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Quantitative Information For Strategic Decisions

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The role of quantitative information at the highest levels of decisionmaking is largely contributory since managerial judgment is always dominant. However, quantitative descriptions are often extremely useful since they offer a degree of precision in the decisionmaking process. The problems of applying quantitative information to contemporary strategic planning illustrate the need for managers to integrate such techniques into the decisionmaking process, while staff analysts must provide quantitative information in both an understandable and useful context. Within these limitations both industry and the military can profit from quantitative techniques.

QUANTITATIVE INFORMATION FOR STRATEGIC DECISIONS

A research paper prepared

by

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Introduction. For the past 10 years, if not 20, the prophets of management science have been forecasting the arrival of the quantitative era. This millennium is to be achieved through the use of mathematical models and statistical techniques as programed into computers. For example, in 1961 one of the foremost management scientists predicted, "Management education and practice are, I believe, on the verge of a major breakthrough in understanding [quantitatively] how industrial company success depends on the interaction between the flows of information, orders, materials, money, personnel and capital equipment."[1] There might be a popular belief that while computers, quantitative methods, scientific management, or systems analysis have not met with wide and willing acceptance in the military, they enjoy a broad popularity in business. Yet even in industry where money, in particular profits, can provide a common yardstick for performance, progress toward complete adoption of quantitative methods beyond the rule of thumb has been slow in coming. In late 1969 another management scientist declared, "When compared to models used in the physical and social sciences for quite similar purposes the models used by managers . . . are almost startling in their naivete."[2] Hence, research reported here shows that quantitative methods and computer applications at the highest corporate decisionmaking levels enjoy only modest acceptance in some companies, while there is outright hostility in others. Thus, through an

objective examination of the writing concerning the application of quantitative methods in business, an insight into their potential application or misapplication in the military is available.

The objective of this paper is then to examine the place for quantitative information in the highest levels of business management and by analogy project the findings into the same level of military decisionmaking. Since quantitative information often implies the use of computers, some of the inherent limitations of computer-based information systems in support of decisionmaking at the highest organizational levels will be discussed. Rather than discuss specific techniques which are used to process quantitative information or details of computer technology, these mechanics will be mentioned only where needed for illustration.* Similarly, original findings concerning quantities of information which enter into the decisionmaker's judgment process will be presented on an intuitive basis. The discussion will develop the case concerning the role of quantitative information in the strategic planning process by first examining this process, with emphasis on the similarities between applications in business and the military. The organizational rather than the geographic aspects of strategy are considered. Next, a contributory application of quantitative information to decisionmaking will be considered to demonstrate suitability. In this application the roles of the decisionmaker and his supporting staff with regard to quantitative information and data are examined. Then, to assist practitioners, a rationale and methods of presenting quantitative information for use in strategic planning and computer aspects are developed. It is not intended to either sell or condemn computers or quantitative methods for decisionmaking at its highest level, but to expose how decisionmakers can obtain useful quantitative information and how staff personnel can more acceptably present this input to the decisionmaker.

Strategic Planning. "... strategy [teaches] the use of engagements to attain the object of the war."[3] This classical concept of strategy as expounded by Clausewitz finds application today in both business and military circles. Therefore, it is not unreasonable to find a common process for arriving at a strategy in both types of organizations. This process, strategic planning, involves establishing and changing the organizational goals, identifying resources to be used to achieve these goals, and the policies for the allocation of these to competing goals.[4] For example, either the decision to redeploy major forces or to devote national resources to an antiballistic missile system would involve military application of strategic planning, while in business it would be used in arriving at decisions to allocate capital and managerial talent to a new product line or the decision to reorient company goals from current profit to increased market share. Inherent in strategic planning is the intentional modification of the organizational structure and processes. This function is carried out at the highest organizational levels, principally at the corporate headquarters in business and similarly at the Department of Defense or service level in the military. Of course, this activity is not the sole occupation of top management; they tend to spend most of their time working with others to assure execution of the strategic plan. These activities include obtaining and using resources consistently with maximum advancement toward organizational goals, and occasionally they are even involved in assuring that specific tasks are carried

*These aspects are the subject of many texts, for example, Van Court Hare, *Systems Analysis: a Diagnostic Approach* (New York: Harcourt, Brace & World, 1967).

out effectively and efficiently. While all echelons of management or command are involved with these supervisory tasks, strategic planning is unique to top management.

While problems addressed in strategic planning may vary widely, from a decision to reallocate significant national resources to acquire a weapons system to a plan for corporate merger, the procedures involved have a basic functional consistency. Most significantly the problems would fall into the instructure or nonprogramed type, that is, problems that cannot be solved by previously established detailed rules. Problems are basically a difference between an existing situation and some desired situation, and they include opportunities, in the sense of realizing a better situation. Generally, problems are recognized through trends in historical information, making projections into the future, and comparisons with others in the form of external criticism or internal recognition of the superior methods of other organizations. Less frequently, a problem may be recognized and identified by application of an abstraction or similarity to a physical or engineering process.[5] Since strategic planning operates in an area where no prescribed rules exist to identify a problem situation, problems are uncovered only when someone asks the right questions to surface the information which can be assembled to identify the problem. Usually it is desired to conduct further inquiry into the problem area. The source of information for this additional study can be specified only by the nature of the problem; by definition it cannot be anticipated or obtained entirely through a prearranged organizational reporting system. The resolution of the problem, the major strategic decisions which set corporate goals and objectives, will always be dominated by managerial judgment, not through the selection of a predetermined rule or policy or some other programable decision.[6]

In addition to its unstructured content, strategic planning is an aperiodic activity. Problems are dealt with as they are recognized, and opportunities are exploited as they are seen. In fact, top management often procrastinates and avoids the strategic planning process, since time spent in that activity is not available for more immediate problems. Further, there is a human tendency to prefer routine problems for which known procedures exist to obtain solutions. This is "... called facetiously Gresham's Law of Planning. It states that programed activity tends to drive out nonprogramed activity, ..." A noted writer on management attributes to this the tendency to avoid strategic planning.[7]

The steps involved in strategic planning are those found in any decision-making procedure, civilian or military:

1. Identification of the problem or opportunity.
2. Analysis of the situation.
3. Definition of the courses of action.
4. Evaluation of alternatives.
5. Selection of the course of action.[8] [9]

Clearly, the recognition that a problem or opportunity in the strategic planning area exists will occur at irregular intervals. Either the top manager or the supporting staff or middle management will recognize the problem and initiate action. These latter two will perform the second step to more precisely define the problem. Also, they will usually state the various available alternatives. Normally, middle managers will provide the data and detailed programs to implement the alternatives, and the staff of the top management distills a summary for presentation to the decisionmakers. Circumstances, however, may arise where top management will participate in or perform these steps. The evalua-

tion of the alternatives to determine advantages, disadvantages, and effects may be performed either by top management or supporting elements, but the basic principle that the strategic decision rests with command, or equivalently the autonomous manager, is universally true.[10] The president of a major corporation clearly distinguished the roles of staff and top management in observing that skilled staff analytic support in the strategic planning area is needed to help the president ask the right questions about plans and to test the reasonableness of assumptions.[11]

It has been shown that strategic planning is the process of setting organizational goals and policies. It produces decisions regarding basic structural issues in both business and the military. These decisions are made as problems are recognized and involve data that cannot be predetermined. A fundamental aspect of the process is the essential and dominant role of the judgment of top management, but the process includes the supporting staff in the preparation of information to guide the manager.

Quantitative Aspects. With the concepts of the strategic planning process developed, it is now appropriate to consider the applicability of quantitative methods to that process. Further, by reconciling the theoretical possibilities with actualities, both credibility for the theory and a means to improve current practice can be seen. A practical indication of the attitude of business managers toward quantitative methods is indicated in the following statement which has been attributed to the president of a large corporation. "Business has gone through a stage in which it was popular to consider it [management] as a science. Now it is increasingly regarded as an art. For there are no absolute answers, and if there are no answers how can it be a science?"[12] Nevertheless, other authorities speak of a slow but increasing use of quantitative methods to support the exercise of judgment by top management, including the application of these methods in systems analysis to support strategic planning.[13] [14] A minimum or contributory application of quantitative methods is suggested by the attitude advocated by a former Assistant Secretary of Defense that in quantitative matters "... the greatest clarity of thought is achieved by using numbers instead of avoiding them, ..."[15]

In the decisionmaking process as described above, quantitative data can be treated along with qualitative aspects of a situation in most of the steps. For example, a qualitative statement of a problem can be obtained from an executive recognizing a pattern or trend in the numerical data contained in corporate reports. Further, through the concept of a problem being a deviation of an existing state of affairs from a desired state of affairs, in the "analysis of the situation" the best way to express terms such as "more" or "better" is often to numerically state how much "more" or "better." Similarly, in the evaluation of alternatives, application of the quantitative techniques of systems analysis can show comparisons of cost, time, and performance factors. These can then be presented to management along with nonquantitative factors, not as a substitute for judgment, but as an improved base of information from which to exercise judgment.

While it is simple to show a role for quantitative methods in strategic planning, explanations are necessary to account for the slow pace of acceptance in both business and the military. In the business world, some top managers have only modest mathematical abilities and training in disciplines where qualitative techniques predominate. Hence, they are not conversant on a quantitative basis.[16] Further, practicing managers tend to approach the recognition of problems and their solution through

very simple analogs which employ only the most rudimentary application of quantitative techniques.[17] Consequently, their natural analytic decisionmaking process is qualitative. The natural supporting role of staff personnel in strategic planning, obtaining data and developing it into useful information for the top manager, is consistent with the application of quantitative methods. Further, the tendency of people with quantitative backgrounds, and especially those with recent training in management science, to fill these staff positions reinforces the trend. A management consultant has estimated that there are only about 19,000 personnel today who are qualified to practice management science, and of those only 20 percent are in industry. The remainder are involved in academic or basic research work. Thus, the slow progress in application of quantitative methods is not surprising, and, further, the typical conception of the theoretically oriented, inexperienced staff man is likely to persist as more and larger staffs are created to provide the quantitative support for top management.[18] If, however, both top management and the supporting staff recognize the natural tendencies that impede the application of quantitative methods, the introduction and use of these techniques can be facilitated.

Managers have traditionally employed criteria for decisionmaking that consider nominally a maximum of about 10 factors; some of these are used to create a concept of the desired state of affairs, while others are used to form an impression of the true state of affairs. The actual decision is then made on the basis of rules of thumb, previous experience, and managerial judgment by an individual who has proven himself in these techniques by undergoing management selection processes and perhaps some training.[19] In this process very little precision in communicating with the staff is needed to get suitable supporting information; in fact, the information is readily obtained through verbal conversation on the telephone. Further, since the decisionmaker himself can easily analyze and compare alternatives, there is little need to formally identify his decisionmaking criteria or constraints. For example, his attitude toward risk need not be specifically given to the person framing and performing preliminary analysis of the alternatives, since it is not required to insure the adequacy of information presented to him. Thus, the traditional managerial decision is made on the basis of 10 factors of verbal, qualitative data.

In contrast, the quantitatively oriented staff man may find it useful to abstract either an actual situation or a proposed scheme of operation to a mathematical model which is capable of dealing with easily 30 to optimistically 3,000 quantitative factors.[20] These are manipulated by a computer using a program which will probably include decision rules which compare or optimize numerically measured factors. With these built-in decisions the analyst can either implement management's guidance or drive the problem in some other direction. The quantitative techniques may furnish the analyst with varying amounts of numerical results. In practice the amount may go from reams of numerical data, which hopefully will show some pattern, to as little as a single number—say profit—which is intended to show the result of selecting the "optimum" course of action. Precise specifications regarding input data are required just as precise directions for manipulating the data are required, if meaningful results are to be obtained with quantitative methods. Conceptually, this method of analysis differs radically from the 10 qualitative factors used by the manager.

In the staff-manager interplay in the strategic planning process, an inherent potential for communications breakdown exists. The most immediate area

where breakdown can occur is in vocabulary. The quantitative people have a tendency to speak the jargon of the discipline of their original training—engineering, mathematics, or econometrics—while the managers have a tendency to avoid learning even the rudimentary vocabulary associated with the quantitative methods of business, statistics, operations research, and systems analysis. Next, the differences arise in solving specific problems. Managers may ignore or reject various quantitative methods and information, or they may question the validity of techniques or results. These objections usually involve an overestimate of the uniqueness or stringency of local conditions by the manager.[21] Other accompanying symptoms may be a defensive attitude, vague questions, or hesitancy to identify decisionmaking criteria. The defensive attitude usually arises when the manager feels the analyst is infringing on his decisionmaking functions; but the latter two aspects often indicate a lack of depth in the manager's understanding of the problem. Any of these defects usually foredoom the qualitative analysis. On the other hand, the analyst tends to misapply statistical procedures to the scanty data usually encountered, rather than accord a role to qualitative aspects of professional opinion or accept unknowns as areas of risk. This tendency leads to either separating the problem into too many pieces or including a wealth of trivia. Disaggregating the problem into too fine a structure can prevent recognition of the large conceptual problems. Retention of trivial factors leaves the manager confronted not with results, but with a multicause and multieffect situation from which he must try to deduce the solution. In either case the usual result is that the analyst overwhelms the manager with the sheer bulk of quantitative data, rather than trying to determine which factors are really important and using these to get useful answers.

Thus, a fundamental problem is that to employ quantitative methods effectively, managers must acquire a knowledge of the capabilities and limitations of quantitative methods. This is probably the most onerous task to confront management yet, but it does not require the manager to become a mathematician. It has been shown that a person with very little quantitative training and modest mathematical ability can in 50 hours of instruction acquire sufficient understanding of quantitative methods to supervise and use the analyst's work. With training, the manager can insure that the analyst has used the proper method, verify that the information being obtained is applicable to the problem under consideration, and perceive the uncertainty associated with the results of the quantitative analysis.[22] Equally fundamental is the tendency of the analyst to have a fixation on the quantitative technique to the exclusion of the real problem. This situation results in what a noted management scientist has called

> . . . mathematician's aphasia . . . [where the analyst] abstracts the original problem until the mathematical intractabilities have been removed (and all semblance to reality lost), solves the new simplified problem, and then pretends that this was the problem he wanted to solve all along. He expects the manager to be so dazzled by the beauty of the mathematical results that he will not remember that his practical operating problem has not been handled.[23]

To be effective, analysts should remember three operating rules. First, in major decisions managerial judgment will always play the dominant role. Second, the unstructured nature of strategy resists quantification and is characterized by imprecise data. And, third,

information that does not contribute to a decision is valueless, regardless how elegantly derived.

A practicing management scientist reports that the quantitative revolution is underway in some leading companies.[24] Similarly, quantitative applications have come into use in the military.[25] Thus, whether or not the preceding discussion is accepted, quantitative methods are being applied to strategic planning. To continue to perform effectively, the manager must learn the capabilities and limitations of analytic techniques together with enough of the vocabulary of business statistics to assess the information furnished him and to frame questions quantitatively. If this accommodation with the quantitative people can be reached, the chances of obtaining meaningful responses from them are greatly enhanced. Similarly, the staff analyst must accommodate by focusing on real problems, bringing qualitative descriptions into quantitative analyses, performing these with due regard for assessing the uncertainty of the information produced, and communicating both meaningful and pertinent information to the decisionmaker.

Information Considerations. If quantitative information is to be used in the strategic planning process, it must be presented to the decisionmaker in conformance with the standards already being applied to other, qualitative information. These standards reflect especially a desire for concise presentations so that the manager may return promptly to present pressing problems and restriction of the presentation to the major issues so that the decisionmaker can maintain a perspective on the total strategic problem under consideration. Thus, the information presented should contain only the minimum number of quantitative factors and qualitative elements to develop the subject logically.[26] A further requirement to apprise the decisionmaker of the uncertainty of the quantitative information is imposed on the analyst, especially in the strategic planning area, since the relevant source data is characterized by imprecision. Normally it would be expected that the analyst would have available to him voluminous data ranging from the partially pertinent to the trivial, but none applicable to all aspects of the problem being investigated.[27] Further, the accuracy or conditions under which the data were obtained may not be known. While it is the responsibility of the staff analyst to extract and present the information in an appropriate form, the manager has an equal responsibility for what he receives. By clarity in his guidance to the analyst, to include specification of quantitative factors in quantitative terms, he can assure that his concept guides the analysis. In another aspect, a willingness to let the analyst select the most available data consistent with the problem to be addressed will avoid straitjacketing the analyst. The first factor, guidance, will insure that the analyst solves the right problem and accurately includes the manager's constraints such as allowable risk or acceptable probability of failure. The second item will reduce the cost to the organization in obtaining the desired information. Both the analyst and the manager should be aware of the fundamental reason for introducing quantitative information into the strategic planning process: the ability to provide more precise descriptions in quantitative terms and thereby reduce the uncertainty facing the decisionmaker.

The analyst is then faced with presenting his data to the decisionmaker who, as was developed before, is capable of interrelating about 10 factors. Further, a survey of commonly used units of measure indicates the human capacity for precision or, equivalently, capacity for information is about three digits. An example of a system of

measure aimed at three-digit precision is the metric system with its system of prefixes for units of micro (1/1,000,000), milli (1/1,000), kilo (1,000), and mega (1,000,000). While three-digit precision is common, consideration of the usual presentation of statistical factors as percentages indicates a strong tendency for people to consider about two digits worth of information concerning a quantitative factor. Certainly this statement is consistent with the previous statement that strategic planning is characterized by imprecise information. The recognition of the limited amount of information which can be presented to influence a decision in strategic planning in turn implies that maximum value, or reduction of the manager's uncertainty, must be derived from each factor and digit presented. Three tools can assist in this task. Application of procedures which have their origins in communication theory can lead to more effective presentation of each quantitative factor. Statistics can aggregate many elements of data into a few useful items of information. And models can identify important operating factors.

In presenting a quantitative description of an item, the following apply:

- Unless the range of the quantitative factor is well known, it should be described. On graphs the range shown implies the range of a factor: for example, it is misleading to show from 0 to 100 percent, if the factor is known to always lie between 70 and 80 percent. Proper practice defines the region of uncertainty which is to be reduced by the quantitative information.
- The limit to which numerical information can reduce uncertainty is the precision or accuracy of this information. Each digit in a number or piece of quantitative information does not contribute equally to the reduction of uncertainty; the order of magnitude of the quantity potentially contributes the most information, then the first digit has the next greatest value. For example, the item of information "$320 million" has the most valuable information in the order of magnitude, hundreds of millions of dollars, the next that represented by the "3" which stands for $300 million, or more precisely 300-399 million.
- Presentation of numerical information with precision beyond accuracy is senseless, if not misleading. For example, the knowledge that the price of a commodity was 2.4932 cents per pound last month is overly precise in addressing today's problem, if a variation of 10 percent could have occurred in a month. In this case the better statement that the price is 2.5± 0.2 cents is sufficient and implies a much truer sense of the uncertainty associated with the quantitative information.
- Digits which do not contribute to the reduction of uncertainty are irrelevant. In addition to the example immediately above, in preparing a graph of stock market averages for a decision-maker who knows this factor lies between 700 and 800, the 7 in a reported 743 average conveys no information. Thus, the bar graph should be limited to a range of 700 to 800.

Often an item of quantitative information will be fully described by a collection of data. Here the difference between data which contributes only in an indirect sense to decisions and information which is the product of analysis and is intended to contribute directly to decisions must be emphasized. Typically, statistical processes are used to get information from the collection of data. For example, a listing of miss distances collected from the test of a strategic missile fully describes that aspect of the test. The average miss distance conveys virtually the same information with only a single data point. Further useful information is the degree of uncertainty associated with the average or a measure of the distribution of the miss distances, e.g., standard deviation. Thus, two items

of quantitative information, the average and the standard deviation, would be as valuable to the decisionmaker as 10 or 100 isolated data points.

In presenting more than one element of quantitative information when describing an item, the greatest efficiency, or equivalently the maximum reduction of uncertainty for the least total number of digits, can be achieved by avoiding any interrelation between the different quantitative items. In the example immediately above, the average and the standard deviation are independent; on the other hand, average, highest measurement, and lowest measurement convey virtually the same information but require far more digits. Further, adherence to this principle will allow the decisionmaker to avoid unnecessarily complex interrelations and ideally address one factor at a time. In consonance with this technique, the analyst should insure that each factor represents some quantity well known to the decisionmaker and preferably with an uncomplicated relationship to other factors under consideration.[28] For example, in a real study it was found to be far more direct to describe a cumulative probability of failure which started at zero and continuously increased as time went on rather than a probability of success which started at 1.00, decreased sharply at first, and later at a decreasing rate as time went on. The technique here is the same as viewing a geometrical figure from a perspective that permits it to be described and measured as simply as possible. Further, if the manager ever encounters the analyst that cannot, given time, fully and simply explain how he derived an item of quantitative data from sufficiently reliable sources, he is probably trying to hide his own uncertainty behind mathematical jargon or recondite abstractions.

Returning to independence of quantitative factors and efficiency, it should be noted that if average, highest and lowest data points are presented, instead of the more efficient mean and standard deviation, the interdependence of the three factors provides a degree of insurance that all three are accurate. For example, the average must lie at a value between the highest and lowest measurements. Alternatively, an extreme departure of the highest or lowest reported value from the average should alert to the possibility of an error driving the average, perhaps even an error in the original data collection. Thus, where accuracy is paramount or where the analyst expects questions concerning the accuracy of his data, he may decide to sacrifice efficiency by introducing redundancy.

The analyst must recognize that false and theoretically unwarranted impressions of precision are conveyed by a single numerical representation of an uncertain quantity. In fact, an authority has identified the problem of differing impressions of uncertainty as one of the chief sources of differences in judgment between decisionmakers when using quantitative data.[29] These uncertainties frequently arise when data is projected outside the range over which it was collected. For example, market trends can be projected into the future, or pilot projects can be projected to larger scales. In these circumstances it must be recognized that the further one projects away from the available data, the greater the uncertainty. Equivalently, the smaller the sample in statistics, the greater the probability of drawing an erroneous conclusion, or in dynamic models (those which show changes in performance with time), the further one predicts into the future, the less the influence of the present state of affairs.[30]

Finally, in selecting the items of information to present to the decisionmaker, the analyst can often use a well-constructed mathematical model. With this model he can determine which controllable and uncontrollable factors

have the greatest effect on the outcome or results of the problem under study and which of the many resultant effects are significant. Thus, the quantitative factors presented for making decisions at the highest level will reflect only a highly simplified and abridged version of perhaps a very complex model. This aggregation is desirable and essential, but a hazard.[31] The hazard is that aggregation, while increasing the value of the few items of information derived, eliminates a large amount of low-value information which can be regained only by returning to the original data. The assistance of a model in determining which factors are critical is implicit in the statement, "The process of building a model is more instructive than putting it through the computer after it is done"[32] by the management science director of one of the largest industrial concerns. Thus included among the tactics of quantitative analysis is an approach for use in limiting the information presented to the decisionmaker to sufficiently few factors to make it also useful.

Useful quantitative information can be included among those limited number of factors which influence decisions in strategic planning. The factor presented must, however, have maximum value through reduction of the decisionmaker's uncertainty, the remaining uncertainty must be understood, and the information must be presented with a minimum amount of mathematical verbiage.

Application of Computers. After the application of computers to clerical tasks was demonstrated in the 1950's, the prophets of management science projected from this initial success to higher roles in business. In fact, some enthusiasts left managers wondering about their own employment status. For example, in 1960 a noted management scientist projected the role of the computer in strategic planning as shown in Figure 1.

As anyone with a credit card, telephone, or checking account will attest, computers are in the business world to stay. Their use has grown in this area much as the prophets predicted. But here the accounting procedures are inherently numerical, and the practices, manual or computerized, consist only of following very simple rules. Thus there is a high degree of compatibility between the computer and the task.

At the other end of the spectrum, it has been shown that strategic planning is unstructured or does not follow any preconceived decisionmaking rules, data requirements cannot be anticipated, and

TYPES OF DECISIONS	DECISION MAKING TECHNIQUES	
	TRADITIONAL	MODERN
Programed:		
Routine, repetitive, Specific process for handling them	1. Habit 2. Standard operating procedures 3. Organizational structure	1. Operations research 2. Computer data processing
Nonprogramed:		**Heuristic**
One shot policy decisions No prearranged process for solution	1. Judgment 2. Rules of thumb 3. Executive selection	1. Train decisionmakers 2. Heuristic computer programs

Source: Simon, p. 8.

Fig. 1—Techniques of Decision Making

quantitative considerations must influence the decision. This situation is exactly the antithesis of the easily automated clerical task. To overcome this deficiency, an essential to substantiating a role for computers as participants in strategic planning, heuristic programing techniques were projected. These heuristic programs were to make the computer capable of teaching itself and included pattern recognition and self-optimization. A great flurry of research, mostly inconclusive, was conducted from about 1955 to 1965. However, automated management is still not technologically feasible. Today, computers can recognize only the patterns of especially designed characters;[33] they can recognize the patterns involved in handwriting or the sound waves and vocabulary of human speech only to a very limited extent. Further, an imminent breakthrough is not currently foreseen.[34] Thus, for the immediate future, one is inclined to dismiss both the old prediction of automation of the strategic planning process along with few prophets still persisting.[35]

If computers are unable to do strategic planning, can they provide support? And, if so, what type of support? In this area there is a wide divergence of expert opinion ranging from the concept of the all-encompassing corporate data bank by which any top manager can obtain any item of data, summary, or projection on his private console[36] to the belief that computers are inapplicable to problems at this level.

Apparently the gigantic corporate data bank or total management information system will fail to appear in the foreseeable future for much the same reason as computerization of strategic planning. As one noted authority has written, "One cannot do [management information] systems planning . . . to support the strategic planning level unless one can describe how to encapsulate a universe of information in the kind of data bank we know how to construct today."[37] This statement is a logical consequence of the inability to predict in advance what data will be required for a strategic planning situation or, in fact, what the situation will be. Further, data compilation against the off chance that it will someday be useful is not worth the cost.

Another aspect that limits the application of computers here is top management's avoidance of direct communication with the computer. This situation is attributable to the procedural difficulty of communicating with the computer, a desire to avoid getting bogged down in the minutia and losing perspective of the problem, and social pressures which equate the use of a computer to loss of intuition.

Many of the methods of statistical analysis, dynamic modeling, and optimization which were previously mentioned as means of preparing quantitative information from raw data can be accomplished easily on a computer. Again a role for the supporting staff is seen. This role of serving as an intermediary with the computer is entirely consistent with the staff role previously developed, that of preparing quantitative information from raw data. Various writers from the business world have illustrated the successes and failures that have occurred. For example, the comment by a vice president of a data processing firm, "technicians didn't speak management's language—only machine language."[38] Another was aired by an executive, "Probably the greatest single problem with systems development is the interface, the difficulty in finding professional computer men who can come into an organization like this and understand the business problems."[39]

Since it cannot be specified what data should be collected and processed, are there criteria for guiding reactions to situations as they arise? Further application of the previously stated criteria that information is valuable only to the

extent that it reduces uncertainty in the decisionmaking process is valid. Existing computer data bases can contribute timely access to information in great depth and detail. These data can be processed as they are extracted to enhance format, summarization, and usefulness, but it may be necessary to compromise some of the details between what is available and exactly what is wanted. The cost of extraction and processing versus value of information should guide this compromise. In the area of timeliness, it should be recognized that top management often does not require the latest information but that they want reasonably current information quickly. Further, as management learns more of the capabilities of computers, they will require the examination of more alternatives, because these can be evaluated promptly and with little additional effort.

As a final caveat, the approach to expansion of the computer into the strategic planning area is crucial to success. A consultant has observed that, "Just going to full budget usually generates mountains of cheap, useless information."[40] It is management's role to insist on the quality and usefulness of data. Traditionally, plans to increase the scope of machine processing business have been justified on the basis of a comparison of machine to manual costs. In strategic planning a more appropriate basis is the relationship of the cost of obtaining and processing the information to its value, since there may be no manual analog.

Summary and the Future. The application of quantitative information as a contributing factor to the highest levels of decisionmaking has been examined. While the inherent applicability and compatibility with the strategic planning process were indicated upon examination of theory, reconciliation with the realities of lagging acceptance showed misapplication by analysts and a lack of understanding by managers. This examination pointed out qualitative descriptions could be included along with quantitative factors to form a basis for the exercise of managerial judgment. But only a limited number of factors, each with limited precision, can be accommodated by the human decisionmaker, and the staff analyst must recognize this limitation when preparing information. By effectively presenting easily comprehended, independent quantitative factors, each with an accompanying indication of associated uncertainty, and by using statistical methods and dynamic models to select the most pertinent factors, the analyst can communicate the most important aspects of a problem for decision. If the commander or manager can learn a little of the language of quantitative methods, he can better guide his staff and interpret their presentations. The use of computers, either as a source of data

BIOGRAPHIC SUMMARY

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from an existing information bank or as a means of processing data and evaluating alternatives by statistical analysis or models, is one of the better methods of obtaining information for strategic planning. Presently, top management does not deal directly with computers, but direct interaction with computers is entirely consistent with the role of the supporting staff.

In the future, as management becomes more conversant with quantitative techniques and computer capabilities and as the computer becomes easier for the commander or manager to deal with, experts feel we may see more direct communication. This development of the computer is expected to proceed to direct evaluation of alternatives by the manager in about 5 years.[41] For the present and immediate future, the appropriate level of influence of quantitative methods is limited to the statement made in 1963 by the then Deputy Assistant Secretary of Defense Alain C. Enthoven,

> This is not to say that all matters can be reduced to numbers, or even that most can be, or that the most important aspects can be. It is merely to say that the most appropriate method for dealing with some aspects of problems of choice of weapons systems and strategies requires numbers. Non-quantitative judgment is simply not enough. What is at issue here really is not numbers or computers versus words or judgment. The real issue is one of clarity of understanding and expression.[42]

Currently in industry it has been said that "The quantitative revolution is already underway in some leading companies."[43] While equivalently in the military, the incumbent Secretary of Defense stated, "Today it [systems analysis] still plays an important role in the current defense spending debate."[44] Thus, it is expected that quantitative methods and supporting computer techniques will see expanded use within their present role of supporting the exercise of the highest levels of managerial judgment.

FOOTNOTES

1. Jay W. Forrester, *Industrial Dynamics* (Cambridge: MIT Press, 1961), p. 8.
2. William F. Pounds, "The Process of Problem Finding," *Industrial Management Review*, Fall 1969, p. 1.
3. Karl von Clausewitz, *On War* (Washington: Infantry Journal Press, 1950), p. 62.
4. Robert N. Anthony, *Planning and Control Systems: a Framework for Analysis* (Boston: Harvard University, Division of Research, Graduate School of Business Administration, 1965), p. 16.
5. Pounds.
6. Rodney H. Brady, "Computers in Top-level Decision Making," *Harvard Business Review*, July-August 1967, p. 76.
7. Herbert A. Simon, *The New Science of Management Decision* (New York: Harper & Row, 1960), p. 13.
8. Brady, p. 71.
9. U.S. Naval War College, School of Naval Command and Staff, *The Staff Study* (Newport: 1969), Text v, p. 2.
10. N.A. Ablahat, "'Development Approach' to Planning," *Administrative Management*, October 1968, p. 59.
11. Robert Mainer, "The Case of the Stymied Strategist," *Harvard Business Review*, May-June 1968, p. 36.
12. Roy Ash, quoted in Tom Alexander, "Computers Can't Solve Everything," *Fortune*, October 1969, p. 127.
13. Robert H. Hayes, "Qualitative Insights from Quantitative Methods," *Harvard Business Review*, July-August 1969, p. 108.

14. Robert F. Vandell, "Management Evolution in the Quantitative World," *Harvard Business Review*, January-February 1970, p. 83.
15. Alain C. Enthoven, "Choosing Strategies and Selecting Weapon Systems," U.S. Industrial College of the Armed Forces, *A Modern Design for Defense Decision* (Washington: 1966), p. 141.
16. Vandell, p. 85-86.
17. Pounds.
18. Vandell, p. 90.
19. Simon, p. 8.
20. Forrester, p. 61.
21. Hayes, p. 117.
22. Vandell, p. 92.
23. Simon, p. 18.
24. Vandell, p. 83.
25. Enthoven, p. 170.
26. J. Edwin Hollingworth, Jr., "The Oral Briefing: a Tool for More Effective Decision Making," *Management Review*, August 1968, p. 2.
27. Sherman C. Blumenthal, *Management Information Systems; a Framework for Planning and Development* (Englewood Cliffs, N.J.: Prentice-Hall, 1969), p. 170.
28. Forrester, p. 61.
29. Hayes, p. 108.
30. Forrester, p. 123.
31. *Ibid.*, p. 107-109.
32. Mayford L. Roark, quoted in Alexander, p. 129.
33. P.L. Andersson, "Optical Character Recognition—a Survey," *Datamation*, July 1969.
34. Thomas Marill, quoted in "One Man's (Expert) Opinions," *Administrative Management*, January 1970, p. 34.
35. Irving M. Miller, "Computer Graphics for Decision Making," *Harvard Business Review*, November-December 1969.
36. Frederic G. Withington, *The Use of Computers in Business Organizations* (Reading, Mass.: Addison-Wesley, 1966), p. 189.
37. Blumenthal, p. 28.
38. Charles Roynard, quoted in Alexander.
39. Roark, quoted in Alexander, p. 168.
40. Hayes, p. 113-114.
41. Blumenthal, p. 3.
42. Enthoven, p. 140.
43. Vandell, p. 92.
44. Melvin Laird, quoted in "Mel Laird: Coach, Quarterback, or Both?" *Armed Forces Management*, October 1969, p. 36.

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Ultimate decisions, the valuations and the choosing of ends, are beyond the scope of any science. Science never tells a man how he should act; it merely shows how a man must act if he wants to attain definite ends.

Ludwig von Mises, "Human Action"