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DECISION MAKING THEORY WITH
GEOGRAPHIC INFORMATION SYSTEMS SUPPORT

A Project
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
Master of Business Administration

by
Sean Alan McFarland

June 2008



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ABSTRACT

Decisions are made to change the current situation, if necessary, to some other future situation. Decisions are made with varying degrees of effectiveness and efficiency and are influenced by a myriad of internal and external forces. Decision Support Systems (DSS) software can effectively aid decision making through processing the facts and producing meaningful outputs for use by the person or team in making the final choice. Geographic Information Systems (GIS), a form of DSS, are very effective when locational data are present.

GIS can help to alleviate and neutralize many of the internal and external forces, including some interpersonal or psychological forces, impacting the decision-making process thus allowing for a more controlled, thorough, and objective analysis of the issues. Decisions are not made in a vacuum and they need data to be effective, which need to be transformed into information. GIS have spatial, temporal, and statistical tools to assist this transformation.

The processes, procedures, and approaches of GIS can be applied across a wide variety of business functions resulting in improved strategic and operational decisions,

increased performance, and fresh ways of thinking about problems. The applications for which GIS can be utilized range from supply chain management to financial management. These disciplines have many location-based data and can benefit greatly from the analysis of historical patterns and the use of temporal processing to forecast likely scenarios. GIS can analyze delivery and sales routes, safety stock and warehouse usage, and customer demographic and purchasing patterns. GIS can aid every step of the decision-making process from situation analysis and problem identification, to alternative generation and evaluation, and display effective and efficient alternatives.

ACKNOWLEDGEMENTS

The fields of operations and information management have drawn closer together over the years. To be successful, a manager must have a thorough understanding of both fields. This paper was intended to meld two MBA programs together into a tool for understanding operational and information systems as a synergetic tool for decision making. My thanks go the instructors at California State University, San Bernardino for their exposition of the subjects that I have taken in the two disciplines. I have also drawn upon my undergraduate work from California State Polytechnic University, Pomona (Cal Poly) in the management, communication, and behavioral sciences; my thanks go to the instructors there also. My thanks go the reference librarians who assisted me with some of the finer points of APA style formatting issues.

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CHAPTER ONE

OVERVIEW OF THE DECISION-MAKING PROCESS

Introduction

Making decisions using location data is not new. Records dating back millennia give examples of decisions of state and of war. Sun-Tzu's *The Art of War* dates back to about 500 B.C., and the author incorporates geographic elements into his decision analysis. This paper will examine the decision-making process from many angles using the normative approach to examine where objectivity, power, and psychographic elements affect it.

The process starts by developing the issues to address and establishes the context for good communications between those who will become involved. Next, the problem is explored and put into perspective in order to focus efforts. Once this is done, alternatives can be generated and evaluated leading to a choice. If the process concluded that action was necessary then implementation and feedback phases would be required. While these phases would normally complete the discussion of the decision-making process, it would entail a larger scope than was planned for this paper.

After the decision-making process is reviewed, the subjects of data, data mining, decision support systems (DSS), and geographic information systems (GIS) are introduced and developed. With the understanding of both the decision-making process and GIS, this paper proceeds to examine the decision process, its implications for the organization, and where GIS can and cannot assist decision making. The conclusion follows this examination. While a formal hypothesis is not postulated for examination stating that GIS can benefit the decision process, this paper instead seeks to offer ways in which GIS can contribute to a better process and outcome. Various appendices are offered to provide detail for the discussion. The next section will review the literature on decision making to see where errors can occur and where assistance needs to be sought.

Decision-Making Process

Do Nothing Option

Drucker (1985) stated what most management students know; "there is one question the effective decision-maker asks: 'Is a decision really necessary?' One alternative is always the alternative of doing nothing" (p. 475). If it is

found after research that the issue will resolve itself, then Drucker (1985) advised that "one does not interfere. Nor does one interfere if the condition, while annoying, is of no importance and unlikely to make much difference. It is a rare executive who understands this" (p. 475). Nutt (2002) found that "people spend little time thinking about how to make a decision" (p. 4).

Background and Context of Decision Making

Luecke (2006) said that "the basic purpose of making decisions is to achieve a meaningful objective" (p. 4). Whether the objective is to gradually improve a process with total quality management (TQM) or to overhaul a process through reengineering, decisions should undergo a thorough examination to ensure the best quality of outcome. Courtney, Kirkland, and Viguerie (1999) stated a basic premise that "all strategy begins with some form of situation analysis—that is, a picture of what the world will look like today and what it is likely to happen in the future" (p. 12).

Pundits will debate about their visions of the future from their vantage point and write books full of analysis of the current state of affairs and future projections, but GIS can portray these concepts pictorially much better than

words or graphs. The decision process has been analyzed by many authors, and it can be divided into three main models: rational, organizational process, and political. The organizational model was not chosen because it prevents decision makers "from forecasting the future and acting on the basis of a predetermined vision. Decision makers are forced to make incremental changes based on standard operating procedures" (Denhardt, Denhardt, and Aristigueta 2002, p. 131).

The political model was not chosen because it is problematic in that "it involves a number of actors with their own agendas, priorities, and timetables." Bargaining occurs between the parties and becomes "a collection of decisions that often is assembled more haphazardly than logically" (Denhardt et al. 2002, pp. 132-133). To further complicate matters, Mintzberg, Raisinghani, and Théorêt (1976) found that "judgment seems to be the favored mode of selection . . ." while the analytical approach was used the least. (p. 258) Clark and Shrode (1979) supported this through their empirical studies and found that "the key variables used in problem definition were ethically rather than factually based" (p. 353). The rational model has distinct advantages in that decisions are orderly,

purposeful, deliberate, consistent, responsible, accountable, explainable, and rational. (Denhardt et al., p. 129) Jankowski and Nyerges (2001) supported this approach because "the benefit of a structured understanding of the decision process is that it lends itself to computer support, hence regularity" (p. 14).

Views of the Decision Process

Murray (1986) separated the decision process into three phases: the analytical phase where situations are perceived and information is gathered; the design phase where alternatives are generated; and the choice phase where alternatives are evaluated and selected. (p. 10) The decision process follows a rational approach as described by Murray that includes a "discrete procedure that leads to goal maximization" (p. 53). Matheson and Matheson (1998) described "a logically correct reasoning process" as one that ". . . considers alternatives, information, risks, and values in the context of the decision frame, and reaches a conclusion based on the evidence" (p. 54). Nutt's (2002) research resulted in a five-stage approach that would attempt to prevent major problems from occurring:

. . . collect information to understand the
claims calling for action, establish a direction

that indicates the desired result, mount a systematic search for ideas, evaluate these ideas with the direction in mind, and manage social and political barriers that can block the preferred course of action during implementation. (pp. 41-42)

These authors have taken a more discrete approach to the process steps than others.

Heirs (1987) followed an iterative approach with the manager focused equally on all stages from question formulation to alternative creation to consequence implication to decision and back through again if no valid alternative was found. "The four stages cannot, therefore, be thought of as a set of stepping stones leading directly from the beginning of the decision-thinking process to its completion" (Heirs, pp. 31-34). Harrison (1981) tended to agree and stated that "it is apparent that the decision-making process is both interrelated and dynamic" (p. 27). It would seem that McCall and Kaplan (1990) combined Peters' (1987) advice to "do it all at once" (p. 46) with the process presented by other authors, which said that decision making follows a logical progression from question

formulation to decision, and instead intertwined the stages:

Discovering what exactly the problem is all about is conjoined with the identification of alternatives and their evaluation. Often a choice is made quite early in the process, with subsequent activity devoted to confirming the early choice. (p. 7)

Nutt (2002) warned though that this tendency to ". . . jump on the first idea that comes along and then spend years trying to make it work. . . . is a key cause of failure, which decision makers fail to see that they fail to see" (p. 5).

McCall and Kaplan (1990) may have drawn upon Witte's work but did not explicitly state so. Witte (1972) empirically investigated the decision process and found that "decisions appear as the result of a gestation process" and "reject[ed] the concept that decisions are the result of a choice at a point in time" (pp. 156-157). Although Witte found that most activity occurs in the latter part of the process, he concluded that:

Information-gathering, alternative-developing, and alternative-evaluating operations . . . do

not culminate in distinct phases in time, but rather are distributed over the total duration of the process. (p. 177)

As an empirical approach, Witte dealt with the realities of the situations as presented to him whether or not the observed parties were using best decision making practices.

The time for making a decision should be judiciously used. De Geus (1999) researched organizational learning and found that decision processes can take "too much time when the ability to learn faster than the competitors is the only real advantage" (p. 51). De Geus defines learning as "hearing a new signal, digesting it, confirming it, [and] acting on it . . ." (p. 51). De Geus found that the typical time for this learning process is between 12 to 18 months. (p. 56) Nutt (2002) researched decisions and found three common process mistakes "in all debacles:¹ rushing to judgment, misusing resources, and applying failure-prone tactics" (p. x). Nutt found seven "traps" that managers can make if they follow these process mistakes (See Appendix A); Appendix B contains practices that avoid these traps.

¹ Nutt defines a debacle as "a decision riddled with poor practices producing big losses that became public" (p. ix).

De Geus (1999) stated that "in fact, the normal decision process in corporations is a learning process, because people change their own mental models and build up a joint model as they talk" (p. 54). Tan et al. (2006) stated that "the goal of [data] visualization is the interpretation of the visualized information by a person and the formation of a mental model of the information" (p. 105). De Geus stated the following about learning and mental models:

The only relevant learning in a company is the learning done by those people who have the power to act. . . . So the real purpose of effective planning is not to make plans but to change the microcosm, the mental models that these decision makers carry in their heads. (p. 56)

These mental models whether practical or visionary affect the way decisions are processed and are themselves affected by data availability, values, and perceptions. Nutt (2002) presented a way to reduce time for the learning process while not advocating a rush to judgment. Nutt found that "learning demands a culture in which decisions can be discussed without [a] blame-finding mentality" (p. 39). If this culture does not exist, then learning will be delayed

because Nutt found that ". . . people seldom own up to failures and delay the day of atonement as long as possible" (p. 38).

Values and their Impact

Jacob, Flink, and Schuchman (1962) found values for decision making to be important because:

Values arise in response to the necessity in all human behavior for the exercise of choice among mutually exclusive alternatives of action. Values have the property of *selectivity*, that is, the quality of ordering the options available in terms which those who have to make the choices will accept as decisive. (p. 15)

Harrison (1981) found that "the personal values of the decision maker and the values of the organization significantly influence the entire process of decision making" (p. 151). With the organization's values setting the managerial objectives, the decision maker's personal values will influence the search activity and the comparison and evaluation of alternatives, but the organization's values will usually supersede when the implementation occurs. (Harrison 1981, p. 151)

Decisions are rarely made in a vacuum free of values and their impact. Simon (1976) stated that "in practice, the separation between the ethical and factual elements in judgment can usually be carried only a short distance" (p. 52). The goals and drives of a company or agency are driven by profit, service, or other mission activities. Wiederhold (1999) warned that:

Combining information from multiple sources . . . increases the risk of violation of individual and commercial privacy. Issues of privacy protection and security must be addressed if broad access to valuable data is to become commonplace. (p. 11)

Murray (1986) said that "rational models posit the absurd assumption that the end or the goal (value-laded concept) can be achieved by a series of neutral (value-free) choices or steps" (p. 16). While this may be true, neutral choices help to maintain some form of objectivity while the manager attempts to control the other forces impacting the decision. If managers allow stereotypes to impact their evaluation of the facts then Harrison (1981) found that "perceptual defense" will cause managers to perceive inaccurately. (pp. 210-211)

Knight (1964) took a different route and said that "we perceive the world before we react to it, and we react not to what we perceive, but always to what we *infer*" (p. 201). Haney (1986) built upon this thought in his discussion of inference-observation confusion where he found it occurs when:

- (1) Someone makes an inference, (2) fails to recognize or remember that he or she has done so, (3) thus does not calculate the risk involved, (4) proceeds to act upon the assumption as if it were certain, and (5) end by taking an unrecognized and uncalculated risk that may prove costly, dangerous, or even fatal. (p. 219)

Leaving aside the physiological reasons for the confusion, such as fatigue, Haney listed other contributing ". . . psychological factors, including emotion and stress, habit and set, values and needs, and group and social influences. In a category by itself was a seldom suspected agent:² our

² For a study of language related issues, Haney's book is recommended and was the required text for the COM 321 class in Communication Problem Analysis at California State Polytechnic University, Pomona in 1986.

language!" (p. 221). During the decision process, summaries or displays of developing ideas can help to minimize errors in perception.

Murray (1986) discussed rational choice models and relayed:

Rational choice models do not preclude conflict resolution and resultant collective choice objectives. Nor do rational model theories ignore the prerequisite realities of value conflict, irreconcilable differences, and intraorganizational disputes. (p. 16)

This is one area where communications can have a large effect. Murray advised about the context of decisions:

. . . because decisions are segmented and discontinuous, and because objectives develop and change over time, behavior and decisions must be viewed in the context in which people, problems, and solutions come together. (p. 31)

In setting up the arena in which the decision takes place, Murray described systems theory as coming from the scientific method of causal analysis where artificially bounded regions could be managed and analyzed. (p. 83)

There must be a way to apply limits to rational thinking without limiting the generation of alternatives.

Issues Related to the Speed of the Decision

McCall and Kaplan (1990) wrote of the advantages of quick action regarding decisions, but these should be limited to prepared responses to crisis situations or their early warning signals. (pp. 69-71) March and Simon (1958) stated this more succinctly in their discussion of responses to stimuli:

At one extreme, a stimulus evokes a response—sometimes very elaborate—that has been developed and learned at some previous time as an appropriate response for a stimulus of this class. This is the "routinized" end of the continuum, where a stimulus calls forth a performance program almost instantaneously. (p. 139)

McCall and Kaplan found another situation where quick action would not be thought of as a panic reaction; ". . . managers can get information quickly if they know their people well enough and if they have an operational network of contacts . . ." (p. 71).

Outside of these situations, the advantages McCall and Kaplan (1990) expounded over a strategy-based analysis would lead to poor decisions. The advantages do not require much thought or understanding from the manager, and this could lead to solving the wrong problem. The advantages only serve as a communication tool in that "they give visible evidence that attention is being given to the problem" and that other personnel could participate if they so choose. (p. 69) The vividness of the information can produce biases where Nutt (2002) warned that "experiences with a powerful impact evoke images that influence how we see ourselves and others. Well-reasoned arguments are swept away by the vivid concern" (p. 79). When data are combined with values and organized to be information, it should be tempered to be more useful and not reactionary.

Decision Description

Now that the basic elements impacting the decision-making process have been introduced, the core of the process will be explored. This will provide the framework for the work that follows. Drucker (1967) found that strategic decisions were not "adaptations to the apparent needs of the moment" but problems dealt with "at the highest conceptual level of understanding. [The managers he

studied] tried to think through what the decision was all about, and then tried to develop a principle for dealing with it" (p. 121). Drucker (1967) outlined the elements of the effective strategic decision as:

1. The clear realization that the problem was generic and could only be solved through a decision which established a rule, a principle;
2. The definition of the specifications which the answer to the problem had to satisfy, that is, of the "boundary conditions";
3. The thinking through what is "right," that is, the solution which will fully satisfy the specifications before attention is given to the compromises, adaptations, and concessions needed to make the decision acceptable;
4. The building into the decision of the action to carry it out;
5. The "feedback" which tests the validity and effectiveness of the decision against the actual course of events. (pp. 122-123)

Problem Identification. Drucker (1967) broke down the first element into four occurrences. "There is first the truly generic of which the individual occurrence is only a

symptom" (p. 123). Harrison (1981) agreed that "if, for example, a particular type of decision tended to recur often, there would be no need to repeatedly search for alternatives. Most likely, a policy or procedure would be established to handle such decisions" (p. 27). Drucker (1967) continued to the next occurrence stating:

Then there is the problem which, while a unique event for the individual institution, is actually generic. . . . Next, there is the truly exceptional, the truly unique event. . . . [The fourth is] the early manifestation of a new generic problem. (p. 124)

Harrison found many organizations where generic decisions having highly programmed outcomes were treated "as if they were unique, in the name of participative management. . . . this represents a tremendous waste of human resources" (p. 14). Nutt's (2002) first-stage claim parallels Drucker's first element where Nutt stated "claims identify the 'arena of action' or topic the decision maker expects to address, and . . . is derived from a need or opportunity stakeholders believe to be important" (p. 42). Through

claim reconciliation, Nutt found that "the concerns and considerations uncovered provide you with new ways to think about the arena of action" (p. 47).

Boundary Conditions. The second element should be researched and understood as fully as possible. Drucker (1967) found that "the more concisely and clearly boundary conditions are stated, the greater the likelihood that decision will indeed be an effective one and will accomplish what it set out to do" (p. 130). Nutt's (2002) second stage suggested doing this by "identify[ing] a need embedded in the claim and offer a problem or an objective. . . . [then] the decision maker examines the reasons for action and decides what results are required" (p. 43). Nutt warned not to use "a ready-made idea found in the claim" because that would limit the search for options, which in turn would limit the chances of finding a superior solution. (p. 43) Before the third element of rightness can be argued, the boundary conditions should be set, but Drucker (1967) found that "it is not always easy to find the appropriate boundary conditions. And intelligent people do not necessarily agree on the them" (p. 131). This is an area where failure-prone practices can have a substantial negative impact. Nutt found a way to correct this by

telling people what is wanted as a result, such as lower cost. This will produce better results than seeking the cause of the cost increase by liberating employees to look for answers and by avoiding the specter of blame. (pp. 4-5)

Compromises. The first two elements must be understood before proceeding on to the third element because compromises occur. Drucker (1967) found that ". . . if one does not know what is right to satisfy the specifications and boundary conditions, one cannot distinguish between the right compromise and the wrong compromise—and will end up by making the wrong compromise" (p. 134). Drucker (1967) continued later to state that "it is fruitless and a waste of time . . . starting out with the question 'what is acceptable?' because [one] loses any chance to come up with an effective, let alone the right, answer" (p. 136). Nutt (2002) agreed and found that:

The decision maker who elects to choose among the claims and claimants moves into an idea-imposition process. Decision makers who take steps to expand the pool of claims before selecting one begin a discovery process. (p. 43)

Nutt found that "an *idea-imposition process* is linked to failed decisions and decision debacles" whereas "a

discovery process [offers] a 'think first' approach that increases that chance of being successful" (p. 45).

Although the discovery process is the best process to pursue, Nutt warned that "a shift in tactics can occur in any process stage and lure an unsuspecting decision maker into the idea-imposition process, as shown in [Attachment C]. . . ." with the false hope that the revised tactics will be cheaper and faster. (p. 53) The fourth and fifth elements are included next to round out the discussion of the decision-making process.

Implementation. The forth element requires changes in workflow. Drucker (1967) stated that "in fact, no decision has been made unless carrying it out in specific steps has become someone's work assignment and responsibility. Until then, there are only good intentions" (p. 136). When changes need to be made to people's:

. . . behavior, habits, or attitudes [for] a decision to become effective action . . . one has to make sure that [those people's] measurements, their standards for accomplishment, and their incentives are changed simultaneously. Otherwise, the people will get caught in a paralyzing internal emotional conflict. (p. 138)

Nutt's (2002) last stage concentrated on two ways to implement the decision: stakeholder involvement in the decision, or persuasion and edict. The former focuses on inclusion where the implementation can start to be built in and where social and political issues can be addressed, and the latter focuses on compliance where the implementation is delayed until the end of the process. (p. 44)

Nutt defined persuasion as calling "on a decision maker to collect arguments that support a preferred course of action and to garner the endorsements of experts, and then combine them with salesmanship" (p. 98). Nutt defined an edict as a prescription of necessary behavior. (p. 44) "This is done without consulting with people who have a stake in the changes the decision would bring" (Nutt, p. 99). Both of these compliance methods, persuasion and edict, will have negative consequences if used often. Nutt found that "after a power play, people will only tell you what they think you want to hear and will no longer tell you what they believe to be true" (p. 52).

Feedback. The fifth element requires feedback. In the 1960's, computers were not as sophisticated as they are today and were looked upon with skepticism as reporting tools. Drucker (1967) stated that "all a computer can

handle are abstractions. And abstractions can be relied on only if they are constantly checked against the concrete. Otherwise they are certain to mislead us" (p. 142). Drucker (1967) recommended to check underlying assumptions:

To go out and look for oneself is also the best, if not the only, way to test whether the assumptions on which a decision had been made are still valid or whether they are becoming obsolete and need to be thought through again. (p. 142)

While this is still prudent advice, information technology can increasingly relay more of the world in which operations occur. To check those assumptions, GIS can dig into internal data marts, data warehouses, and external sources of data to concretely display past, current, and projected conditions.

CHAPTER TWO

CONTEXT FOR SUCCESS

Preparation

The proper setting for making decisions is as important to managers as the proper setting for learning is to students. Creating an environment and structure where decision team members feel comfortable contributing to the process and evaluating the alternatives will go a long way towards generating a quality solution. Whether the type of decision making is routine, creative, or negotiated, the manager should structure the decision group so that these "processes become congruent with changes in the nature of the decision-making tasks being undertaken . . ." (Delbecq 1967, p. 329). Movement through both the task and social dimensions of small-group communication should progress in an orderly manner. The basic tasks are instruction/definitions, division of labor, issue exploration/research, criteria setting, assessment, and conclusions/recommendations. The basic interpersonal elements are introductions, self disclosure, empathy,

display of open/closed attributes, development of role/status, and cohesiveness. (Kell and Corts 1980, pp. 8-9)

The manager should set the tone and insist that group interactions be professional. The people involved should not bicker or engage in non-productive argument. Luecke (2006) suggested that managers need to eliminate this activity and elevate the discussion of differences of opinion to a healthy level. (p. 6) Luecke gave the following examples of where executives or leaders would need to promote this level: in government where self-interest, rivalry, and alliances are dominant; in manufacturing where information can be contrary to established practices; and in research and development where rivalries and power struggles do not promote openness. (p. 12) Heirs (1987) said "the trick of fostering the sort of team spirit that leads to really inspired thinking is not easily defined; some managers do it almost instinctively, others find it extremely difficult" (p. 69).

Involvement of a Decision Team

Division of Labor

More often than not, a decision maker will need assistance on large issues. Pounds (1969) found that methods, such as linear programming, were becoming available to assist managers to solve well-defined problems but likewise stated that managers "must also identify the problems to be solved" (p. 1). McCall and Kaplan (1990) suggested "that recognizing that problems exist is not an automatic part of the decision-making process" (p. 32). Witte (1972) stated that "complex decision processes involve a division of labor . . ." (p. 160). McCall and Kaplan agreed and found that "this division of labor is necessary because many complex problems exceed the capacity of one or a few individuals to comprehend" (p. 18). Another reason for the division of labor is provided by Harrison (1981) who found that "the cognitive limitations of decision makers weigh against a detailed consideration of many alternatives that are too complex" (p. 41). On other fronts, Harrison found that "individual decision making is constrained by imperfect information, time and cost factors, frequently severe cognitive limitations, and

diverse psychological forces" (p. 6). See Appendix D for a cross-section of the psychological factors Harrison discussed.

Vroom and Jago (1988) reviewed the work of Kurt Lewin and found "many [experiments] of which pointed to the efficacy of worker participation in decision making" (p. 12). Vroom and Jago generally agreed with Witte and others and found that:

Contemporary managers, particularly in rapidly changing industries, can seldom possess all the knowledge necessary to make intelligent decisions by themselves. . . . Integration of information necessarily requires participation. (p. 99)

Vroom and Jago did make the caveat that "groups can, *under some circumstances*, outperform individuals" (p. 117).

Hogarth and Makridakis (1981) supported this discussion and relay ". . . two key findings from cognitive psychology relating to human judgment: (1) ability to process information is limited; and (2) people are adaptive" (p. 116).

As Upton (1998) found out, product life cycles and process life cycles have become shorter, and change is occurring more rapidly. (p. 1) Peters (1987) prescribed 45

actions for managers to take during times of change. Peters went on to say, "The bad news: *You can't do it all at once, but you must.* Failure to get on with almost all of this agenda at a brisk pace and you're in for trouble" (p. 46). De Geus (1999) learned of a way to incorporate a couple of Peters' recommendations to accelerate institutional learning: changing the rules (operational processes or procedures) or suspending them. (pp. 57-58) Old rule boundaries may no longer be necessary, or if they were, a fresh understand of why they exist may surface. McCall and Kaplan (1990) suggested that the "ability to detect problems early not only helps in day-to-day decision making but can be essential in handling crises . . ." (p. 11). This early detection is important because De Geus pointed out that once in a crisis there is usually little time and few options available (p. 54). Nutt (2002) found though that "only one in ten decisions has significant urgency, and only one in a hundred can be called a crisis" (p. 142). De Geus concluded from a research of long-lived companies, that "the challenge [is], therefore, to recognize and react to environmental change before the pain of crises" and better yet "to institutionalize change" (p. 54).

Group Dynamics

With the understanding that group involvement in the decision making is highly recommended, it is important to understand the group dynamics and issues that will lead to success or failure. Luecke (2006) advised that the correct people participate in the decision process. (p. 6) Heirs (1987) stated that "a manager has two fundamental tasks - to manage a decision-implementing team and a decision-thinking team" (p. 12). The focus of Heirs' work was on the later. Luecke said that the people on the decision-thinking team should be "knowledgeable, have experience, and have a stake in the outcome" (p. 13). From their studies of upper level managers and their immediate subordinates from the United States and Europe in the 1970s, Heller and Wilpert (1981) advanced that:

Participative decision-making methods depend on the existence of skills among subordinates.

Participation is also associated with higher job satisfaction, more positive attitudes to the company, and greater managerial success. (p. 6)

Vroom and Jago (1988) stated that participation provides leadership practice, and "the resulting development of decision-making capabilities increases the

reservoir of talents on which the organization can subsequently draw" as the participants work "through common problems [that could] lead to the mutual sharing of information, experience, and skills" as well as trust and reliance on one another. (p. 27) Nutt (2002) discussed different types of participation and found it useful for other reasons, such as managing interests, and he found that "participation has a good success record and is even timely, requiring much less time to carry out than either the edict or the persuasion tactic" (p. 107).

According to Luecke (2006) five types of people should be involved with the decision: people with authority to allocate resources; stakeholders who are directly affected by the decision; experts (internal or external) who can provide information about the feasibility of various options; opponents who can present a valid contrary position; and proponents of the position. (pp. 13-14) Luecke may have taken Heirs' suggestion when recommending the involvement of experts because Heirs (1987) offered that:

Involving people who have specialist information and experience at their fingertips in this way not only helps ensure the information will be

there, on tap, when it is needed; it also helps make certain that others, in their own deliberations, will take that information into account. (p. 52)

Extra people are needed because managers have a limit to what they can effectively and efficiently accomplish due to their work load.

A conscientious manager should not succumb to what McCall and Kaplan (1990) found as "a fact of managerial life" that of making "quick-action decision processes for disposing of complex problems" (p. 68). Luecke (2006) suggested first that chances are someone in the group may have the answer, but second and more important, "several individual group members may have partial solutions that, when combined, solve the entire problem" (p. 125). Harrison (1981) found that "it is also true that a group normally provides a broader range of knowledge and a variety of critical viewpoints that may yield a more penetrating analysis of a given problem" (p. 7).³

While advocating five types of people to be on the decision team, Luecke (2006) also suggested limiting the

³ For a detailed discussion of the sociology of decision making see chapter 8 of Harrison (1981).

size of the team to six or seven members. (p. 14) Vroom and Jago (1988) implied from Ivan Steiner's work:⁴

[The] model for expressing both positive and negative effects of increasing group size and for examining the cost-benefit tradeoff [imply that] . . . smaller groups are more likely to suffer from not having the needed informational resources and larger ones from problems of coordination (p. 23)

Luecke said that if the complexity of the decision demands more assistance, then task forces can be used to analyze parts of the problem. (p. 14) This is similar to Meredith and Mantel's (2003) breaking down a project into tasks and further into work packages. (p. 8) Work packages would be the individual assignments within the task force. Task force members would then organize their own work into what Meredith and Mantel called work units. (pp. 8-9)

Approaches to Decision Making

To give a sense of ownership and responsibility to the team, Luecke (2006) outlined three decision-making approaches: consensus, qualified consensus where leader

⁴ Steiner, I. (1972) *Group process and productivity*. Burlington, MA: Academic Press

will decide when no consensus is achieved, and majority.

(pp. 16-17) Drucker (1985) found that Japanese institutions attempt to achieve consensus throughout the organization before decisions are made because for them, "the important element in decision-making is *defining the question*. The important and crucial steps are to decide what whether there is a need for a decision and what the decision is about" (p. 467). Nutt (2002) always found debacles where:

Little time or money was spent rethinking the claim⁵ that specified the arena of action. To avoid this trap, decision makers must uncover and reconcile the concerns and considerations of the people whose support they need to be successful.
(p. 29)

This process allows the eventual implementation to be made quickly with little chance for degradation of the decision due to resistance or operational adjustments because "everyone has been presold" (Drucker 1985, p. 468).

Heller and Wilpert (1981) found that "in times of business turbulence and uncertainty, managers use more participative forms of management to get as many views as possible to chart a better course" (pp. 36-37). As

⁵ Nutt describes a claim as a call for action. (pp. 23-24)

turbulence and uncertainty increase, participation is curtailed and power becomes concentrated. At the extreme of this line of thinking is the crisis situation. Luecke (2006) outlined a fourth approach where directive leadership is used usually in times of crises. (p. 16) Heller and Wilpert found that "during these times, participation is limited as the manager takes a leadership role and dictates the course according to their judgment and training" (pp. 106-107). This could manifest into a management culture with negative effects.

Luecke warned that "command-and-control cultures tend to make decisions in line with the preferences of powerful individuals" (p. 6). This type of culture could result from various influences or could result from directive leadership not relinquishing control when a crisis has passed. Simon (1976) related that during the time of his study, "administrators [had] increasingly recognized . . . that authority . . . is relatively impotent to control decision in any but a negative way" (p. 227). Nutt likewise found problems where "decision makers selected among the claims being offered according to their proponents' leverage and then forged ahead with this claim and its implied arena of action" (p. 25). In a much worse

situation, Nutt warned that "edicts and persuasion fail because neither manages the social and political forces stirred up by a decision. . . . Involving potential critics in the decision-making process clarifies their views . . ." and garners their support. (p. 30)

The directive approach has drawbacks that can be minimized after the crisis has passed. As more people realize that the crisis has passed, they feel the need to participate in direction setting for the organization. Peters (1987), in the introduction to his section on people, gave this axiom as guidance to managers: "there are no limits to the ability to contribute on the part of a properly selected, well-trained, appropriately supported, and above all, committed person" (p. 342). McCall and Kaplan (1990) said that in forming the team "the negotiation over what is important begins early in the problem-solving process; involving the right people at the right times can create shared responsibilities and common perceptions" (p. 101). One of the multiple facets of the power of information that Peters shared, is that information motivates by providing ". . . critical confirmation that the firm see the worker as a partner and problem solver" (pp. 611-612).

Pressures Impacting the Group

Heirs (1987) found that "successful decision-thinking is a product of individual minds working together . . ." (p. 35). McCall and Kaplan (1990) warned that specialization as applied to complex problems ". . . is notorious for leading to rivalries among specialists and a corresponding tendency to distort information to advance the interests of the specialty" (p. 18). Nutt (2002) advised that expected results should be known:

A direction that specifies expected results cuts the ground from under a defensive evaluation by making its self-serving intent evident, so decision makers in the debacles were careful to evaluate a preferred course of action without them. (p. 165)

Murray (1986) related that self interest models of decision making tend not to be comprehensive and lead to choices that are less intelligent and not beneficial to the whole. (p. 122) Luecke (2006) suggested that managers should develop a process that ensures this does not happen by allowing open-minded inquiry to prevail over advocacy for a particular outcome. (p. 18) Luecke detailed the inquiry approach as follows:

An open process in which individuals ask probing questions, explore different points of view, and identify a wide range of options, with the goal of reaching a decision that the group creates and owns collectively. In an inquiry approach, individuals set aside their personal opinions or preferences in order to arrive at a rational decision that is best for the group or organization. They do not advocate on behalf of their pet projects. (p. 19)

While this inquiry approach is the ideal, it is seldom realized, and Luecke suggested using a hybrid of the two approaches. (p. 21)

Heller and Wilpert (1981) surveyed upper management as to their methods of influence and power sharing and found that "prior consultation and joint decision-making were the most prevalent accounting for about sixty percent of occurrences for all types of decisions" (pp. 26-27). McCall and Kaplan (1990) found that "on vague and complex issues . . . managers interactively anchor their sense of reality. They validate their perceptions, opinions, and conclusions in conjunction with the people around them" (p. 30). Heller and Wilpert also found that "when the upper managers were

surveyed if they brought their peers into the decision-making process, the results showed that they did not share power instead reserving the right to make the decision just under 60%" (p. 30). This left the group in an advisory capacity a majority of the time.

Vroom and Jago (1988) took the original decision-making model developed in 1973 by Vroom and Yetton⁶ based on situational theories of participation and improved it in terms of relative effectiveness. Vroom and Jago recognized that the earlier model had several shortcomings. (p. 83) They "acknowledge[d] that having sound thinking and a committed group to implement the decision is often not all that is needed to produce effective decisions. Decisions must also be made in a timely manner" (p. 108). McCall and Kaplan (1990) found that "it is someone's *perception* of the degree of urgency that affects the kind of action that will be applied to a problem" (p. 62). This affects the entire decision process from the frame of the problem to what alternatives are generated, the depth of their evaluation, and the method of their selection. Nutt (2002) warned of how time pressure can cause premature commitments and a

⁶ Vroom, V. H., & Yetton, P. W. (1973). *Leadership and decision-making*. Pittsburgh: University of Pittsburgh Press.

rush to judgment in order to meet one's responsibilities.

"This push from fear (of failure) and the pull toward a reward make it difficult for a decision maker to step into the unknown and to remain there until insight emerges.

These urges mount as time pressure increases" (p. 5).

Likewise, Nutt warned that "decision makers . . . who acted quickly, whether faced with a self-imposed or real deadline, were drawn toward using an edict" (p. 102). With this backdrop of group composition, interaction, and issues, the decision-making process can now unfold.

CHAPTER THREE

FRAME THE ISSUE PROPERLY

Introduction

Ehninger (1974) stated that "beliefs that grow out of arguments . . . because they are attuned to facts, [change] as the facts change" (p. 6). Harrison (1981) studied perception in decision making and found that "the greater the contact with the facts and the more information available, the more likely it is that a perception will be sharp and defined" (p. 202). If one is steadfast to keep their mind on the pulse of what they know, then this would be true, but often times opinions continue after the facts have changed. Drucker (1967) found regarding the use of facts that:

Most books on decision-making tell the reader: "First find the facts." But executives who make effective decisions know that one does not start with facts. One starts with opinions. These are, of course, nothing but untested hypothesis and, as such, worthless unless tested against reality. To determine what is a fact requires first a decision on the criteria of relevance, especially

on appropriate measurement. This is the hinge of the effective decision, and usually its most controversial point. (p. 143)

Drucker (1967) found that "effective executives therefore insist on alternatives of measurement—so that they can choose the one appropriate one" (p. 147).

Luecke (2006) said, "Every successful decision depends on a clear understanding of the issues at hand and the ways each will affect the objectives of the business. It is critical to determine the nature of the problem" (p. 6).

Upton found that where flexibility-improvement efforts were deemed by managers to be unsuccessful, key factors were not explored:

In the vast majority of those cases, the cause could be traced to a failure to identify precisely what kind of manufacturing flexibility⁷ was needed, how to measure it, or which factors most affected it. (p. 133)

Pounds (1969) empirically studied managerial problem finding and found that:

⁷ Upton describes flexibility as being "about increasing range, increasing mobility, or achieving uniform performance across a specified range" (p. 132).

The word "problem" is associated with the difference between some existing situation and some desired situation. . . . Since operator⁸ selection is triggered by the difference to be reduced, the process of problem finding is the process of defining differences. Problem solving . . . is the process of selecting operators which will reduce differences. (p. 5)

Borrowing from Pounds, McCall and Kaplan (1990) offered three standards for identifying discrepancies in current operations: the past, the future or forecasts, and the benchmarks of other operations - internal or external. (pp. 12-13) Pounds concluded his study by stating, "It seems clear, however, that we must understand the process by which differences are defined before we can worry about understanding the process of selecting from among them" (p. 18). Drucker (1967) found that "the effective decision-maker, therefore, organizes disagreement. . . . He starts out with the commitment to find out why people disagree" (p. 153).

⁸ Pounds (1969) refers to operators as elements of managerial activity. "An operator transforms a set of input variables into a set of out variables according to some predetermined plan" (e.g., "lay out a production schedule") (p. 5).

Scope of the Frame

Conceptualization

Framing an issue (big picture) starts with opinions, supported or not by facts, that lead to problem recognition. That then leads to the analysis of why or what issues are at play to cause the difference between the desired and current state of affairs. This is all understood in the context of a frame developed with analytical and psychological underpinnings. Matheson and Matheson (1998) stated that "unless we make a deliberate effort to do otherwise, we frame problems in terms of our beliefs and prejudices, predisposing ourselves to see these problems in certain ways, reality notwithstanding" (p. 35).

Expanding on this idea, Luecke (2006) stated that "beginning with an inappropriate or erroneous frame can lead you to an ineffective conclusion. Alternatively, you may successfully solve the wrong problem - or solve it in the wrong way" (p. 25). Williams (2007) found that framing ". . . may cause the individual to consider a narrow range of concepts/issues, which could lead to inappropriate decisions, as a complete assessment of the situation has not occurred" (p. 15). Nutt (2002) also found issues with the framing process when "the anticipated benefit of the

idea becomes the direction. . . . Decision makers who become fixated on an idea fail to ask 'reframing' questions. . . . Commitment to the idea becomes a trap, which often leads to failure" (p. 117).

Even if the frame is properly envisioned, it needs to be defined carefully. Haney (1986) warned that a situation he labeled as blinding could occur where:

The words we use to define a problem or situation can act as blinders . . . and thus restrict us in our approach to the problem or situation. . . . Blinding may (1) delay or impede desirable solutions and (2) lead to undesirable solutions. (pp. 489-491)

Drucker (1967) warned to not start with facts:

People inevitably start out with an opinion; to ask them to search for facts first is even undesirable. They will simply do what everyone is far too prone to do anyhow: look for the facts that fit the conclusion they have already reached. (p. 144)

Drucker (1954) found that "the most common source of mistakes in management decisions is the emphasis on finding the right answer rather than the right question" (p. 351).

This may occur because management is assuming that they are already on the correct course and just need some answers to adjust their heading.

McCall and Kaplan (1990) found that "there are things [managers] do that have profound effects on how they gather information, process it, and put it together to 'define' the problems they face" (p. 33). These things are digging, which involves listening and asking questions, and knowing the business, which involves thoroughly knowing the people the manager works with and the business they are in; these are two of the keys to finding problems. (McCall and Kaplan, pp. 33-35) Nutt (2002) offered the discovery process as one that would lead to better success than the idea-imposition process. "The discovery process begins with the decision maker polling a diverse group of stakeholders [similar to digging] to uncover their concerns and considerations" (p. 53). If a move is made away from the discovery process, Nutt's research found that decision makers were unable to return to it. (p. 55) Managers must increase their competency for listening⁹ and communication.

⁹ For an often neglected study on listening, refer to Nichols, R. G., & Stevens, L. A. (1957). *Are you listening?* New York: McGraw Hill.

Issues with the Lack of Critical Thinking

Simon (1976) stated that one of the limits to rationality as viewed by the individual is their values and conceptions of purpose. (p. 241) Heirs (1987) found that "there is a prejudice, shared by many people, in favor of simple questions. This prejudice unfortunately leads to poor thinking . . ." (p. 41). Hoos (1972) warned when using systems analysis of:

. . . a chain reaction of poor conceptualization, gathering of data more because they are available than indicative, and dependence on factors only because they are can be counted in the ongoing analysis and not because they are known to be important in the final analysis. (p. 8)

McCall and Kaplan (1990) found that "there is clearly, then, a continuum of problems that lands on a manager's desk, from the virtually prepackaged to the completely ill-defined" (p. 13). The prejudice Heirs found may have been the result of too many prepackaged problems coming to managers.

In their desire to dispatch with the workload and make themselves feel or look as though they are accomplishing something, the more complex issues remain, which may cause

the business to be vulnerable to any of five forces discussed by Michael Porter.¹⁰ Peng (2006) relayed these five forces as "(1) the intensity of rivalry among competitors, (2) the threat of potential entry, (3) the bargaining power of suppliers, (4) the bargaining power of buyers, and (5) the threat of substitutes" (p. 41). While it is obvious to most students of business, Matheson and Matheson (1998) advised to "*frame strategic and operational problems differently*" (p. 38). Drucker (1954) found that tactical decisions are made "to find the most economical adaptation of known resources" whereas strategic managerial decisions ". . . involve either finding out what the situation is, or changing it, either finding out what the resources are or what they should be" (p. 352).

Manipulation. Framing the decision correctly is half the battle. If managers know how to frame issues and can get those issues framed according to their agenda, Luecke (2006) found that "they have a greater chance of producing the decision their favor" (p. 26). Drucker (1967) cautioned managers to understand the issues because "most people start out with the certainty that what they see is the only way to see at all" (p. 154). McCall and Kaplan (1990) found

¹⁰ Porter, M. (1980). *Competitive strategy*. New York: Free Press.

that "problem recognition may be a contest between competing points of view backed up by different degrees of power, and managers sometimes manipulate the context to achieve political ends—even to the extent of keeping secrets and practicing deception" (p.31). Peters (1987) stated that "it is the philosophy of control that must be illuminated as a major force in decision making [because] control, and not technology, emerges as the key referent for analysis of decision making" (p. 223). Technology, now twenty years later, has a much greater capability to identify and display issues to assist with framing the decision.

Ethics. Murray (1986) said though that "just as the individual decision maker maximizes his goal seeking behavior, so, too, the organization seeks to maximize its goals" (p.53). Whether the decision maker accepts the ethics of the organization or advances their own ethics, Nutt (2002) found that values and ethics play a subtle role in decision making:

Tough decisions pose ethical dilemmas. Ignoring these dilemmas sets a trap that ensnared decision makers in the debacles. . . . Ethical issues crop up . . . subtly through alternatives that are

never presented and criteria to judge an alternative that are selected because they favor a preferred course of action. (pp. 35-36)

Rokeach (1973) linked values to decisions and said that "a value system is a learned organization of principles and rules to help one choose between alternatives, resolve conflicts, and make decisions" (p. 14). Luecke (2006) suggested however that managers should be encouraged "to adopt a frame that benefits the organization" (p. 26). The reason for Luecke's suggestion may be that decision makers allow their personal value system to "influence the extent to which [they] will accept or will resist organizational pressures and goals" (England, 1967, p. 54).

Experimentation

Frames. Matheson and Matheson (1998) found that "advocates often subconsciously select the frame most advantageous to their point of view" and advised, "Always question them" (p. 38). Luecke (2006) said one way to understand the problem is by trying different frames "and assessing if whether the available information supports your theories" (p. 30). Heirs (1987) pointed out this issue as one of two distinct hazards. Vital data needs to be obtained, beyond that which indicated the problem, before

acting "if [the problem] is to be solved in the right way." The other hazard considered "more dangerous . . . is the temptation to prolong the research phase indefinitely" (p. 51). McCall and Kaplan (1990) found that "the importance of the problem to the organization often is not the determining factor in the time and effort consumed" (p. 5). Matheson and Matheson found that "some frames are more productive and appropriate than others. One good way to evaluate and improve the quality of the frame is to expose the problem to people with different points of view" (p. 38). Murray (1986) agreed in principle to use alternate frames because users of "rational models necessarily see the world as fixed in time and place, because to factor in the rational equation means to fix elements at some point in time" (p. 86).

Models. McCall and Kaplan (1990) advised that managers "should be aware that all models of how the world works are simplifications of reality and that different people may use different models to explain the same events" (p. 100). Harrison (1981) discussed the interdisciplinary aspects of decision making:

Ideally, then, a decision-making model should include some optimum number of variables that

will help explain the real-world phenomenon being modeled. Such a model should help the decision maker predict real-world phenomenon with sufficient consistency and accuracy to be of considerable value. (p. 52)

De Geus (1999) agreed with McCall and Kaplan and stated "moreover, for the purpose of learning, it is not the reality that matters but the team's model of reality, which will change as members' understanding of their world improves" (p. 62). The model should be easily adjusted to allow for the presentation of ideas. De Geus found that "one characteristic of play . . . is the presence of a transitional object. For the person playing, the transitional object is a representation of the real world" (p. 60).

Computer Assistance. De Geus (1999) found that "computer models can be used to play back and forth management's view of its market, the environment, or the competition. The starting point, however, must be the mental model that the audience has at the moment" (p. 61). Murray (1986), seeing the impact of the personal computer on processes, stated that "an individual's seeming inability to transcend the physical limitations of time and

space is potentially altered by new technologies" (p. 222). Current technologies are making this potential realized through software of ever increasing capability. De Geus found three computer modeling applications to assist in the transcendence:

First, although the models in the human mind are complex, most people can deal with only three or four variables at a time and do so through only one or two time iterations. . . . Second, . . . in working with dynamic models, people discover that in complex systems (like markets or companies) cause and effect are separated in time and place. . . . Lastly, . . . we learn what constitutes relevant information. For only when we start playing with these microworlds do we find out what information we really need to know. (pp. 62-63)

Questions. Heirs (1987) proposed that managers ". . . force themselves to consider whether or not they are asking their organization to answer the best questions" (p. 40). This would minimize the chance of the best answers not being available when action is required, and prevent the wasting of resources on the wrong issues. (p. 40) Usually

thought of as an alternatives-generating process, Hoffman (1982) suggested ". . . that brainstorming can be used for defining the problem as well . . ." (p. 115). A systematic approach could be to work through different rational models to arrive at a pattern to understand the larger processes in which the problem is embedded or a product thereof.

Symptoms. Basing solutions to problems on symptoms can be faulty and waste resources. Hill et al. (1979) found that "too often we address our remedies to what is merely a symptom, rather than to the underlying cause itself" (p. 23). Strong minded managers seeking to cure one of their issues may choose this route, but as Luecke (2006) pointed out "in so doing they seek solutions before they understand the nature of the problem. . . . These solutions will address the symptoms of the problem . . . but [they] may not address the root cause" (pp. 28-29). Nutt (2002) concurred also and found that decision makers who attempt to quickly fix a problem frequently define it in a way ". . . that proves to be misleading and misdirects people's energy. Symptoms are analyzed while important issues are ignored" (p. 119).

Causes. Murray (1986) stated that "unless a decision maker's world view rests on the tenet that problems result

from specific causes, very little can be done in a systematic way to conceptualize, much less to intersect, certain difficulties" (p. 218). To try to overcome the concentration on symptoms, decision makers need to think temporally and to place the symptoms in a larger context. That context will have more in common with the problem or root cause occurring over time than the symptom. Einhorn and Hogarth (1999) stated that "decision makers stumble into mental traps that yield bad decisions" because they fail to understand that "each decision is the outcome of a complex process that usually involves two different kinds of thinking: looking backward to understand the past and looking forward to predict the future" (pp. 132-133). This process will generate many data elements or inputs for consideration. Matheson and Matheson (1998) found that the reasoning process's "objective is to organize and analyze inputs, sort through complexity, and scientifically understand which choice is likely to create greater value" (p. 54). The next section will now concentrate on the generation of alternatives that will lead to choice opportunities.

CHAPTER FOUR

GENERATE ALTERNATIVES

Introduction

Drucker (1985) stated that "unless one has considered alternatives, one has a closed mind" (p. 472). Nutt (2002) stated that "beginning with an answer sweeps away ambiguity. At first this is comforting, but it subsequently limits your ability to see attractive options" (p. 118). No major decision has a simple answer or one that can be relied upon for a number of years as being the right choice. Drucker (1954) stated that "predictions concerning five, ten or fifteen years ahead are always 'guesses'. . . . an 'educated guess' . . . is based upon a rational appraisal of the range of possibilities . . ." (pp. 88-89). Peters (1987) echoed this sentiment by stating two certainties: nothing is predictable, and no firm can take anything in its market for granted. (pp. 11-13)

The computer revolution changed everything during the decade of the 1980s, and that change continues unabated as technology progresses. Peters (1987) stated that "technology has changed the areas of financing, manufacturing, design, distribution, and product

definition" (p. 12). In essence, all of what Zikmund and D'Amico (1986) called the controllable marketing variables of price, product, place, and promotion have been affected. (p. 11) Murray (1986) said that rational thinking "is a new way of looking at the world and at ourselves" (p. 84). It is in this vein that new ideas must be generated.

Artificially Imposed Limitations

People usually make assumptions to limit the range of thought to objects or situations perceived to be true enough for the analysis undertaken. People may be defensive about their assumptions. Matheson and Matheson (1998) stated that "developing a full frame usually requires some cross-functional, assumption-challenging thinking" (p. 38). This may lead to conflict within the organization. In their study of organizations, March and Simon (1958) assumed "that where conflict is perceived, *motivation to reduce conflict . . . is generated . . .*" (p.115). Drucker (1967) found that ". . . disagreement alone can provide alternatives to a decision. And a decision without an alternative [to fall back on] is a desperate gambler's throw, no matter how carefully thought through it might be" (p. 150). March and Simon found that the reaction to

conflict was "a tendency to evaluate a few alternatives thoroughly before searching for new ones" (p. 115).

Drucker (1967) provided the material for Luecke, and Matheson and Matheson when he stated that "whenever one has to judge, one must have alternatives among which one can choose. A judgment in which one can only say 'yes' or 'no' is no judgment at all" (p. 147). Eilon (1969) agreed and observed that "if the decision process produces only one alternative, there can obviously be no free choice exercised by the decision-maker, and therefore no decision" (p. B-178). Luecke (2006) likewise agreed and expanded this to state "in the absence of a realistic set of alternatives there can be no genuine decision" (p. 6). Matheson and Matheson (1998) found the following about choice and the operational culture:

The operational culture typically seeks a single viable choice [that] . . . puts top management in the position of saying "yes" or "no" [thus relegating] . . . the executive role to one of mere approval. . . . The fundamental error . . . was that there were no alternatives, hence no basis for comparison or discussion. There was no real choice. (pp. 40-41)

McCall and Kaplan (1990) supported this cultural statement and found that "managers often truncate information search and analysis" (pp. 67-68). Harrison (1981) found that "until the decision maker is driven to an expanded search activity, the search for alternatives is conducted as close to the familiar aspects of the managerial objectives as possible" (p. 95).

March and Simon (1958) found other reasons for not always striving for optimal alternatives:

Most human decision-making, whether individual or organizational, is concerned with the discovery and selection of satisfactory alternatives; only in exceptional cases is it concerned with the discovery and selection of optimal alternatives .

. . . To optimize requires processes several orders of magnitude more complex than those required to satisfy. (pp. 140-141)

Harrison (1981) found that "clearly in complex and unstructured decision-making situations, the best that the rational decision makers can hope to obtain is a satisficing outcome" (p. 176). This does not mean that the analysis will be simplistic. Harrison (1981) found that judgment has its place as "an essential part of . . .

decisions, where the cause-and-effect relationships are uncertain and . . ." information is lacking. . . . In this case, "value judgments are very important in comparing and evaluating alternatives preparatory to choice. . . . the decision-maker 'orders' alternatives according to how desirable they are within his or her system of values" (pp. 175-176).

Hogarth and Makridakis (1981) found many sources of evidence indicating that "superficial information search and processing biases¹¹ cause gross errors in human decision making" (p. 117). Nutt (2002) agreed and found that faulty claims can originate because "decision makers are prone to using information that is readily available, overlooking information that may be more diagnostic" (p. 77). When using information, decision makers have to keep track of when and how it was acquired, from whom, and in what form to name a few issues. Ehninger (1974) offered a factual way try to eliminate biases and stated that argument is a form of persuasive appeal, which lays out for the decision maker's "inspection and analysis the facts and reasons upon which the appeal is based" (p. 4).

¹¹ The findings of Hogarth and Makridakis, originally appearing in their work as Exhibit 2 on pages 117 to 120, have been summarized by McCall and Kaplan (See Appendix G).

While a formal evaluation should be postponed, Harrison (1981) stated that perception makes some informal evaluations:

Given the decision maker's need to scan the environment in search of relevant alternatives, it is obvious that the perceptual process significantly affects the decision-making process. In fact, the two processes are virtually inseparable. (p. 203)

Intertwined with these processes is the collection of information. Harrison found that "perception is . . . a selective process. . . . The main factor in the selective process is attention" (p. 205). Managers have a busy agenda. Given the limited attention a manager can pay to various issues, they must limit the amount of information collected for decision making. (Harrison, p. 205) Nutt (2002) however warned that "this bias for action causes [managers] to limit their search, consider very few ideas, and pay too little attention to people who are affected, despite the fact that decisions fail for just those reasons" (p. 49).

Removing the Limitations

Simon (1976) stated that "one of the limits to rationality as viewed by the individual is the extent of their knowledge and information" (p. 241). The creativity of music composers can be thought of as rational because of the schooling and training they received to frame their ideas from start through to a logical conclusion. Matheson and Matheson (1998) found that "in many cases, creativity involves nothing more than looking at a problem with fresh eyes, seeing in it something others missed, and refusing to accept the apparent solution. Creativity frames problems differently" (p. 41). The piano has 88 keys, but how many different works have been created by combining those keys dynamically in different patterns and tempos?

Luecke (2006), Callahan, Fleenor and Knudson (1986), and Hoffman (1982) amongst others offered brainstorming as one method for generating alternatives. Callahan et al. (1986) stated that this alternative generation stage demands creativity. (p. 260) Heirs (1987) found that "a combination of both types [analytical and imaginative] of thinking is needed in the creation of any practical alternative" (pp. 64-65). Hill et al. (1979) stated that "it is important to write down all possible alternatives to

the problem solution, no matter how foolish or far-fetched they may seem at first" (p. 23). Nutt (2002) found that "several search initiatives are needed to uncover the required number of ideas before a quantum shift in understanding about what to do can occur" (p. 143). The evaluation phase should follow the generation phase. Hoffman stated "in this way no solution can acquire enough positive valence to pass the adoption threshold nor enough negative valence to drop below the rejection threshold before many alternatives have been proposed and described" (p. 115).

Luecke (2006) said that the merits of a variety of alternatives need to be weighed before the best decision can be made (p. 35). Matheson and Matheson (1998) warned however to "separate the creation of alternatives from their evaluation. Evaluating alternatives as they emerge tends to kill good ideas before they are fully conceived" (pp. 43-44). Nutt (2002) found that quick results have their price:

In each debacle, decision makers embraced a quick fix. The first seemingly workable idea that was discovered got adopted. . . . [and] stops others

from looking for ideas that could be better. . .
. and for an innovative one that provides 'first
mover' advantage . . . (pp. 33-34)

Matheson and Matheson had found that:

alternatives should be

- ▲ broadly constructed, and not simply minor variations of a single concept;
- ▲ reasonable contenders for selection, not ridiculous extremes meant to make some other alternatives appear obviously superior; and
- ▲ sufficiently numerous to represent true choice, yet not so numerous as to confound the ability to evaluate and choose. (pp. 42-43)

Mintzberg et al. (1976) studied alternative selection and found that it "is typically a multistage, iterative process, involving progressively deeper investigation of alternatives" involving a pattern of "screen[ing], evaluation-choice, and authorization" (p. 257). Screening first reduces the list of alternatives to what is feasible; then those are evaluated, and a course of action is chosen; finally that choice is approved by the organization. (Mintzberg et al., p. 257)

Other authors found that the generation and evaluation stages are comingled. Witte (1972) made the following statement at the conclusion of his empirical research: "We believe that human beings cannot gather information without in some way simultaneously developing alternatives. They cannot avoid evaluating these alternatives immediately, and in doing this they are forced to a decision" (p.180). Harrison (1981) follows this line of thought and found that "contrary to some opinions, the search for alternatives is parallel rather sequential. The decision maker considers several potentially acceptable alternatives at the same time" (p. 31). Mintzberg et al. (1976) also agreed with Witte and found "logic in delineating distinct phases of the strategic decision process, but not in postulating a simple sequential relationship between them" (p. 252). Empirically, Witte found out how people were making decisions. Researchers, such as Hill, Hoffman, and others, over the subsequent two decades developed tools that could improve the ways people made decisions.

Idea Generation

Managers usually bring groups together to assist with the decision-making process when issues are larger than an

individual can handle. Luecke (2006) and Callahan et al. (1986) said to consider the group's composition. Luecke offered that groups will "produce a creative friction that sparks new ideas, . . . safeguard against groupthink, . . . and give good ideas more opportunity to develop" (p. 39). Normally the team offers ideas that someone will record; ideas can be generated remotely through teleconferencing. Callahan et al. warned the moderator or manager to guard against an expert dominating the discussion. (p. 261) Luecke likewise warned the moderator or manager to draw out the ideas of the shy participant. (p. 38) Some people prefer to communicate orally, and some to communicate through writing. The manager should get the ideas through the best means possible whether the group meets together or separately. Hartwick, Sheppard and Davis (1982) studied the acquisition, retainment, and recall of information and found that "information presented in group settings may be better retained for later use in decision making than that presented to group members separately . . ." (p. 9). Heirs (1987) stated that all thoughts should be accepted for review:

The professional manager's aim must be to create an atmosphere in which people feel positively

encouraged to think out loud, and in which the thoughts they express are welcomed, respected and taken seriously even if some of them are badly articulated . . . (p. 68)

This is important because McCall and Kaplan (1990) found that "together rank and credibility make a great deal of difference in determining whether a person's view is accepted" (p. 31).

Van de Ven and Delbecq (1974) found that their Nominal Group Technique (NGT), which they developed in 1968, provided almost twice the quantity of ideas than did brainstorming and with greater satisfaction for the process by the participants. (p. 615) Hoffman (1982) reviewed the NGT and found two reasons for this; first "each member's perspective on the problem enters the group's problem-solving efforts uncontaminated by others' points of view," and second "every member's idea has a chance to enter the group's deliberations without having to fight its way in" (p. 116). Hill (1982) found that statistical pooling, where the ". . . best ideas of several individuals who had worked separately" are summed, "was superior to group responses in number of unique ideas and in number of high-quality ideas . . ." (pp. 520-526).

Van de Ven and Delbecq (1974) compared NGT to Norman Dalkey's Delphi Technique and found that NGT produced a non-significant increase in the quantity of ideas (12%), but a significant increase in satisfaction for the process. (p. 615) Hoffman (1982) reviewed the Delphi Technique and found pertinent advantages and risks. He stated two advantages that "besides its obvious advantages for groups whose members are geographically distant, one of its principal objectives is to minimize the effects of status differences on the decision-making process" (p. 116). Ference (1970) noted this effect on the communications process and found that "if the recipient is a superior, there will be a tendency to make the information consistent with the transmitter's perception of what the recipient wants to hear" (p. B-85). The risks involved with the Delphi Technique are first "a lack of understanding of the problem and of the final decision" and second "the lack of members' commitment to the decision" due to the expected conformity to majority preferences. (p. 117) Whether the group works separately in the same room using the NGT or remotely in separate offices, ideas and alternatives must be generated as they are the root for choices.

Einhorn and Hogarth (1999) stated that looking backward "involves looking for patterns, making links between seemingly unconnected events, testing possible chains of causation to explain an event, and finding a finding a metaphor or a theory to help in looking forward" (p. 132). Einhorn and Hogarth gave direction in finding causally relevant variables:

Four categories of cues [are]: temporal order (causes happen before effects), proximity (causes are generally close to effects in time and space), correlation (causes tend to vary along with effects), and similarity (causes may resemble effects through analogy and metaphor or in length and strength). (p. 136)

The next section will examine how the alternatives generated are evaluated and some of issues involved.

CHAPTER FIVE

EVALUATE THE ALTERNATIVES

Introduction

Objectively, Murray (1986) stated two assumptions for the rational process of decision making. The first is "that the decision maker has a choice (or equally valid, that he thinks he has a choice)" (p. 54). It would make little sense to buy an expensive computer system for a process that will no longer be performed next year. The second is that intangible phenomena can be segregated and objectified. (p. 51) Nutt (2002) found some common sense matched up with "best practices [calling] for a comparison of competing ideas to select the one that come closest to providing the hoped-for results" (p. 58).

March and Simon (1958) summarized the existing decision theories into three categories:

- a) Certainty: complete and accurate knowledge of the consequences that will follow on each alternative
- b) Risk: accurate knowledge of a probability distribution of the consequences of each alternative

c) Uncertainty: the consequences of each alternative are possible, but definite probabilities cannot be assigned to consequences. (p. 137)

Wilson and Alexis (1962) found that "certainty implies a state of awareness on the part of decision makers that seldom exists. Genuine uncertainty is almost as uncommon as complete certainty" (p. 154). These two ends of a spectrum of possible states of nature match closely to what occurs in statistical probability analysis beyond the third or fourth standard deviations (i.e., the occurrence is rare). The bulk of what a manager encounters in the middle somewhere hence the need for disciplined analysis. Nutt (2002) warned that "the urge to cut decision-making time and cost" can cause "subjective and judgmental tactics [that] are prone to error. Both place too much emphasis on intuition and too little on careful inference with good data" (pp. 170-173).

Luecke (2006) said to "assess the feasibility, as well as the risk and implications, of each possible choice" (p. 6). Peters (1987) added that quality and flexibility are key to winning results. (p. 28) Upton (1998) found that companies were "increasingly concentrating on flexibility

as a way to achieve new forms of competitive advantage" because managers in a broad array of industries agree[d] that achieving low cost and high quality [were] no longer enough to guarantee success" (p. 131).

Hill et al. (1979) suggested quantifying the alternatives "to rule out those that are not pertinent to the problem solution" by means of "long- or short-range plans and policies, costs, rewards, facilities" (p. 24). Luecke (2006) offered the following variables to consider:

- Costs: actual, hidden, or savings over time
- Benefits: quality, effectiveness, and customer satisfaction
- Financial impact: net income, timing, and need for borrowing money
- Intangibles: improved reputation, satisfied employees
- Time: implementation time, probability and impact of delays
- Feasibility: approach realism, obstacles, organizational resistance

- Resources: personnel acquisition, training, impact on other projects
- Risk: profit, industry position, competitor response, information needs
- Ethics: legality, interest of stakeholders.

(pp. 47-48)

Luecke (2006) reflected the views of many that computers can help "to sort through the data, array them in useful ways, and do some number crunching" (p. 56). Nutt (2002) found that:

Analytical . . . evaluation tactics have excellent track records once a clear direction has been identified. . . . data are gathered from archives, pilot tests, and simulations, and inferences are made from the data using analytical tools. (p. 167)

Hill et al. (1979) suggested that if precise information is available, decision aid tools, such as "*decision matrix, linear programming, game theory, linear regression, mathematical modeling, and forecasting*" should be used to arrive at a more objective decision. (p. 24) Einhorn and Hogarth (1999) warned that "in complex situations, we may

rely too heavily on planning and forecasting and underestimate the importance of random factors in the environment. That reliance can . . . lead to delusions of control" (p. 145). That is why Drucker (1954) warned that trend analysis should always be used with analysis of:

Events which are likely to have heavy impact upon future ['bedrock' underlying] economic conditions but which have already happened Where bedrock analysis tries to find the "why" of future events, trend analysis asks "how likely" and "how fast". (pp. 91-93)

As the decision process continues, Heirs (1987) warned that "no one, least of the manager, should assume at any point that all the necessary information has been accumulated. Facts which seemed irrelevant at first may well become critical later" causing a return to beginning ". . . so that more information can be assembled and distributed" (p. 53). Harrison (1981) also found that decision makers may have to do with limited data:

. . . whatever information is gathered during the search activity is always incomplete or imperfect, and the number of alternatives is

limited accordingly. More importantly, the cost of continually trying to perfect information rises exponentially. (p. 34)

This has an impact on uncertainty and risk. McCall and Kaplan (1990) found that "uncertainty also increases the number of criteria that are applied to the evaluation of alternative solutions, while risk increases the amount of analysis put into understanding the problem" (p. 63).

Uncertainty

Uncertainty should give anyone pause before continuing in their path or process and committing resources human or material because McCall and Kaplan (1990) found that "people (and managers in particular) are inveterate seekers of information, and given some uncertainty, they will seek more information than is required" (p. 16). Harrison (1981) earlier found similar evidence that made it appear "that individuals tend to want too much rather than too little information and take too long to arrive at decisions. Individuals seem unable to make full use of information, especially when it is multidimensional" (p. 6). In an attempt though to address the problems that managers encountered, Pounds (1969) found that they "must allocate

resources to questions before managers know their answers"

(p. 1). Nutt (2002) found that this must be done prudently:

Blunders are made when decision makers use their time and money for costly evaluations and little else. . . . Little time or money is spent to investigate claims, set objectives, search for ideas, measure benefits and risk, or manage social and political forces that can derail a decision. (p. 6)

Although managers usually make decisions under conditions of uncertainty, steps can be taken to understand the degree of uncertainty and minimize its impact on the decision. Courtney et al. (1999) explored uncertainty and found it can be systematically approached:

The uncertainty that remains after the best possible analysis has been done is what we call *residual uncertainty* In practice, we have found that the residual uncertainty facing most strategic-decision makers falls into one of four broad levels:

- Clear-Enough Future
- Alternative Futures

- A Range of Futures
- True Ambiguity. (pp. 5-7)

Courtney et al. explained their findings for these four levels in the following summary. In the first level, a clear-enough future exists when "the forecast will be sufficiently narrow to point to a single strategic direction." (pp. 6-7). In this level, "managers can use the standard strategy tool kit—market research, . . . Michael Porter's five-forces framework, and so on" (p. 12). In the second level, alternative futures exist when "analysis cannot identify which outcome will occur, although it may help establish probabilities" (p. 8). In this level, "alternative valuations can't be handled by performing sensitivity analysis around a single baseline model" because "each scenario may require a different valuation model" (p. 12).

In the third level of residual uncertainty, Courtney et al. (1999) explained that a range of futures exists when "that range is defined by a limited number of key variables, but the actual outcome may lie anywhere along a continuum bounded by that range" (p. 9). In this level, Courtney et al. advised to:

First, develop only a limited number of alternative scenarios—the complexity of juggling more than four or five tends to hinder decision making. Second, avoid developing redundant scenarios Third, develop a set of scenarios that collectively account for the *probable* range of future outcomes and not necessarily the entire *possible* range. (p. 14)

"Analysis should focus on the trigger events signaling that the market is moving toward one or another scenario" (Courtney et al., p. 13).

In the fourth level, "true ambiguity exists when multiple dimensions of uncertainty interact to create an environment that is virtually impossible to predict" (Courtney et al. 1999, p. 10). In this level, "usually [managers] can identify at least a set of variables that will determine how the market will evolve over time Managers can also indentify possible ways the market may evolve by studying how analogous markets developed in other level 4 situations" (Courtney et al., pp. 14-15). Courtney et al. advised that "options should be rigorously reevaluated whenever important uncertainties are clarified—

at least every six months. . . . level 4 situations are transitional, and most will quickly move towards levels 3 and 2" (p. 29).

Hill et al. (1979) built upon Knight's work and said uncertainty exists ". . . when outcomes cannot be predicted, even in probabilistic terms" (p. 114). Murray (1986) described uncertainty as the ". . . imperfect correspondence between information and the environment" (p. 11). Courtney et al. (1999) found that "underestimating uncertainty can lead to strategies that neither defend against the threats nor take advantage of the opportunities that higher levels of uncertainty may provide" (p. 4). In further defining uncertainty, Hill et al. (1979) said that even "where probabilities exist, . . . one's ability to find out those probabilities is severely limited" (p. 114).

Although it is a difficult process, Matheson and Matheson (1998) found that "each of the many uncertainties associated with a project must be quantified. Quantification forces people to structure the issues; it also surfaces additional issues and sources of uncertainty" (p. 47). Once something is quantified it can be measured. Harrison (1981) found that "the use of quantitative techniques in comparing and evaluating alternatives can

reduce uncertainty confronting the decision maker" (p. 41). As decision makers resolve ambiguity, McCall and Kaplan (1990) found and warn that they may desire to eliminate facts inconsistent with their developed positions. (p. 27)

To decrease the uncertainty, Luecke (2006) stated "what the decision maker needs is a range of possible outcomes for each uncertainty, as determined by experienced and knowledgeable informants" (p. 80). McCall and Kaplan (1990) reinforced this statement by saying ". . . more people will become involved in the decision as the manager reaches out to his or her network for advise and information" (p. 63). Upton's (1998) research concluded that ". . . operational flexibility is determined primarily by a plant's operators and the extent to which managers cultivate, measure, and communicate with them" (p. 132). Ference (1970) warned though of situations where:

More weight will be given to information provided by a source if the source has been used more often in the past, if the source has a high position in the organization, or if the source is inside, rather than external to, the organization. (p. B-85)

Risk

While it may be thought that if faced with a choice between a known and unknown with all other things being equal, people would choose the known or at least options with higher probabilities of occurrence, Williams (2007) found a ". . . substantial body of literature covering the framing effect [that] points the contrary" (p. 2). Entman (1993) stated that *"to frame is to select some aspects of a perceived reality and make them more salient . . . in such a way as to promote a particular problem definition . . ."* (p. 52). Williams found that *"in order to understand fully the decision-making process, the role of risk perception must be considered"* (p. 3). Outside of one's tolerance to risk, manipulation can present risk different than it is. Nutt (2002) found that *"ideas with high risk can appear to have little or no risk merely by ignoring questions about risk. To push a pet idea, risk is swept under the carpet. Or risk may be overstated and paralyze the decision maker"* (p. 58). Williams borrowed from Gordon-Lubitz¹² to state that *"the way in which risk information is presented can affect perceptions of risk"* (p. 13). Courtney et al. (1999)

¹² Gordon-Lubitz, R. J. (2003). Risk Communication: Problems of Presentations and Understanding. *Journal of the American Medical Association*, 289 (1), 95.

found that "risk-adverse managers who think they are in very uncertain environments don't trust their gut instincts and suffer from decision paralysis" (p. 4). Williams borrowed from Edwards and Elwyn¹³ to state that "in particular, perceptions of risk are vulnerable to framing effects, which influence the way individuals approach risk, and biases the decision they make" (p. 13).

Hill et al. (1979) used Knight again to say that "risk refers to situations in which outcomes can vary, but where the probabilities of each is known or at least can be estimated" (p. 114). Courtney et al. (1999) found that:

Even the most uncertain business environments contain a lot of strategically relevant information. First, it is often possible to identify clear trends, such as market demographics, that help define potential demand for future products and services. Second, there is usually a host of factors that are currently unknown but that are in fact knowable . . . (p. 5)

¹³ Edwards, A., & Elwyn, G. (2001). Understanding Risk and Lessons for Clinical Risk Communication About Treatment Preferences. *Quality in Health Care*, 10, 9-13.

Nutt (2002) said that "evaluations that explore risk and compare options to one another or to performance norms can be insightful. Expected results must be clear before such evaluations can provide useful information" (p. 35).

Heirs (1987) further commented on risk and said that ". . . probability and contingency thinking, no matter how thorough, cannot eliminate risk. They can only diminish it. . . . The next step is to weigh that risk . . ." (p. 100). Meredith and Mantel (2003) took this concept of risk and expanded it:

To apply risk analysis, one must make assumptions about the probability distribution that characterize key parameters and variables associated with a decision and then use these to estimate the *risk profiles* or probability distributions of the outcomes of the decision (p. 64)

Matheson and Matheson (1998) warned that "individual estimates made in the face of uncertainty are subject to biases. . . . People systematically put too much credibility in their point estimates [of uncertainties] and create ranges that are far too narrow" (p. 48). Meredith and Mantel (2003) say that point estimates are less

accurate than ranges when estimating variables. (p. 68)

Matheson and Matheson (1998) agreed and found:

The operational habit of searching for the facts and collecting extensive data has limited value. Taken to its extreme, this habit buries decision makers under historical data and point projections of present trends, but arms them with neither intelligence nor perspective. (p. 44)

Hogarth and Makridakis (1981) related that "a further important psychological finding is that although the availability of additional information increases confidence in judgment, it does not necessarily increase predictive accuracy" (p. 127). Later in their work, Matheson and Matheson (1998) stated, "It is better to establish ranges for important variables. . . . The range itself should reflect all judgments about possible sources of uncertainty" (p. 47). Courtney et al. (1999) stated that forecasts should be tested:

Of course, managers can discuss alternative scenarios and test how sensitive their forecasts are to changes in key variables, but the goal of such analysis is often to find the most likely outcome and create a strategy based on it. That

approach serves well in relatively stable
business environments. (p. 3)

Kosko (1993) paraphrased Heisenberg and said, "The more one can pin down your own speed (velocity) the less you can pin down your position and vice versa" (pp. 104-105). Whether the speed of market penetration is being measured or some aspect of company operations, Heisenberg's uncertainty principle¹⁴ can be applied as a check on the over-reliance on some type of data leading to false conclusions. In trying to pin down the organization's exact position in the market, the dynamics of the market become less understood.

Humans may prefer discrete occurrences over market functions only because precise data may be known. Einhorn and Hogarth (1999) advised that "inferring causality from just one cue often leads to serious error" (p. 139). This causality concept can transfer to the usage of models. Heirs (1987) warned that "in decision-making we should never fall into the trap of assuming that one model, and one model only, embraces all aspects of a problem" (p. 147). Murray (1986), in discussing the integration the

¹⁴ Heisenberg, W. (1927). Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik. *Zeitschrift. für Physics*, 43, pp. 172-198.

decision making models he researched (rational, political, and legal), stated "that each of the three decision models deals, directly or indirectly, with human problems" (pp. 218-219). When it comes to the question of using a formal model rather than human judgment, Einhorn and Hogarth found that "according to the results of psychological experiments on probability learning, . . ." using a model will result in less overall error" (p. 141).

Wilson and Alexis (1962) studied decision situations and designated two non-mutually exclusive frameworks as "open" and "closed". Open frameworks "facilitate a more complex view of the decision process" incorporating "many dimensions of behavior" (pp. 150-151). Luecke (2006) said that "the potential impact of some uncertainties on the outcome of a decision are not readily apparent" (p. 83). This could be due to the complex nature of human behavior. Open models need to be used when precise data are unavailable. Wilson and Alexis found that the closed framework was the "most commonly used and accepted analytical framework for choice behavior or decision-making in organizations . . ." (p. 152). "The growth of computer operations and effective information systems has greatly enhanced . . . 'closed' models," such as linear programming

for an objective result. (p. 153) Hill et al. (1979) stated that "linear programming is a mathematical technique employed by decision makers to optimize resource allocation when confronted with certain side constraints that limit the range of choices" (p. 178).

Forecasting

Hill et al. (1979) simply stated the concept of forecasting in that "to better anticipate the future, we note certain trends and try to extrapolate their future position" (p. 188). Drucker (1954) stated that "management has no choice but to anticipate the future, to attempt to mold it and to balance short-range and long-range goals" (p. 88). Drucker went on to state that planning tools are needed to allow businesses to development "regardless of the economic fluctuations to be expected over the cyclical period" (p. 90). Goal setting is a combination of personal and organizational value establishment. As such, Heirs (1987) warned that "once you inject human behavior into your calculations, then the complexities ramify beyond the scope of any conceivable program and we must fall back upon our own mental resources - our experience, reason, and imagination and intuition" (p. 82).

Meredith and Mantel and Luecke agreed that computer simulations can reduce some uncertainties. Delays in construction activity occur for various reasons. Meredith and Mantel (2003) found that project managers assign probabilities to the completion time for separate and whole tasks "based on the beta statistical distribution . . . rather than the more common normal distribution because it is highly flexible in form . . ." (pp. 394-395). In trying to define a more realistic working environment, risk analysis using simulation was preferred by Meredith and Mantel (2003) over traditional statistical analysis because probability assumptions can be factored in using Crystal Ball[®] software. (pp. 412-422) Luecke (2006) said that if operations can use a build-to-suit strategy or add customer finishes later, then less uncertainty about stocking decisions will occur. (p. 87) Chase, Aquilano, and Jacobs (2001) discuss the types of processes that could be used are make-to-order, make-to-stock, and a hybrid of these two. (pp. 97-98) Make-to-order removes uncertainty due to the order. Made-to-stock adjusts uncertainty to that of seasonality.

Chase et al. (2001) also discussed custom manufacturing as a variation on the make-to-order process

where a customer gives specifications to operations thus removing form uncertainty. (p. 726) Simchi-Levi, Simchi-Levi, and Kaminsky (2000) discussed delayed differentiation or postponement where finishes are added later as Luecke suggested. (pp. 181-184) Uncertainty of operations is minimized by delaying part of the assembly or service delivery. Simchi-Levi et al. (2000) described that this is accomplished through resquencing of operations, commonality where parts are somewhat interchangeable or adaptable, modularity where different features can be added during the final assembly, and standardization, where features demanded by most customers are added regardless of product. (pp. 181-184) Intangible items, such as market share, cannot be warehoused or moved about. This can present a problem of quantification, but Murray (1986) said that "rational concepts allow the thinker to segregate and to objectify otherwise unlimited intangible phenomena" (p. 51). Matheson and Matheson (1998) stated that "in the end, alternatives must be doable" (p. 42).

Alternatives

Each alternative is an argument that invokes a claim or assertion about reality. Nutt (2002) warned that faulty

claims can arise when "a claim is salient [and] corresponds to your experience. Claims that do not are more apt to be dismissed or discounted" (p. 78). Ehninger (1974) discussed that if the evidence is accepted by the decision maker then the warrant is the part of the argument that relates the evidence to the claim. (pp. 10-11) Complex arguments will have more claims. One of the four types of claims that Ehninger provided is the reason for making a decision; actuative claims are "assertions that something should be done (or should not be done)" (p. 28). The other three types of claims (declarative, classificatory, and evaluative) that Ehninger discussed provide evidence and/or warrants for the actuative claim. (pp. 28-30) The argumentative process can be easily understood as facts giving support to beliefs in turn giving support to policy. A decision is involved in each step, but major decisions are usually a matter of policy determination.

Hill et al. (1979) discussed the decision matrix as a decision aid that "forces a detailed analysis of each alternative . . ." (p. 120). Hill et al. generated the matrix by collecting information about alternatives, evaluation criteria, order of importance, weighting factors, and ratings. (pp. 121-126) Hill et al. believed

this process could be used to keep track of the alternatives through the evaluation process, and ". . . clearly presents the rational behind a given decision" (p. 127).

In reviewing alternatives, future courses of action need to be considered. Matheson and Matheson (1998) found that:

In lieu of unobtainable facts, decision makers must make do with information that provides insight into the future. That information must be meaningful in the sense that it selects only what is helpful in illuminating current decisions, while avoiding needless complexity. At the same time it must be objective and reliable, incorporating the best judgment of people in the best positions to know. (p. 44)

Harrison (1981) found that "one way to determine which alternative is most desirable is to test each one by imagining that it has already been put into effect" (p. 38).

Heirs (1987) said to allow inconvenient questions about simulations for alternatives because they offer a reality check and ensure that the those risks have been

considered as well as contingency plans for those risks.

(p. 86) Simon (1976) stated that "in principle, factual propositions may be tested to determine whether they are *true or false* - whether what they say about the world actually occurs, or whether it does not" (p. 46).

Considered a waste of time and energy by some to address all foreseeable consequences and contingencies, Heirs said that "*such so-called waste is as necessary and unavoidable*" in the alternative evaluation stage as it was in the alternative generation stage and warned strong personality managers to temper impatience and disguise irritation over what they see as unrealistic futures. (p. 87) Temperance does not mean to give away authority over the situation. Heirs said that "in order to produce a useful simulation of the future our imagination must be harnessed to patience, experience, and wisdom" (p. 88). In that vein, Drucker (1993) said that "effective research requires organized abandonment Every product, process, service, and research project needs to be put on trial for its life every few years with this question: Would we now start this project . . . knowing what we know now?" (p. 285).

CHAPTER SIX

CHOOSE THE BEST ALTERNATIVE

Introduction

Drucker (1967) found that "the understanding that underlies the right decision grows out of the clash and conflict of divergent opinions and out of the serious consideration of competing alternatives" (p. 143). Drucker (1967) stated the following about the nature of decisions:

A decision is a judgment. It is a choice between alternatives. It is rarely a choice between right and wrong. It is at best a choice between "almost right" and "probably wrong"—but much more often a choice between two courses of action neither of which is provably more nearly right than the other. (p. 143)

Peters (1987) stated, "There are few greater liberating forces than the sharing of information. . . . Knowledge is power - it always has been; it always will be" (p. 609). Of the multiple facets of the power of information that Peters (1987) shared, there are two pertaining directly to problem solving:

[First,] the widespread availability of information is the only basis for effective day-to-day problem solving, which abets continuous improvement programs. . . . [Second,] visible posting of information radically speeds problem solving and action taking. (p. 612)

As reviewed in previous sections, various issues are in effect during the decision process. Luecke (2006) said the following about making the decision:

When all the previous steps have been carried out properly and the decision team is in agreement on its objective, the team members can rationally evaluate each of the alternatives. Under ideal circumstances, the right choice will be clear. But in reality, some degree of personal preferences, ambiguity, and dissention often makes the final choice difficult. (p. 7)

Murray (1986) pointed out that the presence of the goal (actual or psychological) operates to cause decisional choices or consequences based on quantitative analysis or hunch. (p. 55) In contrast to a logical progression of steps, Einhorn and Hogarth (1999) warned that "when people take actions in situations where random processes produce

the outcomes, they are sometimes subject to delusions of control" (p. 144). Support might be sought for this delusion.

Bias

One of the many "human foibles" that Luecke (2006) pointed out is that of confirming-evidence bias where evidence is sought to support a position and opposing or contrary evidence is dismissed or overlooked. (p. 108) Nutt (2002) found many issues with quick fixes:

Once a quick fix is discovered, decision makers take a defensive posture and collect information to justify its adoption. . . . more time and money is spent doing this type of evaluation than all the other decision-making activities combined. . . . [resources] would be better spent to uncover a more effective action. (p. 34)

Nutt found that "each decision maker in the debacles [he researched] slipped into a defensive posture, attempting to justify the opportunity and defend reasons to support it" (p. 51). Biases will become part of the communication process because Ference (1970) found that "particular interests or concerns will determine if information is to

be eliminated, modified, or added before being transmitted In addition, personal motivations may influence what is transmitted" (p. B-84).

Hogarth and Makridakis (1981) evaluated forecasting and planning and found three processes to help eliminate bias. First, acquisition biases need to be reduced by ". . . [sampling] from as wide a base as possible, . . . and to strive to find information that could *disconfirm* hypothesis and forecasts" (p. 121). Wason (1960) stated that "in general, scientific inferences are based on the principle of eliminating hypotheses, while provisionally accepting only those which remain" (p. 129). Contrary to this, Wason found that "very few intelligent young adults spontaneously test their beliefs . . ." (p. 139). To reduce this tendency, Wason suggested that an attitude be developed that "consists in a willingness to attempt to falsify hypotheses, and thus to test those intuitive ideas which so often carry the feeling of certitude" (p. 139).

Pruitt (1961) found a danger in deciding or taking a position too early that resonates with Wason's findings. Pruitt found an information disparity when comparing two similar decisions:

Although the two conditions were equated in informational input and rational strategy, considerably more information was required before changing a decision in the Postdecisional Condition than before making [a] decision in the Predecisional Condition. (p. 439)

Drucker (1954) took a different route to find disconfirming information and built it into the forecast expectations and found that to adjust for errors in forecasting:

Any management decision must therefore contain provision for change, adaptation and salvage. . . . Otherwise, despite all the technical brilliance in forecasting, management decisions will be merely wishful thinking—as all decisions based on long-range prediction alone inevitably are. (p. 93-94)

In the second process to help eliminate bias, Hogarth and Makridakis (1981) recommended to aggregate information mechanically where possible because people are inefficient at this task. (p. 121) Here computers can offer their support. The third process is where Hogarth and Makridakis recommended that "greater care needs to be exercised in interpreting the apparent *causes of outcomes*" (p. 121). One

should not correlate the unrelated. Langer (1975) pointed out that:

People are motivated to control their environment. . . . The greatest satisfaction or feeling of competence would therefore result from being able to control the seemingly uncontrollable. A second, although not entirely independent, reason is that there is motivation to avoid the negative consequences that accompany the perception of having no control. (p. 323)

Influences Affecting the Decision

Even if a degree of neutrality of exercised, another of the "human foibles" can have an impact on the decision. This is where personal preferences come to influence the decision. Luecke (2006) borrowed the terms anchoring and adjustment from a study of negotiation to refer "to a tactic that attempts to establish an initial position around which negotiations will take place. (p. 99) This can cause a premature end to the evaluation of alternatives if improperly used. The communication process is critical to arrive at a decision. Cook and Hammond (1982) found that consistency is required in the decision process:

Conflict, disagreement, and misunderstanding among group members—are regarded as products of the inability of individuals to process information consistently and to understand the positions taken and judgments made by other members about decision issues. (p. 9)

If the stronger human influences exerted to achieve a desired result are the seeking of conforming evidence and the anchoring of positions, then the softer human influences affecting a decision maker are of conformity and groupthink. Luecke (2006) said “. . . that individuals within a group . . . are subject to the influences of those around them, even when they have the power to ignore them in making a final decision” (p. 117). Hartwick et al. (1982) found that group biases induced long-term influence on individual bias such that more information was recalled for a favored option and other information was suppressed for an opposing option. (pp. 42-43) Hoffman (1982) likewise found that “often the [group] members’ information about the problem was overlooked, rejected, or distorted during the discussion” and that “sometimes groups agreed early on a solution and were difficult to shake loose” (p. 99). Nutt (2002) agreed and found that “people become anchored by the

first information they observe and give it more weight than information that arrives later on" (p. 77). One reason for this difficulty comes when information was evaluated and integrated into the decision process. Ference (1970) proposed that "the extent to which information is altered as it is carried through a communication network will depend on the source, content, and point of entry of the information" (p. B-85).

Janis (1971) used the term groupthink "to refer to a mode of thinking that persons engage in when *concurrence-seeking* becomes so dominant in a cohesive group that it tends to override realistic appraisal of alternate courses of action" (p. 43). To combat influence, Luecke (2006) suggested having the team members "privately write down their judgment before the views of other participants are known" (p. 119). Luecke said that the convergence in groupthink ". . . is less driven by objectivity than by social psychological pressures" (p. 120). If the derived majority view is objectively valid then it should be free of social pressures. To check this, Luecke said someone needs to "challenge the assumptions and conclusions of the majority . . . and deal with facts and ideas that conflict with their own" (p. 121).

Objectivity can come from an unbiased presentation of the facts. Ehninger (1974) pointed out that "argument is superior to alternative methods of decision making" and that "the person who acts out of the self-convincing process of argument understands not only what he is to do, but also why he is to do it" (p. 6). Understanding why something should be done does not always make it palatable. Harrison (1981) found that "the best alternative for the decision maker may be quite distasteful to the people or organizations affected" (p. 41). Heirs (1987) agreed and borrowed from Drucker stating that "real debate between people with conflicting views is not just unavoidable, it is absolutely essential. The best answers . . . [may] arouse the most controversy" (p. 62).

After the alternatives have been evaluated, Murray (1986) pointed out that the rational process will allow for the deliberate selection of alternatives from a preference ranking of possibilities. (p. 54) Sometimes that ranking is legislated or forced on the decision maker. Lowi (1979) stated that "laws set priorities. Laws deliberately set some goals and values above others" (p. 92). Sometimes the alternative that is the best choice is not legally permitted, and it would require extra effort in order to

change the law or regulation. This extra effort if brought into the evaluation process may make this choice less preferable.

Decision Rules

Hill et al. (1979) presented two decision rules that are dependent on the decision maker's forecasts in fairly stable markets because "they do not take into account the probability of future" changes to the parameters of the forecast. (p. 130) The maximax decision rule is optimistic and less probable or risky in that the best outcomes are considered for the alternatives and "the action with the greatest maximum" is chosen. (Hill et al., p. 130) The maximin decision rule is pessimistic and conservative in that the worst outcomes are considered for the alternatives and "the action that maximizes the minimums" is chosen. (Hill et al., p. 130) Drucker (1954) recommended this as an approach to "free decisions from cyclical guesswork by testing the business decision against the worst possible and sharpest possible setback that past experience could lead us to expect" (p. 90).

Heirs (1987) presented a third decision rule based on game theory and decision trees. The minimax decision rule

is realistic and "assumes that while he himself will always make the move which maximizes his own chances of winning, his opponents will always make moves which *minimize* those chances" (p. 83). Harrison (1981) studied maximizing and found that the underlying assumptions are faulty:

Objectives are not fixed. The known set of alternatives is always incomplete because it is impossible to obtain perfect information. . . . Many of the variables that must be considered in any attempt at maximization are not easily quantified. Therefore, a precise preference ranking of the firm's objectives or alternatives that will maximize outcome is most unlikely. (p. 92)

Approximations

A manager's decisions are usually made with less than perfect information. Murray (1986) said that "rational decision making, then, does not require complete knowledge but only enough to make choices based on preferences" (p. 55). Heirs (1987) said that the decision-thinking process is seldom perfect, but through preparation risk is minimized, and decisions can be made confidently. (pp. 96-97) Baumol and Quandt (1964) experimented with this concept

by combining algebraic equations with statistical estimation and simulations to develop of rules of thumb that approximated the true values being sought; they termed this process as the optimally imperfect decision. (p. 26) Kosko (1993) calls making a decision based on enough information as using the fuzzy principle. (pp. 177-178) Tan et al. (2006) relayed that "Lofti Zadeh introduced fuzzy set theory and fuzzy logic in 1965 as a way of dealing with imprecision and uncertainty." Objects do not have to equate to 0 or 1, false or true to be imputed as such. (p. 578) This finds an application in data mining cluster analysis. Having enough information and persuasion, even though more could be provided from both evidence and warrants so that the claim of the argument is accepted, is at the heart of fuzzy logic. Matheson and Matheson (1998) stated that "information quality involves a shift of emphasis from the tangible world we know to the potential world we seek to understand" (p. 45).

Fuzzy Logic

Kosko (1993) used his Fuzzy Approximation Theorem to define problems with fuzzy patches and fuzzy sets. (p. 167) Kosko stated, "What really counts with fuzzy systems, the real value added, is the tie between words and sets and

between knowledge and patches" (p. 177). Fuzzy systems appear by defining a fuzzy patch and then seeing where the unions occur or by establishing fuzzy sets. Kosko stated, "Sloppy rules (if-then) give big patches. Fine rules give small patches" (p. 167). This system could be used to decide where to open a store based on demographics, shopping patterns, and other items used as sets. The location within the fuzzy system would depend on the magnitude of the decision. Matheson and Matheson (1998) pointed out that "except for the few truly critical issues, decision quality rarely requires great precision: a well-informed approximation is usually adequate" (p. 49).

Kosko (1993) gave an example of an automated fuzzy system as one that Isuzu, Nissan, and Mitsubishi use to regulate their cruise controls. (p. 185) Speed is regulated based on the forces acting on the vehicle and on the fuel and braking needs inferred based on fuzzy parameters. Yeh and Li (2003) described a multistage fuzzy inference engine as "decision-making logic, which employs fuzzy rules from the fuzzy rule bases, to determine a mapping from the fuzzy sets in the input universe of discourse U_x to the fuzzy set in the output universe of discourse U_y " (p. 257). From the discussion on framing issue, the fixing of the world that

the rational model needs is similar to fuzzy sets and patches developed as the team models a form of reality.

Hill et al. (1979) reached back to work of Lewin (1935) in social psychology to review intrapersonal conflict and the reasons why managers vacillate between choices. Lewin experimented with three main areas of conflict: approach-approach, avoidance-avoidance, and approach-avoidance.¹⁵ All these types of conflicts delay the selection of the alternative that will be implemented. (pp. 122-123) Hill et al. found that these conflicts arise separately per situation the closer one gets to making a choice for an alternative. (pp. 60-61) Hill et al. found that approach-approach conflicts arise where two beneficial alternatives exist. When one alternative is about to be chosen, then the good aspects of another alternative are remembered and thus opportunity costs come to bear on the decision. Avoidance-avoidance conflicts arise where two negative alternatives exist, and the least damaging one must be chosen. Approach-avoidance conflicts arise where the decision maker is ambivalent to an alternative. On the one

¹⁵ Lewin's 1935 work on personality contained three selected papers from other authors. Lewin's work on conflict seems to rely or build upon one of the papers: Murchison, C. (1933). *Handbook of child psychology* (2nd ed.). Worcester, MA: Clark University Press.

hand, when an alternative is being considered, its negative aspects become known and causes an avoidance of an alternative. On the other hand, when that alternative is avoided, then the salient positive aspects of the alternative are remembered thus setting up the conflict. (pp. 59-61)

Choice Conflict and Resolution

Research could go on endlessly, but the decision would never be made. The dangers of that path have been previously discussed. Luecke (2006) stated that "knowing when to end deliberations is often difficult" (p. 70). Some team members would be comfortable with the data collected and others would not. Every method choice has advantages and disadvantages, but Hill et al. (1979) found two needs of the decision maker that help cut through the intrapersonal conflicts. First is the need for simplicity that "enables the decision maker to impose a framework that organizes a set of choices and events in such a way that action can be taken." The negative side to this is "that it blinds the decision maker to the subtlety of the choices available to him" (Hill et al., p. 63). Second is the need for consistency. "In choosing among alternative options, the decision maker typically needs to behave in ways that

maintain or restore consistency among the several attitudes, beliefs, and values that are part of his personal context" (Hill et al., p. 64).

Hoffman (1982) defined a process model whereby decisions implicitly or explicitly move through defining, specifying, generating, evaluating, and implementing phases. (pp. 110-111) While implicit movement through the phases may be more thorough and generate more valence with the group members, it could require more resources than management feels is necessary to effect a decision. Thus an explicit choice by a group leader or overseeing manager can move the process along. Luecke (2006) said that deciding too early could overlook the benefits of a better choice. Deciding too late could be detrimental to operations or industry position. (p. 70) Harrison (1981) found that "all that is necessary to make the choice a rational one is that an objective exist and that the decision maker perceive and select some alternative that promises to meet the objective" (p. 82). Heirs (1987) said that after alternatives have been generated and expanded, the decision maker "assesses their relative strengths and weaknesses, attractions and disadvantages, risks and rewards, and chooses the one which he judges to be preferable" (p. 149).

The next chapter will explore data and information systems issues and functionalities to prepare for the integrating discussion of where GIS can positively influence many of the issues confronting the decision maker. Some things like managing a value system are not applicable to GIS.

Uncovering patterns and objectively displaying alternatives through complex processing to minimize the negative human influences, blunders, and idea imposition tactics are strengths of GIS.

CHAPTER SEVEN

DATA, DECISION SUPPORT SYSTEMS, AND GEOGRAPHIC INFORMATION SYSTEMS

Data and Systems

Just as words make sentences that in turn make paragraphs, decisions are based on available information that is derived from data. Data leads to information that leads to knowledge that leads to better decision making. In the absence of data, judgment must be used, but even that is based on data of past experience. Organizations both public and private create, process, store, and retrieve data as part of their functions. Whether the purpose of the data are financial for billing, inventory control for manufacturing, personal for governmental processing, or demographic for marketing, data are being created and stored for current or later use by internal or external users.

Huxhold (1993) reviewed the progress of data processing from the 1950s until his day and found that after the initial transaction-based systems were developed, data-oriented applications were devised using database management systems. That shift "changed the focus of

information systems design" (p. 61). Systems were being developed that reached beyond the organizational structure "to information-oriented processing, which supports the information needs of operations, management, and strategic planning of the organization, regardless of the organizational framework in which they are performed" (Huxhold, p. 61).

Kendall and Kendall (2008) related that "transaction processing systems (TPS) function at the operational level of the organization" (p. 2). Power (2001a) stated that TPS "are designed to expedite and automate transaction processing, record keeping, and simple business reporting of transactions" (Major Differences, ¶ 1). TPS generate massive amount of data. Tan et al. (2006) observed that "often, traditional data analysis tools and techniques cannot be used because of the massive size of a data set" (p. 1). Internet purchases and banking transactions can create these sizes of data sets due to the millions of customers and account holders involved.

How those data are best organized and stored using logical data modeling and physical database design techniques, such as data warehousing, is the subject for systems analysts, database designers and administrators.

Users are not normally involved with data design. Cattenstart and Scholten (1999) supported this and found that "the user is not interested in the way data are organized in the database. . . . What is important to the user is that the system is capable of accommodating the user's view of the world" (p. 171).

Decision Support Systems

DSS are higher forms of information systems that use data generated by TPS and other systems to "support decision making in all its phases" while leaving the actual decision up to the decision maker. (Kendall & Kendall 2008, p. 3) In reviewing the history of DSS, Oz (2000) found that DSS were developed to assist managers because they had ". . . neither the time nor the resources to study and absorb long, detailed reports of data and information . . ." (p. 21). The next level up in information systems would be the realm of expert systems and artificial intelligence; rules developed by knowledgeable people (employees or consultants) would be used to build these systems to derive and select ". . . the best solution to a problem or a specific class of problem" (Kendall & Kendall, p. 4). These rule-based systems have a place in capturing and

transferring organizational learning, but this paper will explore DSS and their role to support the decision maker. DSS architecture, networking, and security issues will not be discussed in this paper so that the main concepts can be fully developed, but these issues should be addressed when developing a DSS.

Groups have different needs than a single manager when making a decision. Those needs come with specific problems and synergies. Jankowski and Nyerges (2001) found that trends towards flatter organizational structures and group involvement ". . . created the need for information technology capable of supporting participatory decision making" (p. 2). Kendall and Kendall (2008) found that DSS can be designed for group use with beneficial results:

Group decision support systems (GDSS) software can be designed to minimize typical negative group behaviors, such as lack of participation due to fear of reprisal for expressing an unpopular or contested viewpoint, domination by vocal group members, and "group think" decision making. (p. 4)

Groups are able to coordinate their activities from anywhere via the internet or organizational intranet given

they have access to the necessary data and other tools. Jankowski and Nyerges (2001) found that groups can meet in three other types of space-time venues in addition to the traditional face-to-face meeting;¹⁶ the other three are: "different-place and different-time (distributed) meeting, same-place and different-time (storyboarding) meeting, and different-place and same-time (conference call) meeting" (p. 49).

Interfaces for the human to computer interaction are important for the smooth functioning of any information system. GIS are no different, and Hirschfield, Brown, and Marsden (1991) found that:

Typically, such an interface provides the user with specifically designed menu screens or some other means of choosing between a number of alternative courses of action. . . for example, the selection of data sets, the scale of analysis, the method of analysis, and so on. (p. 158)

DSS must be reasonable to use or decision makers will likely bypass this tool. (Power 2001b, Introduction ¶ 1,

¹⁶ Original material was referenced as Jarke, M. (1986). Knowledge sharing and negotiation support in multiperson decision support systems. *Decision Support Systems*, 2 (1), 93-102.

hp1) Power (2001b) suggested that seven issues are important in evaluating a user interface:

- User interface style
- Screen design and layout
- The Human-Software interaction sequence
- Use of colors, lines, and graphics
- Information density
- Use of icons and symbols
- Choice of input and output devices (User Interfaces, ¶ 6, hp2)

Command line interfaces, while powerful, are hard to learn due to their specificity. Most programs use a combination of menus, icons, and graphical interfaces. These allow flexibility and familiarity.

Power (2001a) derived five main categories of DSS from Alter's proposed taxonomy:¹⁷ data-driven DSS, model-driven DSS, knowledge-driven DSS, document-driven DSS, and communications-driven DSS. (Five Main Categories of DSS, ¶ 1-5) The technology and functionality of computer systems continue to grow and expand as time progresses. Originally

¹⁷ Alter, S. (1980) *Decision support systems: Current practice and continuing challenges*. Reading, MA: Addison-Wesley.

Power had placed GIS only in the data-driven DSS category. Power understood though that new technologies and the internet would change the landscape of DSS. GIS, such as ESRI's ArcGIS and Pitney Bowes' MapInfo, incorporate the functions and attributes of data-driven and knowledge-driven DSS. Power (2001a) described a data-driven DSS as focusing on "access to and manipulation of large databases of structured data and especially a time-series of internal company data and some times external data" (Five Main Categories of DSS, ¶ 1).

Data Mining

Data mining techniques fall under knowledge-driven DSS and have the ability to provide understanding and solve some of the problems of the data domain. Hidden patterns can be sought out of large data sets. (Power 2001a, Five Main Categories of DSS, ¶ 1) Openshaw (1994) provided a definition of pattern and stated:

In a GIS, pattern may often be viewed as a localised excess or concentration of data cases that are unusual, and thus of potential interest, either because of the intensity of their localised concentration or because of their

predictability over time or their similarity in terms of their features. . . . It is far better if the scale and nature of any pattern can emerge from the analysis rather than be imposed upon it.
(p. 89)

This last concept of emergence will come up again in Nutt's comparison of the discovery process and idea imposition process. Although model-driven, document-driven, and communication-driven DSS are important tools for management, they are not the focus of this paper and will not be discussed. Some aspects of GDSS can be considered in the realm of communication-driven DSS.

Tan et al. (2006) found that "data mining is an integral part of knowledge discovery in databases, which is the overall process of converting raw data into useful information . . ." (p. 3). Tan et al. described this process as one that includes in order: input data, data preprocessing, data mining, postprocessing, ending with information. GIS can use geocoding (giving a latitudinal and longitudinal spatial position to data) and feature selection to help prepare the data. (p. 3) Tan et al. found that data usually needs to be prepared for use:

Data preprocessing include[s] fusing data from multiple sources, cleaning data to remove noise and duplicate observations, and selecting records and features that are relevant to the data mining task at hand. (p. 3)

Many times during brainstorming, certain features are not excluded in order to stimulate other alternatives.

Geographic Information Systems

Components

GIS can help identify and map points, lines, and polygons that will impact the decision, such as location of fire hydrants, legal boundaries, and flood plains. Wellar (1993) found regarding GIS data:

. . . geographic locations, distributions, and patterns are effectively described by points, lines, and polygons Points equal sites in GIS. Sites can represent anything located in the real world to which x-y coordinates or a location identifier can be assigned. . . . Lines equal connections or links between and among points or sites in the real world in a GIS. . . . Polygons equal areas, zones, regions, surfaces, or spaces

contained within sets of observable or conceptual
lines in GIS. (pp. 8-9)

Bailey (1994) reviewed statistical spatial analysis
techniques and stated that:

Locational data consists purely of the locations
at which a set of events occurred. . . .

Attribute data consists of values, or attributes,
associated with a set of locations

Finally, *interaction data* consists of
quantitative measurements each of which is
associated with a link, or pair of locations.

(pp. 17-18)

See Appendix E for the types of attributes. Haining (1994)
found that spatial analysis "requires information both on
attribute values and the geographical locations of the
objects to which the collection of attributes are attached"
(p. 45). Temporal analysis can be used to track historical
patterns of attributes and/or interactions and project the
future direction of growth, contraction, or stasis. Just to
keep in mind that organizations are not the only users of
GIS, doctors researching or monitoring conditions
physically and temporally can also use GIS because "GIS

techniques have even been applied to the analysis of genome sequences on DNA" (Longley, Goodchild, Maguire, and Rhind 2001, p. 5).

Capabilities

GIS perform various types of analyses on data and produce maps based on chosen locational parameters. Any number of maps or views of the data can yield insight or produce more questions for further exploration of the issues. Data can be aggregated for clarity or left unchanged and plotted for a different visual effect. Data can be analyzed temporally, spatially, statistically and in combination of these methods for use in forecasting, generating alternatives, and depicting situations. While GIS process mainly geographic data quite well, Visvalingam (1991) found:

However, data collection and aggregation need not be based exclusively on spatial (or geographic) criteria. The temporal dimension may provide a better framework for some other classes of applications which need either to identify critical events (as opposed to critical areas) or to predict, monitor and control the consequence of events . . . (p. 13)

Thrall (2002) found that "GIS technology is the vehicle for making the [visualization] procedure more efficient, accurate, and accessible to analysts, and it increases the productivity of the analyst . . ." (p. 86). Either through a group setting with GGIS or in a stand alone configuration, GIS provide tools to enable an organization to learn.

Landis (1993) reviewed GIS software and found it capable of performing the following sets of functions:

. . . presentation and thematic mapping; data query; spatial query; database integration and updating; routing and minimum path analysis; buffering; point-in-polygoning; overlay; and distance, adjacency and proximity analysis. (p. 26)

See Appendix F for a categorization of these functions. Bailey (1994) likewise found these spatial summarization techniques powerful as a prerequisite to spatial analysis. (p. 16) Hirschfield, Brown, and Marsden (1991) found that "the basic manipulation of data involves the sorting, aggregation and merging of records, their selective sub-setting and cross-tabulation and the cross-referencing of data items to derive new variables" (pp. 157-158).

GIS need data to process. These data can come from internal (organization) sources or external (market) sources. Not all internal data are centralized, integrated, and accessible. Moore (1993) interviewed individuals in organizations acquiring GIS to understand the main reasons involved. (p. 83) All respondents saw it as a better way of processing their work flow because accessibility to departmental data by the other parts of the organization allowed databases to become integrated. (Moore, p. 86) An ancillary benefit was "that the acquisition would force the departments to finally 'clean up' their data so that the GIS databases could be populated" (Moore, p. 86).

Data Mining Applications

Data mining techniques give current GIS the power to find relationships in data. Tan et al. (2006) defined two major categories of data mining tasks: predictive and descriptive. (p. 7) DSS primarily use predictive models, but GIS makes use of both predictive and descriptive models. In the two major categories of tasks, four tasks are the main elements of data mining: predictive modeling, association analysis, cluster analysis, and anomaly detection. Predictive modeling builds relationships between data to derive rules to explain discrete and continuous

target variables. Association analysis discovers patterns that describe data associates. Cluster analysis finds groups of similar data. Anomaly detection identifies significantly nonconforming data. (Tan et al., pp. 7-11) These tasks are called by Keller and Thalmann (1999) a process-centered approach to sharing graphic presentations through the access, query, and manipulation of geospatial data by "a data manipulation language or through an application programming interface (API)" (p. 152). Most GIS have these for power users.

The process of data mining discussed by Power (2001c) agreed with that of Tan et al. (2006) and is said to usually follow these steps: selection and preparation of the data to be mined, qualification of the data, selection and use of the data mining tool(s), and application of the information. (Data Mining Process, ¶ 1, hp 13) GIS give tools to prepare the data, but usually this is done externally in a database or spreadsheet program; the file is then saved with a comma delineated format or other format that the GIS can import and use. Some GIS can use a database directly through the Open Database Connectivity (ODBC) standard. GIS can then qualify the data through selection queries. Bailey (1994) found that advanced

statistical techniques, such as kernel and Bayesian smoothing methods could identify areas of homogeneity, possible models, and analyze "how well models fit the observed data" (p. 27). Where the data are not homogeneous but instead heterogeneous, a larger sample will be required "to capture the full variability of attribute values at all possible locations" (Longley et al. 2001, p. 105).

Sargent (1999) compared the work of analysts to GIS and found that:

. . . operational use of geographic information in a multi-user, multi-organisation application, adds significant new requirements in data maintenance, data transformation, lineage tracking, schema maintenance and metadata update.
(p. 41)

These issues will not be covered in this paper, but are mentioned here to advise the information department staff to be prepared to handle these issues in support of the decision makers.

Data Issues

GIS have not always been able to share data as easily as they do today as evidenced by two international conferences on Interoperating GIS: 1997 in Santa Barbara,

California, and 1999 in Zürich, Switzerland. (Včkovski, Brassel, & Schek 1999, preface) Stock and Puller (1999) found that data heterogeneity prevented effective data sharing. "Data heterogeneity can be classified into schematic heterogeneity, syntactic heterogeneity and semantic heterogeneity." Semantic heterogeneity is the most common data sharing problem and "refers to differences in the definition of concepts and the rules that are used to determine whether a real world entity is an example of a concept" (Stock and Puller, p. 232). If any of these heterogeneities exist, then the data's use in problem solving is greatly hindered. (Stock and Puller, pp. 231-232) This is a specialized area of research and will not be dealt with in this paper.¹⁸ It will be assumed that these issues have been solved for decision making purposes.

Wiederhold (1999) stated that "the objective of *interoperation* is to increase the value of information when information from multiple sources is accessed, related, and combined" (p. 1). Due to the ever expanding list of data sources, Wiederhold advised care in preventing the decision

¹⁸ For a review of heterogeneity as it relates to GIS, see Getis, A. (1994). Spatial dependence and heterogeneity and proximal databases. In S. Fotheringham, & P. Rogerson. (Eds.). *Spatial analysis and GIS*. (105-120). London: Taylor and Francis, Ltd.

maker from becoming overwhelmed by data. Data from sources is not integrated but instead only selected results derived from the combination of sources. (p. 1) Sargent (1999) pointed out that sometimes the results need to be recorded and made permanent in a database, but at other times the results can be transient as with query results. (p. 44) The development of options sets or "clusters of options deemed important . . . based on different thresholds for criteria or geographic location" can be filtered through "Boolean operations in a query language" to lend insight to the problem at hand. (Jankowski and Nyerges 2001, p. 19) The need to record the results will depend on the permanency and accessibility of the data source.

Analysis and Presentation

GIS are very good at presenting the results visually, and GIS make use of many different icons to convey the system functions. Before the advent of GIS and continuing until today, SPSS®, Minitab®, and other statistical packages have analyzed databases to produce information. Location-based information from these packages is still in report form and is limited in overall impact to the viewer. GIS present the summary data pictorially in map form giving the reader or viewer with a clearer understanding of the

underlying descriptive data. GIS can turn descriptive data into predictive information through extrapolating the trends uncovered. GIS allow a user to drill down for detailed views or drill up for summary or aggregate views of the data. (Power 2001d, Data-Driven DSS Overview, ¶ 2 ,hp2)

These relationships, whether found through data mining efforts, spatial analysis, or kriging, can bring insight to the decision process. Clark's (2001) research showed that geostatistics, of which kriging is a method, can solve most problems involving the distribution of a variable in one, two, or three dimensions. (p. 3) Clark's work provided "the simplest application of the Theory of Regionalised Variables, that of producing the 'best' estimation of the unknown value at some location within an ore deposit" (p. 5). Although this specific application is the focus of her work, Clark stated that "estimation techniques can be used wherever a continuous measure is made on a sample at a particular location in space (or time), i.e., where a sample value is expected to be affected by its position and its relationships with its neighbors" (p. 5). This gives rise to many applications in marketing and operations decision making.

Clark (2001) said the following about attempting to analyze market potential of an area:

Kriging can be used to produce the close grid of values necessary to the plotting of contour maps. . . . One of the advantages of kriging as an interpolation technique is that every estimate is accompanied by a corresponding kriging standard deviation. Thus, for any contour map of values, a companion map of "reliability" can be produced. (pp. 107-108)

The assignment of value to the outcomes of an analysis can now be tempered by rationality, and the risk of uncertainty can be reduced. Although Longley et al. (2001) found many forms of kriging, the goal of this type of spatial interpolation is to take measurements "and then to apply these properties in estimating the missing parts . . ." (p. 297). Kriging also provides an avenue for possible savings through focused advertising or outreach programs. Clark stated that "an additional advantage of kriging as an estimation technique is that the maps and/or calculations of the 'standard errors' can be produced without actually taking the samples" (p. 109). Many decisions have a

location component. When location is a major factor in both processing data and providing output, GIS are often the best DSS. (Oz 2000, p. 471)

GIS can process ordered data involving attributes with relationships in time and space. Longley et al. (2001) stated that this "ability to combine the general with the specific" gives GIS strength as a tool for problem-solving. (p. 8) If the ordered data are combined, then GIS can handle variations in up to four dimensions giving the decision maker sufficient room to explore alternatives. Tan et al. (2006) equated sequential data with temporal data having a time element. Records with time series data, showing the changes (or lack thereof) of an item over time, can allow for temporal autocorrelation. This may allow for a smaller sample size with similar results than with using a regular sample size. (pp. 33-35) GIS handle spatial data the best due to the location component. This can allow for spatial autocorrelation that Longley et al. (2001) stated as "quantify[ing] the degree to which near and more distant things are interrelated" by way of their attributes. (p. 99)

Hoos (1972) warned not to gather "data more because they are available than indicative" (p. 8). O'Kelly (1994) agreed and advised that although there is an:

. . . increased availability of adjacency 'facts' from topologically integrated databases, . . . There is little to be gained by making spatial autocorrelation one of the many descriptive statistics collected from a spatial database, unless the sophistication of the user is sufficient to make correct use of this information. (pp. 71-72)

Likewise in agreement is Openshaw (1994) who found that people were urged "to analyse data purely because they are now available for analysis, despite the absence of either an a priori experimental design or testable hypothesis" (p. 83).

GIS have procedures to handle data accuracy issues: outliers, missing values, and duplicate data. Outliers can be queried out and eliminated from the display. Missing values can be estimated through proximity analysis. Duplicate data can be masked to show only one instance of that data; the caveat here is to make sure duplicate data are not aggregate into a larger value when displayed.

Aggregation is appropriate for drilling up. (Tan et al. 2006, pp. 40-46) Bailey (1994) reviewed the statistical techniques in GIS and found that GIS could "address existing deficiencies in data selection and aggregation algorithms, such as areal interpolation, . . . error propagation, . . . and missing value interpolation" (p. 16). GIS have proximity analysis as a basic feature, so there will not be a discussion on the selection of the correct proximity measure.¹⁹

The result of a successful data mining procedure is information. To get that information across in a usable form, it must be presented in an understandable form. Tan et al. (2006) advised the following about data visualization:

Successful visualization requires that the data (information) be converted into a visual format so that the characteristics of the data and the relationships among the data items or attributes can be analyzed or reported. . . . The overriding motivation for using visualization is that people

¹⁹ For a discussion on proximity measurements and cluster evaluation see Tan et al. chapters 2 and 8 respectively.

can quickly absorb large amounts of visual information and find patterns in it. (p. 105)

What functions GIS cannot do remains the responsibility of the manager to purvey, which are to set the stage, to manage value systems, to deal with politics only to name a few, and finally to choose the alternative best suited to solve the issue at hand. It can help to frame the issue by displaying historical data and patterns, displaying ideas in the alternative generation stage, accepting group input from disparate locations, evaluating and projecting alternative future outcomes, and displaying these with consistency and objectivity. With that insight, the final chapter will explore the many decision-making issues to see where GIS may assist to minimize or control the errors and maximize the quality and quantity of decision alternatives generated for choice.

CHAPTER EIGHT

ASSISTANCE FROM GEOGRAPHIC INFORMATION SYSTEMS

Introduction

GIS are a form of DSS, and this tool leaves the manager to make the final decision. Along the journey from problem identification to solution selection, many forces implicitly and explicitly affect the decision process; some forces are subtle, and some forces are overt. It is up to the decision maker to set the stage and frame the issue properly. This person may or may not need assistance from others. If a group is to be established, whether local or dispersed, that situation brings with it many human influences both negative and beneficial. The resources of time, personnel, and budget available will impact the degree of investigation. This section will recap the decision-making process and point out where GIS can assist with this process and where it is not applicable.

Decisions can be strategic or operational; both can require complex analysis to effect a proper course of action. By nature, the strategic decision will have a greater impact on the organization. Longley et al. (2001) found that ". . . strategic operations require a range of

spatial analytical tools and data types, and entail a move from 'what-is' visualization to 'what-if' forecasts and predictions" (p. 40). An incorrect operational decision though can quickly have a negative impact on the organization. These decisions can hopefully be reversed or corrected if the proper statistical process control monitoring and control tools are in place, such as proper sampling procedures, x-bar charts for monitoring the centering of the process, and range charts for monitoring the variation in the process (Evans and Lindsay 2005, p. 694). Bromley and Coulson (1991) found that GIS contribute to "improvements in operations largely stem[ming] from the combination of better mapping and the quicker access possible to a greater range of data sets" (p. 55).

Situational Analysis

First, it is important to know the current state of affairs that the organization finds itself. If the organization is aware of its strategic position, the actions of its competitors, and the environmental influences acting on its operations, then the first question can be asked if a decision is required to address some issue the organization is facing. The do nothing

alternative that Drucker reminds managers of comes after some research. GIS can assist the manager to display the current situation in many different facets. If temporal data are available, then forecasts are possible through means of extrapolation. Multiple layers can managed the show different maps or views of an area of concern to examine the situation. Paper reports have their place, but often the common saying that "a picture is worth a thousand words" holds true; GIS view can aggregate many pages of a report or reports into a cohesive view of a situation. Castle (1993) found that GIS have the capability of "efficiently conveying considerable amounts of information and for showing spatial relationships not discernable in tabular or textual documents . . ." (p. 87). If it is found that the situation will not resolve itself, then a decision must be made to intervene.

The rational model approach described by this paper flows logically through situation analysis and information gathering to alternative generation to alternative evaluation to alternative selection and finally to implementation. GIS can help with all these phases. As each of these phases are examined in detail, certain aspects involved with these phases will be found to have human

components, only some of which can be compensated for by GIS. An example of a component that GIS cannot compensate for is what Nutt (2002) called the management of social and political pressures. (pp. 41-42)

Nutt (2002) outlined seven blunders that can occur during the decision process and their corresponding corrective practices (See Appendixes A and B). The first, fourth, fifth, and seventh practices can be aided by GIS. As a tool, GIS can play a greater or lesser role in each of these four practices. To review all seven practices, first, the decision maker can act to involve others to define the issues; GIS can help by displaying to the decision maker and others what the situation is. Second, the decision maker is better suited to "consider the interests and commitment of stakeholders" (Nutt, p. 28). Third, when analyzing a situation, the decision maker must define what goal or outcome is expected or the research will flounder. Fourth, GIS can present a number of options for consideration to increase the search for alternatives depending on the underlying data. Fifth, as with practice four, alternatives can be generated, but it is up to the decision maker to assign probabilities to alternatives in order for risk to be calculated. Various GIS views can then

be labeled accordingly and stored for later analysis or reporting. Sixth, the decision maker must deal with the ethical considerations that an alternative presents; GIS will not know what is acceptable or defined as ethical by the group affected. Seventh, GIS can enable an organization to learn, but the decision maker must try to promote an open review of the process that led to the decision good or bad.

Nutt (2002) warned of not “. . . jump[ing] on the first idea that comes along . . .” (p. 5). At first, inexperienced users of GIS may be tempted to do this because they may have never seen data relationships displayed so clearly. Wellar (1993) found that a virtually “unlimited number of and diversity of sites” could be entered into GIS, and “also information about locations of sites and their spatial relationships can be visually shown on maps” (p. 9). De Geus and Tan et al. (2006) discussed mental models and their fluidity, which is affected by data availability, values, and perceptions. Given the proper data, GIS can assist with model formation with different views of reality. The values are left up to the decision makers. Perceptions are the realm of the psyche and intuitive cognition and employ a series of bias filters to

incoming data. GIS can impact perception by forcing the decision maker to deal with the data. Darymple and Parsons (2000) stated that "the perceptual process controls both the quantity of information received through attention and the quality or meaning of information as it is affected by bias" (p. 94). For learning to occur and mental models to change, Nutt found that "decisions [need to] be discussed without [a] blame-finding mentality" (p. 38). GIS can help here to objectively present the alternatives and situations.

Values both personal and organizational play an important role in decision making as evidenced by the works of Jacob et al., Harrison, Simon, Murray, and Knight. All these authors have a different take on the subject, but objectivity is an overriding factor that will help temper the analysis. Jacob et al. (1962) found that "values have the property of *selectivity* . . ." (p. 15). GIS can present many alternatives for consideration and selection. Harrison (1981) compared personal and organizational values and found that personal values will influence the search activity. (p. 151) Personal values may decide where to look or what parameters to include in the analysis, but the data could show other views of the situation that if taken

objectively may override certain preconceptions and cause a minor reassessment of the decision maker's values. Although Murray (1986) thought it was absurd to assume that value-laded goals were achievable through value-free processes, GIS can lend rationale and meaning to the pursuit of the goals through objectivity. (p. 16) Knight (1964) found that people reacted to inferences and not perceptions. (p. 201) GIS can help keep the perceptions clear and the inferences to a minimum unless justified by the data by displaying developing ideas during the decision process. GIS cannot assist with physiological or psychological reasons for inference-observation confusion described by Haney (1986) as fatigue, ". . . emotion and stress, habit and set, values and needs, and group and social influences" (p. 221).

During a time when personnel resources must be pulled together quickly, people with the required skills must be located quickly. GIS can map out the network of an organization's personnel and thematically display them according to skill sets. McCall and Kaplan would have said that this would help maintain a manager's operational network of contacts. The personnel department maintains an internal phone list for communications as well as a roster

of employees for training and development planning. The information technology department maintains a hardware inventory list for asset and license management. All of these location-based lists could be organized and kept as layers in an organizational GIS.

Drucker's (1967) first two elements of an effective strategic decision contained problem identification and delineation components. (p. 122) Upton, McCall and Kaplan, and De Geus all suggested trying to detect problems early. GIS can help to display what the current situation is where operations are being impacted. Murray (1986) described the scientific method of causal analysis as binding regions artificially so they can be managed and analyzed. (p. 83) GIS can do this quite well through thematic layouts. Nutt and Drucker both said to fully explore the problem before moving on to solve it. GIS have many tools for the exploration and display of data. After a sufficient number of alternatives have been generated to "expand the pool of claims" and "satisfy the specifications of the boundary conditions," the decision maker can move to the third element and review those alternatives which are acceptable. (Drucker 1967, p. 134; Nutt 2002, p. 43) The fourth element of implementing the decision is not usually the job of GIS,

although it could be used to track work assignments. The fifth element ties in with the first and monitors the situation as a feedback system by continuing to check internal data marts, data warehouses, and external sources of data to concretely display past, current, and projected conditions.

Context for Success

Before delving further into the subject of alternative generation and problem solutions, the issues surrounding the context for success should be reviewed to see where GIS can and cannot help set the stage. Both Drucker and Luecke offered that professional differences of opinion would help spur alternatives. GIS cannot manage the attitudes that decision makers bring to the table. Harrison (1981) found many psychological factors that contributed to the cognitive limitation of the decision maker, which are listed in Appendix D. (p. 99) Given the decision maker or team has sufficiently intelligence and capability, GIS can assist with almost all the factors Harrison found. Jankowski and Nyerges (2001) agreed and stated that "reducing the complexity of a decision problem by reducing the cognitive workload of participants is one goal of

developing collaborative [DSS]" (p. 4). After the learning curve for operating GIS has flattened, time and cost factors can become minimized. Memory retention and information processing can be offloaded to the GIS. Decision makers with closed belief system can only be partially helped with GIS; GIS can show possibilities, but it is up to the person or group to accept what is offered. GIS can help the decision maker to think abstractly if they are used to thinking concretely. The last two factors involving the decision maker are independent of GIS capabilities: risk tolerance, and level of aspiration. Both of these affect the amount of information required to make a decision.

Vroom and Jago, Lewin, Witte, and others suggested that groups become involved with decision making especially in complex situations due to the limitations on the individual. GIS can help make the individual decision maker more effective and efficient by providing analysis and presentations, but the decision maker needs to integrate other information and ideas. (Vroom and Jago 1988, p. 99) This is echoed by Jankowski and Nyerges (2001) who found "increased decision quality and shortened meeting time when using GDSS as compared to conventional meetings . . . [as

well as] high user satisfaction and enhanced decision confidence . . ." (p. 52). GIS usually cannot help the decision maker select the group unless potential team members' capabilities have been recorded in an accessible personnel database. Although Luecke made suggestions as to the group composition, the choice is up to the decision maker. The complexity of the task may require a many groups to coordinate in studying various aspects of the problem. After the team is selected, then GIS can integrate the results into views. Bromley and Coulson (1991) found that ". . . the data held within a GIS are far more accessible to staff scattered in different locations . . ." (p. 53).

Power was found to be a force that limited alternatives. Nutt (2002) found that power acted earlier to restrict the problems being solved. (p. 25) McCall and Kaplan (1990) found power to become active in specialized groups during the decision process when they "distort information to advance the interests of the specialty" (p. 18). Luecke (2006) found that power was exercised in command-and-control cultures limiting the selection of alternatives to those in line with a forced direction. (p. 6) In all of these cases, GIS can become a tool to hinder outcomes through the intentional filtering out of valid

alternatives and views in favor of an interest. To combat this, Nutt suggested establishing expected results at the beginning. (p. 165) Luecke suggested to allow open-minded inquiry by asking probing questions and exploring different view and options. (p. 19) GIS can assist with this later suggestion. McCall and Kaplan also found a subtle power that can come not from a dictatorial manger or self-serving group, but from time and ". . . someone's *perception* of the degree of urgency" required. (p. 62) GIS cannot combat this influence except through forecasting of temporal data if available to allow the decision maker to reassess their perception.

Issue Framing

Now that the stage is set and the subtle and overt forces that impinge upon the decision-making process are known and accommodated for as much as possible by the GIS, the next topic to be reviewed is to see where GIS can and cannot help frame the issue properly. In an overview, almost the entire process can be assisted by GIS. Framing the issue is about understanding what the current and desired situation is that caused the perception of the issue for the organization. (Pounds 1969, p. 5) The

situation has gone beyond the do nothing option, and an issue has developed that needs a solution. Harrison (1981) found that perception will more likely be sharp and defined if facts and information are available and studied. (p. 202) GIS can process many facts into information for the decision maker to assist in defining the differences, but Drucker (1967) warned first to ensure that the facts are relevant to the issue at hand and have a form of measurement. (p. 143) GIS have different forms of spatial and temporal measurement tools to assist here. Hoos (1972) likewise agreed with Drucker and warned the decision maker to stop the ". . . gathering of data more because they are available than indicative . . ." (p. 8). Campbell and Masser (1995) likewise warned that "information cannot simply be thrown at a problem in order to produce solutions" (p. 44). GIS can be a negatively enabling tool in this regard if not checked.

In setting up the problem frame, Matheson and Matheson (1998) found that beliefs and prejudices impact the process. (p. 35) GIS cannot manage these psychological issues, nor can GIS manage the words used to define the frame, which Haney (1986) said could restrict the approach to the problem and delay good solutions or produce bad

solutions. (pp. 489-491) Another negative use of GIS by a decision maker, like the use by a powerful manager, is in the support of predetermined conclusions. (Drucker 1967, p. 144) Managers have been doing this for some time, but GIS give them another tool do so. GIS can assist in finding beneficial alternatives, but the right question must be asked first. (Drucker 1954, p. 351)

Most of Porter's five forces can be modeled in GIS. Sales, inventory, and location data on the organization's products and/or services can be mapped against competitors. The threat of potential entry and of substitutes may not lend themselves as well as the bargaining power of suppliers and of buyers to GIS modeling. The bargaining power elements would have more location-based data because they are part of the supply chain. If the issue facing the organization is not clear, then to help understand the problem Luecke (2006) advised to try different frames to asses "whether the available information supports your theories" (p. 30). Matheson and Matheson (1998) advised doing this assessment with "people with different points of view" (p. 38). In so doing, a common knowledge about the events and realities that people are trying to model can be shared until "some optimum number of variables that will

help explain the real-world phenomenon being modeled" can be understood. (Harrison 1981, p. 52) As De Geus advised, it is "the team's model of reality" more than the reality itself that is important. (p. 62)

GIS can assist with the modeling process in many ways. First, as people explore their ideas in open inquiry, GIS can display results and provide feedback on the acceptability of the frame under development. Bailey (1994) found that exploratory spatial analysis "techniques may prove just as useful in analysing model validity as they do in suggesting the model in the first place" (p. 19). As background for the second way, Luecke found that shrewd managers could affect the decision outcome if they could get the issue framed according to their agenda. (p. 26) McCall and Kaplan (1990) even found power entering the process of issue development by means of manipulating "the context to achieve political ends—even to the extent of keeping secrets and practicing deception" (p. 31). To combat these practices, the second way for GIS to assist the modeling process is to maintain the objectivity and openness of the data so that views and alternatives will be available and not hidden and that ideas can be explored in the face of attempts to restrict them. Third, as the models

are developed, GIS can display temporal data and views to "play back and forth management's view of the market, the environment, or the competition" (De Geus 1999, p. 61).

Computers can effectively assist people in generic ways, but with the data intensive environment of GIS, computers can help to push beyond symptoms to find possible causal links. Many definitions of GIS have been promulgated, and Longley et al. (2001) offered two definitions of GIS as tools ". . . *for revealing what is otherwise invisible in geographic information . . . [and] for performing operations on geographic data that are too tedious or expensive or inaccurate if performed by hand . . .*" (p. 10) De Geus (1999) found that ". . . most people can deal with only three or four variables at a time and do so through only one or two time iterations" (p. 62). GIS can handle many more variables and cycle through temporal data very effectively. Hill et al., Luecke, Nutt, and others warned not to attempt to solve symptoms but to dig for causal relationships through time. GIS can assist the two kinds of thinking Einhorn and Hogarth (1999) recommended: "looking backward to understand the past and looking forward to predict the future" (pp. 132-133).

Alternative Generation

Once an acceptable frame is chosen, alternatives must be generated to see what may work. It is important to realize that if no reasonable alternatives are found, the decision maker should return and work through the frame again rather than accepting a substandard proposal and moving forward with it; Nutt (2002) found many errors with the idea imposition process if management refuses to return to the framing stage. During the alternative generation stage, many ideas will compete for acceptance. Drucker (1967) found this process healthy and that ". . . disagreement alone can provide alternatives to a decision" (p. 150). GIS can display these ideas as they progress.

Drucker, Luecke, and Matheson and Matheson all warned that if the alternatives are to be presented to another group or person to make the decision, care must be given to present a range of alternatives or they are only approving and not a deciding. Even GIS can enable this type of error by presenting a one-sided case over other alternatives. McCall and Kaplan (1990) found where "managers often truncate[d the] information search and analysis" possibly because they did not have the tools that GIS provides (pp. 67-68). With the use of GIS, Bromley and Coulson (1991)

found that "hitherto unknown or untapped data sources become available, and information previously ignored because of the problems involved in access to that information then become available to the decision-maker" (pp. 53-54). March and Simon (1958) found in their day that ". . . the discovery and selection of satisfactory . . ." rather than optimal alternatives were then best use of resources. (pp. 140-141) GIS can now help to raise the bar on the optimality of the alternatives generated and reduce the magnitude of the process complexity required for their generation.

As cause-and-effect relationships become uncertain, Harrison (1981) found that judgment must be used, which calls into play a decision maker's value system. (pp. 175-176) The lesser one relies on judgment and instead relies on objectivity, the less chance bias will be introduced. GIS can assist in reducing some of the information processing biases presented by Hogarth and Makridakis; Appendix G is used for the discussion that follows. GIS can show how frequently an event occurs thus reducing overstatement errors. If some feature is expected and produces a bias towards it, then GIS can help to seek alternative features not currently displayed thus reducing

the bias. Although McCall and Kaplan (1990) found that "people seek information consistent with their own views," others involved with the decision process can research and display other views. (p. 18) Although a decision maker may downplay conflicting information, GIS can still display it. GIS have statistical modules making it difficult to have samples, with larger than normal standard errors (standard deviation of the sample means), be representative of the population when this is not the case. A GIS cannot help where the issues reside in the human realm. Vivid experiences can overcome objectivity and statistically validity. The presentation order of the features or views has undue importance. GIS cannot assist if people cannot apply consistent judgment in similar cases. GIS cannot support beliefs in non-valid statistical guesses.

Nutt (2002) and Harrison (1981) both warned of not giving sufficient time for information collection thus introducing bias and faulty analysis leading to failed decisions. Bromley and Coulson (1991) found that "within a GIS, complex systems of overlays derived from several data bases can be developed and printed rapidly . . ." and with less expense and time than by other means. (p. 53) GIS can get at the more diagnostic information and end the reliance

of readily available data. (Nutt, p. 77) GIS can extend a decision maker's knowledge and information thus overcoming what Simon (1976) stated as "one of the limits to rationality . . ." (p. 241). Creativity is needed during the alternative generation phase. GIS can model information to display data in many ways to uncover patterns and to see "in it something others missed . . ." (Matheson and Matheson 1998, p. 41).

Thrall (2002) found that "GIS is the data organization engine and the vehicle for visualizing the results on a map" (p. 86). Dynamically linking views with their underlying tables can allow for insight to come through exploration of the spatial data. (Longley et al. 2001, p. 285) GIS can capture the brainstorming process recommended by many authors by saving, as Hill et al. stated, "all possible alternatives to the problem solution" in separate maps or views. (p. 23) During this process, views can be grouped for further inquiry; those with little difference can be combined or eliminated later. Only later will the alternatives be subjected to the analytical modules of GIS to screen out what is not feasible (Mintzberg et al. 1976,

p. 257) yet retain sufficiently numerous reasonable contenders for selection. (Matheson and Matheson, pp. 42-43)

Groups lend a certain amount of complexity to the decision process by means coordination and idea transfer. Whether remotely or in closed session, group GIS (GGIS) or participatory GIS (PGIS) can facilitate the process if the decision team is not physically together, or a standard GIS can serve to record idea themes for later analysis. These tools can help the initial decision process phases of fact finding and information sharing where members can work together or independently in committees, task forces, conferences, and boards. (Kell and Corts 1980, pp. 10-17)

Luecke and Heirs advised that certain skills must be exercised by the group leader, such as drawing out contributions from shy members even if these contributions are not well formed. Many of these skills are interpersonal, and GIS cannot help in this regard. Kell and Corts found "that group members tend to be better satisfied working under a leader skilled in human relations . . . than one skilled in solving problems" (p. 158). With this being the case, GIS would be thought to be tasked with picking up more of the problem solving tasks; software can

only do so much. A GIS can help to minimize the effect of rank and credibility on the acceptance of a particular view by displaying it and determining if it matches reality.

(McCall and Kaplan 1990, p. 31)

GIS can better be used in a group setting using the Van de Van and Delbecq's NGT or statistical pooling discussed by Hill et al. GIS can be set up on servers so that idea contributors can work independently on shared data. Views can be generated with a contributor's identity masked so that each idea to enter the group's problem-solving efforts and not have to be challenged on the way in. (Hoffman 1982, p. 116) Masking might be necessary to limit idea proposal biases when the reviewer is a superior. (Ference 1970, p. B-85) Even if the proposals are not masked, GIS can minimize the undue weight given to information because of the provider's position, location, or frequency of use; either the information will be objectively useful or not. (Ference, B-85) Once the ideas have entered the decision process, then patterns and causal analysis can be done to project future trends. Einhorn and Hogarth (1999) gave four cues to find causal variables that match up nicely with the capabilities of GIS: temporal order, proximity, correlation, and similarity. (p. 136)

Alternative Evaluation

After the alternatives have been generated, the main evaluation can begin. Of the three categories of decision theories that March and Simon (1958) discussed, certainty is the easiest for GIS to map because "complete and accurate knowledge of the consequences" are known for each alternative. (p. 137) It would just be a matter of modeling the data and generating features and views, and the number of views would be less than with risky or uncertain alternatives. When the future is less certain, as it usually is, risk comes to bear and causes alternatives to have probabilities of occurrence attached. It makes little difference whether a GIS has certainty or a probability attached to an alternative; GIS will create views of the alternatives. Although uncertain alternatives may cause some stress for the decision maker, they only need to work with GIS to make more views for analysis. Working with GIS statistical modules may lead to inferences causing a shift away from uncertainty towards risk assessment and the assignment of probabilities. Wilson and Alexis (1962) discussed "closed" and "open" frameworks for use with more or less precise data respectively. (pp. 150-151) GIS can help bridge the gap between the two frameworks by

developing warrants allowing closed-type analyses to provide evidence to the claims of the open models requiring more complex analytical constructs.

In assessing new ways to compete, Upton (1998) promoted flexibility, which can take the form of new supply chain configurations, delivery routes, etc. (p. 131) Lummus, Vokurka, and Krumwiede (2008) studied supply chain integration and found that higher levels led "to improved performance and faster and more reliable delivery performance . . ." in many areas including lower supply chain costs, increased order fulfillment speed, delivery speed, and delivery flexibility. (pp. 59-60) GIS can assist to develop these new business processes even though they may be risky or uncertain. Hill et al. (1979) found that when precise information is available then more traditional tools could be used, such as linear programming and linear regression, and forecasting, to arrive at objective decisions. (p. 24) GIS offer some of these analysis features as modules or can easily be programmed to perform the tasks.

Due to the way GIS can process most data in complex datasets, GIS can show patterns and oddities thereby assisting the decision maker to heed Einhorn and Hogarth's

(1999) warning to not "underestimate the importance of random factors in the environment" (p. 145). Drucker (1954) warned the decision maker to combine traditional economic analysis with trend analysis to form the correct questions of why, how likely, and how fast future events may occur. (pp. 91-93) GIS can help with some of the economic analysis and most of the trend analysis. Courtney et al. (1999) discussed the evaluation of alternatives and forecasts and stated that "this approach serves well in relatively stable business environments" (p. 3). When these environments experience an increasing rate of change, this advice would be well heeded if regular analysis is used. GIS can be used to process more complex data and thus increase the rate of change of the analysis to compensate for the changes in the environment to a point. Pang and Shi (2002) developed a process-based model focused on "the spatial processes instead of map layers" that allow for rapid update of structures as movements occur. (p. 341) Further development and implementation of this model will provide many options for alternative exploration and pattern recognition for the decision maker.

Many ideas are generated with NGT and brainstorming techniques, but with cases of general analysis or

uncertainty, decision makers were found to desire more information than may have been required. (Harrison 1981, p. 16, McCall and Kaplan 1990, p. 6) GIS offer great tools to explore options and build layers of information, but GIS should not become a license for a fishing expedition. The decision maker needs to stay focused because as Hogarth and Makridakis (1981) pointed out, extra information only ". . . increases confidence in judgment, it does not necessarily increase predictive accuracy" (p. 127). GIS can assist with an issue Harrison found where "individuals seem unable to make full use of information, especially when it is multidimensional" (p. 6).

Some of the recommendations Nutt (2002) made for preventing blunders can be assisted by GIS: investigate claims, search for ideas, and assess risk. (p. 6) GIS cannot assist with Nutt's other recommendations: set objectives, measure benefits, and manage social and political forces. (p. 6) GIS can help to limit what Nutt found as the manipulation of risk by decision makers, less concerned with objectivity than with pushing a specific outcome, by displaying the possible scenarios for objective discussion. (p. 58) These scenarios might be the proximity

to flood planes or extent of competitor penetration in the market being considered.

Even the best analysis will have some uncertain elements because "information . . . is always incomplete or imperfect" (Harrison 1981, p. 34). Courtney et al. (1999) explored the question of how to deal with uncertainty that remained and found a four-level systematic approach that could be modeled with GIS. (p. 5) Starting with the least amount of uncertainty and moving towards the abyss of the unknown, Courtney et al. described the clear-enough future, alternative futures, a range of futures, and true ambiguity. (pp. 5-7) In developing the models for these approaches, Matheson and Matheson (1998) found that "in lieu of unobtainable facts, decision makers must make do with [objective and reliable] information that provides insight into the future" (p. 44). There will be times when this is not possible, and this will typically occur with higher levels of uncertainty. GIS can develop models from whatever information it is given as factual propositions as long as it has a locational component. Simon (1976) then stated that those models may be evaluated to see ". . . whether what they say about the world actually occurs, or whether it does not" (p. 46). If it does not currently

occur, Harrison advised to test each alternative ". . . by imagining [through GIS] that it has already been put into effect" (p. 38).

GIS can model trends to forecast the clear-enough direction. The use of GIS expands with the level of uncertainty. Alternative futures will be determined through probability analysis and the development of various valuation models. GIS can develop a range of futures from the probable outcomes of ". . . a limited number of key variables . . ." (Courtney et al. 1999, p. 9). Although Courtney et al. advised against developing more than five alternative scenarios, GIS can offload this mental processing and keep track of as many scenarios as desired in separate views and layers for delegated analysis by different team members or by different teams. (p. 14) True ambiguity offers the least chance of GIS being effective because ". . . outcomes cannot be predicted, even in probabilistic terms" either because they are not known or are sufficiently difficult to ferret out. (Hill et al. 1979, p. 114) The use of GIS at this point becomes a guessing game. Assuming that GIS have provided useful assistance in moving the decision process along and allowed many alternatives to be objectively evaluated, the next

step is to see where GIS can assist in the choice of the best alternative.

Peters (1987) discussed information's power to affect decision making through its widespread availability and visible posting. (p. 612) GIS synthesize disparate data into visually concise and comprehensible output ready for incorporation into reports or display on the internet. Campbell and Masser (1995) found the main advantage of GIS ". . . as the ability to integrate data sets from a wide variety of sources and . . . to make this information more widely accessible . . ." (p. 33). Jankowski and Nyerges (2001) likewise found in their study of PGIS that "being able to bring disparate sources of information together from various organizations is seen as a major advantage in the use of PGIS" (p. 51). This would "have significant implications for the ownership and control of information and consequently the distribution of power" (Campbell and Masser, p. 43).

Luecke, Ference, and Nutt found where biases affect decision making through the control of information. GIS will process and display data according to given instructions. This can play into the hands of the unscrupulous manager promoting their confirming-evidence bias through the

seeking of evidence to support a position and dismissing or overlooking of evidence to oppose or contrast a position.

(Luecke 2006, p. 34) Information is typically shared during the decision process, and Ference (1970) found biases in the control of information before and during transmission.

(p. B-84) These types of biases are hard for GIS to compensate for because there is no way for GIS to know what is required; GIS would treat the adjustment as another view of the information.

If the decision team is acting in good conscience to try to combat bias, Hogarth and Makridakis (1981) suggested three processes to lower bias. The first process was to propose an idea after checking a wide base of data, and then try to find information that will disconfirm it. (p. 121) This process is different than enacting a confirming-evidence bias because Wason (1960) stated that "in general, scientific inferences are based on the principle of eliminating hypotheses . . ." (p. 129). Nutt (2002) agreed with Pruitt (1961) and both warned against deciding or taking a position early. GIS can allow the decision maker to explore many options and variations, do proximity analysis, and add layers to check their original assumptions.

Second process Hogarth and Makridakis (1981) suggested was that information should be aggregated mechanically where possible. (p. 121) This will help to eliminate the human error component provided the data are input, labeled, and joined correctly. TPS can provide input data for GIS enabling a good statistical base to support analysis, such as Poisson chi square mapping. Other high-level systems, such as Computer Aided Facility Management (CAFM), can provide data for GIS as most of the data are location based; CAFM systems track physical assets, manage real estate portfolios, and determine cost allocations among other functions. (McPartland 2003, p. 14) Castle (1993) found that ". . . approximately 80 percent of all types of information have a locational component . . ." (p. 86). The third process suggested was to carefully review the results and accurately determine causal relationships. (p. 121) GIS modules, such as ArcInfo Geostatistical Analyzer, can provide some correlations, but it is up the user to interpret and correctly label the causal relationships that will be used for decisions later.

Communication and group interaction when deliberating an idea are critical the decision process. GIS can help to keep the discussions objective, but this must extend to the

control of the layers and views produced. Luecke (2006) warned of anchoring around an initial position for the purpose of negotiations. (p. 99) GIS must be allowed to explore all options ". . . which will fully satisfy the specifications [of the problem] before attention is given to the compromises, adaptations, and concessions needed to make the decision acceptable . . ." (Drucker 1967, pp. 122-123). After GIS assists in providing the alternatives, then deliberations and judgments can be made about acceptability. Cook and Hammond (1982) found that the main dysfunctional group issues pertained to the inconsistent processing of information and of group member positions and judgments. (p. 9) GIS can consistently process data for clarity and normalization of analysis over time (apples to apples). GIS can assist in recording group member positions in the form of views, which can be retrieved later for review. The recording of judgments may not be handled as well by GIS; views can be created from judgments, and some metadata can be recorded stating the reasons for the judgments.

Biases that come from the group or individual can affect the alternative selection process. Ference (1970) found that when the information entered the decision

process, from whom it came, and its content affected how it was subsequently altered. (p. B-85) GIS can keep track of these items and keep the process objective, but it cannot alter the human psyche as it relates to these issues. It should not matter if the front line supervisor or the vice president provided some information; it should matter if their assumptions bear out in reality. Computers do not care about human feelings; they only process and display information. Even so, Janis (1971) found that when groupthink is happening, ". . . it tends to override realistic appraisal of alternative courses of action" (p. 43). GIS can combat this only through an objective review of the data and to have someone strong enough to "challenge the assumptions and conclusions of the majority" (Luecke 2006, p. 121). Sometimes the evaluation of the decision leads in direction that is not currently possible to take. Provided the aspects of bias and political control over the process have sufficiently been neutralized, Lowi (1979) stated that "laws set priorities" (p. 92).

Alternative Choice

Decision rules can be used to help set the decision direction. Three decision rules can help determine the

decision outcome based on expectations of the organization's efforts and those competitors or controlling forces: maximax, maximin, and minimax. (Heirs 1987, p. 83; Hill et al. 1979, p. 130) GIS can model any of these situations given the proper data; it is up to the decision maker to assign probabilities of outcomes. Hill et al. found that these rules do not account for changes in forecast parameters and thus should be used in stable markets. (p. 130) Management scholars may revisit these rules to see if GIS and current computing capabilities can now incorporate changes in forecast parameters for application to more dynamic markets. Harrison (1981) did offer the dissenting opinion on maximizing and found the underlying assumptions to faulty because of two main items: the lack of perfect information, and many variables required for maximization are hard to quantify. (p. 92) GIS can attempt to provide missing data through proximity analysis and kriging, and can assign attributes to data; unless quantities are known for some variables, some GIS modules cannot be used.

Decisions are not always based on certainty. Tan et al. (2006) and Kosko (1993) offered fuzzy logic as a method for managing uncertainty and finding a point when enough

information has been obtained for a valid decision.

Matheson and Matheson (1998) agreed and found that ". . . decision quality rarely requires great precision . . ." (p. 49). Woodcock and Gopal (2000) found fuzzy set theory used among other things to model human decision making. "Fuzzy sets are increasingly being used in GIS" (p. 154). Jiang and Eastman (2000) found that "the logic of fuzzy sets bridges a major gap between [the multi-criteria evaluation approaches of] Boolean assessment and continuous scaling in weighted linear combination" (p. 176). GIS can use data mining, cluster analysis, and proximity analysis to design fuzzy GIS with fuzzy sets and patches based on the decision maker's model of reality. Part of the design has to do with accepting ". . . varying degrees of membership in map classes for a single map polygon . . ." (Woodcock and Gopal 2000, p. 155). Accepting this and relaxing some of ". . . the restrictions imposed by classical set theory [will allow] queries regarding areas meeting certain criteria, or membership levels" instead of only the area of each class. (Woodcock and Gopal 2000, p. 170) This is currently accomplished "in a map overlay procedure [where]

the intersection or union of various map categories is determined and their area measured" (Woodcock and Gopal 2000, p. 170).

The point at which a choice is made has changed from the completion of a thorough and exhaustive analysis to the collection of enough information to trigger the choice. Care must be given though to follow the Discovery Process Nutt (2002) proposed so that the Idea Imposition Process does take over thus causing problems (See Appendix C). Eilon (1969) observed that the analysis of the information should be penetrating enough to allow the alternatives to be ranked by an agreed upon criterion. (p. B-178)

When the alternatives are narrowed to the final candidates of what will satisfy the conditions of the problem and negotiations are in progress to determine what is acceptable, Hill et al. (1979) and Lewin's (1935) research on conflict will play a role in the outcome. GIS can only assist in these interpersonal matters to display the aspects of the alternatives under deliberation. Whether or not all the members on the decision making team agree if enough information has been collected, when it comes time to make the choice Hill et al. found two ways to help with the conflicts. First, GIS can help to simplify the set of

choice through aggregation or other imposed frameworks. (p. 63) Second, GIS cannot help the decision maker "maintain or restore consistency among the several attitudes, beliefs, and values that are part of his personal context" (p. 64).

Aside from the interpersonal issues, GIS can become involved in most of the decision processes from definition, generation and exploration, evaluation, to implementation. Although implementation was not included in the scope for this paper, it could be tracked by assigning color codes or other feature identifying markers to the layers, views or parts thereof to delineate responsibilities and progress. GIS offer management a tool that can assist decision making in many ways. As with any tool, one must learn how to use it be effective, and one must learn its dangers and safeguards to prevent organizational injury from misuse.

CHAPTER NINE

CONCLUSION

This paper researched the many facets of the decision-making process from the beginning through to just before the implementation phase. It looked at the values that drive perspectives, the objective criteria that must be met, the politics and power plays involved in directing activities, and the internal and external factors that come to bear upon the individual or group decision makers as they move through the process. It was found that GIS can support decisions quite effectively where location data are present through spatial and temporal mapping of current and future situations and scenarios. This support is readily available because Castle (1993) found that ". . . approximately 80 percent of all types of information have a locational component . . ." (p. 86). Wellar (1993) found that GIS enable different and new ways of perceiving business fundamentals, achieving higher levels of productivity, and generating new ideas. (p. 5) Moloney, Lea, and Kowalchuk (1993) likewise noted the beneficial effects of GIS on performance and profitability. (pp. 109-110) Bromley and Coulson (1991) added more support to this

claim by finding that GIS contributed to improvements in operations by quickly bringing additional data to effectively bear upon the issues. (p. 55)

The normative approach to decision making flows through a specific process of identifying issues to address, generating and evaluating alternatives to address those issues that when followed will yield a thorough investigation of the issue on which to base a choice. Many forces both internal and external will attempt to shorten the path for supposed rational reasons usually resulting in a less than desirable and sometimes detrimental outcome. GIS were found to help keep the decision process on track thus yielding a quality decision. To set the context for success correctly, the communication channels and the involvement of the necessary parties to the decision should be thought out and established by the manager. After this is done, GIS were found to support communications through GGIS or any variation of the space-time meeting venues that Jankowski and Nyerges (2001) explored. (p. 49) GIS were found to assist the decision maker to overcome most of the psychological factors listed in Appendix D, which if not addressed would limit the cognitive abilities of decision makers. GIS were found to objectively open up the

possibilities for discussion while limiting the amount of office politics involved. Perceptions can be altered through a fresh look at information objectively derived from data.

The next step of framing the issue was found to be aided by GIS through the use of its spatial and temporal tools to explore the scope of the issue. Time is a useful tool to see the progressive or cyclical nature of a problem. GIS can use Pang and Shi's (2002) model to see rapidly changing events or use more standard displays of static information to arrive at a frame. (p. 341) De Geus and Einhorn and Hogarth advised to look historically and project trends. GIS were found to do this openly until a frame is agreed upon by the decision team. Worrall (1991) provided some potential uses of geographic information in a public policy setting in Appendix H.

Inherent with frame development is the processing of spatial and temporal data until the problem becomes clear, which GIS were found to do quite well. This carries over to the generation of alternatives. GIS save views in separate files that can be recalled and displayed upon demand thereby enabling the collection of many alternatives for later evaluation. Priorities can change in the turbulent

business environment and during times of governmental regulatory reformation. GIS can recall previously saved alternatives to quickly get back on track after an emergency has passed. As the process of generating of alternatives unfolds, GIS were found to quickly process disparate and previously unused (due to lack of access) sources of data to uncover previously unknown patterns and possibly uncover causal relationships that would extend a decision maker's knowledge and information to overcome what Simon (1976) stated as "one of the limits to rationality . . ." (p. 241). Most decisions require data from different areas of the organizations, and Moloney et al. (1993) provided some generic sources of data available to an organization in Appendix I. Landis (1993) found that "most business planning decisions are fundamentally spatial. . . . *Because GIS is designed to process and display spatial data, it can be extremely useful for long-term business planning and decision making*" (p. 24).

Einhorn and Hogarth (1999) stated that causal relationships can be found through temporal order, proximity, correlation, and similarity. (p. 136) GIS were found to have these analysis capabilities at there core. GIS were found to assist in reducing biases listed in

Appendix G especially in the ability to process data. Complex business decisions add to the cognitive load a decision maker must carry when performing their duties. GIS were found to serve as a vehicle to carry some of this burden thus freeing up cognitive capacity and allowing for more creative approaches to problem solving. GIS were found to make use of both predictive and descriptive models to allow this creativity. Landis (1993) found that "by bringing the dimensions of space and location into the decision-making process" GIS were found to enhance business productivity by reducing costs, improving the quality of goods and services, and expanding the market. (p. 51) Landis though found GIS had its largest impact on the ability to improve "the quality of information used by business managers to make key design, product, marketing, and management decisions. . . without necessarily adding complexity" (p. 51).

The tools that allow GIS to assist in the generation of alternatives were also found to assist in the evaluation of alternatives. As each alternative is developed, a probability of occurrence can be assigned and notated on the map. GIS were found in some cases to lead the decision maker out of uncertainty towards risk assessment through

its analysis tools. When the available data are more precise, "closed" analysis frameworks can be utilized; less precise data require more exploratory "open" frameworks. (Wilson and Alexis 1962, pp. 150-151) In more complex analyses requiring a two-step approach, GIS were found to work in both frameworks; closed-type analyses could provide input for the open-type analyses that would follow. These usually multi-dimensional problems require a diverse information set, which Harrison (1981) found individuals unable to utilize to its fullest. (p. 6) GIS though was found to effectively integrate and process multi-dimensional data whether it was temporal or from disparate sources. (Campbell and Masser 1995, p. 33; Janlowski and Nyerges 2001, p. 51)

The various tools that GIS can bring to bear on the analysis were found to support the process of establishing ". . . scientific inferences [that] are based on the principle of eliminated hypotheses . . ." (Wason 1960, p. 129). GIS were found to assist this process by testing each facet of a hypothesis in a separate view ". . . by imagining that it has already been put into effect" (Harrison 1981, p. 38). This projection along with the mechanical aggregation of information that Hogarth and

Makridakis (1981) suggested are two processes that allow GIS to combat and lower bias in decision making. (p. 121)

GIS were found to reduce misconceptions and miscommunication of results and positions of group members through consistency and objectivity. Cook and Hammond (1982) found that issues surfaced due to inconsistencies in the processing of information. (p. 9) GIS will record results and positions in views for later recall if questions arise. Another area of dysfunctional analysis comes from groupthink, which ". . . override[s] realistic appraisal of alternative courses of action" (Janis 1971, p. 43). GIS were found to embolden the group member, recognizing that groupthink was occurring, to take Luecke's (2006) suggestion to "challenge the assumptions and conclusions of the majority" (p. 121).

The final step in the decision-making process for this paper is the choice phase. All that has gone into the preparation of the alternatives brings the choice to one that may require negotiation to effect acceptability. GIS were found to serve as an effective communication and presentation tool with the ability to produce maps of alternatives for dissemination to the affected parties or to the organization as a whole through the internet,

intranet, or tradition print media. Absolute certainty rarely exists. (Wilson and Alexis 1962, p. 154) The choice often becomes that of what probability the decision maker chooses to accept. GIS can display maps of the alternatives with their corresponding probabilities under consideration, but developments in fuzzy logic can assist the decision-making process to display the more correct or more acceptable alternative using certain user parameters.

The latest research in GIS has been to incorporate fuzzy logic to deal with issues of data heterogeneity, of data accuracy, of the impracticality of precise data, and of lack of the need for optimality. As with all fuzzy systems, which are controlled by the decision maker, the preponderance of the warrants that relate the evidence to the claim will lead to one choice over another. Fuzzy systems have been found to be incorporated in GIS to show when enough information has been collected in order to make the choice.

More research needs to be done in the area of GIS, as a management tool for decision making, to bring it into the mainstream of regular practice and application to today's problems. The current research is focused on specifics of functionality of GIS as a technical tool. While this is

important as a technical issue, today's managers do not seem to think visually. With the ever increasing capabilities of computers, GIS should take its rightful place in the workplace as a tool for modeling issues and solutions. This paper concludes that GIS is an important tool in the decision maker's arsenal to deal with complex issues with locational components.

APPENDIX A
HOW BLUNDERS PROMPT TRAPS

APPENDIX A

HOW BLUNDERS PROMPT TRAPS

Traps	Failure-Prone Practice Blunder	Premature Commitment Blunder	Misuse of Resources Blunder
Failing to take charge by reconciling claims	Support for claims and its arena of action assumed by the decision maker	First claim (or claimant) that seems important is accepted	Failure to look for hidden concerns or considerations and the more pressing claims that they suggest
Ignoring barriers to action	Power and persuasion used to implement decisions	Action taken before social and political forces are understood	Interests and commitments of stakeholders go unexplored
Providing ambiguous directions	Direction assumed and never clarified	Unwilling to acknowledge a concern without offering a remedy	Little time spent to identify desired results
Limiting search	A quick fix or what others are doing is adopted	Pressure for answers makes the conspicuous solution seem timely and pragmatic	Little spent on a search for ideas or for innovation
Misusing evaluation	Evaluation used to measure costs, ignoring benefits	Defensive evaluation used to justify the conspicuous solution	Money spent defending ideas and not in exploring their risk
Overlooking ethical questions	Values behind ethical questions are overlooked	All decisions are seen as ethically neutral	No time or money spent uncovering values
Failing to learn	Fail to see how perverse incentives operate to cover up outcomes	Expectations demand good outcomes	Few resources used to learn or to do so without removing perverse incentives

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APPENDIX B

PRACTICES THAT AVOID THE TRAPS

APPENDIX B

PRACTICES THAT AVOID THE TRAPS

Traps to be Avoided	Best Practice	Steps Required
Failing to take charge by reconciling claims	Network with stakeholders	Involve stakeholders to uncover and reconcile concerns or considerations or to formulate the claim
Ignoring barriers to action	Intervention or participation	Demonstrate the need to act and ways to consider the interests and commitment of stakeholders
Allowing ambiguous directions	Set objectives	Create clear picture of expected results
Limiting search	Innovation or search	Increase the number of options considered and those with potential first mover advantages
Misusing evaluation	Explore risk and compare the benefits of the options	Expose options with unacceptable risk and validate the choice
Overlooking ethical questions	Look for important values and offer mediation	Uncover and confront the ethical questions of internal and external stakeholders
Failing to learn from the decision-making experience	Create win-win situations for all stakeholders	Look for and remove perverse incentives and encourage honest appraisal of company actions

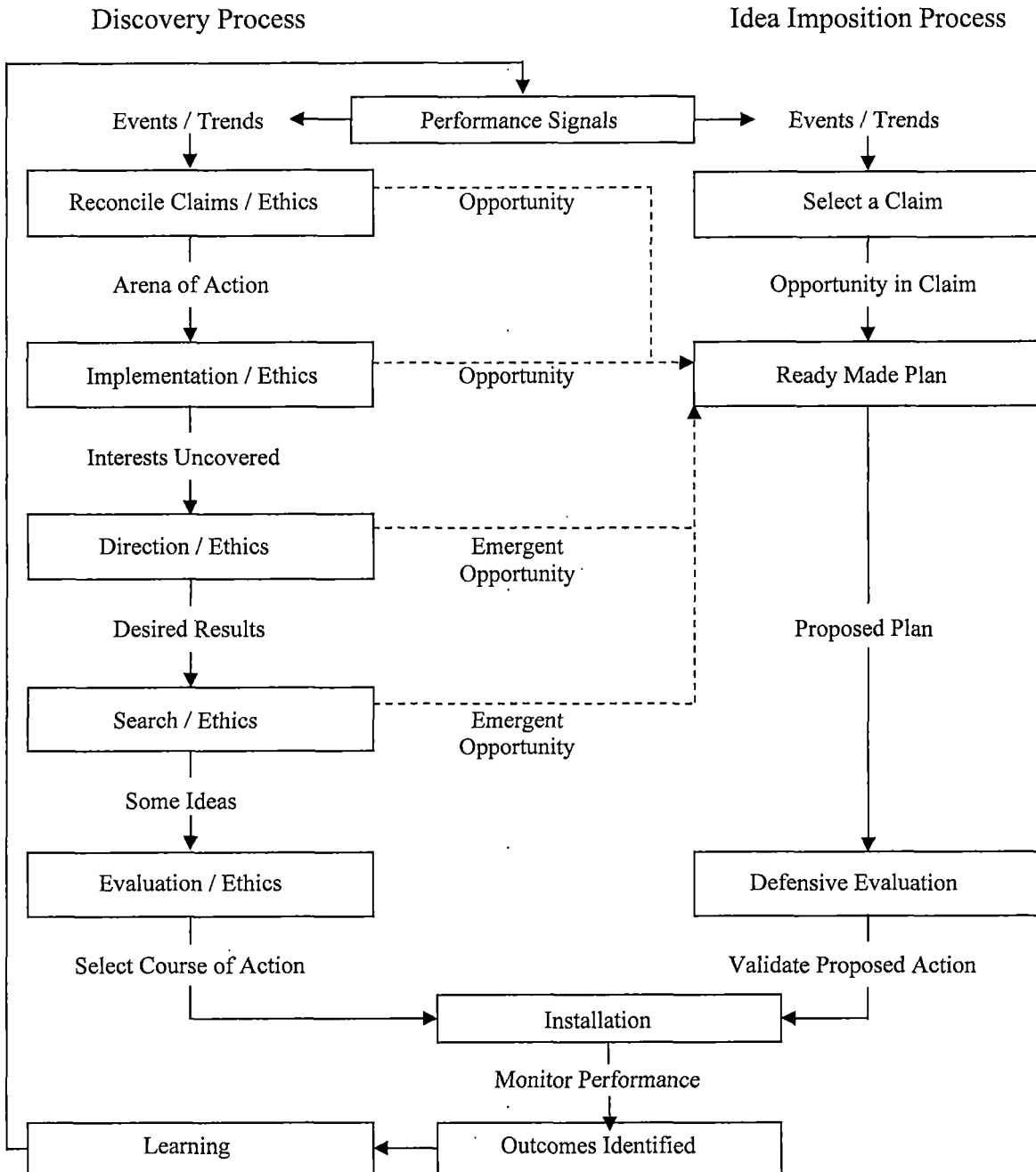
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APPENDIX C

SHIFTS BETWEEN THE TWO DECISION-MAKING PROCESSES

APPENDIX C

SHIFTS BETWEEN THE TWO DECISION-MAKING PROCESSES



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APPENDIX D

PSYCHOLOGICAL FACTORS THAT CONTRIBUTE TO THE
COGNITIVE LIMITATIONS OF DECISION MAKERS

APPENDIX D

PSYCHOLOGICAL FACTORS THAT CONTRIBUTE TO THE COGNITIVE LIMITATIONS OF DECISION MAKERS

- Human decision makers can retain only a few bits of information in short-term memory.
- The intelligence of the decision maker appears to be a limiting factor in processing and retaining information. More intelligent decision makers seem better able to cope with high loads of information processing.
- Dogmatic decision makers (that is, those with closed belief systems) tend to unduly restrict the amount of information they are willing to process, thereby limiting their cognitive processes.
- Decision makers who tend to think in concrete rather than abstract terms tend to be somewhat limited in their ability to process information.
- A decision maker's willingness to accept risk may limit the amount of information required to arrive at a choice. Risk takers may require less information than risk avoiders.
- A decision maker's level of aspiration influences the amount of information he or she needs to arrive at a choice. If the level is high, the decision maker may require more information; if the level is low, the decision maker may need less information. Consequently, the level of aspiration represents another special type of cognitive limitation.
- In general, older decision makers appear to have more cognitive limitations on handling information in a decision-making situation than younger decision makers.

Source: p. 99 of Harrison, E. F./The Managerial Decision-Making Process/2nd edition/Copyright © 1981 by Houghton Mifflin Company. Used with permission.

APPENDIX E
TYPES OF ATTRIBUTES

APPENDIX E

TYPES OF ATTRIBUTES

- Nominal: Serves only to identify or distinguish one instance of a class of entities from other members of the same class.

Example: Numbers, letters, colors, place-names

- Ordinal: Values have a natural order. No mathematic manipulation is possible. Only median may yield value.

Example: Classification designations, ranking

- Interval: Differences between values makes sense

Example: Temperature

- Ratio: Ratios between values makes sense

Example: Weight

- Cyclic: directional data including flow direction on a map, or compass direction, or longitude. Problems exist due to data type limits, such as 360 degrees for a compass; 361 degree does not exist as a convention as it would be the same as 1 degree.

Example: Degrees

Source: Longley et al. (2001, p. 66)

APPENDIX F

SPATIAL ANALYSIS CAPABILITIES

APPENDIX F

SPATIAL ANALYSIS CAPABILITIES

- Analysis of Data Related to Points
 - Spatial query
 - Geocoding
 - Proximal analysis
 - Dot-density mapping
 - Nearest-neighbor
- Analysis of Data Related to Lines
 - Network analysis
 - Flow analysis
 - Routing
 - Optimum path analysis
- Analysis of Data Related to Polygons
 - Polygon processing
 - Point-in-polygon
 - Choroplethic mapping
 - Polygon overlay
 - Polygonization
 - Spatial aggregation
 - Buffering

Source: Huxhold (1991, pp. 57-61)

APPENDIX G

A FEW OF THE MANY INFORMATION PROCESSING BIASES

APPENDIX G

A FEW OF THE MANY INFORMATION PROCESSING BIASES

Bias/Source of Bias	Description/Example
Availability	<ul style="list-style-type: none">• If a person can easily recall specific instances of an event, he/she may overestimate how frequently the event occurs (and vice versa).• Chance events or cues can hinder or help by pointing a person in a particular direction.
Selective Perception	<ul style="list-style-type: none">• What one expects to see biases what one does see.• People seek information consistent with their own views.• People downplay information that conflicts with a consistent profile.
Concrete Information	<ul style="list-style-type: none">• Vivid, direct experience dominates abstract information; a single personal experience can outweigh more valid statistical information.
Data Presentation	<ul style="list-style-type: none">• The items presented first (primacy) or last (recency) in a series assume undue importance.• Whether information is collected sequentially or all at once affects what is processed.
Inconsistency	<ul style="list-style-type: none">• People have trouble applying a consistent judgmental strategy across similar cases, even though they believe they are consistent.
Law of Small Numbers	<ul style="list-style-type: none">• Small samples are deemed representative of the larger population (a few cases “prove the rule”), even when they are not.
Complexity	<ul style="list-style-type: none">• Under time pressure, processing of complex information may be quite superficial.
Gambler’s Fallacy	<ul style="list-style-type: none">• Seeing an unexpected number of similar chance events leads to belief that an event not seen will occur (e.g., after observing 9 successive reds in roulette, believing chances for a black on the next roll are greater than 50/50).

Source: Condensed and adapted by McCall and Kaplan (1990, p. 18) from Hogarth and Makridakis (1981, pp. 117-120).

APPENDIX H

POTENTIAL USES OF GEOGRAPHIC INFORMATION

IN A PUBLIC POLICY SETTING

APPENDIX H

POTENTIAL USES OF GEOGRAPHIC INFORMATION

IN A PUBLIC POLICY SETTING

- More sensitive monitoring of change in demographic, social, economic, ecological and environmental conditions
- Developing a better understanding of the processes of change
- More accurate forecasting of the changing needs for publicly provided services, such as schools, housing, community facilities, leisure and transport
- More precise identification of spatial variations in living conditions as a basis for the development of social policy and the more precise targeting of local government resources
- More rigorous identification of target markets for promotion of local services and the generation of income
- More attractive and responsive service planning by more accurately identifying the determinants of demand and by more expertly forecasting the changing pattern of need for services as a basis for setting priorities in the deployment of resources
- Improving the quality of service management by developing more efficient and economical approaches for undertaking activities, such as refuse collection, landscape maintenance and route scheduling
- Improving the cost effectiveness of asset management by developing more accurate property systems and asset registers
- Improving statutory planning processes by developing the means for modeling and simulating alternative scenarios and by developing the techniques to assess the suitability or conformance of development proposals in the context of statutory plans
- Improving the policy-making process by developing more sensitive methods for the evaluation and analysis of policies and programmes

SOURCE: Worrall (1991, pp. 2-3)

APPENDIX I
TYPICAL ORGANIZATIONAL LOCATION-BASED DATA

APPENDIX I

TYPICAL ORGANIZATIONAL LOCATION-BASED DATA

Generated Internally

- Product performance data, or the amount of each product sold by each channel and by each location
- Distribution data, or lists of distribution points for each product and attributes of each distributor
- Sales territory data, or the definition of territories and the resources allocated to each
- Survey data, or data that are purchasing, attitudinal, or behavioral in nature
- Marketing/advertising expenditure distribution within and across markets

Obtained Externally

- Socio-economic and demographic variables
- Demographic and product usage estimates and projection data
- Census and postal geographic centroid and boundary files
- Street-based address information
- Physical data, such as rivers, streams, shorelines, land use, etc.
- Retail and distribution locations

SOURCE: Moloney, Lea, and Kowalchuk (1993, pp. 109-110)

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