer automatically selects the nearest junction as its destination.

If each origin area were assigned a single MI and CO, there would be little ambiguity about the plan and its execution would be straightforward. In many cases, however, a single origin area may supply cars to many destination areas. In this case the MI's and CO's must be assigned priorities, so that the destinations that actually receive cars will be dependent on the number available in the origin area.

These instructions (or ones like them) are used by car distributors to implement their decisions. What is not clear is how the specific instructions ultimately implemented are selected. There are few formal mechanisms, reports, or analytical tools available to help the car-distribution manager create and test alternatives on most railroads and no well-specified objective or goal to support the selection process.

There is an interesting paradox in all of this. There is little evidence to suggest that car distributors struggle to cope with the numerous options that are, in theory, available to them; without too much difficulty, they manage to make decisions--in fact, they make many every day. Yet the principal reason given for not using analytical problem-solving techniques has been the overwhelming complexity of the car-distribution problem.

Applying Cars to Orders

Knowledge

Car orders from shippers initiate this decision process; these orders are accumulated by local agents, who transmit them once or more each day to the car distributors.

Design and Choice

The car distributors and the local agents share responsibility for the process of applying cars to orders. In some cases, MI's are used to direct specific cars of a particular type to specific shippers from distant terminals. Most often, however, the local agents choose which cars to apply to which orders. It again is very difficult to determine how or why the decisions are made.

In some respects, the local agency is involved in both commercial and operating activities, and feelings of alienation from both the railroad and shipper are evident in the attitudes expressed by local agency personnel. There is a feeling that shippers require the personal contact afforded by the personnel at the local agency, yet this may inevitably lead local agents to make decisions that are in the best interest of the shipper but not the railroad. The commercial and operating roles played by the local agency need to be clarified.

In summary, the managerial tasks necessary to carry out car-distribution activities in a manner consistent with corporate objectives have been identified and the organizational, information, and decision structures adopted to carry out these tasks have been described. Last, the use of the framework for analysis to identify areas where improvement is needed will be demonstrated.

IDENTIFYING AREAS OF POTENTIAL IMPROVEMENT

The description of the car-distribution process provided earlier is a rather strong normative statement about the way car distribution ought to be managed. The main underlying hypothesis is that, given the interdependencies that exist among parts of all transportation firms, substantial management time and effort must be given to the process of ensuring that all actions are coordinated and consistent, especially since the advances in the information and decision systems have improved our ability to achieve such coordination and consistency.

Actual management practices employed to control the car-distribution activity have been described in a way that facilitates diagnosis of the weaknesses in current practice. To this end, those aspects of the organizational, information, and decision structures that appear to be susceptible to improvement are described briefly below.

Organizational Structure

Lack of Interaction Between Car-Distribution and Other Departments

The functional structure adopted by most railroads tends to inhibit interdepartmental participation. A freight-car committee overcomes this problem to some degree, but its principal activities at present are in the area of long-term investment decisions. Interaction to support tactical implementation activities like car distribution is not easily accomplished by committees that meet infrequently.

Lack of Authorized Planner of Car-Distribution Activities

When the organization was analyzed in terms of the task authority structure, it became clear that car distribution is an action-oriented group; the planning that is required to guide the execution process is often absent.

A continuous planning effort is required to reconcile the conflicting constraints and objectives that each major department of the railroad might wish to impose on car distribution and then to translate an agreed-on plan into rules that can guide day-to-day performance. The activities that would be performed by a car-distribution planning group are those that were specified in Figure 4 under corporate direction setting and tactical system planning.

Inadequate Output Control of Car-Distribution Activities

In identifying the accountability relationships relevant to the car-distribution activities, it became clear that the motivational philosophy relevant to the major actors has tended to focus on behavioral control rather than output control. The results of car-distribution activities are not measured and used in the evaluation of individual decision makers; instead, their ability to behave like car distributors seems to be more important.

Behavior control of this type is used most frequently when the output is difficult to measure and attribute to specific decisions. However, the assessment of available information suggests that it is certainly possible to measure the output of car-distribution activities. To use output control, it is also necessary to specify what the desired output is. A more formal planning process to support car distribution would be needed to achieve this.

Information Structure

Lack of Predictive Information to Support Decision Making

Since movement between points on the railroad is time consuming, car-distribution disposition instructions are always based on estimates of future activities. Unfortunately, the information system provides few forecast data helpful to car-distribution decision makers.

Inadequate Car-Order and Percentage-Demand-Fill Information

Car-distribution decisions are instigated by order information, yet the information is collected in an informal manner and is never accumulated systematically. The effectiveness of car-distribution decisions is inherently limited by the quality of the car-order information, and the ability to evaluate car-distribution actions is limited by the quality of the historical car-order data.

The lack of reliable and organized information about car orders from shippers also means that the railroad as a whole is unable to determine what the demand for their product (or service) really is. For example, tonnage and revenue forecasts are typically based on historical car loadings, even though true demand may have been quite different from actual car loadings.

Inadequate Travel-Time or Movement-Cost Information

One objective that is certainly important to car distribution is the minimization of transportation costs required to execute whatever plan is chosen, yet there is little formal cost information in the form of either travel times or movement expenses provided to decision makers in car distribution.

Decision Structure

Lack of Documented Car-Distribution Decisions

Historical data that document empty-car movements are collected and disseminated, but the decisions actually made by the car distributors are not similarly documented. This problem relates in part to the structure of the computer instructions, which do not always define an unambiguous course of action. It also reflects the very technical orientation of the car distributors themselves.

Lack of Alternative Decisions

Despite the fact that the number of alternative possible disposition decisions is enormous, there is no systematic effort to create and evaluate even a few different alternatives. In general, the tools and information provided car distributors do not facilitate the testing of alternative actions. In addition, because those actions that are perceived as most important are in response to some form of crisis, there often is no time to consider alternatives.

The eight aspects of the organizational, information, and decision structures that require improvement have been identified by comparing actual managerial practices with a normative description developed by analyzing the physical process of car distribution and its role within the railroad. By using this approach, it has been possible to diagnose the problem in a manner that accounts for the realities of the decision-making environment. Future research will seek to use the diagnosis results to guide the development of decision support systems for transportation managers.

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