INFORMATION TECHNOLOGY: A COMPETITIVE TOOL FOR MANAGERS

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OBJECTIVES

Information technology clearly has become a major tool of competive strategy. This is true in most industries, and especially in transportation and logistics.

To manage the development and implementation of information technology-based strategy is a difficult task. Managers need a conceptual framework to guide this process. This paper proposes such a framework, suggests several practical techniques for strategy development and implementation (based on the framework), and concludes with recommendations for management actions and for research. (1)

BASIC PREMISE

In our view, strategic analysis of information technology options must be based on this basic premise:

TECHNOLOGY CHANGE SHOULD BE PLANNED AND MANAGED
AS PEOPLE CHANGE

To achieve a sustainable competitive advantage, it is not sufficient to plan information technology changes in isolation. Parallel, coordinated people change is essential if technology changes are to be effective. People are the basic resource of an organization. For every strategy being considered, there are certain people in the organization whose performance is critical to the success of that strategy. These critical individuals and groups not only must accept and be comfortable with the new technology, but also must modify their basic patterns of work to take advantage of the new technology if the technology change is to succeed in changing strategic advantage:

THE FUNDAMENTAL OBJECTIVE OF CHANGES IN INFORMATION TECHNOLOGY
IS TO BRING ABOUT CHANGES IN THE WAYS IN WHICH PEOPLE WORK

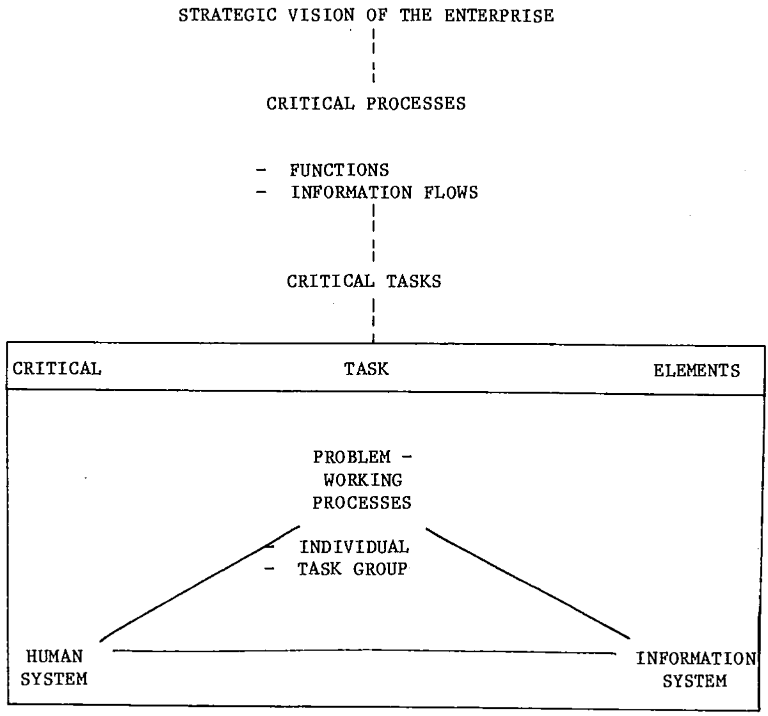
CONCEPTUAL FRAMEWORK

The central ideas of the conceptual framework are expressed in Figure 1, Linking Strategy to People, and in Figure 2, Integrated Action Program.

Figure 1 expresses a general approach to formulating strategy. The first step in managing information technology effectively is to have a clear strategic vision of what the organization's business is to be. This strategy may be based heavily on the use of information technology, or information technology may play only a supporting role.(2)

For any strategy, there will be certain processes the performance of which is critical to the successful execution of the strategy. These critical processes must be identified. Then, for these processes, the

FIGURE 1. LINKING STRATEGY TO PEOPLE



functions to be performed and the information flows to support the performance of those functions must be identified.

For each critical process, there will be several tasks whose performance is critical to the successful working of that process. These critical tasks must be identified.

Tasks can be characterized usefully in terms of the individual and group processes by which people work on the problems posed by the task. These "problem-working processes" are supported by, and influenced by, the human system around the tasks and by the information system. These three groups of variables - problem-working processes, human system, and information system - are the critical elements which characterize each task and influence task performance (Figure 1). (3)

The major aspects of the human system include organizational culture, organizational structure, social structure, reward systems, and human resource development systems (Figure 3). The ability to bring about desired changes in problem-working processes may be retarded or helped by some of these aspects of the human system. To be effective the process of change must explicitly recognize and, where appropriate, take actions to change some of these variables in coordination with information system and problem-working process changes.

FIGURE 2. INTEGRATED ACTION PROGRAM

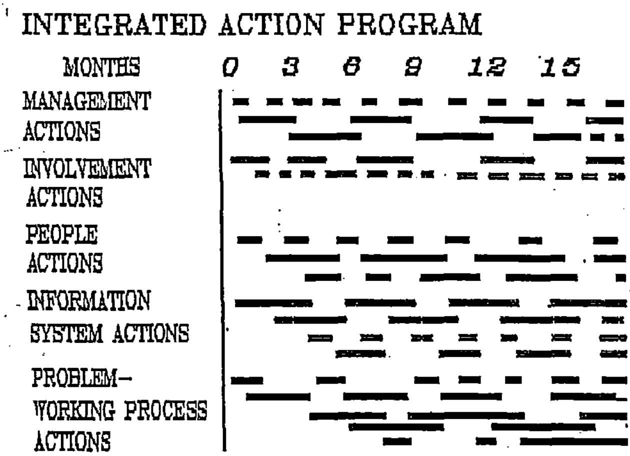


FIGURE 3. KEY HUMAN SYSTEM VARIABLES

ORGANIZATIONAL CULTURE
- VALUES-SHARED, CONFLICTING:
- ORGANISATIONAL UNIT
- PROFESSIONAL GROUP
- CAREER LADDER GROUP
- OTHER
- STYLE
- RULES OF THE GAME

ORGANISATION STRUCTURE
- DIVISION OF LABOR
- DEPARTMENTALISATION-ORGANIZATION STRUCTURE
- JOB DESCRIPTIONS-FORMAL, INFORMAL
- INTEGRATIVE MECHANISMS
- PERSONNEL AUTHORITY RELATIONSHIPS
- FORMAL COMMUNICATION NETWORKS

SOCIAL STRUCTURE
- FRIENDSHIP PATTERNS
- POWER AND INFLUENCE RELATIONSHIPS
- STATUS AND IDENTIFICATION RELATIONSHIPS
- INFORMAL COMMUNICATION NETWORKS

REWARD SYSTEMS
- COMPENSATION
- PROMOTION
- ADVANCEMENT OPPORTUNITIES
- RECOGNITION OPPORTUNITIES
- PERFORMANCE APPRAISAL
- PERFORMANCE MEASURES

HUMAN RESOURCE SYSTEMS
- DEMOGRAPHICS
- SKILLS
- MOTIVES, EXPECTATIONS
- RECRUITMENT-SELECTION
- TRAINING AND DEVELOPMENT

The major aspects of the information system include hardware (computers and communications), software, databases, and service delivery mechanisms - ways in which users get assistance in acquiring new capabilities (Figure 4). This listing reflects a "technology" or "supply" perspective. From a user perspective, the key element is the electronic work station (Figure 5), (4) the interface between the individual or task group's problem-working processes and the resources reached through the information system. The workstation's linkage functions link the user to resources both within and outside the organization (e.g., customers, suppliers, and other system users; and information resources such as databases). (5) The workstation's problem-working functions support the individual's activities of working on problems (Figure 6). (6)

FIGURE 4. MAJOR INFORMATION TECHNOLOGY COMPONENTS

- HARDWARE
  - COMPUTERS -
    - MAINFRAME, MINI, MICRO
    - BATCH, REMOTE, JOB ENTRY, INTERACTIVE
    - SINGLE SITE, MULTIPLE SITES
    - STAND-ALONE, NETWORKS, DISTRIBUTED PROCESSING
- COMMUNICATIONS - HARD-WIRED, TELEPHONE, NETWORKS, AND GATEWAYS
- DATABASE - INTERNAL, EXTERNAL
- SOFTWARE -
  - PRE-PACKAGED APPLICATIONS - EITHER OFF-THE-SHELF OR BUILT BY INTERNAL EXPERTS
  - BOUNDED APPLICATION-GENERATING - DATA BASE, SPREADSHEET
  - EVOLUTIONARY APPLICATION-GENERATING
- SERVICE DELIVERY MECHANISMS
  - INFORMATION PROCESSING CONCEPTS SUPPORTED: TRANSACTION PROCESSING (DP), MANAGEMENT INFORMATION SYSTEMS (MIS), DECISION-SUPPORT SYSTEMS (DSS)
  - USER SUPPORT PROVIDED - RELATIONS TO INFORMATION SYSTEMS STAFF
    - I.S. STAFF FORMULATE SPECIFICATIONS AND DEVELOP SOFTWARE
    - USER FORMULATES SPECIFICATIONS AND I.S. DEVELOPS
    - USER FORMULATES AND DEVELOPES OWN SOFTWARE
      - WITH SUPPORT OF SYSTEMS EXPERTISE
        - IN I.S. DEPARTMENT
        - IN FUNCTIONAL DEPARTMENT
      - WITHOUT SUPPORT

FIGURE 5.

THE INTEGRATED VOICE-DATA WORKSTATION AND ITS LINKAGES

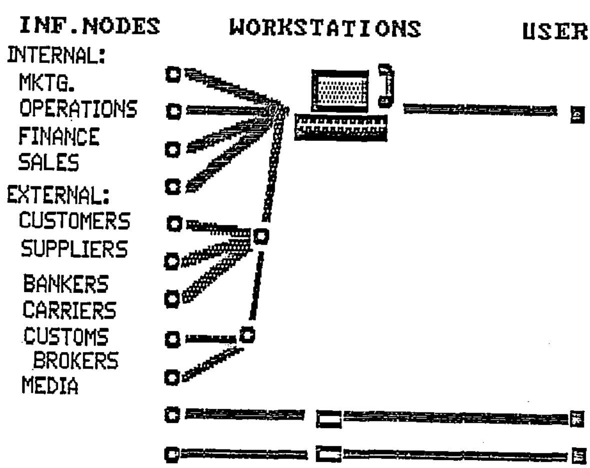


FIGURE 6.
PROBLEM-WORKING PROCESS: TYPES OF ACTIVITIES IN WORKING ON A PROBLEM

- BASIC ANALYSIS PROCEDURES:
  - GOAL FORMULATION/REVISION
  - SEARCH
  - PREDICTION
  - EVALUATION
  - CHOICE
- PRIMARY SUPPORTING PROCEDURES:
  - INTELLIGENCE
    - DATA ACQUISITION
    - DATA ANALYSIS
  - HYPOTHESIS FORMULATION AND TESTING
  - PROCEDURE CONSTRUCTION/REVISION
- PROBLEM-STRUCTURING
  - PROBLEM IDENTIFICATION
  - PROBLEM DEFINITION
  - PROBLEM-SOLVING STRATEGY
    - PROBLEM DECOMPOSITION
    - PROBLEM STRUCTURING -- LEVELS OF ABSTRACTION
    - OTHER STRATEGIES
- INTERACTION
  - COMMUNICATION AND PRESENTATION
  - NEGOTIATION AND CONFLICT RESOLUTION
- IMPLEMENTATION
  - ACTION SPECIFICATION
  - MONITORING
  - EVALUATION AND REVIEW

Technology planning and implementation should be visualized in terms of potential changes in the linkage and problem-working functions provided by the workstations. These changes can be expressed through the concept of a Strategic Information Map (Figure 7). This "map" shows how the critical tasks are supported by specific design features of the information strategy.

Figure 2, The Integrated Action Program, expresses a view about the process of strategy implementation. Planned change must focus on changes in problem-working processes, but must also include changes in both the human system and the information system. The information technology change is only part of the forces influencing the problem-working processes, and therefore task performance; the human system offers incentives and constraints on the processes as well, and actions in the human system are almost always necessary to achieve effective change in the problem-working processes.

For an information technology-based strategy to be effective, it is essential that the strategic concept and strategy implementation plan be integrated so that changes in all these major elements are consistent and coordinated:

- the strategic vision,
- the critical processes,
- the critical tasks, and
- the problem-working processes, information system, and human system supporting those tasks.

FIGURE 7. STRATEGIC INFORMATION MAP

NODES
- USERS
  - PROBLEM-WORKING PROCESS SUPPORTED
  - ATTRIBUTES OF THE WORKSTATION ENVIRONMENT (E.G., CHALLENGE, AUTONOMY AND CONTROL, JOB FEEDBACK, ETC.)
- INFORMATION RESOURCES - DATABASES, OTHER RESOURCES

LINKAGES
- NODES LINKED
- LINKAGE TYPE -
  - MANUAL, COMPUTERIZED
  - INTERNAL (VERTICAL, HORIZONTAL, INTRAGROUP); EXTERNAL (CUSTOMERS, SUPPLIERS, COMPETITOR, ENVIRONMENT)
- LINKAGE ATTRIBUTES
  - TYPES OF INFORMATION (WHAT DATA, DATA QUALITY, PATTERNS OF DATA, TIMELINESS OF INFORMATION COST)
  - HOW TRANSMITTED (MEDIA, FORMATS, EQUIPMENT REQUIRED OF RECEIVER, KNOWLEDGE REQUIRED OF RECEIVER)
  - INTERACTIONS OF SENDER AND RECEIVER (WHETHER TWO-WAY INTERACTIONS REQUIRED OR AVAILABLE, DEGREE OF DEPENDENCY ESTABLISHED)

CRITICAL TASKS
- NODES INVOLVED
- LINKAGES INVOLVED
- PROBLEM-WORKING PROCESSES INVOKED - INDIVIDUAL
  - HUMAN PROCESSES
  - WORKSTATION FUNCTIONS SUPPORTING THE HUMAN PROCESSES
- PROBLEM-WORKING PROCESSES INVOKED - TASK GROUP
  - HUMAN PROCESSES
  - LINKAGES UTILIZED

SOME USEFUL TECHNIQUES

This conceptual framework serves as a basis for development of a number of specific techniques.

The Information Technology Strategic Assessment (ITSA) (7) is a systematic approach to assessing the strengths and weaknesses of the organization's present or proposed strategies. The ITSA is a set of questionnaires which can be used to guide initial information collection about the organization and its present strategy and processes. Additionally, the ITSA is also useful for focused information gathering during the process of developing and analysing alternative strategies.

The Strategic Information Map is a useful tool for visualizing the information system - existing or proposed - from a perspective of user service. As described above, this includes identification of the information flows both internal to the organization - vertical, lateral, or inter-group flows - and external to the organization - customers, suppliers, competitors, others, and also the support to problem-working processes by planned workstations.

Specific Information Linkage Criteria are proposed for assessing the quality and effectiveness of information flows internal and external to the organization (Figure 8). (8) Workstation Design Criteria (Figure 9) (9) are also proposed for assessing the quality of the workstation functions provided, in terms of individual motivations and effectiveness and the quality of working life.

FIGURE 8. ATTRIBUTES OF LINKAGES

CHARACTERISTICS OF THE INFORMATION TRANSMITTED
- TYPES OF INFORMATION
  - WHAT DATA
- QUALITY OF DATA - ACCURACY, PRECISION, PERCEIVED RELIABILITY, COMPLETENESS
- PATTERNS OF DATA - IN ADDITION TO ITEMS TRANSMITTED, THERE MAY BE VALUE ADDED IN THE COMBINING OF DATA FROM VARIOUS SOURCES IN UNIQUE OR OTHERWISE USEFUL WAYS
- TIMELESS OF INFORMATION -- DEGREE OF CURRENCY
- COST

HOW IT IS TRANSMITTED
- MEDIA, FORMATS, EQUIPMENT REQUIRED OF THE RECEIVER
- KNOWLEDGE REQUIRED OF THE RECEIVER

INTERACTIONS OF SENDER AND RECEIVER
- WHETHER TWO-WAY INTERACTIONS ARE REQUIRED OR ARE AVAILABLE
- DEGREE OF DEPENDENCY ESTABLISHED

FIGURE 9. USER SATISFACTION: CRITERIA FOR WORK STATION DESIGN

TASK SUPPORT
CHALLENGE
    SKILL VARIETY, GOALS,
    OUTCOME UNCERTAINTY
    CURIOSITY
AUTONOMY AND CONTROL
    CHOICE
    CONTINGENCY
    POWER
FEEDBACK
    PERFORMANCE FEEDBACK
    SELF-ESTEEM
    PERSONAL RELEVANCE
PERSONAL GROWTH
    PROGRESSIVELY HARDER TASKS
    OPPORTUNITIES TO LEARN
TASK IDENTITY
TASK SIGNIFICANCE
PERSONALIZATION
COOPERATION
COMPETITION
RECOGNITION

FIGURE 10. BASIC STRATEGIC PLANNING METHODOLOGY

I. INITIAL ASSESSMENT
II. STRATEGY FORMULATION - INITIAL
III. IMPLEMENTATION PLANNING
    AS NECESSARY, ITERATIONS OF
    - ASSESSMENT
    - STRATEGY FORMULATION
    - IMPLEMENTATION PLANNING
IV. IMPLEMENTATION MONITORING AND PLAN REVISION

The Integrated Action Program (Figure 2) is a management tool to structure the strategy implementation process into a series of tasks in a coordinated work program. An overall Strategic Planning Methodology has been outlined (10) which integrates these techniques in a manner consistent with the conceptual frameworks (Figure 10).

THE CRITICAL TASK ELEMENTS - AN EXAMPLE

The definition of the critical task elements is at the core of our methodology. To illustrate these concepts, we will examine briefly some aspects of the task of managing the use of locomotives ("power") on a railroad. (11) "Power dispatchers" are the individuals who make detailed operating decisions about the uses of locomotives. The processes which power dispatchers appeared to follow were studied by observations of dispatchers at work and by interviewing dispatchers and other personnel. Several railroads were examined.

The work of the power dispatcher

The primary role of locomotives is to pull trains of freight cars over the railroad from one location to another. The processing of locomotives in yards is a central element in power utilization (as it is with car utilization):

1. When a train pulls into the yard, the locomotives are inspected to see if there are any maintenance needs.
2. The locomotives are detached from the cars. The cars are moved through the yard by a yard engine to wait on tracks for departure to their next destination. If locomotives require repair or scheduled maintenance, they are moved to appropriate locations. All other locomotives are moved to a holding area to wait to be assigned to an out-bound train.
3. When required repairs on locomotives are completed, they are moved to the holding area.
4. When an out-bound train is to be assembled, appropriate locomotives are selected from the holding area and moved to the train.

There are numerous uncertainties in this process. In addition to the uncertainties about the arrival time of a locomotive at a yard, the occurrence of unscheduled repairs and the many factors influencing the time required to accomplish maintenance (whether scheduled or unscheduled) create additional uncertainties. Therefore, the numbers, types, and locations of power units available to be assigned to particular trains is always uncertain.

The problem faced by the dispatcher is to assign the necessary number of locomotives to each planned out-bound train. He also tries to improve the distribution of available locomotives by repositioning units among yards when necessary. He tries to assign locomotives to trains to meet several goals:

a. train departure requirements - providing enough locomotives at the right place at the right time to enable a scheduled, or unscheduled, train to depart when desired;
b. meeting minimum power requirements - having the required total horsepower available to haul each train, which requires estimating the number of cars for each train in advance, or alternatively, holding some cars for a later train if sufficient power can't be supplied;
c. observing required standards for maintenance and other servicing of power units;

d. achieving desired goals for utilization of the units;
e. and others.

This problem is complex not only because of the multiple goals, but also because of the uncertainties indicated above. The power dispatcher is continually having to adjust his plans for using particular locomotives to reflect the randomly-changing availabilities of particular units. Further, requirements for power to be assigned to trains depend not only on the scheduled trains, but also the numbers of cars in a yard requiring movement to particular destinations, and corresponding operating decisions that are made about train lengths and about running unscheduled trains.

Individual problem-working process

Figure 11 shows the general structure of a typical dispatcher's processes of working on the power management problem. At the beginning of his shift, the dispatcher develops an initial dispatch plan which will guide his work during the shift. This involves

1. reviewing available data and assessing the present situation - locations where there are too few or too many locomotives, the numbers and status of units in the various repair shops, and their expected times of availability for use, and other data;
2. development of a preliminary plan for his work shift, specifying how he plans to deploy the available locomotives to meet the expected train requirements;
3. adjustments of the preliminary plan to redeploy locomotives to obtain better plans;
4. finalization of a plan for the shift.

Once finalized, the plan serves as a basis for executing the decisions - assigning specific locomotives to particular trains scheduled to depart at particular times. Then, the dispatcher begins executing the plan. Inevitably, as time goes on, various operational contingencies rise - e.g., breakdowns on the road, inspections identifying needed but unanticipated repairs, delays in completion of maintenance, greater or lesser numbers of cars to be moved than were planned for, etc. These result in the need for the dispatcher to revise his plan throughout his shift as he executes it.

FIGURE 11. GENERAL PROBLEM-WORKING PROCESS-OVERVIEW

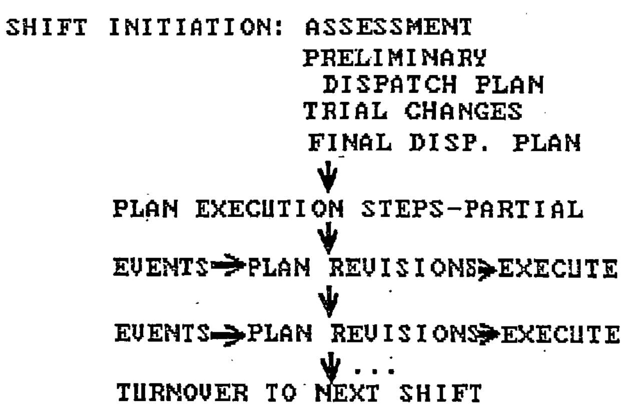


Figure 12 and 13 show the processes in which dispatchers developed and revised plans in greater detail. Figure 12 shows in detail the processes used to accomplish one step in Figure 13, the search for additional locomotives. Different dispatchers perform this search in different ways. Some search broadly, while others search deeply.

While these figures do not capture all of the richness of detail of the actual processes, they do suggest the complexity of the processes used by actual dispatchers.

FIGURE 12. BASIC PLANNING METHOD

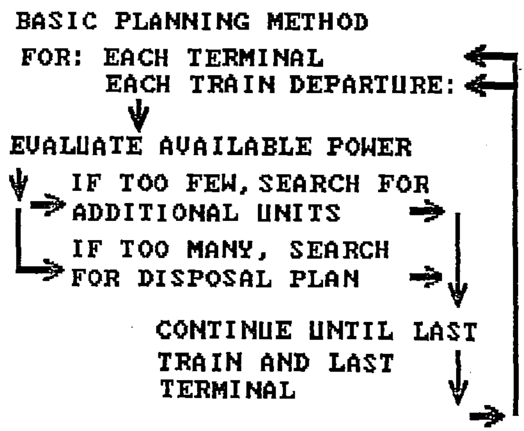
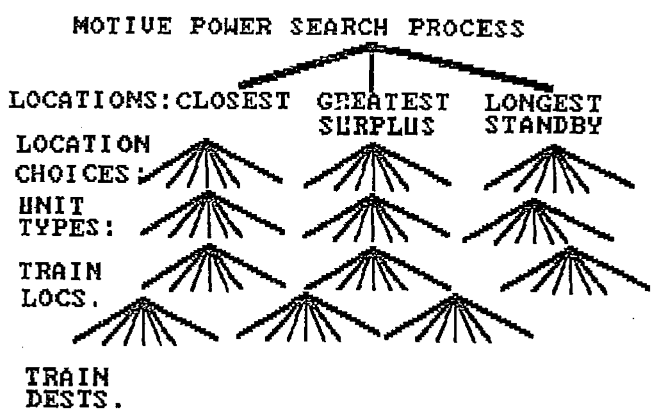


FIGURE 13. MOTIVE POWER SEARCH PROCESS



Improving problem-working processes

Several conclusions emerge from this examination:

1. The task of dispatching power is complex, involving many choices and many criteria, in a dynamic, pressured, and uncertain context.
2. The power dispatchers typically have worked at their jobs long enough to have developed good methods for working successfully on this complex problem. In addition, they have acquired substantial experience with, and insight into, the issues with which they are dealing. Their methods are "good enough" that they produce results with which the individuals and the organization survive.

The basic objective of this research was to improve the utilization of power, through the provision of computer tools. There are two basic approaches to achieve this objective:

1. optimization approaches - develop large-scale computer models which endeavor to find dispatch plans which "optimize" some objective such as the utilization of power;
2. heuristic support approaches - develop computer tools which enhance power dispatchers' abilities to work more effectively on this problem.

In the first, "optimization," approach, often advocated by operations researchers and other computer specialists, the objective is to minimize the need for human input, and, if possible, to replace the human with a computer model. The premises of this approach are that it is feasible to develop a computer model which incorporates all the relevant factors at a level of completeness and detail sufficient to produce results sufficiently detailed and valid to be used under all possible operating conditions.

We doubt that it is feasible to follow this approach successfully in a problem as complex as that of power management, or in many other similar tasks in transportation and distribution organizations.

In the second, "heuristic support," approach, the objective is to find ways of providing computer tools which the dispatcher himself finds useful as he works on the power management problem. That is, the premises of this approach are that the experience and insights of the dispatcher are valuable, and cannot be captured completely in a computer model. Instead of trying to build a single large computer program or model which tries to find "the best" dispatching plan, one should try to understand the ways in which humans work on this complex problem and endeavor to develop techniques which make this human "problem-working" process more effective. (12)

This requires several things:

1. understanding how the dispatcher operates now;
2. development of ways of improving the dispatcher's performance, while still leaving him in control of the process;
3. incrementing improved capabilities in steps, in which the user tests and reacts to new capabilities, and at each step can accept them, reject them, or suggest improvements (13)

Thus, several observations emerge from this example:

I. It is essential to understand the processes by which people work on problems now, in order to design methods to improve those processes.

II. In most situations, the objective of improving human problem-working processes is more desirable and more effective than the objective of replacing people by computers.

III. Improving human problem-working processes requires active acceptance of the objective by the individuals now working on the problem, and active participation in the process of developing new tools by those individuals as users and "testers" of possible tools. This requires that those individuals developing new tools gain the confidence and support of users prior to, and throughout, the process of implementing each successive improvement in the tools.

IV. Usually there will be organizational factors which influence the individual dispatcher's capability and willingness to try new approaches. For example, promotion and other reward criteria may penalize failures and not reward risk-taking, thereby causing individuals to be reluctant to try new methods. It may be necessary to change these organizational forces.

The individual in the task group

The processes used by individual dispatchers must be examined in the context of the activities of a number of other individuals with whom the dispatcher interacts.

Each day, all the relevant operating personnel participate in an operating conference, conducted by telephone. Additional interactions take place each time it is necessary to assign locomotives to a specific train at a specific terminal; Figure 14 shows the usual participants and sequence of interactions. Figure 15 shows the organizational locations of each participant in the process shown in the preceding figure.

It is immediately apparent that the organizational dimensions of this process are complex. The individuals who participate in the process of managing locomotives are in different formal organizational units.

FIGURE 14. COMMUNICATION LOCUS-POWER DISPATCHER TASK

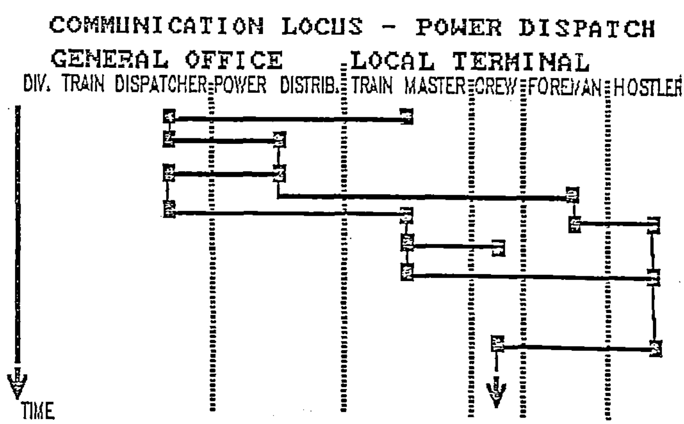
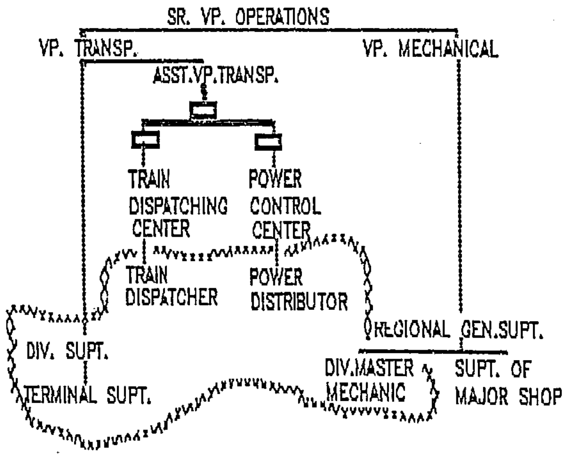


FIGURE 15.

ORGANIZATIONAL LOCATIONS OF PARTICIPANTS - POWER DISPATCH TASK



Therefore, we can expect that they have different criteria for effective performance, different goals, different perspectives, and different skills, training, and experience. Further, we can expect that in the normal nature of organizations, each unit has different goals, styles, and processes, and that there is some mixture of conflict and mutual support affecting the relationships among various units.

In general, then, we can add these observations to the four earlier:

V. The task of dispatching power is a complex organizational process, involving participants in a number of organizational units.

VI. Typically, any change in the procedures used by one or more participants in the process will have some impacts on the ways participants in other units do their work, and some of these impacts may be perceived as negative by those other units.

VII. To gain acceptance of improved procedures by the individuals in different organizational units who participate in the dispatching process, we need to recognize the many, possibly different, pressures on each of the participants, and develop ways of accommodating those pressures.

Conclusion: The Three Critical Task Elements

This brief description of the issues in improving power dispatching illustrates our identification of the three critical task elements in Figure 1: problem working-processes, information system, and human system variables. If we are trying to use information technology to improve the functioning of an organization to achieve some specific objectives:

I. We must understand the problem-working processes of those whose behavior we want to see changed, in order to identify ways in which those processes can be changed to achieve the objectives.

II. The problem-working processes must be understood at two levels:
   A. the individual level, and
   B. the task group level, in which a number of individuals interact in the process of working on the problem.

III. The organizational forces operating on individuals may significantly affect their readiness and capacity to accept changes in their problem-working processes. Therefore, human system forces on the individuals in the task group must be understood, again at two levels:
   A. forces on the individual, and
   B. forces affecting relationships among, and interactions between, individuals in the task group.

Thus,

IV. Every task is accomplished through the interactions of three major elements (Figure 1):

   a. the problem-working processes of individuals and the interactions of the processes of the individuals in the task group:
   b. the information system - both manual and computer components - which supports the problem-working processes; and
   c. the human system - the set of organizational forces and relationships which impact on individual and group behavior and particularly the willingness and capacity to accept changes in the problem-working processes being used.

V. In general, for change to be effective, all three elements of a task must be evolved to remain congruent. That is, to successfully accomplish desired changes in problem-working processes requires effective changes in information systems capabilities and may also require changes in some elements of the human system forces influencing individual and group performance and readiness and capacity to accept change.

ACTIONS FOR MANAGERS

The theoretical concepts also lead to specific action suggestions for managers:

1. Senior managers should consider carefully whether they themselves should take charge of managing information technology-based change.
2. Managers should manage technology change as people change, with a strategic vision, following the concepts expressed in Figure 1.
3. Managers should integrate people change and technology change, using techniques such as:

   a. developing an Integrated Action Program, incorporating coordinated actions of five major types: management actions, involvement tasks, people system tasks (concerned with changing elements of the human system, such as revising job descriptions or changing rewards criteria), information system tasks, and problem-working process tasks (Figure 2);
   b. conducting an Information Technology Strategic Assessment, an in-depth examination of the organization's present strategies and capabilities;
   c. using the Strategic Planning Methodology proposed;
   d. developing a microcomputer action program as part of the Integrated Action Program.

4. Managers should focus change on the individuals in the organization by:

a. using a user-dominated strategy to develop information support to individuals and task groups (13);
b. humanizing the technological environment by adopting explicit design criteria (such as Figure 9) to guide the development of electronic work stations and supporting software;
c. taking steps to focus people's attention on their own problem-working processes through stimulating discussion, analysis, and development of improvement suggestions.

5. Managers should implement technology-based change in a phased, controlled manner.
6. Senior managers should provide effective staff support to line managers to help them manage people-based technology change in their organizations. This requires careful planning for the integration of support provided by both the information systems (IS) and human resource (HR) staffs. It may be desirable to consider significant rearrangements of information systems and human resources staffs, such as:

a. establishing a new organizational unit, pooling selected staff from HR and IS
b. designating a single senior executive to whom both HR and IS report, and who coordinates the delivery of their services to line managers
c. merging HR and IS into a single staff function to be truly effective in providing people-based technology change support to line managers.

ACTIONS FOR RESEARCHERS AND EDUCATORS

Further research is needed to develop and test both concepts and techniques for information technology-based strategic management. The theoretical concepts and practical techniques presented briefly here are only one possible approach, and need to be subjected to careful testing and refinement and to critical debate.

Such research should be at both the theoretical and practical levels. Research involving strategic planning efforts at specific companies would be particularly valuable.Research is especially needed on:

1. the structure of problem-working processes and on ways of designing computer support to enhance human problem-working. This is a high priority area and would have major impact in transportation, distribution, computer - integrated manufacturing, and numerous other applications. (14)

Other important topics include:

2. techniques for assessing strategic choices incorporating information technology considerations (2)
3. testing and refinement of the conceptual framework described here (or alternative frameworks), through application in developing information technology-based strategies and implementation plans
4. case studies of transportation and distribution organizations and their uses of information technologies for strategic purposes
5. development of software systems that support user-dominated applications development (evolutionary application-generating systems)
6. development and testing of practical techniques for managing the phased change implementation process outlined here (1)
7. examination of alternative approaches to organizing and managing

support to line managers (e.g., alternative forms of human resources and information system organizations), including necessary training for existing personnel to adopt new roles.

8. development of management training programs to better equip senior managers and line managers to manage technology change as people change.

More important than specific topics is the question of general research approach. It is essential in our view to form interdisciplinary research teams, combining the skills and perspectives of organization behavior, cognitive psychology, information systems, and managerial strategy. Such teams would do basic research and would also work closely with industry to test research results in practice.

Dialog between researchers and managers in industry is especially critical on these topics. The transportation industry could take a lead role in this type of research-industry cooperation.

This theory also has important implications for education. It is essential that we educate students (and professionals) with the skills to manage both people change and information technology change. These people are needed in transportation and in many other industry sectors. Appropriate educational offerings need to be designed for bachelors, masters and doctorate degree levels, and for continuing education for managers. (Design has already begun for a management program to help managers deal with technology change as people change.)

CONCLUSION

We began our discussion with a basic premise: change in information technology should be managed as people change. We explored this premise, discussing a conceptual framework which pulled these ideas together from a theoretical perspective. We illustrated elements of the theory with the example of railroad power dispatching. We then looked at the implications of these ideas for actions by managers and by educators and researchers.

We come at these issues as transportation professionals, interested in figuring out how to manage the priority issues in our industry. Yet, we find ourselves having to dig deeply into issues which are of general interest and which are applicable to many other sectors as well.

We hope the reader will find these concepts useful in organizing his or her own thoughts on how to deal with information technology. We look forward to critical discussions of these ideas as we try to shape these concepts further and carry them into practice in industry. We also invite suggestions of examples and opportunities for case studies.

NOTES

1. This paper is a summary of the Fourth Annual William A. Patterson Transportation Lecture presented by the author on May 1, 1985 at Northwestern University: M.L. Manheim, 1986, "Information Technology and Organizational Change: Strategies for Managers," Fourth Annual William A. Patterson Lecture, Evanston, Illinois: Transportation Center, Northwestern University.

The author acknowledges the following for their contributions, direct or indirect, to this research: Raphael Amit, Benjamin Mittman, Robert Duncan, Robert P. Neuschel, and Philip Kotler, Northwestern University; John Robinson, The Harper Group; Harvey Romoff, CP Ships; Eliot Levinson, M.I.T.; Jane Fedorowicz and Liam

Fahey, Boston University; and Peter Keen, London School of Business.

The author alone bears full responsibility for any errors or omissions in this work. The support of the William A. Patterson Fund is gratefully acknowledged.

2. For the general literature on strategy formulation and implementation, see for example: M.E. Porter, 1985, Competitive Advantage, New York: The Free Press; C.H. Hofer and D. Schendel, 1978, Strategy Formulation: Analytical Concepts, St. Paul: West Publishing Company; J.R. Galbraith and D.A. Nathanson, 1978, Strategy Implementation: The Role of Structure and Process, St. Paul: West Publishing Company. For approaches to using information technology for competitive advantage, see: J.A.Y. Bakopoulos and M.E. Treacy, 1985, "Information Technology and Corporate Strategy: A Research Perspective," CISR WP #124, Sloan WP #1639-85, Cambridge, Mass.: Center for Information Systems Research, M.I.T.; S. Barrett and B. Konsynski, 1982, "Inter-Organization Information Sharing Systems," Management Information Systems Quarterly, Dec., 93-104; R. Benjamin et al., 1983, "Information Technology: A Strategic Opportunity", CISR WP #108, Sloan WP #1507-83, Cambridge, Mass.: Center for Information Systems Research, M.I.T.; M. Gerstein and H. Reisman, 1982, "Creating Competitive Advantage with Computer Technology," Journal of Business Strategy, 3:1, Summer, 53-60; B. Ives and G.P. Learmonth, 1984, "The Information System as a Competitive Weapon," Communications of the ACM, 27:12, December, 1193-1201; P.G.W. Keen, 1981, "Information Systems and Organizational Change," Communications of the ACM 24:1, January; F.W. McFarlan, 1984, "Information Technology Changes the Way You Compete," Harvard Business Review, 63:3, May-June, 98-103; J.F. Rockart and L. Flannery, 1983, "The Management of User Computing," Communication ACM, 26:10, October, 776-784; J.F. Rockart and S. Scott-Morton, 1984, "Implications of Changes in Information Technology for Corporate Strategy," Interfaces, 14:1, January-February, 84-95; C. Wiseman, 1985, Strategy and Computers, Homewood, III.: Dow Jones-Irwin. B. Ives and G.P. Learmonth contains a good summary of previous literature.

3. Adapted with modifications from R. Duncan, 1983, Diagnosis for Organization Design, Unpublished lecture note, Kellogg Graduate School of Management, Northwestern University, Evanston, Illinois; C. Philip, 1979, Improving Freight Car Distribution Organization Support Systems: A Planned Change Approach, M.I.T. Studies in Railroad Operations and Economics, Vol. 34, Cambridge, Mass.: Center for Transportation Studies; MIT; C.K. Mao, 1982, "Integrating Organizational and Technological Perspectives: An Approach to Improve Rail Motive Power Management", Unpublished Ph.D. Dissertation, Department of Civil Engineering, M.I.T.; M.L. Manheim, 1984, "Improving Organizational Effectiveness", Logistics Resources (in press), Cleveland: Leaseway Trucking Corp.

4. This concept evolved out of discussions with Peter Keen.

5. This categorization evolved out of discussions with Rafael Amit. See also M.E. Porter, 1985, op. cit.

6. M.L. Manheim, 1985, "Theories of Decision-Making and Their Implications for Development of Creativity-Supporting DSS", paper presented to DSS-85, Fifth International Conference on Decision Support Systems, San Francisco, April. Published as "Creativity Support Systems for Planning and Decision Support," Microcomputers in Civil Engineering (in press); M.L. Manheim, 1966, Hierarchical Structure: A Model of Planning and Design Processes, Cambridge, Mass.: M.I.T. Press; M.L. Manheim, 1969, "Search and Choice in Transport Systems Analysis", Highway Research Record 293, Washington, D.C.: Highway Research Board, 54-82; M.L. Manheim, 1979,

Fundamentals of Transportation Systems Analysis, Vol. 1, Cambridge, Mass.: M.I.T. Press.; H. Mintzberg, 1980, The Nature of Managerial Work, Englewood Cliffs, N.J.: Prentice-Hall; H. Mintzberg, et al., 1976, "The Structure of 'Unstructured' Decision Processes", Administrative Science Quarterly, 21, 246-275; C.H.P. Brookes, 1985, "A Framework for DSS Development," in Joyce Elam (ed.), Transactions of DSS-85 Fifth International Conference on Decision Support Systems, Providence, R.I.: Institute for Advancement of Decision Support Systems - The Institute of Management Science, 80-97.

7. The Information Technology Strategic Assessment concept was initially developed by Benjamin Mittman.

8. This list of attributes expands on and modifies concepts initially proposed by John A.Y. Bakopoulos and M.E. Treacy, Op. Cit.

9. Adapted with modification from J.R. Hackman and G.R. Oldham, 1980, Work Redesign, Reading, Mass.: Addison-Wesley; T.W. Malone and M.R. Lepper, 1985, "Making Learning Fun: A Taxonomy of Intrinsic Motivations for Learning", in Snow, R.E. and M.J. Farr, (eds.) in press, Aptitude, Learning, and Instruction III: Conative and Affective Process Analysis, Hillsdale, N.J.: Erlbaum; T.W. Malone, 1981, "Toward a Theory of Intrinsically Motivating Instruction", Cognitive Science, 4, 333-369.

10. M.L. Manheim, 1986, "Information Technology and Organizational Change: Strategies for Managers," Fourth Annual William A. Patterson Lecture, Evanston, Illinois, Transportation Center, Northwestern University.

11. C.K. Mao, 1982, Op. Cit.

12. D.J. Isenberg and M.L. Manheim, 1986, "Human Computer Interaction: An Approach to Designing More Effective Decision-Support Systems in Transportation", paper presented at WCTR, Vancouver.

13. The philosophy of user-dominated development and incremental implementation was the original focus of the Decision-Support Systems (DSS) approach: P.G.W. Keen and M. Scott-Morton, 1978, Decision Support Systems: An Organizational Perspective, Reading, Mass.: Addison-Wesley; P.G.W. Keen, 1980, "Decision Support Systems: A Research Perspective", in G. Fick and Ralph H. Sprague, Jr., Decision Support Systems: Issues and Challenges, Oxford: Pergamon Press, 23-44; W.C. House, 1983, Decision Support Systems; Petrocelli: New York; J. Martin, 1984, An Information Systems Manifesto, Englewood Cliffs, N.J.: Prentice-Hall; S. Alter, 1980, Decision Support Systems: Current Practice and Continuing Challenges, Reading, Mass.: Addison-Wesley; J.L. Bennett, 1983, Building Decision Support Systems, Reading, Mass.: Addison-Wesley,

14. M.L. Manheim 1985, Op.Cit.; D.J. Isenberg, 1984, "How Senior Managers Think", Harvard Business Review, November-December, pp. 81-90; D.J. Isenberg, 1985a, "Thinking and Managing: A Verbal Protocol Analysis of Managerial Problem Solving", Academy of Management Journal (in press); D.J. Isenberg, 1986, "The Structure and Process of Understanding: Implications for Managerial Action", in H. Sims and D. Gioia (eds.), Social Cognition in Organizations, San Francisco: Jossey-Bass; D.J. Isenberg, 1985b, The Art of Action Planning, Class note 0-486-029, Boston, Mass.: HBS Case Services, Harvard Business School; D.J. Isenberg, 1985c, Working papers on strategic opportunism; D.J. Isenberg and M.L. Manheim, 1986, Op. Cit.