A FRAMEWORK FOR THE DIAGNOSIS OF TRANSPORTATION ORGANIZATION PERFORMANCE

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1. INTRODUCTION

A coherent theory for the management of service operations in general and transportation operations in specific has not yet been developed, some substantive research in this field is needed. As a response to the above situation, this paper presents a theory on the management of transportation operations, which is particularly useful to conceptualize both the organizational and technological aspects of transportation processes as well as diagnose the performance of the processes.

Review. Operations management theorists - e.g., Fitzsimmons and Sullivan [1982] - usually focus on the modelling of the physical or technological process, but pay little attention to the organizational factors which in fact embody the performance of the physical system. On the contrary, organizational theorists - e.g., Hickson, Pugh and Pheysey [1969]; and Randolph [1981] - emphasize the importance of relating the organization structure to the underlying technology of the system. Their common approach is to find correlations between two sets of aggregate typologies: one concerns the nature of organization (such as centralization, decentralization, etc.) and the other concerns the nature of technology (e.g., environmental uncertainty, task interdependence, degree of routineness of work, etc.) However, the nature of the technology is normally defined too abstractly and generally to have any practical meaning to transportaion operating managers, so are the results of their analysis.

Prepositions. In response to the limitation of the above two traditional approaches, this study adopts the following three general prepositions:

1) production technology of a transportation system should be studied in a more detailed and practical way than that conducted by the above mentioned organizational theorists,
2) organizational variables should be an inherent part of the theory of operations management, and
3) explicit linkages between the technological and organizational systems should be more delicate than a set of correlative relationships between two families of typologies.

Research Paradigm. This study postulates that an organization is a goal-seeking mechanism. To explain and predict the behavior of a goal-directed system, a dual-system control paradigm is proposed. According to this paradigm, a transportation system is conceived of as a control system which consists of two complementary parts:

1) *the controlling system* - the organizational aspect of the system which possesses the controlling capacity, and
2) *the system being controlled* - the technological aspect of the system which defines the tasks to be controlled and their interrelationships.
The performance of the total system is then determined by how well the controlling capacity is matched with the characteristics of the underlying controlled tasks [Exhibit 1].

Key Theme. The analysis of the transportation operations management system is with a pragmatic aim of improving the performance of the total system. The specific objective of this study is the development of theories and operational methods which collectively enable us to
1) understand both the controlling and the controlled systems in the context of transportation operations management,
2) diagnose the symptoms involved in the total system,
3) identify the desired directions of change for the total system.

Empirical Example. To test the theories and the methodologies developed in this study, the management of railroad motive power - locomotive - operations is adopted as an empirical case. The data are collected from a major U. S. railroad.

In the following pages, Sections 2 and 3 present theories methodologies concerning the controlling system and the system being controlled respectively; Section 4 synthesizes the theories and methodologies into an organizational diagnosis framework. Section 5 presents some empirical results along with practical diagnosis techniques; and finally, Section 6 is the conclusions and recommandations.

2. THE SYSTEM BEING CONTROLLED

Following the dual-system notion, a key function of the theory of the system being controlled is to define a set of control objects which, on the one hand, characterize the underlying technological nature of the controlled system; on the other hand, can be explicitly assigned - in terms of decision responsibilities and performance accountabilities - to some identifiable *organizational units* of the controlling system. These organizational units comprise of individual persons or groups of persons which have or should have some capacity to control the performance of the control objects. In this study such control objects are called *work units*. In other words, in the conduct of transportation performance diagnosis, the work units and the organizational units as well as their relationships (both between the two sets of units and within the same set of units) are our focal points. In this section, we shall present how to identify the work unit.

2.1 *Theory*

The delivery of transportation service relies primarily on the cycling of a number of resources (e.g., vehicles and crew) on some supporting facilities (e.g., guideways and terminals) [Manheim, 1979]. This notion of *resource cycling* can be further elaborated into a series of concepts which will eventually allow us to specify the work units, as well as their interrelationships and managerial implications.

Resources Cycling and Flows of Work. A transportation operating system is primarily structured in accordance with the *flows of work* [Exhibit 2], in which any operation can be performed only after a successful execution of some upstream operations, e.g., before the completion of car switching and assembling operations, no train can be dispatched from the terminal. More specifically, because there are natural orders of operations, which are dictated by the nature of the technology adopted by a transportation operating system, the *resource cycles* (which embody the flows of work) can usually be systematically fragmented into distinct status or time *phases*. Furthermore, these status or time phases can normally be related either directly to the activities which are essential to the delivery of transportation service, or to a function of which the primary purpose is to provide a smooth connection between two interrelated activities. In this study, the former set of activities is called *core operations*, e.g., loading, unloading, linehaul, maintenance; and the latter one is called *interface buffers*, e.g., the schedule slack between two consecutive linehaul operations. Thus, from operations management perspective, most trasportation processes can be thought of as the transition of various phases of resource cycles which consist of core operations and interface buffers. Because the notion of interface buffers is less obvious than that of core operations, further explanation is needed.

Buffering Mechanism. Uncertainty and interdependence, are two essential factors which receive the common concerns of many organization theorists, e.g., Thompson, 1967. In order to 1) cope with - reduce, absorb or avoid - task uncertainty and provide an "as if" certainty basis for action, 2) decouple the interdependence among operations so as to minimize the effort of coordinations and the likelihood of conflict, and 3) localize the chain-effect resulting from interdependence, one effective strategy is to create various buffering mechanisms at the interface of two interacting processes. In this study, among others [Mao, 1982], two types of buffers are of particular interests.

The first is the *physical buffer* - the resources inventory created to absorb the uncertainty produced from adjacent processes. For instance, stand-by vehicles that are purposely deployed at certain strategic locations waiting to serve unpredictable traffic generated in the neighboring area, represent the typical physical resources buffer. A key point here is that, although the transportation operating managers cannot stock their output service as their manufacturing counterpart, they do inventory the input resources (empty freight cars, stand-by locomotives, extra-board crew) to protect the unpredicatable fluctuation of traffic and to cope with the uncertain supply of resouces due to operational variation.

The second type of buffer is an informational one, e.g., the schedule slack time built into a transporation operating schedule. When taking a broad view, we may even conceive of the operating schedule in whole as an informational buffering mechanism, because such a schedule provides a common guideline to a series of interrelated processes and, to a large extent, allows them to act independently within that guideline.

Vehicle Cycle as an Example. To gain more insight into the above notions, an example should be helpful. In the following, we choose the vehicle (e.g., rail locomotive), among other resources employed in transportation operations, to demonstrate how to construct an analysis framework based on the resource cycle concept.

The derivation starts from the identification of the cycles in which a vehicle engages. By categorizing the status-phases involved in the life-long activities of a locomotive, four types of vehicle cycles can be observed - operating cycle, maintenace cycle, service cycle, and life cycle - which are hierarchically interrelated as shown in Exhibit 3. Each component shown in the exhibit stands for a performance area. Several observations can be made from the above example.

1) The resource cycle can be specified in varying degrees of detail; however, their fundamental elements are either core operation or operational buffer, or some collection of the above two elements.
2) Within the life-long time frame of a locomotive, the performace areas specified above satisfy the mutually exclusive and collectively exhaustive criteria.
3) The interdependence of the performance areas derived from a resource cycle can be specified through the analysis of the underlying cycling process.
4) Different performance areas involved in a resource cycle demand different analytical methods and measures for assessing the process, and different management skill and talent are required accordingly. For instance, the elements in-motion (e.g., linehaul, set-off, pick-up) can be appropriately analyzed through classical engineering approach - vehicle motion mechanism, while the analysis of schedule slack requires another set of knowledge, such as system operating reliability, trade-off between service level and resource consumed.
5) Issues concerning other resources can be addressed by adding appropriate components to the original resources frame. For instance, to address energy issues, some fuel consumption elements may be added to the in-motion components (e.g., linehaul, set-off and pick-up) in Exhibit 3.

The resource cycle framework highlights the cyclic nature of transportation work flows and the systemic mutual-dependence among various core operations and operational buffers. Such a framework provides not only the analysis with perspective, but also effective heuristics in deriving the hierarchy of performace areas along a particular resource dimension as well as the control issues - concerning other interacting resources cycles.

Work Unit. To translate the performance areas (resource cycle components) into work units, we need to introduce a new term - management cycle. Putting the notion of planning-control cycle proposed by various management control theorists (e.g., Anthony and Dearden, 1976) into a common framework, such a cycle can be generally categorized into three distinctive but interrelated phases - planning, execution and performance review. In this study we term the cycle comprised by the above three activities the management cycle. We argue that the control of individual performance areas (resource cycle components) involves all three phases of the management cycle. Therefore, to specify the work units involved in the management of the selected resource, we can construct a matrix as shown in Exhibit 4. The entries of the matrix represent the elementary work units which collectively define the totality of the tasks to be controlled concerning a particular resource.

Three points are worth noting: 1) The elementary work units thus specified may vary in their degree of detail, depending on how detail we fragment the resource cycle; 2) Depending on the issues, analysis perspectives and the structure of the controlling system, the work unit actually assigned to the controlling organizational unit may consist of one or many elemetary units; 3) The work units are interrelated in two ways - one is the technological interdependence resulting from the underlying resource cycling process, and the other is the administrative interdependence resulting from the procedures of management cycle.

2.2. Methodology

The notions of resource cycle and work unit are operationalized through the following procedures: 1) translate work flow of a transportation process into resource cycles, 2) select one class of resource and break its cycle into components, 3) specify the hierarchical and horizontal mutual-dependence (inherent in the nature of core operations and operational buffers) among the components of the resource cycle, and 4) construct the work unit matrix through the specification of the managerial tasks involved with the planning, execution and performance review for each component of the resource cycle. Example is given in Section 5.

3.THE CONTROLLING SYSTEM

3.1 Theory

The work unit's counterpart in the controlling system is the organizational unit. In order to examine the correspondence between the above two sets of units, given the function of and the interrelationships between the individual work units, the next step is to analyze the roles of and interactions between the individual organizational units.

After reviewing various schools of thoughts, Galbraith [1977] summarized the following five variables as the key to the design of an organization: task, structure, information and decision process, reward systems, and people. In a recent study on several transportation organizations' performance, Philip [1980] advocated the concept of seeking congruence among three elements - organization structure, information system and decision process - so as to appropriately support the transportation activities.

In this study, comparing with Galbraith's framework, the task variable has been elaborated and expanded into the system being controlled as discussed in the preceding section, and as a first approximation, both the reward system and people are considered as an integral part of the organization decision mechanism. Given these two premises, we are allowed to reduce our focus chiefly on three dimensions as suggested by Philip in the study of the transportation controlling system. In fact, this reduced construct is consistent with Simon's proposal [1976, p.288] in which the key theme is arguing "the importance of designing an organization in accordance with its underlying information processing structure". To further operationalize the above concept, this study adopts a hierarchical analysis approach, i.e., the following three sets of behaviors concerning the transportation controlling system are probed:

1) How the system as a whole behaves in response to an organization-wide problem.
2) How a group of organizational units works together as a team to carry out a decision-making process.
3) How an individual behaves when he encounters a decision problem.

Our hypothesis is that, through such a segmented analysis, the results can collectively provide us with a sufficiently rich conceptual framework to enable us to put the function of the controlling system into perspective, to conduct insightful diagnosis concerning the actual system performance, as well as to develop norms for organization change if needed. The following is the summary of our conceptualization of a transportation controlling system which is conducted through three different perspectives.

Macro Organization Structure. The first perspective views the system as a whole. According to March and Simon [1958], the basic features of an organization strucuture and function are derived from organization's problem-solving process, and the departmentation of an organization can be mapped to a means-ends hierarchy which relates the individual tasks to the organizational purpose. Incorporating the above concepts with Thompson's [1967] three-level notion of organizational function, this study considers an organization as a three-level problem-conversion mechanism which performs three major types of controlling functions (control cycles) respectively [modified from Anthony, 1965 and Newman, 1975]:

1) steering control - at the lowest level, which streamlines the physical operations and pursues production efficiency,
2) functional control - at the middle, which guides and provides necessary buffers (e.g., operating plans, schedules) to insulate the low level operations in a closed system and exercises incremental adjustments (within the bounds imposed by the top level) to enable the lower level operations to accomodate short-run fluctuations, and
3) meta-control - at the top, which provides the ultimate buffer between the organization and the external environment and controls the structure of the organization. It is this control cycle which allows the organization to behave as an open system and to pursue the effectiveness of the total system.

Failure in the above control cycles indicates malfunction of the controlling system.

Organizational Team Process. The second perspective empahsizes the organizational decision-making process. Due to the interdependence of the transportation process, individual organization unit can rarely have direct access to all the information needed or control of all the factors involved in a concerned decision. As a consequence, decision-making in such a context is not an individualistic behavior but a team process. To accomplish a decision in a transportation organization, a decision-net that links the following units together can usually be identified [modified from Connolly, 1977]:

1) the direct decision-maker: the organization unit which executes decision-making function that directly determines the performance of the underlying work unit,
2) the indirect decision-makers: those units which are either controlling the immediate upstream/downstream decisions (in terms of work flow) or performing an immediate supervisory function,
3) the information units: those units which provide information to support the direct decision-maker's decision, but in principle perform no decision-making function, and
4) the action units: those units which perform the decision-taker's role and implement the decision when it is actionable.

In short, the decision-net is a task-specific team structure - which reflects the mutual-dependence of the underlying work units as well as the structure of the controlling system. To integrate several individual-based decision-making processes into a team-based one, communication and coordination are the essential integrating media. The quality of the interrelated decisions made by the task team rely on the nature of communication channels available and the basis of mutual-influence.

Individual Decision-Making. The third perspective concerns individual decision-making behavior. The notion of human information-processing system is applied [Newell and Simon, 1972; Lindsay and Norman, 1977; Libby, 1981]. The key theme here is to identify the strengths and weaknesses of an individual decision-maker through the analysis of his cognitive process involved in his decision-making behavior. Two issues of particular interest are 1) the problems associated with the limited human cognitive capacity - specifically, the major concern are two phenomena: information-overload [Miller,1960] and bounded rationality [Simon, 1976], and 2) potential biases of individual decision heuristics [Libby, 1981]. External aids are essential to the break through of the bottlenecks in human information-processing system [Lindsay and Norman, 1977]. Any available external decision-aid system must accomplish two ends 1) expanding the individual's cognitive limits and breaking through the rationality bound, as well as 2) detecting and offsetting the potential biases of individual's decision heuristics.

3.2 Methodology

Operational procedures and techniques are developed in this study to support the diagnosis of the controlling performance from each of the above three perspectives. The technique suggested for examining the general linkages between the dual systems is the construction of a task-responsibility matrix [Exhibit 5, modified from Cleland and King, 1972] which displays the relationships between the work units and the responsibility / accountability of the organization units as well as three management control cycles. Inadequate linkages will be explicated through such an analysis.

The diagnosis of team-based decsion behavior is conducted through the analysis of communication locus [Eilon, 1968] and the decision base - information base used in a particular decision - of individual actor involved in the process (Examples are given in Section 5). These analyses allow us to examine the adequacy of communication and coordination process.

Decision heuristics are the focus in the diagnosis of individual decision behavior. Protocol analysis [Newell and Simon, 1972] and introspection analysis [Libby, 1981] are two alternative techniques. The key theme is to specify the requirements of the external aid system which is capable of improving individual decision quality.

4. ORGANIZATIONAL DIAGNOSIS FRAMEWORK - A SUMMARY

A diagnostic system consists of two primary components: a large body of substantive knowledge and a set of systematic procedures [Simon, 1981]. The theoretical constructs presented in the preceding sections (2.1 and 3.1) provide us with the needed substantive knowledge which enables us to:

1) observe and organize relevant information about the dual-system in study,
2) identify problematic symptoms of the system through the normative ideals informed by the theories,
3) generate explicit hypothesis of desired states to be achieved by the system, and
4) develop alternative change plans.

The methodologies presented in Sections 2.2 and 3.2 provide operational techniques and procedures which instruct us how to proceed with the diagnosis. The above notions can be synthesized into a dual-system diagnosis framework as shown in Exhibit 5.

The three-level diagnosis strategies - organizational, team and individual - imply three different but interrelated approaches to improve the organizational performance: 1) refining or improving the macro task management structure, 2) devising or improving the integrating mechanism for multi-functional team process, and 3) installing or improving the support systems for individual decisions.

The three levels of diagnosis, in practice, could be a multi-faceted iterative process, in which all three foci - organizational, team and individual - are first examined in a preliminary way, then all three or part of them are examined in more detail. The actual emphasis of diagnosis will depend on the following factors:

1) the characteristics of organization problems in study - a typical scenario might be: "there is a symptom which brings us into the situation; we first look quickly at all levels around the symptom; we then redefine the problem, or maybe focus on different individuals and different team process when we shift to more detail".
2) the nature of the intervention process, e.g., the entry point (level of organization and functional area), the organization's capacity to change, the intervenor's resources constraints (time, knowledge, skill, etc.).
3) the strategies of intervention, e.g., whether a pilot project is necessary to establish the intervenor's credibility through the quick feedback effect of the project.

5. A RAIL MOTIVE POWER MANAGEMNET CASE STUDY

This section is devoted to the demonstration of how to apply the dual-system diagnosis framework in the context of rail motive power (locomotive) operations management. The analysis is conducted progressively from organizational level to individual level.

5.1 Descriptive information about the Dual-System

To obtain a general picture of the overall task of power management, on the controlled system side, the resource cycle concept is applied [Exhibit 2] to the development of the power cycle hierarchy [Exhibit 3]; the work units involved in power management is specified through the contruction of a power cycle vs. management cycle matrix [Exhibit 4]. On the controlling system side, relevant organizational units are identified through the analysis of the organizational chart, job description and formal reporting system. A task-responsibility matrix is then documented [Exhibit 5].

To demonstrate the diagnosis of team process and individual decision behavior, the control of power dispatching operation is selected. Communication locus analysis is applied to examine the function of the decision-net in handling an emergency case [Exhibit 8]. The decision basis for each key actor engaged in the process is explicated [Exhibit 9]. Introspection analysis is used to diagnose the decision heuristics of the power dispatcher [Exhibit 10].

5.2 Problematic Symptoms

From the above diagnostic data, various symptoms can be identified and summarized as follows.

1) Inadequate Planning Support and Performance Review.
From the task management structure represented by the task-responsibility matrix, a number of problematic symptoms were found in the planning-phase and performance review-phase. These symptoms were: a) planning was an implicit process and consequently higher level accountabilities (such as fleet sizing and productivity) were not properly assigned to specific individuals, b) a number of fundamental performance indices were either problematic or not reported at all, and c) feedback on performance either did not exist or was not effectively used to guide further planning in many work units. In short, effort-oriented control rather than result-oriented control consumed the management's energy; the meta-control (adaptation) function of the power operations management system did not perform adequately.

2) Weak Integrating Media of Muti-functional Team Process.
Due to the absence of formal authority relations, in Exhibits 7 and 8, the linkages between the transportation (train dispatcher and power cntroller) and mechanical (master mechanics and roundhouse foremen) personnel should receive our particular attention. Because of the emphasis of the formal performance review system, mechaical officers were normally concentrated on the control of "shop margin" (number of locomotives allowable to stay in shop); efforts to support non-scheduled extra-train service were considered personal favors to the transportation officers and not formally rewarded. In such a setting, smooth operations were interrupted occasionally.

3) Unbalanced Power Dispatching Decision Heuristics.
Because deliberate planning aimed at higher power productivity was not rewarded by the system, the power dispatcher was normally not concerned about the long power idle time and low achieved TON/HP ratio (loading ratio).

4) Information-overloaded Power Dispatcher.
Time pressure and massive volume of data characterized the decision context of the power dispatcher. A rational deployment algorithm was difficult to apply due to the size of power fleet and rail network. Information-overload was a critical problem to the power dispatcher.

5.3 Some Desired Change Directions

To improve the performance of the total system, a variety of change dimensions are available [Mao, 1982]. Based on the above diagnostic information, three interrelated change directions can be specified.

1) Refining the General Task Management Strucure.
The task management structure provides the general context for power management. To effectively control the performance of power management, the host railroad must reconstruct its management control cycles, particularly the higher level cycles - functional control and meta control. The responsibilities and accountabilities associated with the missing linkages between the work units and organizational units must be assigned to specific organizational units.

2) Improving the Supporting system of Team Process.
To support the multi-functional power dispatching process effectively, one alternative (among others) the host railroad can take is to refine its performance measurement system and the reward system accordingly. More specifically, the railroad can devise a set of deliberately designed performance indicies which take into account the interdependence of the work units involved in the above team process; then assign the accountabilities of these work units' performance (measured by the above mentioned indicies) to organizational units who are actors in the power dispatching decision net. Given such an integrating mechanism, team members' decisions would be coordinated as desired through the functioning of reward system.

3) Installing Individual Decision-Aid System.
To improve the power dipatcher's decision quality, it is necessary to install a computer-aid decision system. The design criteria for such a system is that it should be capable of overcoming the information-overload problem, minimizing premature decisions, advancing the "saticificing" level and facilitating more extensive inquiry into decision relevant information. Normative elements should be integrated into the system as needed so as to offset the potential biases of the current heuristics and enhance the decision rationality.

5.4 Further Work

In addition to the the procedures (5.1 through 5.3) mentioned above, a complete organizational intervention should further includes 1) developing detailed alternative change plans (both substantive and procedural plans), 2) assessing these plans, and 3) selecting one or several to begin implementing. However, the remaining procedures are not the emphasis of this paper, we terminate our analysis here.

6. CONCLUSIONS AND RECOMMANDATIONS

The dual-system control paradigm, as demonstrated in this study, is a relatively flexible analysis framework to accommodate a variety of theories which are relevant to transportation operations management. The many theoretical constructs developed and synthesized in this study are only a first-cut result toward an ultimate theory of transportation operations management. Elaboration and refinement for each module of theories concerning both the controlling system and the system being controlled are suggested.

The inventory of the techniques included in this study is less than exhaustive. To advance the utility of the theory, the development of operational methodology is critical. Further synthesis and refinement of the descriptive diagnosis and prescriptive analysis techniques from various disciplines are recommended.

The theories and methodologies proposed in this study are in principle applicable to the general context of transportation operations managment. The application of the theories and methodologies to other resources classes (besides the motive power) and transportation modes (besides railroad) are recommended so as to test and refine the analysis paradigm.

(More detailed information about the material presented here can be found in [Mao, 1982]).

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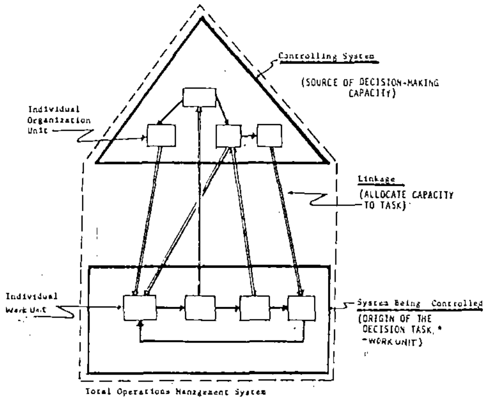
Exhibit 1 A DUAL-SYSTEM PERSPECTIVE OF OPERATIONS MANAGEMENT



*: The structure of the decision tasks in principle is also in hierarchical form; for simplification reason, it is represented as one dimensional.

Exhibit 2 CONCEPTUALIZATION OF RAIL OPERATIONS - FLOWS OF WORK

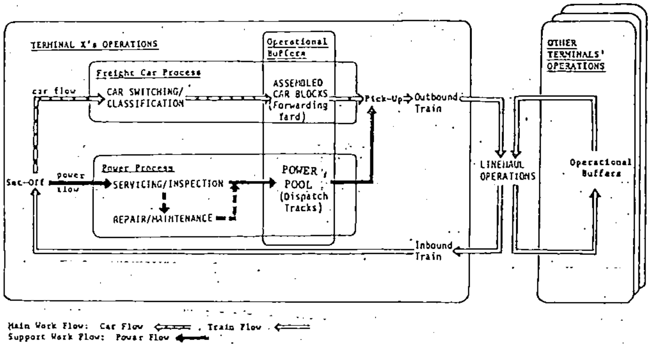


Exhibit 3 POWER CYCLE HIERARCHY

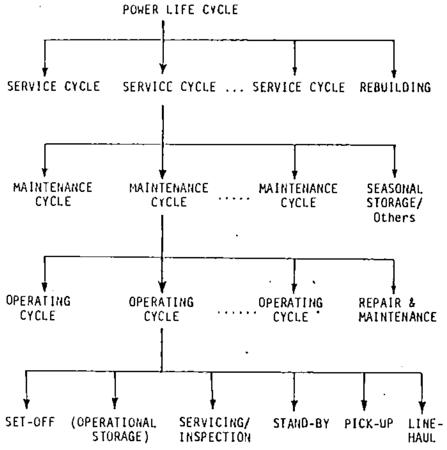


Exhibit 4 WORK UNIT MATRIX - TOTAL CONTROL TASK OF POWER MANAGEMENT

Power Cycle / Managt. Cycle	Life Cycle	Service Cycle	Maintenance Cycle	Operating Cycle
(Premises)	power requirement (traffic level and pattern) desired service quality, system operational profile (efficiency indices of the lower level power cycling)	power availability level	power active fleet	train schedule, tonnage, maintenance schedule
Planning	power availability level	active fleet size, storage margin, storage policy guide	shopping margin (units out-of-service for maintenance), maintenance schedule, serviceable fleet sizing (annual profile)	hp/ton policy, to be hauled, utilization standard
Execution	overhaul rebuilding, acquisition/disposal plans; control of power service cycle	storage assignment, maintenance cycle control	shopping assignment, mechanical reliability monitoring, shop operations supervision	working plan development - power pool For each train, W/P assignment, detention time control, power dispatching - coordination among power dispatchers, train dispatchers and power servicing foremen; mechanical servicing supervision
Review	efficiency indices (total fleet, fleet composition, total power available) quality indices (total service quality)	efficiency indices (active fleet, productivity) quality indices (aggregate train performance account power)	efficiency indices (achieved serviceable fleet) quality indices (enroute failures)	efficiency indices (actual W/P ratio, speed achieved, time utilization); quality indices (train performance account power)

Exhibit 5 TASK-RESPONSIBILITY MATRIX and MANAGEMENT CYCLES

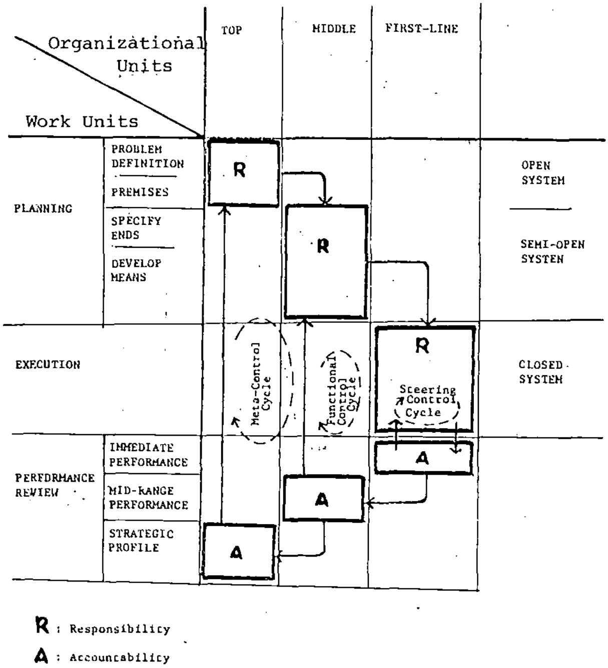


Exhibit 6 DUAL-SYSTEM ORGANIZATIONAL DIAGNOSIS FRAMEWORK

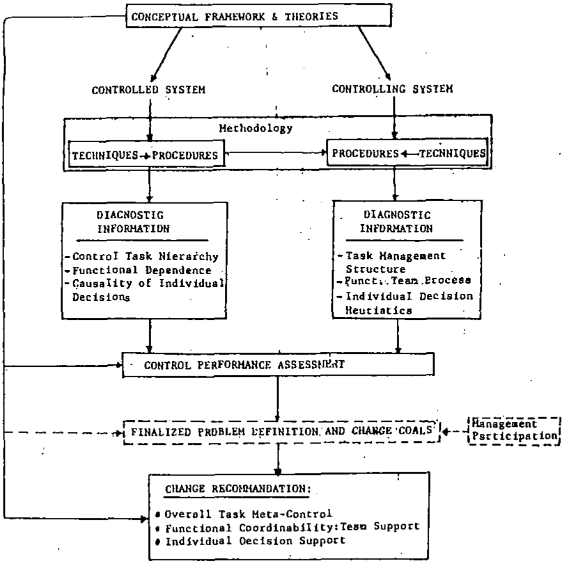


Exhibit 7 TASK-RESPONSIBILITY MATRIX - POWER CASE STUDY

ORGANIZATIONAL UNITS / work units	GENERAL MANAGEMENT	SVFO	VPT	VPM	TRANSP. DEPT.	MECH. DEPT.	TRANSP. DIVISION SUPT.	MECH. REGIONAL GENERAL SUPT.	TRAIN DISPATCHER	POWER DISPATCHER	TERMINAL SUPT.	LOCAL ENGINE TERMINAL	ENGINE SHOP
SYSTEM-WIDE PA ? SYSTEM-WIDE PA (FLEET SIZING AND COMPOSITION) ?	Dec ?	? Prop — Sup	Exec	Exec									
SERVICE CYCLE (STORAGE, OFF-LINE) ?		Deci ?	? Sup		Prop ?								
MAINTENANCE CYCLE (SCHEDULE)				Dec ?		Prop ?		Exec					
OPERATING CYCLE (TRAIN SCHEDULE)		Appr.	Deli	Noti	Prop	↑	Sup.		Exec.				
TRAIN DISPATCHING									Delig.	consult.	Exec.		
POWER DISTRIBUTION									consult	Decision	consult		
TERMINAL POWER POOL									Consult	Decision	exec	exec	
POWER MAINTENANCE				?		?		Sup.		↑↑		Delig. exec.	Delig. exec.
SHOP PERFORMANCE								Review		?		Accoun.	Accoun.
POWER IDLE/TERMINAL ?					Review ?					Accoun			
TRAIN PERFORM./TERMINAL DUE TO POWER					Review					Accoun		Accoun	Accoun
SERVICEABLE FLEET				Rev.		Rev.		Acc					
POWER PRODUCTIVITY ? POWER SERVICE QUALITY		Rev.	Acc										

Exhibit 8 COMMUNICATION LOCUS FOR DELIVERING EXTRA TRAFFIC

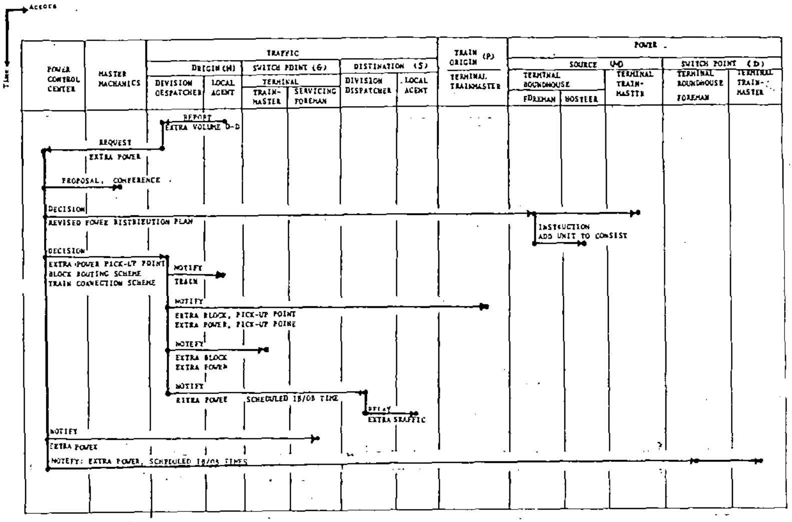
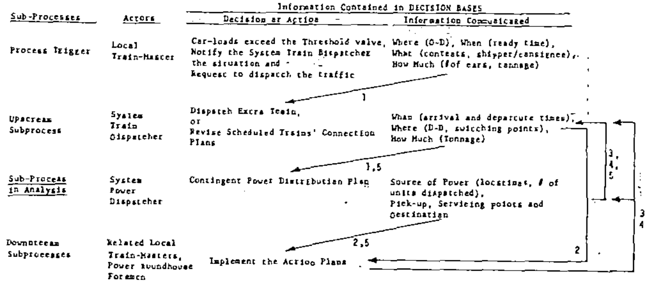


Exhibit 9 DECISION BASES INVOLVED IN POWER DISPATCHING DECISION NET



Sub-Processes	Actors	Information Contained in DECISION BASES	
		Decision or Action	Information Communicated
Process Trigger	Local Train-Master	Car-loads exceed the Threshold valve, Notify the System Train Dispatcher the situation and Request to dispatch the traffic	Where (O-D), When (ready time), What (contents, shipper/consignee), How Much (# of cars, tonnage)
Upstream Subprocess	System Train Dispatcher	Dispatch Extra Train, or Revise Scheduled Trains' Connection Plans	When (arrival and departure times), Where (O-D, switching points), How Much (Tonnage)
Sub-Process in Analysis	System Power Dispatcher	Contingent Power Distribution Plan	Source of Power (locations, # of units dispatched), Pick-up, Servicing points and Destination
Downstream Subprocesses	Related Local Train-Masters, Power Roundhouse Foremen	Implement the Action Plans	

Remarks:
1: Decision Premises
2: Action Guidelines
3: Providing States/Constraints information of the system under their control to facilitate the direct decision-maker's search for alternative action plans and evaluation of the potential outcome
4: Confirming proposed action plans (train shcedules/power distribution plan), or notify infeasibility of the plans
5: Intervening interdependent subprocesses to a)release the constraint of action space, or b) change the premises of decision

Exhibit 10 POWER DISPATCHER'S DECISION HEURISTICS