Numbers, quantification, and the amplification of weak strategic signals

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ABSTRACT

Many business situations require decision and action under very incomplete states of knowledge, that do not allow the use of the most rigorous quantitative approaches - where there are at best only "weak signals" of impending problems or opportunities. While the idea of a weak signal is often invoked, existing management theory regarding this concept is very incomplete. Borrowing concepts from weak signal analysis, this paper attempts to provide an organizing perspective to the process of making management decisions in the presence of inevitable uncertainties. Quantification itself and the use of formal methods are important tools for amplifying signal strength to arrive at problem formulations. The discussion derives hypotheses for further discussion and research, and provides an illustrative example from an important real world business decision.

Keywords: management decisions, weak strategic signals

INTRODUCTION

Modern economic institutions have steadily progressed toward data driven operations, with concomitant dependence upon databases and formal quantitative analyses. Within this context organizations are increasingly drawn to methods which support key decisions by specific quantitative metrics derived from the quantitative data, i.e. "the numbers." However, this emphasis is often criticized, and on several grounds. Managers may use numbers misleadingly or in a self-serving manner, frequently to justify preferred courses of action. Conversely, managers may be unskilled in formal methods or interpretation of outputs. They may just neglect or even ignore the numbers. Finally, a frequent criticism is that many important executive actions must be taken under very imperfect states of knowledge, when there are only "weak signals" of problems or opportunities (Ansoff, 1975).

The weak signal concept is an interesting one. Many writers continue to invoke it in myriad situations, with recent examples ranging from the effectiveness of nursing leaders (Kerfoot, 2003), journalism regarding innovation (Uskali, 2005), the anticipated performance of NFL quarterbacks (Yasinskas, 2008), to the convergence of the IFRS and GAAP accounting practices (Henry, et. al., 2007). However, most discussions do not pursue the analyses rigorously. Indeed, even the extant theory regarding weak signals has to date been somewhat thin. Beyond a few accepted accounting or quality control metrics, there is no fully agreed, well developed set of candidate generic signals for managers as they attempt to anticipate problems and opportunities. Managers cannot escape the mindsets of their functional areas, and these mindsets may not always be useful in detecting weak signals. Even managers with rigorous training – so that the mindset might properly be said to approach a paradigm (Kuhn, 1980) – may still miss signals due to the incompleteness of the paradigm itself. More fundamentally, the weak signal concept has not been explicitly articulated to the familiar themes of the decision-making sequence and problem analysis. These gaps in applied knowledge are the focus of this paper.

Despite these theoretical shortcomings the underlying premise of this paper is that, properly processed, "the numbers" often do form a sound and legitimate basis for making management decisions. With our increasingly technology driven society formal methods and data intense analyses assume ever-expanding roles in the formulation of business strategy. These methods may include; market assessments, value chain analyses, decision-theoretic models, risk mitigation and theories from optimal estimation and control. Quantification imposes interesting requirements on the organization to ensure that the resulting analyses properly incorporate the inherent intent of the numbers and ultimately reduce the unavoidable uncertainties from both external and internal sources. The process must ultimately lead to cognitive simplification and focused metrics that are meaningful to the desired decisions. To address these issues this discussion introduces the concept of weak signals, and then their complexities in the context of the formulation of strategy. Amplification of weak signal into strong ones to allow for rigorous problem formulation involves complex processes, serious information search, and often many of the above methods. Propositions concerning signal detection and amplification are introduced.

WEAK SIGNALS

The weak signal concept is a derived analogy from the hard sciences, especially information and communications theory (Shannon, 1948; Weiner, 1949). Signals pass through established, but finite channels, which are subject to "noise" and error. Through use of filtering

mechanisms, proper signals may be distinguished from the surrounding noise (Kalman, 1960). Error correcting codes (Reed & Soloman, 1960) serve to keep communication moving near the capacity allowed by the channel(s). However, when applied to the non-technical problems facing managers, the use of these rigorous concepts must be considered "metaphorical" (Coffman, 1997).

Ansoff (1975) provides us with an early and still definitive discussion of the concept for executives. He conceives of the strength of a signal as defined by the level of knowledge held by the manager. There are five levels. First, there is the sense of a threat or opportunity. Second, the source of changes that produce this threat or opportunity is known. At the third level the nature, magnitude and timing of concrete impacts from the changes are known, at least basically. At level four decision makers have some knowledge of the concrete, alternative courses of action available in response to the changes; they may already be responding. The highest state of knowledge, level five, is one in which the final outcome is known or may be reasonably projected.

In Ansoff's parlance, a weak signal is characterized by only broad knowledge, e.g. the existence and perhaps origin of changes, and perhaps the general nature of those changes. That is, it is a signal at level one or two above. Managers typically collect volumes of data while the signal is weak and the problem is still only partially defined. These data are then systematically processed to develop a clearer perspective of the impact of change, the potential alternative responses and estimates of the response outcomes are established. The process is iterative in nature, requiring diligent review and update to avoid potential pitfalls. For instance, there is a tendency of many decision makers to place inordinate weight upon the most recent data (Boyd, et. al., 1993) or upon early analyses and preliminary conclusions (Kozielecki, 1972). However, this might truncate information search or distort decision processes.

It is instructive to view these processes of knowledge acquisition with respect to the sequence of activities in the classic decision making structure. Figure 1 is a representation of the sequence suggested by Gibson, et. al. (1976). The decision making process is initiated when a problem or opportunity has been identified in early steps of the process (Segev, 1977). The side arrows in the figure indicate additional activities that guide the process, such as information search. Note that Ansoff's (1975) first two levels are usually reached early on, prior to recognition of a definitive problem gap. Weak signals would hence be early in the sequence. To Ansoff, these signals should be an immediate spur to begin information search earlier than otherwise, and the gathered information itself would largely lead to a more thoughtful definition of the gap. To him the difficulty is not necessarily that managers miss weak signals, but that they engage in too little search, too late.

How do managers identify, observe, quantify and measure the dominant influencing variables? Most often these are determined by established practices within the organization. Analysts' and managers' functional backgrounds and personal frames of reference lend an accepted organizational context, facilitating acceptance to the underlying analyses (Kuhn, 1980). They add proper meaning and temporal context to the data gathering and reformulation processes. However, as suggested above, reliance on knowledge of their functional areas may also lead managers to "pigeon hole" a situation, prematurely settling on problem definitions and search procedures.

Proposition 1. Decision makers are more likely to perceive a weak signal when the evidence regarding the disturbance contains actual numbers.

Proposition 2. Decision makers are still more likely to perceive a weak signal when available numbers include quantities relevant to their functional areas.

Strategic Signals

Managers tend to use data to formulate and justify decisions and later to defend them. Occasionally they make sequential decisions based on weak or partial data merely to initiate action while more data is collected. Both individuals and organizations may seek ways to signal their possession of some desirable trait, such as integrity, quality, reliability, etc. Thus a manager must be alert to two kinds of signals: those intentionally generated and transmitted by some actor(s), and those that are not intentional and may or may not derive from a specified set of actors. In this discussion, Ansoff (1975) seems to treat weak signals as primarily of the latter kind: perceived by the observer but not necessarily intentional.

Nevertheless, analysis of strategic signals must deal with both kinds of signal. Strategic interactions are by nature situations in which an actor's final outcomes are determined not only by what they do but also by what other actors do (Morgenstern & von Neumann, 1947; Nash, 1951). Intentional signals, and even some unintentional ones, are clearly acts by others. In some sense, communication itself may be considered a strategic game. It is this strategic aspect that gives the topic its depth, significance, and great complexity. The complexity is greater yet because the exchange of signals is really occurring not across dyadic linkages, but across a vast network of present and potential stakeholders (Rowley, 1997).

The exchange of signals and application of higher level processing functions involves considerable interaction, which enables participants to socially construct a perspective of the influencing environment (Berger & Luckmann, 1967). Consistent with their individual frames of reference they perceive, react to, and adjust to these environments Weick (1969). Communication is the key mechanism for developing true perceptions of environments and reality (Weick, 1969; Smircich & Stubbart, 1985; Prahalad & Bettis, 1986).

Proposition 3. Intentional signaling is a key mechanism that enables participants to respond to their shared environment.

Role of Paradigms

Although data-driven procedures and analyses form the backbone of many operational decisions, an organization's strategic activities determine its character within its environment. Figure 2 illustrates the classical multi-stage model of strategic management (Thompson, et. al., 2008). It superimposes the paradigms or functional area specific knowledge that dominate each stage (Kuhn, 1980). At each stage component decisions and feedback craft subsequent decisions. Early stages may be characterized by large measures of uncertainty, ambiguity and bias arising from individuals' characteristics (Andrews, 1971). As all knowledge is refined and reformulated in later stages the decisions become less ambiguous and more consistent with the organizational mission.

An organization's "paradigmatic" knowledge flows from the various functional areas, e.g. finance, marketing, human relations, accounting, operations, etc. Each area possesses well-established and accepted variables, metrics and methodologies (paradigmatic knowledge) for translating data into useful decision making information. They define what data must be

collected and how they must be analyzed to identify and resolve "problem gaps", i.e. disparities in what is measured versus what is desired. These are moderated by the culture, politics and individual preferences within and outside of the organization and are often redefined by more qualitative and less-quantifiable social interactions and influences.

Various factors influence or determine the credibility of "the numbers." These factors include; the source and context of the data, the specific variables employed, the acceptability of these variables within the functional areas and in many cases the credibility of the individual making the assertion (Segev, 1976). Analysts providing data to managers are routinely judged by their accuracy in previous analyses and the manner in which they project confidence and commitment and ultimately influence major decisions (Simon, 1945; Allison, 1971; Bower, 1965) as part of "uncertainty absorption" (March & Simon, 1958).

Proposition 4. A weak signal is more likely to be detected if it is first perceived in variables from a paradigm familiar to a staffer or manager.

Proposition 5. Staffers and managers more effectively "trigger" information search when they invoke the variables and ideas of familiar paradigms.

Quantitative information is often used to determine the performance of individuals, groups or organizations. Feedback is an essential component of these analyses throughout the evaluation processes (Weick, 1969; Ilgen & Moore, 1987). These evaluations are guided by the decision makers' frames of reference and experience frames of reference. Indeed every stakeholder in the decision process has his preferred methodologies and metrics. Managers must be cognizant of all stakeholders' and their interests and prioritize them according to established objectives (Mitchell, et. al., 1997).

AMPLIFIED SIGNALS AND PROBLEM GAPS

Problem gaps are deviations of actual performance or states from performance or states (Kepner and Tregoe, 1965) illustrated in Figure 3. Theory and accepted practice (paradigmatic knowledge) determine the desired values of relevant metrics. Managerial experience, moderated by organizational and external contexts, determine the desired values and establish the key problem gaps (Milutinovich & Mankelwicz, 1983). These in turn are known with limited precision which form tolerance and knowledge limits.

The progression from a weak signal (with disturbance and / or source known), to the next higher state of knowledge may be long and difficult. Early scanning and search activity will greatly smooth the process (Ansoff, 1975). With the articulation of a recognized problem gap, the organization begins a "problemistic search" (Simon, 1945) for relevant information.

Precise definitions of the states of key variables are essential to problem formulation (Kepner & Tregoe, 1965) and hence to effective decision-making. , which is the foundation of effective managerial decision-making. Again, our view is that "the numbers" really do matter! It is true that the most rigorous and data intensive methods may not be used at these early stages. Nevertheless, selection of appropriate variables, search and measurement procedures, and analytical methods greatly facilitate the process of formulating and reformulating the problem gap. Paradigms suggest desirable levels of a variable(s) as well as methods for collection and analysis.

Simon (1945) suggested that in the presence of inevitable uncertainties even with rational decision making based upon properly focused quantitative analyses the limit to what might be achieved is a "bounded rationality." The bounds are determined by limitations in the data, with associated ambiguities, as well as limits to human capacities. The numbers themselves add an interesting dimension to the discussion. They are symbols that properly formulated can exert powerful influences on the decision process. They establish cognitive values for performance and gaps in performance but often assume an identity unto themselves, which evoke great concern for accuracy and the need for more data.

Strategic Feedback

As an organization begins to seek information to amplify a weak strategic signal, its activities may or may not be evident to other organizations. Indeed, it may try to conduct the search in secret, or it may actually itself send out intentional signals to gauge the response of others. The feedback from the organizations search activities can then be of two types: knowledge of the results of its search efforts and knowledge of the reaction by the others. If the improvement in the state of knowledge concerning the initial weak signal prompting the search is not rapid, it may be difficult to assess the effectiveness of the search. Responses by other organizations may be difficult to interpret. The process may not be quick.

Figure 4 presents a representation of a general model for the effects of feedback proposed by Ilgen, et. al. (1979). It highlights the influences of individual difference characteristics and external constraints in modifying the behavior of the recipient of information at each stage of the response process It is important to note that while individual level concepts may remain important in consideration of weak signals, the strategic feedback relevant to discussion here is likely to be much more formal - rooted in the paradigmatic knowledge discussed above. Processing of this feedback also takes place within the enacted, socially constructed context of organizational activities, many of which will be highly programmed. For instance, financial and accounting metrics are well-accepted feedback for the health of an organization. Problem gaps and potential solutions are rapidly identified when they can be expressed in such familiar and easily quantifiable terms.

With respect to job performance feedback for individuals an analogous process of responding to perceived and accepted inputs occurs. The feedback must be clear and current. Individuals will respond within the norms of their experiences (Ilgen, et. al., 1979; Ilgen & Moore, 1987). Ambiguities in this process will result in misinterpreted stimuli and result in erroneous or inappropriate responses. The process is further hampered by differences among individuals' frames of reference and "filtering" of information within those difference characteristics. While organizations are not people, they may be blindsided in the same way. The CEO and other managers conducting information search in response to weak signals may individually or collectively fail to perceive or accept important new information. Herold & Greller (1977), identified several dimensions of such performance feedback from a large set of samples across a broad based employee population. Of the many dimensions they found that generally the most effective dimensions were negative feedback and social feedback. Employees responded vigorously to reports of deviations from objective standards and from feedback from co-workers and supervisors.

Expanding upon those results, Mankelwicz, et. al. (1987) found that CEO's generally related to a larger set of dimensions than did employees for measures of strategic performance.

They also found that CEO's responded more to positive feedback from both objective metrics and social sources. Many CEO's, especially the males, tended to minimize negative feedback and focus on the positive feedback, objective or otherwise. Indeed all the organization's stakeholders (stockholders, directors, etc.) generally correlate the CEO performance to the health of the organization and use formal, largely financial, measures of such performance.

Cognitive Failures

Again, new information and strategic feedback are needed to amplify an initial weak signal into a state of knowledge sufficient to allow effective problem formulation. This information should be such that fit within familiar paradigms and is recognized by organizational processes. However, as suggested above, individuals' personalities and frames of reference sometimes impede both initial perception of the weak signal and the information needed to amplify it. Both political and psychological factors may push management toward less reliance on "objective" methods of measurement (Castrogiovanni, 1991) or the paradigms underlying those methods. Additionally, executives at all levels tend to make cognitive simplifications in their decision-making, while simultaneously remaining vulnerable to many common decision boases (Bazerman & Moore, 2009). Failures in the cognitive processes may be explained from several perspectives: by Prospect theory (Kahnemann & Tversky, 1979), Expectancy theory (Vroom, 1964) and Attribution theory (Heider, 1944). These theories add additional insight into how managers process information, quantitative or otherwise.

Attribution theory suggests that managers tend to make judgments on the performance of other participants and stakeholders based on past experience and give special significance to behaviors that are unexpected and chosen freely (Jones & Davis, 1965). Through appropriate communication and feedback these judgments and attributions have motivational impacts, which may guide further search activity. In terms of Expectancy theory, these judgments and attributions influence perceptions of the likelihood that the search will be rewarded and the value of those rewards, i.e. the level of Instrumentality (Vroom, 1964; House, 1971). Indeed in response to feedback on their own performance employees and managers alike may adjust their efforts consistent with expectations. When managers lack feedback expressed in formally derived performance numbers, they may resort to attributions from experiences condition by their individual frames of reference, which often leads to "fundamental attribution errors" (Kelley, 1967). They may attribute poor performance of others to inherent shortcomings or their own failings to external factors.

Managers may misinterpret and ignore uncertain or ambiguous threats because of such errors and enact action inappropriate to failing projects (Staw & Ross, 1978). Additionally Prospect theory (Kahneman & Tversky, 1979) suggests that people and organizations are often inordinately driven by bottom-line numbers, e.g. gains and losses, and will rationalize and enact otherwise irrational responses to avoid near-term losses. Such risky behavior often exposes them or the organization to even greater long-term losses. The discussion thus suggests two related hypotheses.

Proposition 6. At any organizational level an individual's frame of reference may distort the guidance provided by weak or even strong signals.
Proposition 7. Even risk averse and otherwise astute decision-makers may fail to detect or even ignore weak signals

These theories provide a structure for discussing and analyzing the means by which cognitive distortions may occur throughout the business decision process. They highlight the need for decision-makers to exercise diligence and unbiased assessment of situational variables using appropriately formal methodologies.

Ethical Failures

As dramatically illustrated by the ethical failures in the decisions made in recent well-publicized cases such as; Enron, AIG and Bernie Madoff, to name a few, flawed decisions resulted in huge negative impacts to numerous individuals and organizations. These ethical problems are analogous to more directly quantifiable factual problems, in that there were significant gaps between enacted behaviors and those required by the norms or codified standards of typical businesses and organizations. In these cases the variables were essentially moral factors. They involved processes similar to all decision-making activities; assessment and judgment, choice and action (Rest, 1986). Jones (1991) suggested that the greater the "moral intensity" of the situation the greater the likelihood that positive, appropriate moral behavior will result. Many factors inherent to the individuals and organizations have significant influences on behavior. Moral intensity could be expressed in six measurable dimensions: magnitude of effect, probability of effect, concentration of effect on a specific group(s), social consensus on the issues, immediacy in time, and proximity in space.

This paper has treated weak signals in the manner of Ansoff (1975). In this sense, it is intuitive that few weak signals will initially carry a high moral intensity, even if subsequent information search revealed significant ethical difficulties in the underlying issues. The reason is simple; a weak signal by definition carries little information about the magnitude or probability of effect. Nevertheless, the weak state of knowledge may still allow inference concerning the other factors, especially about possible social consensus (strong or weak?) or the concentration of effect (on a powerful salient stakeholder?). In many cases it may thus be the moral aspects of a signal that bring it to management attention and search – a fact already discussed in Simon (1945).

Irrespective of the lack of definitive quantitative scales, moral awareness is a central variable in the quest for socially appropriate moral behavior in competitive organizations (Butterfield, et. al., 2000). If the importance of the decision and social consciousness are sufficiently high, the information assimilation and evaluation activities of the decision-making making process should be intensified and focused. Indeed, the authors assert:

Proposition 8. Moral intensity adds to signal strength.

In any situation moral intensity interacts with and is moderated by individuals' difference characteristics. Research into this aspect of human behavior seems to indicate that "Utilitarians" are less likely to violate social norms and raise fewer moral issues than "Formalists" (Reynolds, 2006). Additionally higher level employees are generally more prone to more faults in moral reasoning than lower level individuals (Ponemon, 1992). Employees and students in the accounting field exhibit fewer moral lapses than comparison groups involved in other areas (Lampe & Finn, 1992) that are less likely to focus on precise quantification and structured formalization.

In much of society quantitative measures, such as profit, return on investment, financial ratios, market share, stock price and analogous measures tend to be largely economics-based in nature and the key drivers to many business decisions. Indeed the Enron, AIG and Madoff cases mentioned above amply illustrate how the masterminds of those deceits used the power and influences on stakeholders' psyches to distort reality and achieve acceptance. These individuals and organizations deftly exploited highly aggregated data to conceal the true relationship between actual performance and the accepted metrics (Boyd, et. al., 1993). Only through disaggregation and accurate quantification were the fraudulent activities uncovered and the culprits prosecuted.

Proposition 9. Using formal methodologies with proper attention to key variables and numbers enhance decision makers to more rapidly detect and amplify weak signals of fraud, theft, and ethical mishap.

It is tempting to ask why so many scandals, failed ventures and ill-conceived business decisions continue to occur. The issue is certainly not with the formal processes of quantification or the specific numbers themselves. Aside from cases of purely fraudulent activity what are the sources of such flawed decisions? Factors such as:

- Focus on the wrong numbers
- Incomplete knowledge
- Distortions occurring through changes in frames of reference among those contributing to the decision
- Structural problems and inconsistent or ambiguous information flow within the organization (Mintzberg, 1983)
- Aggregation of data that hide key influence variables and influences contribute to poor quality information that sway managers in misguided directions. Even well-intended decision-makers are led to make inappropriate decisions based on flawed or misinterpreted information.

Proposition 10. Not all weak signals will be detected, and there is no guarantee that appropriate response will always result in favored outcomes.

The following example will highlight many of the thoughts articulated in this paper. The example illustrates the multitude of issues addressed by a large corporation in deciding whether to and how to create a new market in a business arena unfamiliar to the corporation. It highlights the advantages and difficulties associated with quantification and process of weak signals.

LTV'S ATTEMPT TO ESTABLISH AN OPTICAL RECORDING DISC MARKET

In the early 1980's the LTV Corporation, a multi-billion dollar conglomerate with large interests in aerospace, energy and steel industries, established a new-venture team to explore the possibility of creating, developing and establishing a dominant position in a new and unfamiliar business area (Dr. Dayton Eden, personal communication, December 1986). With the success of compact disc (CD) technology in redefining music industry with respect to the recording and the distribution of music and the well-recognized potential advantages of such optical media for the

data processing industry, LTV executives where intrigued by the possibility of opening a new market and possibly a new industry with projected multi-billion dollar sales. At that time no such market existed since the technology was limited to CD "hole-punching" or "hole-burning" systems that did not lend themselves to the manufacture of erasable or rewriteable optical media. Academic and commercial institutions worldwide were researching thin-film materials that might provide the technical basis for such systems. Scientists within the aerospace segment of the organization believed they had at least two thin-film materials that could form the technical basis for a completely recordable, erasable and re-writable optical disc. Discs in this format would combine many of the size, capacity and performance benefits of CD optical discs with the flexibility required of data storage media, much like those offered by magnetic disks and tapes. The issue was how to evolve these material technologies into a viable business.

Technology Issues

Through its research and development in the manufacture and application of thin-film materials that exhibited unique, controllable optical response properties, LTV was involved with the production and exploitation of two optical materials for coatings of various weapon system products. Both were "phase change" materials that would change optical properties with subjected to properly-conditioned pulses of laser light at specific wavelengths. Early experiments showed that optical effects of both materials could be controllably switched between at least two states by varying the characteristics of the laser pulses. Such effects could theoretically be used to create completely erasable and rewriteable optical discs. This was in sharp contract to CD technology, which was essentially an irreversible "stamping" or "hole burning" process. The technology meant that LTV could build data storage and processing systems that would perform much like magnetic disks with much higher capacities.

LTV had established patent positions with respect to both materials and developed corresponding patents for the application of these materials to the production of plastic discs with coatings of these materials: (Eden, US Patent Number 4637008, 1987), (Smith, US Patent Number 4598395, 1986), (Eden, US Patent Number 4587565, 1986). Figure 5 taken from US Patent 4637008 illustrates the temperature-stress, phase-change cycle that provides the theoretical basis for modifying the optical properties of the material using heat created by an appropriately condition laser pulse. They also established patents for the methods of creating the coatings using thin-film evaporative deposition techniques (Case, 1985).

Since there was as yet no established market or industry for such products, and plans for their development were still embryonic, many interested organizations began the process of establishing standards for all aspects of the materials, data discs, drives, data formats and potential distribution media.

LTV lacked knowledge and fundamental capability in all these areas. Its experience with the manufacture of thin-film products was confined to military applications that were of limited quantity and high cost with high-quality military standards and long development times. It had no experience with high volume, low cost quick response consumer products. It faced significant challenges in changing the processes and organizational mindset with respect to these variables. Very significantly, it was proficient with and highly-recognized for developing products through the multiple-year and sometimes multiple-decade progression of military products from research to production. It was unfamiliar with the uniquely short, cycle times of consumer products, especially in the consumer-electronics world.

Management and Marketing Issues

While LTV as a corporation had a reasonable number of people trained in technologies closely related to those required for the proposed market entry, their fundamental talents were predominantly in the development of military products. Furthermore despite the fact that LTV enjoyed financial success in the aerospace industry they possessed limited resources for new investments, particularly in unfamiliar market segments. The corporation also had a significant "branding" impediment to overcome. The emerging competition on the other hand were well familiar with products of these types since most were commercial concerns with vast experience in the related technologies, e.g. IBM, 3M, Sony, Phillips, Memorex and TDK to name a few. LTV recognized these shortcomings and approached most of the "players" in the related industries but could not reach suitable arrangements (teaming relationships, collaborations, partnerships, etc.). Most of the organizations attempting to develop this new business area were investing several tens of millions of dollars to properly position themselves for the projected new market. Indeed the potential business was conservatively estimated to be multi-billions of dollars with many lucrative spin-off product lines. Until the market was more defined none wanted to prematurely relinquish pieces of the pie without due cause.

Actions, Results, Lessons

LTV established an exploratory team to both extend its technical base and to assess a proper strategy for market entry. The technical efforts focused on refinement of materials and manufacturing processes. The management efforts concentrated on establishing an overall entry strategy, developing a development plan and making recommendations to the CEO of the corporation. After a year and a half the team concluded although the potential market was indeed large, the corporation could not at that time successfully establish a winning position for the following reasons:

- The corporation lacked critical technical and management personnel
- At best the effort would have to transition outside of the aerospace division since it had the wrong orientation with respect to specific knowledge and development time
- The effort was insufficiently funded and improperly focused. The competitors were too far ahead and unlikely to cooperate with LTV on any basis that might be of interest to the corporation. They already had technical and management experience to launch entries on their own and did not need the elements that LTV had to offer.
- LTV was already too late to make a successful entry, given its current overall position.

The recommendation to the CEO was that LTV not attempt its entry. The corporation decided to continue its research into the fundamental technologies with potential benefits to its military product lines. LTV never became a player in the industry in any manner, but continued its research for several more years.

Subsequent to these events the optical disc market has burgeoned, as anticipated, into a multi-billion dollar sets of markets including such products as; optical discs in recordable and rewriteable formats, associated CD and DVD drives, spin off consumer electronic products,

games, publishing media, entertainment products, to name a few. With respect to the decision making process the example offers the following lessons:

- Formal processes and quantitative analyses play a significant role in many business decisions for many modern organizations
- The area-specific knowledge is key to those evaluations and define the paradigms and metrics upon which decision-makers rely
- Feedback is instrumental at each step of the decision-making process in guiding the direction of search, data-collection and verification
- The strength of weak strategic signals is amplified at every step in the decision making process and those signals are moderated by situational and environmental variables
- Other moderators such as basic business acumen play large roles at all levels of the organization especially for higher level decisions where data and information may be highly aggregated

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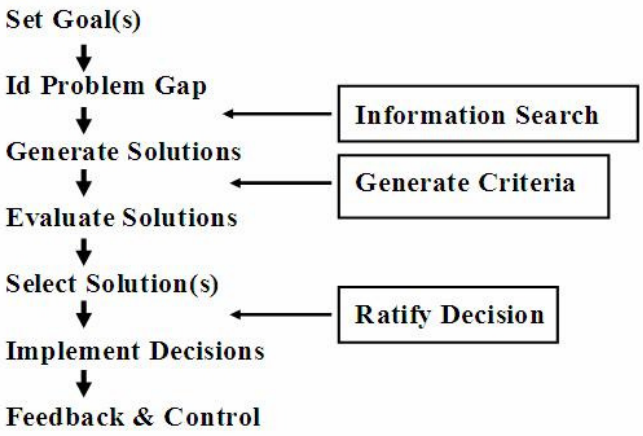

Figure 1 Chain of Decision Activities

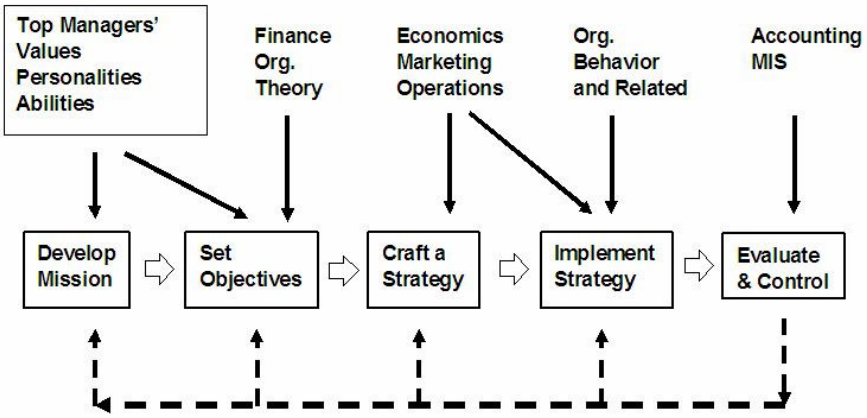

Figure 2 Paradigms inform the five tasks of strategic management.

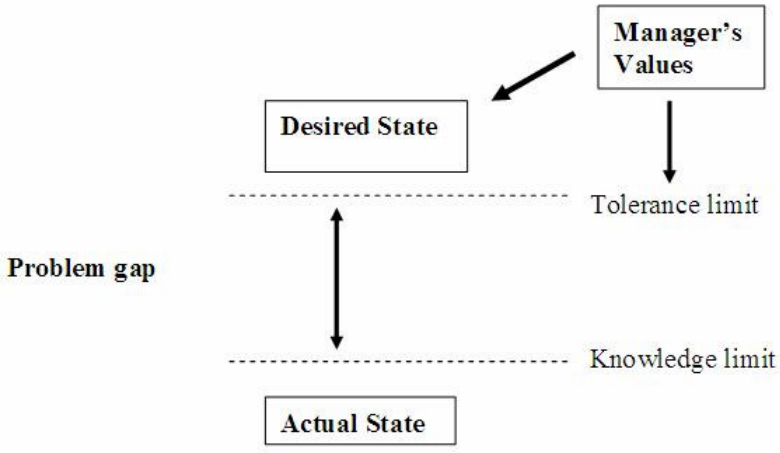

Figure 3 Managers' values impact the acceptance of both the desired state and the tolerance limit.

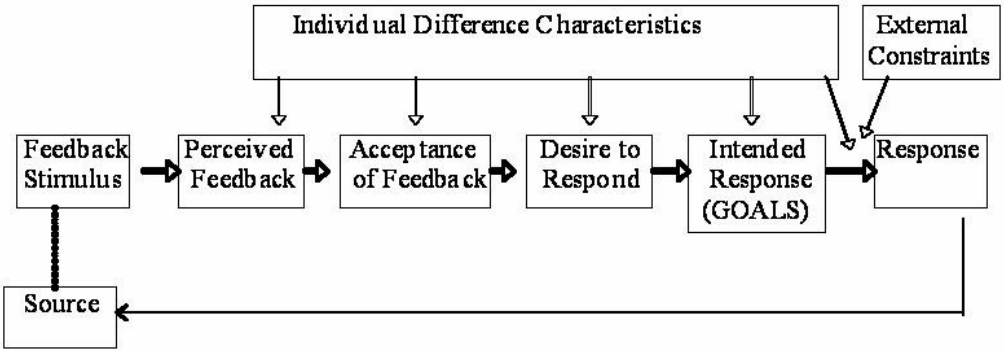

Figure 4. Effects of feedback on the recipient (Ilgen, et. al., 1979).

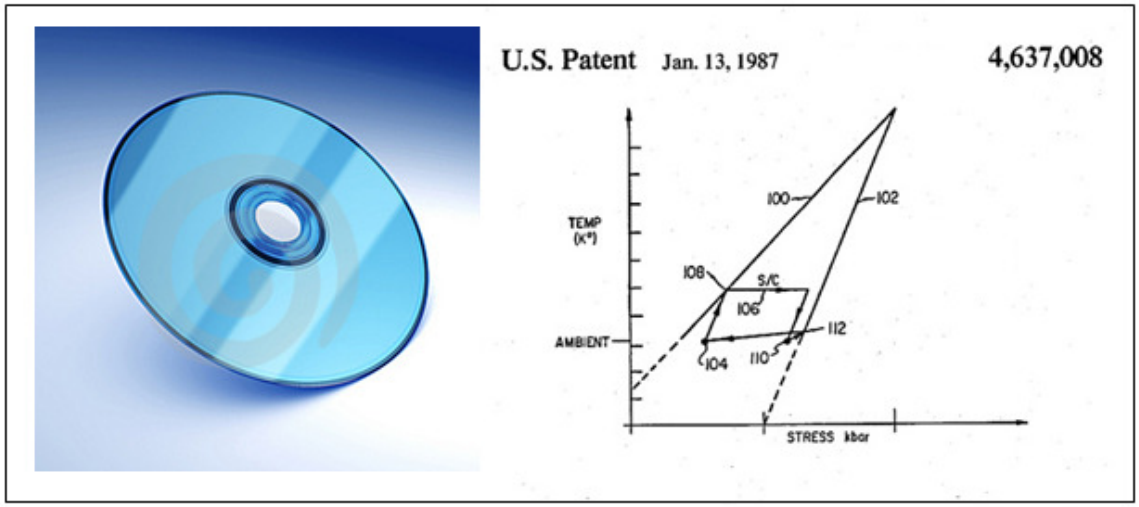

Figure 5: Temperature/Stress Phase Diagram - Optical Disk Recording Properties