Incidental Paper

CENTRALIZATION AND DECENTRALIZATION:

THE COMPUNICATIONS CONNECTION

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Program on Information Resources Policy

Harvard University

Center for Information Policy Research

Cambridge, Massachusetts

An Incidental Paper of the Program on Information Resources Policy

CENTRALIZATION AND DECENTRALIZATION: THE COMPUNICATIONS CONNECTION

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July 1983, I-83-2

Project Director: John C. LeGates

The Program on Information Resources Policy is jointly sponsored by Harvard University and the Center for Information Policy Research.

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EXECUTIVE SUMMARY

The equilibrium of forces driving organizational decision making toward a more centralized or decentralized form is constantly changing as the relative strength of the forces varies. Information, and especially communications, plays an important part in the play of these changing forces.

Conscious managerial efforts can be made, taking into account compunications factors, among others, to determine the proper locus of decision making and to arrange systems which insure that decisions are made in their proper locus.

Five positive forces drive decision making toward a more centralized locus: returns to scale, optimization, standardization, importance, and coordination of interdependent activities.

Three negative forces drive decision making away from a more centralized locus: information overload, a reaction against compulsion, and the lack of flexibility.

Five advantages of decentralized decision making are that it forces the development of impartial standards; it provides for initiative, innovation, and new leaders; it is more responsive to client requests; it simplifies the decision-making process; and it minimizes the use of information resources.

Three disadvantages of decentralized decision making are duplication of effort, a tendency toward suboptimization, and a reduced amenability to change.

Other forces -- for example, structural difficulties, human factors, and technology -- also affect the locus of decision making.

Compunications capabilities have accentuated micro-management and skip-echelon -- two management/leadership behaviors which had existed in the past in less dramatic forms. Yet, compunications can also be part of the solution toward achieving the appropriate locus of decision making.

CHAPTER ONE: INTRODUCTION

Those who study centralization and decentralization of decision making in organizational structures have identified forces which tend to drive that activity toward a more centralized form or toward a more decentralized form.[1] These forces eventually establish an equilibrium in any particular organization at any particular time for any particular decision. That equilibrium is what we see when we observe that a particular decision or that decision making in general in that organization is centralized or decentralized or some mix of the two.

Unfortunately for those who cherish stability, that equilibrium is not static; it is constantly changing as the relative strength of the forces varies. Information plays an important, if not critical, part in the play of these changing forces.

Kenneth Arrow wrote, "Decisions, wherever taken, are a function of information received."[2] Both the speed at which information moves and the amount of information which may be manipulated by a single decision maker have increased dramatically in the past few years--a phenomenon which has not gone unnoticed.

Since the development of the telegraph, submarine trans-Atlantic cables, and wireless transmission in the latter part of the nineteenth century, the speed and volume of information

being transmitted over great distances has grown at an increasing rate. Over the past decade, the development of integrated circuits and micro-processors has resulted in rapid improvements in processing technology as well. Indeed, the two technologies have been converging. This convergence of communications and computers has been called "compunications" by Anthony G. Oettinger and "telematics" by two Frenchmen, Simon Nora and Alain Minc, in their report to the President of France.[3]

In the introduction to their report, Nora and Minc discussed the effects of technological revolutions in the past, but they went on to write:

> . . . the "computer revolution" will have wider consequences. The computer is not the only technological innovation of recent years, but it does constitute the common factor that speeds the development of all the others. Above all, insofar as it is responsible for an upheaval in the processing and storage of data, it will alter the entire nervous system of social organization.[4]

The purpose of this study, then, is to describe the continuing impact of compunications (or telematics) as one factor in the complex systems of forces which act on the nervous system of organizations. Specifically, that purpose is to describe how the equilibrium determining the locus of decision making may be shifted toward a more centralized or a more decentralized form. It is not clear today that either one or the other situation will predominate.

In 1958, Leavitt and Whisler suggested that the impact of automatic data processing technologies would result in the

recentralization of decision making in organizations.[5] When they wrote that article, automatic data processing meant large, massive computer installations which were very expensive and, of necessity, were installed at the corporate headquarters. More recent authors have argued differently.

For example, Bell argued that, "The new revolution in communications makes possible both an intense degree of centralization of power, if the society decides to use it that way, and large decentralization because of the multiplicity, diversity, and cheapness of the modes of communication."[6]

In their Report, Nora and Minc argued that:

> Telematics offers varied solutions which can be adapted to all forms of control or regulation. It allows the decentralization or even the autonomy of basic units. Better still, it facilitates this decentralization by providing peripheral or isolated units with data from which heretofore only huge, centralized entities could benefit. Its task is to simplify administrative structures by increasing their effectiveness and improving their relations with those under their jurisdiction. It also allows the local municipalities more freedom. It reinforces the competitiveness of the small and mid- size business vis-à-vis the large enterprises.[7]

In the past five years, we have seen the rise of distributed data processing, not only through time-sharing arrangements using terminals connected to central computers, but also by stand-alone personal computers with their own built-in processing capability. This increase in availability of computer technology at all levels, combined with the rapid communications available through satellite relay and high-density land lines, has provided superior information processing capabilities at all levels of

organizational structures. The foregoing might lead one to believe that advances in compunications lead toward a more decentralized form of decision making.

Life is not so simple, however. Since 1958, we have also seen reports that President Kennedy and Secretary of Defense McNamara talked directly to the captains of ships at sea during the Cuban blockade of 1962; that President Johnson determined the daily target list for aircraft bombardment in Southeast Asia from the White House; that Secretary of Defense Brown was in direct contact with a Marine Second Lieutenant in the first landing craft to hit the beach during the Lebanon Crisis of 1958; and that President Ford talked directly to the pilots of Marine helicopters during the assault to rescue the crewmen of the Mayaguez (not to mention that President Nixon called a football play to the Washington Redskins).[8] This aspect of telecommunications (that is, real-time contacts between the highest levels of an organization and its lowest levels) means that it is now possible for a centralized headquarters to become intimately involved in the operations of the most remote field unit.

How, then, has this revolution in technology affected the locus of decision making in organizations? That is not a casual question. The failure of managers at all levels to recognize the forces affecting their organizations, and the resultant failure to anticipate the consequences of those effects, can seriously degrade the organization's ability to function, and

might even affect the organization's survival. Conscious efforts must be made to determine the proper locus of decision making and to arrange systems which insure that decisions are made in their proper locus. This paper will review the available literature and describe some of the considerations upon which those conscious decisions must be made.

PART ONE

CENTRALIZATION AND DECENTRALIZATION

According to Hannan and Fried, "the arguments advanced for centralization are generally based on efficiency. In contrast, the arguments for decentralization deal with effectiveness."[1] Although they were discussing the location of automated data processing equipment, the same general comment might be made about decision making in general. The difference between effective decision making and efficient decision making will sometimes escape the casual reader. Both of the expressions describe the production of some intended effect, but efficiency implies the production of that intended effect with the optimum use of available resources.

One might also argue that centralization and decentralization are two sides of the same coin. When one discusses organizational structure and tries to state that the organization is centralized or decentralized, one may be making a judgment based on one's own perception and not the reality. No organization exhibits purely centralized decision making or purely decentralized decision making. Some decisions in the organization are centralized and other decisions are decentralized. It is the mix of decision making, both centralized and decentralized, which determines the perception about a particular organization,

and which results in a description of that organization as centralized or decentralized. There are good reasons for establishing the locus of decision making toward one extreme or the other, and certain disadvantages associated with either action. Table 1 is a listing of those reasons and considerations, a fuller discussion of which appears in Chapters Two and Three.

TABLE 1: Forces Affecting the Locus of Decision Making

Centralization	Decentralization
Positive	**Positive**
Returns to Scale	Forces Impartial Standards
Optimization	Initiative/Innovation
Standardization/Uniformity	Responsiveness
Criticality/Importance	Simplify Decision Making
Coodination of Inter-dependent Activities	Minimize Information Resource Requirements
Negative	**Negative**
Information Overload	Duplication of Effort
Based on Compulsion	Suboptimization
Lack of Flexibility	Less Amenable to Standardized Change

Typically, one is given the analogy of a pendulum to describe the shift of locus from one extreme toward the other. A better analogy from mechanical engineering might be a system of springs. Each one of the entries in Table 1 can be thought

of as a spring in tension or compression, and all of them together can be thought of as a system of springs which will establish equilibrium at some point. Positive forces can be thought of as springs in tension, pulling the locus of decision making toward their respective extreme, and the negative forces can be thought of as springs in compression, pushing the locus toward the opposite extreme.

No analogy is perfect, but the analogy of a system of springs expresses far better the complex interactions of the various factors than does that of a pendulum. Realizing that the map is not the territory, and the analogy is not the reality, one can add another group of factors to this grand design. Following the discussion of forces affecting centralization and decentralization in Chapters Two and Three, Chapter Four looks at the "real world", namely those factors which can be thought of as friction, or as constraints/aids to one or more of the "pure" forces. These additional factors establish the equilibrium locus at some point other than the "ideal" or "theoretical" point one would normally expect.

CHAPTER TWO: CENTRALIZATION

Five positive and three negative forces affect the centralization of the locus of decision making (Table 1). The five positive forces tend to drive decision making toward a more centralized locus, while the three negative forces tend to drive decision making away from a more centralized locus. The five positive forces are: returns to scale, optimization, standardization/uniformity, criticality/importance, and coordination of interdependent activities. The three negative forces are: information overload, the basis of compulsion, and the lack of flexibility.

Returns to Scale. According to Simon, "in decision-making, economy of scale means mainly creating central units for handling certain classes of decisions expertly, where it would be too costly to distribute experts more widely through the organization."[1] The same comment was made by Hannan and Fried when they wrote, "The most frequent argument advanced in support of centralization is that it results in economy of scale."[2] In both cases, the argument is for reduced cost, or for economy of resource use. While it might be true that a more decentralized organizational structure might result in improved effectiveness, cost considerations would tend to drive the locus of decision making toward the center.

Optimization. Optimization is also related to efficiency, in that it implies the obtaining of a maximum result from the minimum possible effort. The optimization of the entire organization can, and usually does, result in less-than-optimal performance in some of the organization's parts. Centralization is then required to prevent the parts of the organization from optimizing their particular area to the detriment of the organization as a whole.

Standardization/Uniformity. No two people are the same, and no two units of an organization are the same. The perceived benefit from a standardized or uniform appearance may require centralized direction. Without centralized determination of structural requirements for buildings and signs, as well as personnel uniforms, we would not be able to recognize a MacDonald's franchise in all parts of the world, as indeed we can. Simon, Smithburg, and Thompson mentioned this force 30 years ago when they wrote, "The drive for uniformity may stem from esthetic considerations, or it may provide the overhead unit with a plausible substitute for a real goal. The drive for uniformity in either case, is a powerful force in raising the level of administrative integration."[3]

Kochen and Deutsch have made reasoned criticism of the frequently used argument that standardization is a benefit of centralized decision making. They say that "in the first place, standardization is not a universal net benefit. . . . Second, standardization may be imposed upon clients by a centralized

management without the input of clients. . . . Third, when standardization is not in the interest of a key firm in a centralized industry, this may result in a delay of standardization contrary to the interests of clients and other participants."[4]

Their first argument was basically one of quality of life. Standardization of consumer products would most likely result in a rather drab existence if we could find only one version of each particular consumer good when we went shopping. They do realize that some maximum variety would eventually be reached where the marginal value of adding one more different type of a particular consumer good would not be worth the marginal cost involved.

Their second argument concerns the relationship of the organization and its clients. If the clients are not consulted prior to the implementation of some standardized procedure or product, the organization may find itself in a situation of producing something no one will purchase.

The final argument is that, while standardization may be beneficial, it might be against the best interests of one of the key players of the organizational structure. If that key player is sufficiently powerful, standardization may be delayed even though it is of benefit to the organization and its clients.

Criticality/Importance. Kochen and Deutsch have constructed models in an effort to determine mathematically the optimum degree of decentralization, and have found that their models "suggest that the optimum degree of decentralization increases

with any decrease in the margins of error and of breakdown that are considered acceptable in the performance of the service."[5] In other words, the more critical or important a decision may be, the higher the level at which the decision will be made. Regardless of whether he is more capable to make the decision, no executive facing a situation which might have significant impact upon his organization (and possibly on his career) is willing to permit that decision to be made at a level lower than his own. As Koontz, O'Donnell, and Weihrich wrote in their text, "The fact that the cost of a mistake affects decentralization is not necessarily based on the assumption that top managers make fewer mistakes than subordinates. They may make fewer mistakes, since they are probably better trained and in possession of more facts, but the controlling reason is the weight of responsibility."[6]

Nowhere is that more evident than in the case of national security. The history of our own country clearly demonstrates that U.S. Presidents have been intimately involved with detailed military operations only when the nation's survival was at stake. Washington went so far as to journey out to inspect the troops sent to quell the Whiskey Rebellion. During the War of 1812, Madison took personal responsibility for defending the city of Washington (and did rather poorly, at that). During the War Between the States, Lincoln was intimately involved in the military operations taking place in the eastern half of the continent. He might have been just as intimately involved with

western operations if adequate communications had existed at the time.[7]

Since the advent of strategic nuclear weapons and the beginning of the Balance of Terror in the late 1940s and early 1950s, U.S. Presidents have maintained strict control of military operations. When even the most minor incident might result in escalation to general nuclear war, a prudent president will always maintain tight control.

Coordination of Interdependent Activities. Finally, a major force in the systems of forces driving decisions toward a more centralized locus is the need for coordination of interdependent activities. As Simon has put it, ". . . the interdependencies that make coordination desirable are those that the economists call externalities; that is, actions whose consequences fall on a part of the organization other than the one taking the decision."[8] Simon goes on to say that coordination may not be required if some other mechanism is devised, such as pricing, to force the decentralized decision-making unit to take into account those externalities. He does caution, though, that prices which do not reflect important externalities can be a cause for divergence between decentralized decisions and higher-level goals, and hence a motive for centralization.[9]

In addition to the positive forces listed above which tend to move the locus of decision making toward a more decentralized form, there are negative forces which tend to slow down that

movement or reverse its direction. Those forces are information overload, the basis of compulsion, and a lack of flexibility.

Information Overload. Twenty years ago, Simon wrote that

> the critical task is not to generate, store or distribute information but to filter it so that the processing demands on the components of the system, human and mechanical, will not exceed their capacities. A good rule of thumb for a modern information system might be that no new component should be added to the system unless it is an information compressor--that is, unless it is designed to receive more information than it transmits. The scarce resource today is not information, but capacity to process it.[10]

Such a comment is even more true today with the massive increase in the amount of information which is available to decision makers. Inman alluded to the same difficulty when he said:

> In 1972, when the Indo-Pakistani Conflict task force was sent out to the Indian Ocean, there was an immediate "Turn on everything you know about that section of the world" response. Well, when you say that to the large technical operations, they indeed know how to turn on that kind of process. They start flowing huge volumes of data; the computer may well be selecting anything that may be relevant in the broadest sense. And the poor guy in the field is drowned.[11]

The problem is not restricted to the highest levels of an organization. In discussing Command, Control, and Communications (C^3) challenges in this decade, Capone said that a key challenge "is the need to come to grips with the battlefield information explosion." He concluded that thought by saying, ". . . there has been a great deal of talk about C^3 as a 'Force Multiplier', but if the commander is swamped with data produced by his C^3 systems he can be in worse shape than he was before. In this case the 'Force Multiplier' is less than one--and that's distinctly

unhelpful."[12] Even with an adequate "compression" system in place, difficulties can arise with respect to multiple tasks. In their survey of the U.S. command system, Bryant, Trinnaman, and Staudenmeier commented that

> the basic security interests of the United States require that command and control be exercised from the highest levels to insure that international crises do not escalate uncontrollably in the nuclear era. At the same time, the possibility of simultaneous crises overloading the centralized decisionmaking authority requires the continued existence of decentralized commands.[13]

The overload, then, can come from one of two sources. Either so much information may be provided, or data may be available, that the decision maker is unable to assimilate all that is available, or so many crises or decision-making requirements may be occurring at the same time that the decision maker is unable to react.

Kochen and Deutsch summarized the problem of information overload in centralized organizations when they wrote of them that "their liabilities include overload and congestion of their communication channels and facilities, with resulting long delays or partial or general breakdown of the system."[14]

The Basis of Compulsion. Information overload is a serious detriment to centralized decision making, but the fact that the more centralized an organization becomes, the more it acts by decree and autocratic dictate, can also cause problems. As Simon commented, ". . . centralization is equated with bureaucracy (in the pejorative sense of that term) or with authoritarianism

and is often named as a prime force causing dehumanization of organizations and alienation of their members."[15] The human relations school of management called for participatory decision making, for more "democracy" in the workplace, and for job enrichment. These and other demands were a reaction against the perceived treatment of human beings as if they were cogs in a machine, and it was claimed that centralization led to dependence, dissatisfaction, lack of involvement, and divided loyalties on the part of members of the organization.[16]

Lack of Flexibility. Finally, the monolithic response of a highly centralized organization can lead to a lack of flexibility. After stating that a decentralized organizational structure is more flexible in its reaction to new inputs, Golembiewski argues that "in a centralized structure, in contrast, strong forces support a decision. It can be very right or very wrong, but in either case strong forces are mobilized to get the entire organization committed to that decision.[17] He goes on to say that "centralization implies rigid policies that may prove capricious guides for behavior. The capriciousness will be most apparent where many activities are performed on many products in markets that are complex and changing."[18] A concrete example of this argument was put forward by Hannan and Fried in their article. They argued that:

> often, applications developed for a centralized operation are far more complex and costly than those developed for divisional needs. Also, maintaining the system for one division could potentially affect all divisions. If the central computer is disabled, all

divisions are adversely affected. Not only are the risks increased, but centralization forces divisions into a common mold that may be inappropriate for their needs.[19]

CHAPTER THREE: DECENTRALIZATION

Table 1 lists five advantages or forces which tend to drive decision making toward a more decentralized process. In addition, three difficulties or disadvantages are listed in the table. The five advantages of decentralized decision making as listed in the table are that it forces the development of impartial standards; it provides for initiative, innovation, and the development of new leaders; it is far more responsive to requests from clients of the organization; it simplifies the decision-making processes; and it minimizes the use of and requirement for information resources. The three disadvantages are duplication of effort, a tendency toward suboptimization, and a reduced amenability to organization-wide, standardized change.

Forces Impartial Standards. Golembiewski's argument that decentralized decision making forces the development of impartial standards is primarily one of span of control. If the span of control is so wide that the decision maker is incapable of using a centralized decision-making procedure, then it is also too wide for that decision maker to maintain close supervision of his subordinates. The manager, therefore, needs some measure to evaluate those subordinates. As Golembiewski argues, ". . . there literally may be no alternative but administrative chaos to the development of non-arbitrary measures of performance in many

decentralized organizations."[1] While he does agree that it is possible to have a decentralized form of decision making with a narrow span of control, Golembiewski states that "there is precious little room in the decentralized firm for 'close supervision' or 'management by crisis'."[2] While there is no guarantee that a more decentralized form of decision making will result in impartiality, there does seem to be a strong tendency in that direction -- particularly if the standards focus upon results rather than on methods.

Initiative/Innovation. Perhaps one of the most important advantages of decentralized decision making is that it tends to develop initiative, innovation, and new leadership. Golembiewski wrote that

> decentralization encourages the development of effective managers. The key factor is that as far down the hierarchy as substantial delegation exists, supervisors cannot be narrow specialists. Oppositely, such individuals can--and do--hide their inadequacies in a functional structure, which imposes a more limited and different set of demands upon them.[3]

Kochen and Deutsch agreed when they wrote that

> if the organization is decentralized, promising candidates for executive posts can be given responsibility for an entire division or major sub-firm, possibly rotated among several units, and can be observed for their ways of coping with the challenges. In this way, decentralization enlarges the pool of potential candidates and permits more sensitive and informed selection.[4]

Initiative and innovation are also important and can be easily developed in a decentralized organizational structure. By giving the lower level managers the leeway to make their own decisions,

higher level management is accepting the possibility that some of those decisions may be erroneous. Still, the capability to try varied solutions to the same types of problems at different locations means that innovation is possible and is, in fact, encouraged. Such is not the case in a centralized decision-making structure. As Smithies argues:

> The first possible benefit of decentralization arises from the fact that the overall objective function is unknown and may remain so. Although this may seem a strange benefit, the diversity that arises from decentralization may be preferable to consistent adherence to an objective function that may turn out to be the wrong one. For this reason, a decentralized school system may be preferable to one that imposes uniform standards. In the former case there will be "good" and "bad" schools but the system on the average may be higher than that of the centralized system. As another example, decentralization of the armed services served as a useful counterweight to excessive reliance on strategic bombing in the first post-war decade.
>
> Another advantage of decentralization is that individuals have more opportunity and inclination to exercise initiative than they would in a centralized system. Even though an administrator may devote some of his energies to increasing his own influence and prestige, the benefits to the whole organization may be worth that cost.[5]

Responsiveness. Responsiveness is another major advantage of decentralized operations and decision making. In their discussion of the decentralization of automatic data processing, Hannan and Fried listed six advantages of decentralized operations. Of those six, the first three related to responsiveness. Those three were (1) local direction, flexibility, and assignment of priorities through user control of the staff; (2) analysts more responsive to the user; and (3) analysts more responsive to user problems, personnel, and requirements.[6]

In their discussions of the proper role of decentralization in a service organization, Kochen and Deutsch repeatly mentioned the importance of responsiveness to the client. "The main virtue of functional decentralization, as of pluralization and dispersion, is responsiveness to local demand and sensitivity to environmental change," they said.[7] In addition, "An important reason for decentralizing a service organization is to make it more responsive to its clients."[8] Finally, although they recognize that centralization provides the potential and capability for concentrating resources, they go on to say "effective control has a certain utility for its own sake. Some users would prefer a small, poorly catalogued and maintained collection of their own to the larger, better organized resources of larger libraries. Presumably what they cherish is predictability, accessibility, and responsiveness."[9] There is probably no more frustrating experience, and one which we have all endured, than to go into some bureaucratic office for some service and then to be told that they can make no decision at that level. The failure of the front line office to respond to the client causes significant problems for the client and for the organization, and may lead to a client's unnecessary hostility and lack of confidence in the capability of the organization. In private enterprise, the result is a lost customer; in public enterprise, the result is an irate citizen.

Simplify Decision Making. The coordination of decisions involving interdependent subunits of the organization is one of

the forces driving toward centralization of decision making. As Simon points out, however, decentralization "may simplify the decision-making process by separating out groups of related activities--production, engineering, marketing, and finance for particular products--and allowing decisions to be taken on these matters within the relevant organizational subdivisions."[10] He does go on to say, however, that "advantages can be realized only if the units to which decision is delegated are natural subdivisions--if, in fact, the actions taken in one of them do not affect in too much detail or too strongly what happens in the others."[11]

Minimize Information Resource Requirements. Simon lists three reasons why complex systems tend to be hierarchic in organizational structure. The second reason he gives is particularly appropriate to the minimization of information resource requirements. He argues that:

> It was pointed out many years ago that as the number of members of an organization grows, the number of pairs of members grows with the square (and the number of possible subsets of members even more rapidly). If each member, in order to act effectively, has to know in detail what each other member is doing, the total amount of information that has to be transmitted in the organization will grow at least proportionately with the square of its size. However, if the organization is subdivided into units, it may be possible to arrange matters so that an individual needs detailed information only about the behavior of individuals in his own unit, and aggregative summary information about average behavior in other units. If this is so, and if the organization continues to subdivide into suborganizations by cell division as it grows in size, keeping the size of the lowest level subdivision constant, the total amount of information that has to be transmitted will grow only slightly more than pro-

> portionately with the size. Hence, the amount of communication required for organization members will remain nearly constant.[12]

Although the foregoing is an argument for hierarchic systems, it is clear that the same argument can be applied to the reduction of required information which is achieved in a decentralized organizational structure. Arrow and Hurwicz argued precisely that point when they wrote, ". . . it is the minimization of information requirements for each participant in the economy which constitutes the virtue of decentralization."[13] Arrow and Hurwicz argue that it is unnecessary for the manager of a lower level unit to know all the information about the goals of the organization as a whole. They argue that, instead, the manager need know only the utility function of his own suborganization and the pricing structure of the resources he requires. "For a given set of prices, a process manager need know only the prices and the technology of his own process in order to arrive at the optimal level for his process."[14] By establishing subgoals for the suborganization and by manipulating the prices charged to the suborganization for its use of resources both internal and external to the organization as a whole, higher level management can orchestrate the accomplishment of organizational goals without having to involve themselves in the day-to-day routine operations of the suborganization. Not only does the manager of the suborganization <u>not</u> need to know information regarding the organization as a whole beyond that minimal point, but higher level managers do not need to know detailed information about the suborganization

either. Smithies argues that:

> A further advantage of decentralization is that it reduces the cost of information. In a geographical situation, much local information can be routed direct to operating units and need not go to the central authorities. And even if the central authorities were prepared to pay the cost of the information, the resulting central bureaucracy could be so large as to suffer from diseconomics of scale.[15]

Problems associated with the decentralized format for decision making include duplication of effort, suboptimization, and a reluctance to assimilate standardized change. All three of these disadvantages reflect the earlier generalized statement that centralization is usually related to efficiency and decentralization is usually related to effectiveness.

Duplication of Effort. Duplication of effort is a natural response to decentralized decision making. One of the major advantages of centralization is that it results in a concentration of resources and a more efficient use of scarce materiel, personnel, and facilities. As Smithies argues, "Decentralization can result in duplication of facilities such as R&D, general support, and so forth. But again, some such duplication may be a worthwhile cost of the competition that can often add vitality to the whole organization."[16] Indeed, it is this duplication of effort which leads to innovation by permitting the various suborganizations within the larger organization to attempt different approaches to the solution of similar problems. Some of those approaches may be incorrect and result in failure, but others will be more successful and the overall results to the

organization may be better than could be achieved if all units attempted to approach the problems from the same point of view and with the same marching orders. Without doubt, duplication of effort results in inefficiencies which can increase the cost of doing business in the short run. It is the potential for innovation which may or may not justify those added costs.

Suboptimization. Suboptimization was briefly mentioned earlier in the discussion of Optimization. Suboptimization means that a subunit of the organization is optimizing its particular area of interest at the expense of the goals of the larger organization. The first weakness of decentralized organization structures listed by Simon was that "they encourage the formation and loyalty to subgoals that are only partly parallel with the goals of the organization.[17] When Hannan and Fried listed disadvantages to decentralized analysis for automatic data processing systems, two of those disadvantages were the difficulty of maintaining control of applications design as it affects the economic utilization of hardware and the tendency of divisions to invent solutions to their problems rather than use corporate-wide systems.[18] The first disadvantage they listed is a significant problem in distributed data processing. Each unit with its own processing capability is likely to develop applications programs which bear a great deal of relevance to the local unit, but which may either have no relevance at all for the organization as a whole or may not be interoperable with the organization-wide operating systems. Small units can

generate specific programs to solve their specific problems, and may find those programs superior to the more general and complex programs designed at corporate headquarters to solve the myriad problems of varied suborganizations. The difficulty lies in the development of many programs at many suborganizations which cannot usually be interchanged among the interdependent parts of the organization and which may lead to a fragmentation of that organization.

Less Amenable to Standardized Change. The final difficulty with decentralized decision making is that a decentralized organizational structure is less amenable to a standardized change of the organization as a whole. Golembiewski writes, ". . . the freedom of the decentralized units may be expressed in terms of resistance to innovations developed by the auxiliary services reserved to top management."[19] He goes on to document that statement with an example:

> Villers, for example, recounts the curious history of a safety device for a punch press that also made possible very marked increases in output. The device was adopted by the various plants in a decentralized firm in time, but "time" in this case meant more than ten years. Such cases try the souls of top-level management, testing both their patience and their maturity.[20]

This chapter and the previous chapter have dealt with the "pure, theoretical" forces affecting the locus of decision making. In the next chapter, we will take a look at the "real world" and how technology has affected the actual placement of that locus.

CHAPTER FOUR: THE REAL WORLD

Newman, Summer, and Warren have listed seven questions to be answered in order to determine the appropriate locus for decision making. Those questions are:

1. Who knows the facts on which the decision will be based or who can get them together most readily?

2. Who has the capacity to make sound decisions?

3. Must speedy, on-the-spot decisions be made to meet local decisions?

4. Must the local activity be carefully coordinated with other activities?

5. How significant is the decision?

6. How busy are the executives who might be assigned planning tasks?

7. Will initiative and morale be significantly improved by decentralization?[1]

Questions 1 and 2 relate to the decision-making process itself. Questions 3, 4, and 5 relate to responsiveness, interdependence, and criticality respectively, all significant factors to be considered in the determination of the locus of decision making. Question 6 relates to cost-effectiveness and the potential for overload of high-level executives. Finally, question 7 relates to the psychological aspects of the situation. In some cases, it may be more appropriate to permit lower level decision makers to have the final say in order to develop initiative and morale within the organization.

In Chapters Two and Three, we examined the forces which tend to drive decision making toward a more centralized or a more decentralized form. The treatment in those two chapters was oriented toward the "pure" forces, and an attempt was made to define those forces which act in the establishment of the equilibrium position of the locus of decision making. There are, however, other forces acting upon the system of forces much as friction acts on a system of springs (recalling our earlier analogy). Those other forces can be crudely divided into at least three groups: structural difficulties, human factors, and technology. This chapter deals with the description of those forces.

Structural Difficulties. Various structural difficulties are associated with the establishment of a locus of decision making. Those difficulties include the history of the firm or organization, the availability of managerial talent and its quality, and the locus of performance. Koontz, O'Donnell, and Weihrich wrote, "Whether authority will be decentralized frequently depends upon the way the business has been built."[2] They go on to write that:

> Those enterprises which, in the main, expand from within--such as Marshall Field and Company and International Harvester Company--show a marked tendency to keep authority centralized, as do those which expand under the direction of the owner-founder. The Ford Motor Company was, under its founder, an extraordinary case of centralized authority. . . . On the other hand, enterprises that represent amalgamations and consolidations are likely to show, at least at first, a definite tendency to retain decentralized authority, especially if the unit acquired is operating profitably.[3]

While history may not have a decisive effect on whether an organization is "centralized" or "decentralized," there does appear to be strong justification for the argument that history may shift the locus of decision making from its more "ideal" position as established by the forces described earlier to some other locus.

Koontz, O'Donnell, and Weihrich described the problems of the availability and quality of managerial talent by writing:

> A real shortage of managerial talent would limit the extent of decentralization of authority, since dispersal of decision making assumes the availability of trained managers. But too often the mourned perennial scarcity of good managers is used as an excuse for centralizing authority; executives who complain that they have no one to whom they can delegate authority are often trying to magnify their own value to the firm or are confessing a failure to develop subordinates.[4]

Centralization may indeed be forced upon an organization because of a lack of sufficiently capable management personnel. If, however, one finds that the organization remains with its locus of decision making shifted toward a more centralized position after a sufficient time has passed for new managerial talent to be found or trained, one might well wonder about the real reason for the shift.

The final structural difficulty, according to Kootz et. al., "is basically a technical matter depending upon such factors as the economies of division of labor, the opportunities for using machines, the nature of the work to be performed, and the location of raw materials, labor supply, and consumers."[5] In those cases,

the authors continue, "Authority tends to be decentralized when performance is decentralized, if for no other reason than that an absentee headquarters manager is unable to manage, although there are exceptions."[6] It is interesting to note that the authors go on to write:

> It does not follow that when performance is centralized, authority is centralized. True, authority can be more easily centralized if performance is, and if a company wishes tight control over decision making, centralized performance will aid this. But there are too many other factors to give geographic concentration a controlling influence in centralization. Here, again, what is done depends on situations.[7]

The structural difficulties described above can be most easily understood as constraints upon the performance of a particular organization. They are "states of the world" and, as such, will have an important effect upon the locus of decision making in a particular organization. That effect may distort the location of decision making which might have been achieved had the "pure" forces been allowed to act unchecked.

Human Factors. Human factors which can affect the "ideal" locus of decision making can be further divided into two groups: those which tend to shift the locus of decision making toward a more centralized position, and those which tend to shift the locus toward a more decentralized position.

Of those forces which tend to shift the locus of decision making toward a more centralized position, most seem to be failings in human personality. One of the primary reasons is that of failure or reluctance to delegate authority. In his

discussion of the costs associated with decentralization, Golembiewski wrote:

> Perhaps the biggest "cost" they imply is associated with the wide delegation by top management necessary for decentralization. Centralization of authority is reasonable under the traditional theory of organization, and perhaps necessary. The influence of this theory upon many managers has been marked. The decentralized delegation of authority comes with great difficulty for most of them.[8]

Koontz, O'Donnell, and Weihrich discussed the same problem in describing the manager who was unwilling to let go. They wrote that "A great fault of managers who move up the executive ladder --or of the pioneer who has built a large business from the small beginnings of, say, a garage machine shop--is that they want to continue to make decisions for the positions they have left."[9] That reluctance to let go of what one once had, and to move on to something different, can combine with other reluctances (to trust one's subordinates to do a job, to delegate authority with responsibility, for example) to cause serious difficulties. Both the reluctance to let others make mistakes (which one could prevent by doing the task oneself) and the reluctance to let subordinates try their own ideas will affect the manager's ability to delegate authority.[10]

There is also the darker side of the human personality. "Sometimes top managers are despotic, brooking no interference with the authority and information they jealously hoard."[11] Kochen and Deutsch distilled that problem when they wrote that "often the motive for centralizing is primarily someone's urge

to maintain or increase power."[12] They go on to explain, "Centralization can help the moderately powerful to maintain or increase their power. They do this by concentrating resources, decision making, supervision, and control. Decentralization, by dispersing resources, tends to dilute the power of the strongest."[13]

The human factors which have tended to force decision making toward a more decentralized form can be lumped together into a general category of overload. As Golembiewski wrote in describing the growth of a chain of grocery stores, "Rapid growth of the food chain created irresistible pressures for change. There were too many stores for the existing pool of district managers and their capable assistants, and there were no reinforcements to fall back upon. The firm more or less backed into decentralization."[14] It is interesting to note here that a lack of managerial talent forced a decentralization of decision making. The availability of managerial talent was listed earlier as one of those structural difficulties which might tend to drive an organization toward centralization. The difficulty, however, arises in the locus of performance which, in this case, overrides the lack of available managerial talent. With the geographic dispersal of the grocery stores, and the minimal number of qualified managers, the organization was unable to centralize, and was forced to decentralize and to accept the possibility of temporary difficultieswhile the inexperienced personnel were developing into capable, qualified managers.

In their article, Leavitt and Whisler wrote:

> If centralization becomes easier to implement, managers will probably revert to it. Decentralization has, after all, been largely negatively motivated. Top managers have backed into it because they have been unable to keep up with size and technology. They could not design and maintain the huge and complex communications systems that their large, centralized organizations needed.[15]

It would seem reasonable, then, that improvements in technology might tend to drive the locus of decision making, as well as structural and human factors.

Technology. Structural difficulties are "states of the world," and may or may not be subject to change over time. The human factor will be with us as long as organizations are made up of humans. Technology, on the other hand, is a changing factor which affects the locus of decision making and which is changing rapidly.

In 1950, Simon, Smithburg, and Thompson wrote:

> It is apparent that improvement in communication has made centralization possible. When national governments can communicate by telephone at any time with their representatives throughout the world, it is unnecessary to allow those representatives much discretion in the choice of decisional premises.[16]

In a later work, Simon remarked:

> When the cable and the wireless were added to the world's techniques of communication, the organization of every nation's foreign office changed. The ambassador and minister, who had exercised broad, discretionary, decision-making functions in the previous decentralized system, were now brought under much closer central control. The balance between the costs in time and money of communication with the center, and the advantages of coordination by the center had been radically altered.[17]

In discussing the "full trust and confidence" syndrome of a commander's responsibility and its relation to technology, Capone said:

> In my judgment, the degree of adherence to this tradition tends to be inversely proportional to the state of one's technology. If you can't talk to your subordinate you have to trust him. Conversely, rapid and reliable communications from Headquarters to the unit on the line often offers irresistible temptation for high-level "kibitzing".
>
> In all fairness, though, each of us has at one time or another, fallen victim to what I call the "Nelsonian Syndrome". And by that I mean that we demand and expect instant, rapid, reliable and secure communications with our subordinates--but we prefer to hear from higher authority once a year by slow mail.[18]

The effect of improvements in telecommunications, however, is not an entirely one-sided affair. Simon writes, "As the costs of long-distance communication go down and the volume of information that can be transmitted increases, the opportunities for low-level inputs to high-level decisions are greatly enhanced. As I have already shown, this is a force toward greater decentralization."[19] When Leavitt and Whisler published their article in 1958, computing technology had entered its second generation. Computing machines were complex, large, expensive, and required large numbers of personnel to maintain and operate them. It was not unreasonable then to believe that decision making might become more centralized through the use of that new computing technology. That attitude continued for several years. Simon wrote, "The second force working toward recentralization of decisions has been the introduction of computers and automation."[20]

With the development of time-sharing, remote terminals with access to a central data base, and mini- and micro-computers for use in distributed data processing, the economics of the situation turned around. Today it is possible for computing power to be located inexpensively at whatever location is deemed most appropriate.

Lest one assume that the pendulum (or, better, our system of springs) is moving too far toward the side of decentralization, it is interesting to note that "Even the great convenience of the telephone has not lessened people's need for face-to-face contacts. On the contrary it appears that cheaper, faster, more ubiquitous telecommunications devices are increasing the need for face-to-face contact."[21] Perhaps it is even a matter of status. Kochen and Deutsch continue:

> Yet, people at higher organizational levels prefer to talk face to face rather than communicating by writing or through computer terminals. While previously disadvantaged people prefer using technological media to direct human contact, saying that for the first time they feel that they are treated like everyone else, their more privileged colleagues view having to deal with a machine rather than a person as a demotion that is degrading or dehumanizing. Thus, successful and upward-mobile white nurses, teachers, librarians, and students often resist or fear the use of computers while their black counterparts are often eager to do so. Physicians, lawyers, and business executives are more likely to delegate direct use of a computer terminal to a staff assistant than do it themselves.[22]

Such an antagonism toward the use of computer terminals may be a passing phenomenon waiting only for the death or retirement of senior level management. Younger people today, and particularly children, are growing up in an environment of computer

terminals and are quite comfortable with them. As they move into the working environment, it is likely that they will want and need computer terminals to accomplish their daily tasks.

Technology, then, is a significant factor in determining the locus of decision making, if only because it is changing so quickly and so dramatically. Simon wrote:

> Finally, the degree to which decisions are centralized or decentralized in an organization depends not only on the desirability of one or the other mode of operation but also on its feasibility. Any change in technology that makes it cheaper and easier either to centralize or to decentralize decisions will tip the balance in that direction.[23]

PART TWO

THE COMPUNICATIONS CONNECTION

Decision making takes time. Each step of the process requires a certain length of time to complete, and it is through its potential for reducing the time requirement for each step (and for the entire process) that compunications is most likely to affect the decision-making process. The capability to transfer the necessary information and to process properly that information is critical to the decision-making process, and it is a prime factor in the determination of the locus of decision making. In Part 1, we discussed the system of forces which determine the locus of decision making. That discussion was general, but it did include several implicit references to the importance of communications (the information transfer system) and computers (the information processing system) in the determination of that locus.

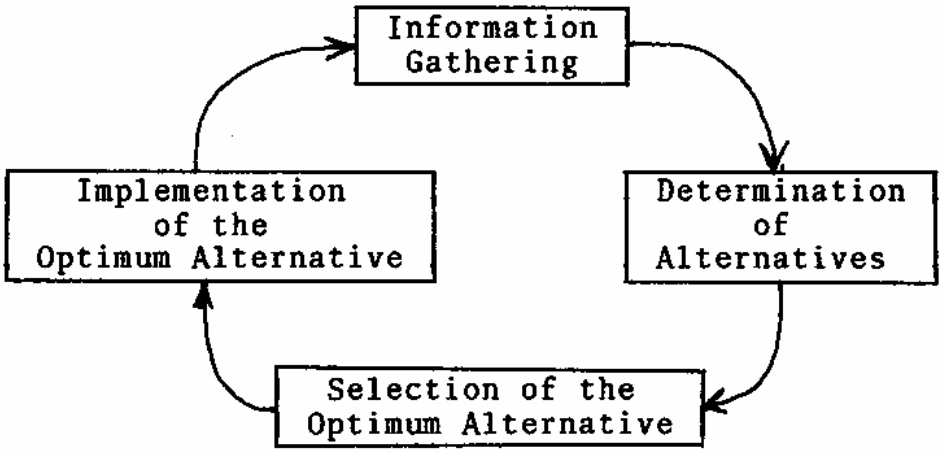
In Part 2, we will more explicitly examine the role of compunications in the decision-making process in general and its effect upon the determination of the locus of decision making in particular. Compunications is certainly not the only factor in the determination of that locus, but it is the factor which has changed most dramatically in the last decade.[1]

Chapter Five is a brief discussion of the decision-making process and the effects of time upon that process.[2] Chapter Six discusses certain behaviors which have been facilitated by improvements in compunications. Chapter Seven is the final chapter in the study.

CHAPTER FIVE: THE TIME DIMENSION

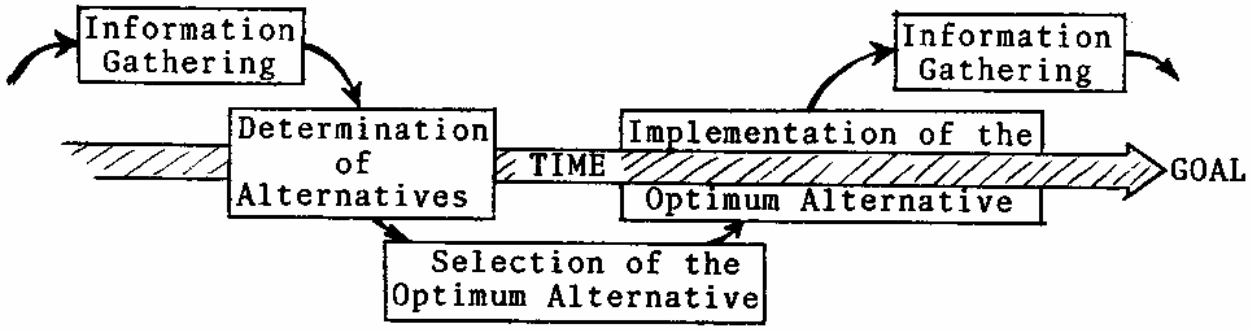
Elementary discussions of decision making typically involve a two-dimensional closed loop as shown in Figure 5.1.

Figure 5.1: Rudimentary Decision Process Model



The connecting link in closing the loop is feedback, or the evaluation of the effects achieved by the action which resulted from the decision-making process. This analogy is too simplified for our purposes, since it does not consider the effects of time on the decision-making process. What is called feedback or follow-up in the loop becomes the information-gathering step of a new cycle in the decision-making process described by the helix in Figure 5.2. The decision-making process in Figure 5.2 moves forward through time toward a particular goal.

Figure 5.2: Goal-Directed Decision Process Model

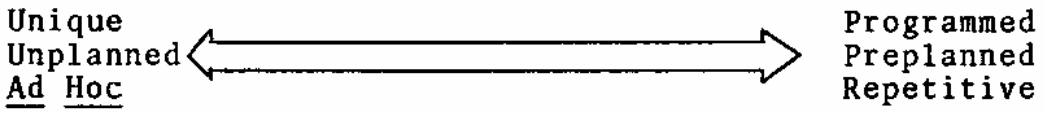


As each step or phase of the decision-making process is completed, movement occurs to the next phase. First, information is gathered concerning a particular situation. Then, alternative courses of action are determined, and there is a selection of the optimum alternative which is then implemented. Finally, more information is gathered to determine the effect of the decision which was selected. Additional information is also obtained as to changes in the situation; actions of opponents; changes in the issues, players, or stakes; and a further determination of alternatives is then made for the selection of a new optimum and the implementation of a new option. That is a continuous process which moves forward through time and is never ending.

The Spectrum of Decision Making. The decision-making process is a dynamic process of continuing activity. Decision making, however, is not restricted to that dynamic process, since there is also a process of decision making which might be considered static. Various processes of decision making can be identified along a spectrum between two extremes. Those extremes are

programmed decisions as opposed to unprogrammed decisions, or planned decisions as opposed to ad hoc decisions, or repetitive decisions as opposed to unique decisions.[1]

Figure 5.3: The Decision-Making Spectrum



If a particular decision must be made on a repeated basis, or if a decision must be made as a result of some future activity which can be anticipated, then it is possible to develop a decision prior to the event itself happening. Contingency plans are one example of this end of the decision-making spectrum. Given some set of conditions, it is possible to determine the action which should be taken as a result of those conditions. The decisions required can then be preplanned; upon the occurrence of the particular trigger mechanism or event, the decision can be implemented.

On the other end of the spectrum, situations may occur which have not been anticipated. In those cases, an unprogrammed, ad hoc, unique decision must be made. In that case, the elements of decision making would occur as the expanded dynamic process described earlier.

Decisions, then, can be made as a result either of preplanned activity for contingency, as a result of a unique, unprogrammed

or unplanned process reacting to some stimulus from a "breaking" situation, or as some mix of the two. The effect on the decision-making process of the availability of preprogrammed contingency plans is to reduce the time required to complete the decision-making task. In the case of contingency plans, all that is required of the decision maker is that he recognize some pattern which represents a situation which has already been evaluated, implement the preplanned decision, and then follow-up to determine that the results obtained were the results desired.

Unfortunately, it is extremely difficult, if not impossible, to anticipate all contingencies. Frequently, the anticipated scenario does not precisely (or even closely) match the actual situation. In such cases, the decision maker is forced to apply modifications to the preplanned decision or to revert to the basic decision-making process. Programmed decisions are best employed in the case of repetitive activities. In those cases in which a particular decision must be made on a repetitive basis, standard operating procedures can be established which provide the guidelines as to the proper decision given a particular set of circumstances. Anyone who has been involved with a bureaucracy, whether it be government or corporate, is well aware of the situation of repetitive decision making.

An interesting aspect of the decision-making spectrum is its relationship to the amount of time required between recognition of a situation requiring a decision and the implementation of that decision. As one moves toward the programmed extreme

of the spectrum, the time required to complete the decision-making process is reduced.

Time Constraints on Decision Making. We noted earlier that the decision-making process is a dynamic movement over time toward a particular goal which may itself shift as the iterations of the decision-making process continue. This process involves the repetitive cycling through the four phases of the decision-making process. There is rarely sufficient time to accomplish fully each phase of the process.

What does the real-world constraint of insufficient time do to the elements of decision making? During phase one, the information-gathering portion of the decision-making process, the presence of time constraints will cause a reduction in the search for information. The report of a study done by Sigfried and Susan Streufert at Pennsylvania State University included the following comments in its introduction:

> Unfortunately, decision makers are not always in possession of all relevant information that would be useful (or necessary) for a forthcoming complex decision. They may not even be aware of some informational dimensions that might optimally be considered. Further, obtaining additional information and differentiating/integrating that information requires time and may at times delay the decision point beyond acceptable limits. Often a decision-maker must consider the trade-off between engaging in more information search to obtain greater certainty or to include potentially more relevant information in complex decision making vs. the necessity to make decisions or to conclude plans "on time". . . . In addition, information search activities add to the workload of the decision maker and potentially reduce the amount of time available for planning and decision making per se.[2]

Without sufficient time, the decision maker will tend to stop early in the information-gathering process and will be unwilling to spend a great deal of time trying to add another small amount of information to the store already present. The time constraint will cause the perceived marginal value of additional information to become so small as to be negligible.

During the second phase, that of determination of alternatives, a time constraint will cause the elimination of the ideally exhaustive determination of available alternatives. Also, the decision maker will be strongly influenced to make the potential mistake of attempting to evaluate the alternatives during the determination phase. The first alternative which appears to be workable may be the one selected if time constraints are serious. The literature on management has described this phenomenon and introduced the concept of "satisficing". As Kast and Rosenzweig point out, "In this framework optimality is a utopian concept because of the lack of complete knowledge and a tendency for the decision-maker to test alternative solutions which are readily apparent. He does not attempt an exhaustive search and evaluation program."[3] Such behaviors do not necessarily portend disaster, as the authors go on to write that such a procedure "does not mean that decision-makers cannot approach optimality. On the contrary, most studies indicate that even in complex, dynamic situations, decision-making processes described by the open-system model will lead <u>toward</u> the best solution."[4]

In the third phase, that of the selection of the optimum alternative, there may be a reduction in the amount of time devoted to evaluation as a result of time constraints. The decision maker may fail to consider the consequences of all alternatives, and may then select those alternatives which appear at first blush to be adequate without considering the long term effects of such a selection.

Finally, the effects of time constraints upon the implementation of a decision will vary depending upon the type of decision to be implemented. If the decision is a simple "yes" or "no," then time constraints may have very little effect upon the successful implementation of that decision. If, however, the implementation of the decision requires a certain amount of preparation, or some other activity over time, then the decision may be rendered ineffective by the lack of sufficient time to implement it properly.

The effects of a time constraint upon the decision-making process seems self-evident. While there are other factors which impinge upon the decision-making process, the emphasis here will be upon that of time because time is the one factor which appears most strongly affected by the rapid change in the capabilities of the information transfer system and the information processing system.

The Velocity of Decision Making. There is indeed a velocity at which events move. That velocity of events may be low or it may be high or everything may be happening at once. Events may

be so slowly paced that the decision maker has a great deal of time to accomplish and complete the decision-making process, or he may have only an extremely brief period of time in order to make his decision. In any case, the decision maker must maintain the velocity of his decision making at or greater than the velocity of events.

Fishburn comments, "It might be argued that if sufficient time is set aside to attempt to spell out strategies, consequences, and perhaps states of the world, by the time that process is completed that decision is obsolete or no longer necessary."[5] The speed of decision making is even more important in the life and death struggle of war. General Starry, Commander-in-Chief of the US Readiness Command, wrote that a commander "needs to turn that information-decision cycle in time inside the enemy's information-decision cycle so that, instead of simply reacting to what the enemy does, he can seize the initiative."[6]

By definition, if the velocity of decision making is less than that of events, the situation will be "overtaken by events" and the decision will have been made tacitly, if not overtly, to take no action. If the velocity of events is faster than that velocity required by a complete and exhaustive use of all of the phases of the decision-making process, then it will be necessary to increase the speed of the decision-making process until it is greater than that of the situation. Various means exist to increase that speed.

As mentioned above in discussing the effects of time constraints on decision making, conscious or unconscious efforts may be made to limit the search for information, to reduce the number of alternatives, and to reduce the amount of evaluation conducted to determine the optimum alternative. The velocity of decision making, however, can be increased only so far--eventually an upper limit is reached beyond which that velocity cannot be increased. One can consider the spectrum of decision making mentioned earlier, and relate the means to increase velocity to a movement along that spectrum from the extreme of unprogrammed, ad hoc decision making to the extreme of preplanned, repetitive decision making.

Compunications Effects. One factor we have not yet considered, and which is of critical importance, is the amount of "dead time" which is built into a decision-making process. For instance, during the information-gathering phase, there exists a certain amount of time between the request for information of a specific nature and its receipt by the requestor. This time relates primarily to the speed of the information-transfer system, but is also related to the information-processing system. The more quickly one can communicate with the individual holding the information and the more rapidly large amounts of data can be manipulated to obtain the desired information, the faster the decision-making process itself will be. The development of an appropriate search strategy to find the required information is a critical part of the information-gathering

phase--either in the search of secondary-source information already stored in some location (library, computer, or people's memories) or (less often) in primary research.

The second phase, that of determination of alternatives, is not so seriously affected by compunications as are the other phases, but benefits can be found there as well. Computer graphics capabilities are improving greatly and are frequently used to present numerical data in a more understandable form than that of columns of figures.

The information-processing system comes into its own in the third phase. The determination of the optimum alternative is ideally suited to the use of modern computational equipment, especially when quantitative factors are important. Whole disciplines have grown over the past decades to assist managers in the selection of the optimum alternative, and Operations Analysis is a respected area of scholarly and practical interest. Many, if not most, of the management science techniques from operations research depend upon the data-manipulation (or "number-crunching") capability of high speed data processing machines to produce results (and upon data that are not always worth crunching).

Finally, the implementation of the chosen option can be accomplished only if the particular decision can be communicated to the action agency. Again, the information transfer system is of critical importance during this phase.

Any increase in speed, capacity, and reliability of the information transfer system and the information processing system is of vital importance to the reduction in time required for decision making.

CHAPTER SIX: MICROMANAGEMENT AND SKIP-ECHELON

The tremendous increase in the capability of compunications technology has provided the capacity for accentuating two management/leadership behaviors which had existed in the past in less dramatic forms. These behaviors have been called micromanagement and skip-echelon. Micromanagement is a behavior most often found during times of "normal" operations, while skip-echelon is a behavior most often found during a "crisis" situation. In both cases, responsibilities usually performed by one level in the organization are preempted by a higher level. Naturally, the relative "good" or "evil" associated with these behaviors is strongly dependent on the situation in which they arise and on the location within the hierarchy of the individual making the determination. The first part of this chapter will address the behavior called micromanagement, while the second will address skip-echelon.

Micromanagement. Lower levels in a hierarchy have applied the term micromanagement to reflect the detailed direction of "operational" activities by those who are "supposed" to be the higher level policymakers. It is the opposite of "macromanagement" --that behavior in which policy and guidance come from above while the lower levels are left to make the operational decisions on their own. The origin of the term micromanagement is unclear,

but it apparently came into popular use in the United States Department of Defense. At first, the Military Service staffs used the term in references to actions taken by personnel in the Office of the Secretary of Defense (OSD). Recently (and ironically), the level of concern has shifted to the point that some OSD personnel have accused staff members of certain Congressional committees of "micromanaging" various defense programs.

In his Report to the Secretary of Defense, Steadman wrote that "Washington certainly was too deeply involved in the details of actually running the war, particularly the air war in the north."[1] He was, of course, referring to criticisms of the operation of the Department of Defense during the VietNam War. During a seminar on Command, Control, Communications, and Intelligence (C^3I), Rose commented in the spring of 1981:

> Last month, during a hearing on the intelligence community budget in Washington, a visual appeared on the screen identifying a few million dollars in support to provide that same capability to the Rapid Deployment Joint Task Force. When I inquired of the general who was testifying why this item was in the budget when the people down at McDill [Air Force Base, Florida] had indicated to me only a few weeks earlier that they didn't need it, the general responded, "They may not think they need it, but we feel they do." In other words, "They don't know what they need." One would expect in an ideal world that requirements would start from the bottom and work up, but in Washington there's a syndrome that drives requirements from the top. "We've got it, and by God somebody is going to use it," is sometimes the attitude--and we could also talk about vendor-generated needs that crop up.[2]

The tendency toward micromanagement of the Defense Department by congressional committees, particularly evident during the budget process, may be the natural outgrowth of two separate

tendencies. The increase in congressional staff size requires some activity for staff members to perform. There is a natural tendency to fill that void with more activity, and that activity must, of course, appear substantive in order to justify the large numbers of people. The second tendency may have been the growth of the challenge to "tell us where to cut" on the part of the Defense Department itself when told to cut the size of the budget. Such a challenge is frequently made in an effort to get the opponent to acquiesce for lack of the capability to respond. Unfortunately for the budgeteers in Defense, the Congress took up that challenge and now tells the department precisely which line items of the budget to cut and by how much. Such activity, however, is not restricted to the Department of Defense. Reports of activities within the Department of Defense (and the government in general) are more readily available, and are published more frequently, than are the activities which occur behind the closed doors of corporate board rooms. It is unlikely, though, that corporate behavior has been any different from that which is observed in the public sector.

Nor is it safe to assume that micromanagement is a recent phenomenon. While it may not have been called by that term, the behavior is a fixture in history. In a study of the Spanish Armada, Holworth wrote that King Philip of Spain was primarily at fault for many of the problems which existed in the Armada. He said that those problems were caused by the King's attempt to plan and direct from his palace in Spain not only the grand

strategy, but also even the smallest details of supplies, discipline, and tactical procedures.[3]

During a seminar on C^3I issues, Odom made the following comments which apply equally to the behaviors of micromanagement and skip-echelon:

> I don't accept the notion that because you have a general staff there is nothing left for the CINC to do, or that because you have some command and control from the center you can micro-manage everything, or make all the intermediate command levels irrelevant. There is going to be a certain amount of trauma. There is no way to run these operations without making people mad. And every commander is going to feel he has been abused and his prerogatives have been overridden--and that is something you just have to accept.[4]

Micromanagement is, of course, a form of highly centralized decision making. Although it can exist without the benefits of high speed data processing and rapid secure communications, the practice of micromanagement is made much easier by the improvements in compunications technology.

Skip-Echelon. Micromanagement can be thought of as the detailed involvement of one level with the level immediately below it in the hierarchy. Skip-echelon, on the other hand, refers to the phenomenon of personnel on one level being involved in detailed decision making several levels below. In a speech, Capone commented:

> It is the senior's urgent desire to discover first hand what is going on that leads to "skip-echelon" communications. We may deplore "skip-echelon" but the fact is it happens--and in crisis, it happens quicker. When the potential outcome of an incident may be the ultimate direct confrontation of the US and the USSR and the possibility of escalation to nuclear war, then the tendency to skip-echelon increases exponentially.[5]

This capability to skip from the highest echelon to the lowest was described by Leney when he discussed the control of nuclear weapons by the United States. He referred to that system when he wrote:

> This chain of communications bypasses the unified and specified commanders, and could bypass all levels between the chairman [of the Joint Chiefs of Staff] and the captain of a missile submarine, or an ICBM squadron. With the current communications capabilities available to the President it is possible for the NCA [National Command Authorities] to bypass the entire military chain of command (as has been done in periods of crisis).[6]

The tendency to exercise skip-echelon has increased with the increased availability of rapid update of computer data bases and high-volume, real-time, secure communications. Rather than be solely concerned that such a capability will lead to abuse, one should also consider the great potential that such a capability provides for rapid, accurate response to critical situations.

In a seminar discussing just that potential, Oettinger said that two significant principles cover all the compunications systems in the executive branch of the government. He listed those two principles as:

> 1. the chief's principle: direct access to and control and supervision of all systems;
>
> 2. the Indian's principle: unfettered access by all hierarchies to all systems.[7]

He went on to argue that

> "the first principle increases the practical ability of a President and other chiefs to choose what information to receive themselves and what information to have their subordinates receive. It allows them to zoom at the most knowledgeable people and the most

> relevant data wherever in the hierarchy or world they may be. . . . The second principle puts analysts and experts in constant touch and interchange with people and data elsewhere in their own and other hierarchies, without altering their responsibility and the focus of their attention. They are given unlimited peripheral vision and the means to avail themselves of relevant expertise or data irrespective of the location."[8]

Summarizing his argument, Oettinger wrote:

> Clearly, the opening of information lines up, down and across would legitimize a leaping over organizational boundaries that, while essential for real accomplishment, is done nowadays only at official risk and peril. Organization lines reflect lines of authority, but while knowledge is power, the gathering of information is not the exercise of authority. It therefore seems perfectly proper for a manager to leap several levels down in search of answers, or for a subordinate to leap across organizational lines and occasionally over his boss' head so long as decisions and orders travel by normal channels.[9]

Simon may have been referring to this capability when he wrote that "as the costs of long-distance communication go down and the volume of information that can be transmitted increases, the opportunities for low-level inputs to high-level decisions are greatly enhanced. As I have already shown, this is a force toward greater decentralization."[10] He goes on to write, "With all sorts of organizational and extra-organizational sources providing inputs, the locus of decision making becomes even more diffuse than it has been in the past."[11]

Naturally, all is not sweetness and light for this new capability. There are many problems associated with its use. Again discussing the military command, control, and communications system, Leney wrote, "Currently, the President gets directly involved in relatively small military operations. Should a

major war break out, with many operations being conducted simultaneouslv, he could no longer deal with them all. If his subordinates are not trained and experienced at making independent judgments, then there could be problems."[12] Besides being a masterpiece of understatement, that comment contains a great deal of truth. Bryant, Trinnaman, and Staudenmaier wrote that

> the basic security interests of the United States require that command and control be exercised from the highest levels to insure that international crises do not escalate uncontrollably in the nuclear era. At the same time, the possibility of simultaneous crises overloading the centralized decisionmaking authority requires the continued existence of decentralized commands.[13]

Finally, Ganley and Ganley asked the question: "And what is the real price in terms of readiness and morale of area commanders of being short circuited by the President or the Pentagon? The day will doubtless arrive when several flashpoints will occur simultaneously, and it will not be practical to conduct operations from Washington."[14] That is, of course, assuming that Washington still exists and that the compunications system is still functional.

Other problems are associated with the skipping of intermediate levels. There are the loss of the use of the expertise which resides on those levels and the failure to maintain their currency in the situation as it unfolds. In addition, there is the natural human resentment of being bypassed. In writing a criticism of a book reviewing the situation of the United States Army during the Vietnam era, Gropman wrote that "The author

contends that the politicians bear no responsibility, asserting that the military has hidden for too long behind a claim of 'political softness'. But that is not the major military complaint: it is, rather, political control down to the tactical level."[15] As Keegan wrote, "The power of tactical decision has now moved back from military headquarters into the Kremlin or the White House, and now rests in the same hands, will indeed be exercised in the rooms where the power of strategic decision has always centered."[16]

But the difficulty does not stop there. Ganley and Ganley wrote:

> While C^3I is an integral part of nuclear crisis management it is, fortunately, used more frequently for various less dramatic present day international crises. Such crises have historically had a way of getting out of hand, which can no longer be tolerated in a nuclear age. So, now that we have such sophisticated communications means in place, decisions are rarely left to the discretion of the regional or local commander. Shortly after an alert, the President, or the Secretary of Defense, personally takes control of the situation.[17]

Perhaps a more informal version was discussed during a seminar, when Snodgrass commented:

> After all, many military commanders think the worse thing that ever happened was the establishment of the national military command center in the Pentagon, which in essence wires up the whole world, real-time, secure voice. They have been delighted that it has taken so long and has been so inefficient and didn't work because, again, what fun is it to be a four-star general, head of CINCPAC, if any time a real war starts Lyndon Johnson goes over the bombing list every night and tells you what you can or can't bomb? You didn't go to West Point 25 years ago and train your whole professional life to have somebody look over your shoulder. So C^3 is impinging on the relationship of

> field commanders to the National Command Authority in ways that were never possible before. And you can find very respectable military opinion which says that the Iranian raid failed because the commander is so busy looking back over his shoulder and talking to Washington under the spotlight that he isn't able to take the chances he needs to take.[18]

Perhaps the best summary of the difficulties associated with skip-echelon was made in a letter to the editor of the Air Force magazine:

> As C^3 technology improves, it may become more of a curse than a blessing. Even under the best conditions, there is no substitute for choosing good personnel for the job, then standing back and letting them do it.
>
> C^3 conjures visions of a football coach who not only tries to call all of the plays, but also installs earphones in each player's helmet to direct them each step of the way. If that weren't bad enough, imagine how players trained that way will perform when the coach's plug is pulled.
>
> Merely having C^3 capability is an almost irresistible temptation for rear echelon commanders. Imagine you are at home watching the Super Bowl with a direct line to your favorite quarterback's helmet. Could you resist?[19]

CHAPTER SEVEN: PART OF THE SOLUTION

One of the more common clichés used to motivate problem solving is the adage "If you are not part of the solution, then you are part of the problem." Without commenting on the logic of such a statement, we can use the expression to approach our main topic of interest. While compunications may be part of the problem as discussed in Chapter Six, it is definitely part of the solution as shown in Chapter Five. In this complex world, no simple answers are to be trusted.

Compunications does give the central headquarters a tremendous ability to involve itself in as much low-level decision making as it might want, but the limits of the human capacity for information processing will generally define the boundaries of practical centralized decision making. Perhaps the best argument for decentralization is that it limits the ability to control the flow of information. A recent report by the Carnegie Foundation for the Advancement of Teaching concluded that, unless changes are made in the educational system, Americans may find themselves drifting into "a new kind of dark age--a time when small cadres of specialists will control knowledge and thus control the decision-making process."[1] Although the report was concerned that a new priesthood of literati would develop and take advantage of the general population's inability

to interpret available information, the same result will obtain if information itself is controlled.

Totalitarians, both in the public sector and in the private, have known that the control of information is basic to the control of people. The dramatic improvements in compunications technology have made that control both easier and more difficult: Easier in the sense that the flow can be interrupted faster and more completely (as, for example, in Poland late in 1981) or more difficult in the sense that disruptions hurt the disruptor more than the disruptee (as, for example, in Iran when the Shah's government was unwilling to interrupt the telecommunications network to prevent rebel long-distance telephone calls).

Chapter Five discussed the capability of modern compunications to reduce the time required to obtain and process information, and how that capability can improve the decision-making process. Such a reduction in the time required will affect the centralization or decentralization of decision making only if time constraints had contributed to a dislocation in the preferred organizational locus (established by the "ideal" forces described in Chapters Two and Three) in the same manner as the "real world" forces described in Chapter Four. If the speed of events is greater than that of a centralized decision-making process, the decision making must be decentralized. Compunications can change that situation by increasing the speed of centralized decision making. It will remove an obstacle to centralized decision

making; it will not, of itself, cause centralized decision making (or decentralized decision making, for that matter).

In Chapter Six, we discussed two "abuses" of the decision-making process which compunications technology has made simpler to achieve than in the past. Excellent reasons can be found on both sides of the argument to justify whichever point of view one might hold. However, whatever problems compunications technology has allowed to develop can also be solved by the appropriate use of compunications technology. As one small example, the difficulties of skip-echelon can be eliminated to a large extent by a system used by many large organizations. When echelons are bypassed, information copies of the messages can be sent to all intermediate levels to keep them informed. If the bypass is oral, rather than written, the intermediate levels are added to the communications net and maintain silence unless there is a disagreement. Such a system was used by the author in obtaining clearances for airstrikes during the Vietnam War. The request was made directly to the level with the authority to grant the strike while the intermediate levels monitored the transmission and could interrupt if necessary. While such a "teleconference" does not quite fit the definition one usually expects, it is an effective means of providing fast response without losing the intermediate levels' expertise.

Compunications technology represents a capability--no more and no less. It is a tool which can be used with all of the other tools man has developed for whatever purposes the wielder

of the tools may entertain, either for good or for ill. The rapid growth in the amount and the capability of compunications technology will affect the centralization or decentralization in the same manner as all of the other factors--through the interaction of all the forces involved. Its effect will be more noticeable only because its rate of growth and change is so much greater. It is still the manager/leader who must finally determine the appropriate locus of decision making. That responsibility cannot be delegated to a machine or a process. They can only aid and assist in what must be a conscious, human decision.

NOTES

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11. Ibid.

12. Ibid., p. 12. It is interesting to note that the subsets mentioned in the quotation refer to the theory of combinations. The total number of combinations C of N things taken P at a time is given by the formula:

$$C = (N!) \div ((P!)(N-P)!)$$

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PART TWO: The Compunications Connection

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2. An elementary discussion of the decision-making process in included in Appendix Two.

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APPENDIX ONE

A Brief Historical Overview of Compunications

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INTRODUCTION

Compunications is a term coined to reflect the convergence in the technologies of computers and communications. Both technologies have a lengthy history and have been developing separately until recent times. For the purposes of our historical journey, communications can be thought of as "information transfer systems" and computers can be thought of as "information processing systems." In both of these systems, two factors are of vital importance: speed and capacity.

Perhaps most interesting in this historical journey is the realization that in both information transfer systems and information processing systems, change has not come at a steady pace. Throughout two millenia and more of human recorded history, both of these systems have remained at a relatively stable level of speed and capacity. Only in the past century have both increased their capabilities dramatically. Indeed, many of the current works by sociologists, futurologists, and the like have been based on this dramatic and recent change in growth rate. In the first section of this appendix, we will look at the changes in the information transfer system, or the communications half of our compunications combination.

THE INFORMATION TRANSFER SYSTEM

Table 1 lists some of the mechanisms of information transfer for an overview of their maximum speeds.

Table 1: Information Transfer Mechanism Speeds

670,000,000 mph	Electronic (telegraph, telephone, radio)
670,000,000 mph	Visual (semaphore, bonfires, smoke signals)
660 mph	Sonic (drums, horns, whistles)
100-600 mph	Aircraft
60 mph	Carrier Pigeon
30-60 mph	Vehicle (motorcycle, automobile, truck, railroad)
15-30 mph	Ship
9 mph	Horse (postrider, coach)
6 mph	Man

We have runners today who can complete a mile in less than four minutes, a speed of approximately 15 miles per hour. Marathon runners can sustain a slower speed for greater distances.

The use of a horse, either by a single rider or through coach service, can increase the speed of transmission by about 50 percent. A horse will typically canter at a speed of around 12 to 14 miles per hour and, as in the case of humans, a horse can maintain a canter much longer than it can maintain the faster gallop.

The fastest living mechanism used regularly to transfer information is the carrier pigeon which can travel at about 60 miles per hour, although it has been clocked at speeds in excess of 90 miles per hour.

The development of internal combustion engines in the last century has introduced mechanical devices to increase the mechanism speed to some degree. Railroads provided an early and rapid increase in the speed of information transfer between those locales which were served by railroads. Later, trucking and air transport systems were developed to make use of the wider network of roads and the much faster speed of aircraft.

Messages which need not be hand-carried (or talon-carried in the case of the carrier pigeons) can be transmitted over long distances at sonic or light speeds by relatively primitive systems, some of which are listed in Table 2.

Even though each of the mechanisms in Table 1 has a given speed of propagation, message transmission will rarely match that speed for two reasons. First, most mechanism speeds cannot be sustained over great distances and will, therefore, require relay; and second, network economics require batching and switching.

The use of relays is required in most systems involving the mechanisms listed in Table 1. For instance, although long distance runners can maintain a high rate of speed for a relatively long distance, eventually they will tire and must be replaced by other runners in relays if the message must be carried very far. The same is true of the horse, either when used by a

Table 2: Information Transfer Systems

500 BC	Persian Empire	postrider	9 mph
0-500 AD	Roman Empire	postrider	9+ mph
1305-early 1800s AD	von Taxis (Europe)	coach	4 mph (summer) 3.5 mph (winter)
early 1500s AD	Aztec Empire	runner	11 mph
late 1500s AD	Elizabethan England	coach	7 mph (summer) 5 mph (winter)
1627 AD	d'Medici (Florence-Rome)	semaphore	
late 1700s AD	British Postal Service	coach	9 mph
1800 AD	French Empire	tachygraphe	120 mph
1860 AD	United States	postrider	8.6 mph
1850 AD	United States	telegraph	670,000,000 mph (between telegraphers)
1900 AD	United States	telephone	670,000,000 mph

postrider or when used with coaches. In both cases, a system of relays must be devised to replace the tired animal with a fresh one.

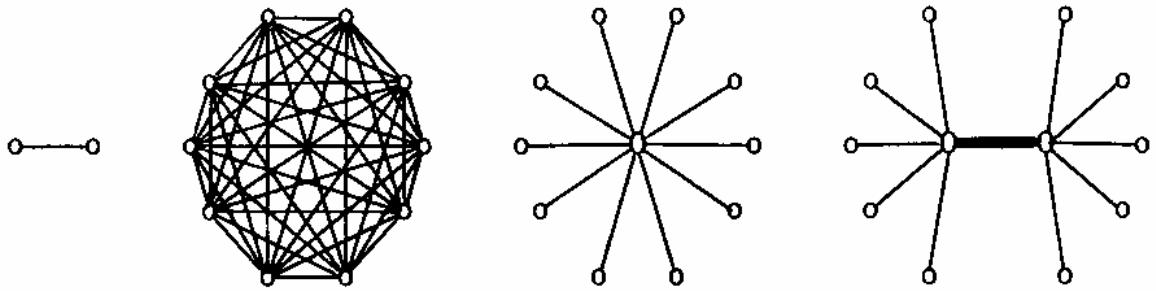
Even when one moves into mechanical or electronic mechanisms for information transfer, similar difficulties arise which require the use of relays. In the case of vehicles, fuel tanks must be refilled and drivers must be replaced, while in the case of other mechanisms, such as sonic or visual or electronic, the signal itself must be reinforced. Distance and atmospheric

disturbances will attenuate sound and may render visual signals unreadable, and noise will obscure the electronic signal unless it is periodically boosted at relay stations.

Even radio can sometimes require relay. The higher frequencies of radio are subject to line-of-sight problems in that their beams are so powerful that the Earth's magnetic field cannot bend them, nor will they be reflected by the ionosphere or the Earth's surface. If the receiving station is below the curvature of the Earth, then higher frequency radios require intermediate relays to complete the message transfer. It is true that lower frequency radios are capable, in some cases, of global range. We are all familiar with short wave radio, and most of us are aware that high frequency radio (HF) is one of the primary communications systems in the less developed countries. While useful, these systems are still subject to limitations of capacity and reliability which prevent them from assuming the role of the perfect information transfer mechanism.

The second problem is that of network economics. Figure 1 provides a quick overview of the difficulties associated with networking and their solutions. Figure 1A shows a network with two termination points. The system provides for communication between two points, and these two points are connected by one information transfer mechanism. Once we exceed two points, however, as in Figure 1B, a complexity develops which causes significant problems in economy. If each of the ten points shown in Figure 1B connects to each of the other nine, the number

Figure 1: Information Transfer Networks



A B C D

of single connections becomes quite large. Mathematical formulae can provide a precise number for these interconnections and show us that numbers of paths increase very rapidly as the numbers of termination points increase.

One solution to this difficulty is shown in Figure 1C. Figure 1C is a network in which one central switching facility is connected to each of the termination points. Any particular termination point which wanted to reach one of the other termination points would connect first with the switching facility and then through it to the desired termination point. By adding the one switching center shown in Figure 1C, we drop the number of interconnections to the total number of termination points. Figure 1D is a modification of the star network shown in Figure 1C, and could be used in a situation where switching centers were incapable of handling the total number of termination points or where distance considerations make a single trunk between two (or more) switches the less expensive alternative. By splitting

the total number into smaller and more workable networks with their own switching centers, and then connecting the switching centers together, one can devise a network at minimum cost which will provide the same or better service than that provided by the complex system shown in Figure 1B.

Table 2 (page A1-5) shows some of the systems which have been used for the transfer of information--the point being that system speeds are indeed slower than the maximum mechanism speeds, and that system speeds have not changed greatly until the past century.

Herodotus tells us that the Persian Empire maintained a system in 500 B.C. which could sustain a rate of approximately nine miles per hour. His description of that system has been used many times and, in fact, a part of it has been taken by the United States Postal Service as its unofficial motto. Herodotus wrote:

> Nothing mortal travels so fast as these Persian messengers. The entire plan is a Persian invention; and this is the method of it. Along a whole line of road there are men (they say) stationed with horses, in number equal to the number of days which the journey takes, allowing a man and horse to each day; and these men will not be hindered from accomplishing at their best speed the distance which they have to go, either by snow, or rain, or heat, or by the darkness of night. The first rider delivers his dispatch to the second, and the second passes it to the third; and so it is borne from hand to hand along the whole line, like the light in the torch race, which the Greeks celebrate to Vulcan. The Persians give the riding post in this manner, the name of "Angarum".[1]

Little changed in the days of the Roman Empire half a millenium later, although the Romans being Romans, they did

claim that their service was slightly faster than that of the Persians. During the Dark Ages, large systems of information transfer were not possible in Europe. Personal couriers or wandering minstrels provided oral history and news transfer. A thousand years later, approximately 1500 A.D., the von Taxis family of Germany (known as Tasso in Italy) "operated its huge postal system throughout part of Europe with varying degrees of fortune for more than four hundred years."[2]

The von Taxis organization, however, did not do as well as the Romans and the Persians 1500 years earlier, in that the standard information transfer speed was four miles per hour in summer and only three and a half miles per hour in winter.[3]

At about the same time, across the Channel in England, rules were established requiring that "postriders must travel at seven miles per hour in summer and five in winter, and some two hundred years later the mail was moving no faster. In fact, at the close of the seventeenth century the mails were estimated to be traveling on the average at the rate of five miles an hour."[4]

Fuller tells the story of information transfer through land mechanisms when he writes:

> About 500 B.C. Persian postriders were carrying messages a distance of fifteen hundred miles in little more than seven days. In 1861, 2,361 years later, the famous Pony Express riders in the United States carried President Abraham Lincoln's first inaugural address sixteen hundred miles in seven days and eighteen hours. And aside from its express service, the fastest the British Postal Service was able to transport the mails by the late eighteenth century, even with the careful planning that went into developing

John Palmer's stagecoach service, was about nine miles an hour.[5]

The foregoing has been a discussion of information transfer through the use of systems employing land travel mechanisms. There are, of course, two other mechanisms which could be (and were) used. Ever since the early sixteenth century, European nations had colonies overseas which required communication. Efforts were made even in antiquity to maintain communications with areas separated by large bodies of water. Typically, methods used to maintain communications systems were based upon water travel mechanisms which were erratic and unreliable at best. The usual procedure was to give the message to a ship's captain who might be going in the proper direction and hope that someday it would get to the addressee. Trans-Atlantic communications did not develop into a systematic and reliable process until the Black Ball Line initiated its regular packet service between New York and Liverpool in 1818. "They carried both passengers and light, valuable freight, but the most remarkable thing about them was that they sailed on schedule with or without full cargoes, in fair weather or foul, in summer or winter."[6]

The use of an air mechanism to establish an information transfer system was first recorded in 40 B.C. when Brutus used carrier pigeons during the seige of Madeira. Throughout history and down to the present day, carrier pigeons have been used to good effect in providing fast and generally reliable communications.

"In 1150 A.D. the Sultan of Baghdad established a pigeon postal service."[7] The brothers Rothschild maintained a highly sophisticated communications system begun in 1804 to maintain their financial empire.[8] Wellington used carrier pigeons at Waterloo in 1815, and the first news of Napoleon's defeat was brought to England by carrier pigeon.[9] "Pigeon mail carriers were extensively used in the French Revolution of 1848, and homing pigeons were still in service in World War II on a standby basis in case of electronic communications failure."[10]

Indeed, carrier pigeons were used during both World Wars I and II, and they are still used today by the military forces of Switzerland. "Much time, for example, is devoted to training carrier pigeons (this is not silly: pigeons are radar-proof and their wavelengths cannot be jammed)."[11]

Even modern day journalists have used the birds. In 1979, when guerrilla formations were assembling on the eve of the cease fire in Rhodesia, the British Broadcasting Corporation reported that "Journalists covering a remote Patriotic Front assembly point in Matabeleland have acquired 10 carrier pigeons to get their copy back to base. There are no telephone links at the four assembly points in Matabeleland, and the journalists have been told by military experts that the roads may be mined by the patriotic front."[12]

Before we cease our discussion of speed as a factor in an information transfer system, it might be worthwhile to recall some instance in which speed was of critical importance. Speed

has been one of the primary emphases of information transfer systems, and the comments by Fuller with regard to the American Postal System are just as true of other systems. About the efforts in the United States to improve the speed of the postal system, Fuller writes:

> It had always been a rule of the Post Office that intelligence, as they called it, should never travel faster than the mails. The reason for this was simple. In the slow moving world Americans inhabited in the early nineteenth century, news was golden to anyone who could get it ahead of the mails that gave it to everyone. Word of trouble in Europe obtained before it became common knowledge, or even the weather in Alabama, might be enough to give a cotton speculator all he needed to know to make a fortune in the cotton market. To prevent such speculation, and to give everyone the same information at the same time, the mails had to travel as fast as man, and the Post Office Department through the years had gone to great expense to see that private messengers did not outrun the mails.[13]

This was not the first time that the speed of the mails or of information transmission had effects far beyond what might be expected. "The foundation of the Rothschild fortune was advance information by carrier pigeon of the defeat of Napoleon at Waterloo, so that the Rothschilds could make quicker stock market decisions."[14]

When ships brought news from Europe to the colonies, and later to the United States, they would typically land first in Newfoundland at Halifax. Certain private merchants would insure that any news from Europe would be sent to them over land so as to arrive before the ship itself reached the more southern ports. The same problem existed between various cities in the United States.

> Postmaster General McLean had become sensitive to this problem in the 1820s when the importance of rapid communication between the great cotton market at New Orleans and the money market in New York became apparent. . . . so great was the need for speed on certain routes around the country that Congress authorized the postmaster general to use pony expresses in 1836, years before the famous Pony Express from Saint Joseph, Missouri, to Sacramento had been thought of.[15]

The capacity of the information transfer system is as important as is its speed. How, then, has the capacity of information transfer systems changed over time? In early days, messages were sent from one individual to another over distances by the use of an intermediary. That intermediary would memorize the message to be sent, proceed to the receiving individual, and then speak back the message. The capacity of such a system was limited to the capability of the transmitting individual to memorize the message to be transmitted. In some cases, individuals specially skilled in memorization could deliver messages of great length and complexity. Typically, though, the message would be short and uncomplicated in order to prevent possible distortion by the intermediary.

Pelton has written that "The most important breakthroughs of the ancient world in the field of communications were the dual invention of written language and numbering systems."[16] The development of a written language enabled the communicator to put his thoughts precisely on a piece of paper or parchment and have the messenger transmit the document to the receiver. This system had a concurrent benefit in that it was no longer necessary for the intermediary to know the message.

Just as there were no significant changes over history in the mechanisms for transmitting the message, the capacity available did not greatly change either. In general, high capacity remained the province of the physically transmitted, written message for most of our history. There were, however, certain systems using auditory or visual signalling devices which could transmit messages of varying complexity. For example, armies in battle would frequently carry a unit flag (or device or totem) which identified their unit--not so much for unit esprit or morale (although that purpose was also served), but to enable the general commanding the army to know the location and activities of specific units. In fact, our own American history provides an excellent example of the importance of flags, although other examples abound throughout history.

> The first recipient of two Medals of Honor received both for what today could be cited as "denying a large and well-equipped enemy force of its effective means of command and control." That is not what his citations say, but it is what US Army Captain Thomas W. Custer did to receive his two medals: He captured two Confederate battle flags during the [War Between the States].[17]

The large and very loud horns used by Vikings to signal the return of ships, Alpine horns and conch shells used for similar signalling in the mountains of Southern Europe and in the South Seas, as well as bonfires used in all parts of the world, are examples of signals which rapidly conveyed a minimal amount of information. Other systems could be more complicated. For instance, African drums have been used throughout history to transmit messages which can be quite complex. That fact was

recognized by early slave holders in the American South, and recognized to the point that laws were made forbidding the use of drums:

> African drum music was an effective means of long-distance communication. For one thing, it was far more complex in its rhythms and structures than Western music and thus difficult for whites to understand. For another, drums could approximate the tones and pitch of human speech, so slaves were actually able to "talk" to each other and thus convey intricate messages--not just code-like signals.[18]

The system of smoke signals used by the American Indian was another information transfer system of limited capacity but great speed and range with appropriate relay, as is the semaphore. Semaphores are specialized flags which have been used for many years. In 1627, Carmine d'Medici of Italy established a telecommunications system using men on towers holding semaphore flags.[19]

Not to be outdone, the French promptly (165 years later) devised a mechanical system:

> The semaphore was first introduced by Claude Chappe, who installed twenty-two stations between Lille and Paris in 1792, capable of transmitting letters and words by means of three moveable arms on a vertical pole. This "Tachygraphe" as Chappe named it, later "Telegraph", was adopted by the French army at the instigation of Lazare Carnot, whose chain of stations linking Paris with the Rhine frontier transmitted the news of the capture of Condė in 1793 in twenty minutes. . . . In good weather messages could travel at an astonishing 120 miles per hour.[20]

Apparently, it was a characteristic of the more rapid signalling systems using flags, drums, smoke signals, or whatever, that they were of lower capacity than the message-handling systems which traveled over land. The speed at which these systems

could move, however, was generally greater; and since speed was of vital importance in many cases, capacity was sacrificed for speed. This trade-off seems to be a common occurrance.

The capacity of information transfer systems has improved as dramatically in the past century as has their speed. Figure 2 (next page) shows the sequence of inventions in telecommunications since the 1840s.

The first telegraph implemented in 1845 could transmit an extremely limited amount of information because the coding system had not been developed which was used to great effect in the last half of the nineteenth century. Once the code named for Samuel B. Morse was instituted, the transmission rate of messages increased by about three times. Later, in the early 1900s, telex was developed to send messages which could be printed out on the receiving end, no longer requiring the human operator to encode on one end and decode on the other. The telex, or teletype, requires a frequency band width of 170 Hertz (Hz). Voice quality channels require a frequency space of four thousand Hertz, and television requires four million Hertz.[21]

A coaxial cable can carry as many as 80 television channels using frequency division multiplexing or as many as 80,000 simultaneous conversations.[22] The capacity of electronic information transfer systems is very great, and might seem to be unlimited when considered for use only for transmission of voice or pictures. As we will see in the next section, however, the amount of data transmitted between computers is enormous and growing so that

Figure 2: Capacity of Information Transfer Systems

Source: Martin, James. Telecommunications and the Computer, 2nd Ed. (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1976), p. 7.

channel capacity is not unlimited, but it is still clearly much greater than that which was available a hundred years ago--and throughout recorded history.

The examination of an information transfer system would not be complete without one other comment. Speed and capacity can mean little if there is no reliable delivery of the message through loss, theft, misrouting, or distortion.

Typically, the life of an aide-de-camp in early armies was brief. These men were used to transmit the general's orders to the various units on the field, and, since this fact was well known to the opposing army, the aide-de-camp did not last long. Carrier pigeons, when used to transmit messages, would also frequently be lost. Through the vagaries of storm or hawk, the pigeon and its message would not arrive at the desired location. Any time a message had to be physically moved from one point to another, the danger existed that the message would be lost or misrouted (whether intentionally or unintentionally). As a result, redundancy was a common practice to insure that important messages were received by the intended recipient. Even that practice, however, had its pitfalls. An example from the Napoleonic campaigns provides a graphic indication of such problems. Haythornthwaite writes:

> In April 1809 Napoleon dispatched a message to Berthier by telegraph, following it with a qualifying message half an hour later by courier. The telegraph message, delayed by bad weather, took six days to arrive; Berthier received the horse-borne second message two and a half days before the first, and acted upon it, with consequences which could have been tactically catastrophic.[23]

The telegraph referred to in the above quotation, of course, is the tachygraphe described earlier. Physical restrictions on the more rapid signalling devices as in smoke signals, drum signals, or semaphore signals, generally caused delays in transmission time. The problems in reliability, however, were generally those caused by the human element. When a message had to be physically carried from one point to another, it was subject to all the difficulties of transporting a valuable commodity across the countryside. Not only were there the problems associated with the difficulties of cross-country travel, but also there were those who were interested in the message itself.

The history of communications is also the history of government control of communications. As Fuller notes, "Organized postal systems sprang not from the desire of separated friends to communicate with one another, but from the needs of leaders of government. For in the ancient world--where postal services originated--no less than in the modern, the control of communication and the control of government went hand in hand."[24]

Control of the means of transmission was just one step away from the examination of the messages transmitted. One brief example will suffice: "Under Charles II government officials opened and resealed suspicious-looking letters and made this practice a fine art when one of the king's postal agents built a miraculous machine that could break a letter's seal so keenly that it could not be detected."[25]

Many are the stories told of messages mislaid, or waylaid, which had consequences far reaching in their effects. With the development of electronic information transfer systems, speed was dramatically increased, since human relays were not needed, and message handling was reduced to that minimum required at either end of the transmission link.

THE INFORMATION PROCESSING SYSTEM

Information processing systems, or computers, have been in use for millenia. One of the earliest recorded examples of a sophisticated information processing system was a table of charts detailing the motions of the planet Venus used by the Babylonians in 1921 B.C. Other devices for the processing of information would be maps, clocks, calendars, and calculating machines.[26]

One of the earliest calculating machines known is the abacus, of which Postley wrote in 1960:

> Today this computing device remains the most widely used, although its use is confined mostly to the Orient and to the Middle East. It is commonly used there in even the most modern business establishments, and the clicking sound of the beads in use is common in a business office in Tokyo or Hong Kong. The abacus has been shown repeatedly to be equivalent to a modern electro-mechanical desk calculator in speed and flexibility, although its operation is considerably less automatic and therefore far more dependent upon the skill of the operator.[27]

It is interesting to note that here, as well as earlier in the discussion of the use of carrier pigeons for information transfer, even the oldest systems co-exist with the more modern systems. It seems likely that this same condition will continue, in that the exotic new systems coming into the marketplace today will most likely not displace totally the current systems in use, but will add to them and introduce a richer mix of systems available for use.

Postley goes on to write that the earliest calculator was probably invented by John Napier (1550-1617) who developed

machines to perform multiplication, division, and the extraction of square and cube roots, without human intervention: "Near the middle of the 17th century, Blaise Pascal of France developed a 'calculator' with an ingenious mechanical arrangement."[28]

Pelton writes, "The prototype of the first computer punchcard was produced by the French weaver Jacquard in 1804, in order to weave elaborate designs on his loom. In 1822, Charles Babbage sealed the fate of all of us who have been harrassed by modern day computers when he thought of applying the Jacquard 'punchcard' to a calculating machine."[29]

From Napier in Scotland, to Pascal and Jacquard in France, to Charles Babbage in England, the progression of computers finally arrived on the North American continent when the Parmalee Calculator was produced in the United States in 1850. According to Postley, "It added only a single digit at a time, and the maximum total was limited to 50."[30] Table 3 is a compilation of some of the steps along the road to the modern information processing system.[31]

References to computers now classify them by generation in order to have some framework in which to discuss the state of the art. The first generation of computers is considered to be that of machines which use electronic vacuum tubes in their construction. The introduction of transitors is considered to be the second generation, and their replacement by integrated circuits is the third. Integrated circuits are single chips made up of many transistor equivalents. Each one of these chips

Table 3: Information Processing Systems

Antiquity	The abacus was the earliest computing device and is still in use today.
Late 1500s	John Napier invents the first machines to perform the actual numerical operations of multiplication, division, and the extraction of square and cube roots without the intervention of a human operator.
Mid 1600s	Blaise Pascal develops a calculator with an ingenious mechanical arrangement which is the possible forerunner of modern mechanical adding machines.
1804	Jacquard produces the first computer punchcard for use on his loom.
1822	Charles Babbage invents a "difference engine," the first successful mechanical computer design.
1850	The Parmalee Calculator, the first keyboard adding machine, was produced in the United States.
1875	The Baldwin Calculator marks the start of the United States calculating machines industry.
1885	The Felt "Marconi Box" becomes the forerunner of the modern comptometer.
1889	The Burroughs Listing Accountant is the first successful machine to print its results and is the basis of the current Burroughs line.
1897	William Hollerith invents what is to be the forerunner of the modern punch-card machine and the basis of the IBM line; the machines are first used by the US Bureau of the Census in 1900.
Late 1930s	Electro-mechanical calculating machines develop simultaneously in Germany and the United States.

1946	The first general-purpose computer is dedicated.
1948	Bell Laboratories unveils the transistor.
1971	Intel advertises its 4004 microprocessor for the first time.
1975	Apple I is produced, setting off the microcomputer market.
1976	The first Cray-1 supercomputer is placed in service at the Los Alamos National Laboratory.

has a number of electrical components which make it a system unto itself. The fourth generation of computers is based upon improvements in the quality of integrated circuits and in the number of electronic components which can be crammed into a single chip. Large-scale integrated circuits, very-large-scale integrated circuits, high-speed integrated circuits, and other names are applied to these improvements in the basic concept. Today, a fifth generation is planned and has received much attention in the trade press: "The planned fifth-generation computer is not defined by such components but by the 'architecture' consisting of a variety of independent function units, such as 'pattern recognition', 'reasoning', and 'learning' devices."[32]

CONCLUSION

The development of microprocessors and high-speed, low-cost computers has been covered in detail over the past few years. Suffice it to say that in speed and capacity, the information processing systems have developed in a way quite similar to that of the information transfer system. It is clear, then, that we have entered a new period in human history. Change is upon us, and the rate of change is rapidly increasing. Too frequently, in the midst of the struggle, we forget where we have been in our frenzied efforts to extricate ourselves from where we are. An understanding of the historical perspective may prevent that difficulty.

NOTES

1. Herodotus, The History of Herodotus, Vol. 6 of The Great Books (Chicago: Encyclopaedia Brittanica, Inc., 1952), p. 277.

2. Wayne E. Fuller, The American Mail: Enlarger of the Common Life (Chicago: The University of Chicago Press, 1972), p. 5.

3. Ibid., p. 5.

4. Ibid., p. 8.

5. Ibid., pp. 10-11.

6. Ibid., p. 193.

7. Wolf Von Eckardt, "It Wouldn't be a City Without Pigeons," The Washington Post, March 25, 1978, p. B1.

8. "The Rothschilds: New Power in International Banking," Business Week, January 12, 1976, p. 50.

9. Robert Wielaard, "Long-Distance Pigeon Racing is National Sport in Belgium," The Associated Press, August 19, 1980, Tuesday PM cycle; and Von Eckardt, p. B1.

10. Von Eckardt, p. B1.

11. "Switzerland is Ready for War," The Economist, November 21, 1981, US Edition, p. 58.

12. British Broadcasting Corporation Summary of World Broadcasts, "Deployment of Cease Fire Monitoring Group," December 31, 1979.

13. Fuller, pp. 172-173.

14. Daniel Bell, "Communications Technology--For Better or For Worse," Harvard Business Review, 57(May-June, 1979), p. 20.

15. Fuller, p. 173.

16. Joseph N. Pelton, Global Talk (Alphen aan den Rijn, the Netherlands: Sijthoff and Nordhoff, 1981), p. 23.

17. John A. Reichley, "Some Thoughts on Command and Control," Military Review, November, 1981, p. 97.

18. Irving Wallace, David Wallechinsky, and Amy Wallace, "When Drums Were Outlawed," Parade Magazine, January 24, 1982, p. 17.

19. Pelton, p. 24.

20. Philip J. Haythornthwaite, Weapons and Equipment of the Napoleonic Wars (Dorset, UK: Blandford Press, 1979), pp. 105-106.

21. Pelton, p. 24.

22. Anthony G. Oettinger, unpublished class notes, "Knowledge and Power," Social Sciences 106, Fall 1981.

23. Haythornthwaite, p. 106.

24. Fuller, p. 3.

25. Ibid., p. 7.

26. Pelton, p. 25.

27. John A. Postley, Computers and People: Business Activity in the New World of Data Processing (New York: McGraw-Hill, Inc., 1960), p. 26.

28. Ibid., p. 26.

29. Pelton, p. 26.

30. Postley, p. 27.

31. Sources in the bibliography for Table 3 are: Toffler, pp. 25-26; Postley, pp. 26-27; Scunnel, p. 1; "For Business, Time of Risk and Opportunity," p. 39; Conaway, p. 8.

32. "Four-Day International Conference on Fifth-Generation is Held," Japan Economic Journal, October 27, 1981, p. 9.

APPENDIX TWO

The Elements of Decision Making

The art of decision making has been the subject of study for many years. The literature discussing it is extensive, but hardly exhaustive. Many of the more basic texts discussing the art of decision making are included in the bibliography. The following is an attempt to synthesize the general thought regarding decision making.

The elements of decision making are frequently listed by the various authors involved in the study of the art, and one can find about as many different lists as there are different authors.[1] In general, however, most of the lists in one way or another can be organized into four basic steps which reflect the answers to three questions and the resulting action. The three questions are:

What is the problem?

What can be done about it?

What should be done about it?

The four steps, then, are information gathering, determination of alternatives, selection of the optimum alternative, and the implementation of the chosen option.[2]

Information Gathering. The gathering of information required to make a decision is the first and possibly the most important step in the decision-making process. As Kast and Rosenzweig wrote, "Information is a key ingredient in decision-making processes, and it is important for organizations to devote attention to designing appropriate systems of information flow."[3] With respect to crisis decision making, the Steadman Report went so far as to say, "Information is the key ingredient in any crisis" and then commented several pages later that "there is no such thing as enough information in a crisis. Somebody will always want more."[4]

The information-gathering step has received little attention in the literature, and it was not until the development of what is now called the case study method of instruction that the gathering of information received the emphasis it deserved. No activity can take place unless there is a recognition that a problem exists, and that is only the first step in the process leading toward a solution. As Kelly writes, "Decision-making is more likely to go wrong because of selecting the wrong problem than because of faulty analysis of the problem."[5]

The information to be gathered includes, but is certainly not limited to, the background of a particular situation, as well as the players and their stakes. The information-gathering phase continues for as long as time and resources permit, and could last as long as the decision-making process itself. Indeed, if the decision to be made is not irreversible, the information

gathering may continue even after the decision is made. In general, though, the information gathering phase of the decision-making process is terminated at some point, and the information which has been gathered is then reviewed to accomplish the second phase of the process.

Determination of Alternatives. The next phase depends for its success upon the completeness of the prior phase. The determination of the alternatives available to the decision maker can only be accomplished if sufficient information is gathered to provide the decision maker with the capability to elicit two or more alternatives.[6] In an ideal world, this step should result in an exhautive list of all possible alternatives. Unfortunately, even the simplest problems with which we are confronted do not attain this ideal, and it is here that individual leadership or managerial skill can make the difference between success and failure (or at least between great success and moderate success). As Jones has written, "It is the most important contribution of a good leader and can be more important than, and can often obviate, much of the analysis to follow."[7] While the ideal is generally unattainable, most authors will suggest that as many alternatives as can be found, given the constraints under which the decision maker must operate, should be found--remembering, of course, that the alternative of no action is as valid a decision as any other.

It is difficult to avoid some evaluation of the alternatives generated at this early stage of the decision-making process,

and it is only natural that some decision makers might atempt an identification phase and not an evaluation phase. Should the decision maker attempt to evaluate the alternatives as they are generated, there is the possibility that valid, or even preferred, alternatives may be eliminated from consideration. Whether or not evaluation is conducted at the same time as the alternatives are determined may decide the optimality of the eventual decision. The technique of "brainstorming" makes that procedure explicit by training people in the acceptance of any ideas regardless of how strange or unworkable they may at first seem to be. In any case, once the alternatives have been determined, the next phase of the process begins.

Selection of the Optimum Alternative. The third phase of the decision-making process is the one which has received by far the most attention. Many of the management science techniques (decision trees, operations analysis, etc.) are devoted to the proper selection of the optimum alternative. While the best alternative is not always intuitively obvious, the application of rigorous mathematical analysis may produce an optimal solution for those problems which can be quantified.

The application of various constraints to the list of alternatives may quickly indicate certain alternatives which cannot be used, and leave a remaining group of alternatives from which the optimum must be selected. It is imperative, however, that the decision maker not get ahead of himself by eliminating those alternatives during the determination step in the previous phase.

Frequently, an alternative which, on first examination, may seem unusable might later be discovered to be the optimum. In any case, it is not the purpose of this appendix to detail the methods and procedures by which an optimum alternative is selected. Suffice it to say that some method must be used, and that there are many available methods in the literature which can be applied to that determination.

Implementation of the Chosen Option. Once the alternatives have been ranked and the optimum alternative has been determined, then the selection of a particular alternative must be made by a conscious choice. It is possible that the alternative determined to be optimum (by whatever procedure used) is not the alternative which will be chosen for implementation. If it is not, the decision maker is saying by that choice that other constraints and other considerations outweigh those which were used to determine the original optimality. Whether that is the case or not, phase four involves an implementation of some alternative. That implementation requires the communication of the decision to those agencies or actors who will be responsible for the carrying out of the selected alternative. Once the option has been selected, all that remains is to communicate the decision to those who will accomplish the action desired.

NOTES

1. See, for example, in the bibliography: Allison, p. 71; Newman, Summer, and Kirby, p. 317; Kast and Rosenzweig, p. 369; Koontz, O'Donnell, and Weihrich, p. 238; Simon, New Science, p. 40; Simon, "Consequences", p. 214; Starry, pp. 2-3; and Janis and Mann, Chap. 7, pp. 171-179.

2. In New Science (p. 43), Simon listed three similar questions which he credited to John Dewey: What is the problem? What are the alternatives? Which alternative is best? Later, in "Consequences" (p. 214), Simon wrote "the decision-making process in an organization encompasses (1) determining what items will be on the agenda and receive attention; (2) inventing and designing alternative plans of action; (3) evaluating alternatives and making the choice; and (4) post-audit decisions and their consequences."

3. Fremont E. Kast, and James E. Rosenzweig, Organization and Management: A Systems Approach (New York: McGraw-Hill Book Co., Inc., 1970), p. 355.

4. Richard C. Steadman, Report to the Secretary of Defense on the National Military Command Structure, DTIC Technical Report AD-A086048, July, 1978, pp. 27,31.

5. Joe Kelly, Organizational Behavior: An Existential-Systems Approach (Homewood, IL: Richard D. Irwin, Inc., 1974), p. 466.

6. The availability of only one alternative or option is, of course, a non-decision process. One should remember, during the information-gathering phase, that the search can never be exhaustive (that requires infinite time and resources) nor can it be accomplished with certainty as to the precision or accuracy of the information gathered.

7. Larry R. Williams, "Modern Approaches to Defense Decision Making," US Army War College, DTIC Technical Report AD-A059397, May 12, 1978, p. 18.

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