STRATEGIC PLANNING AND MANAGEMENT INFORMATION SYSTEMS--
SOME IMPLICATIONS OF PRESENT RESEARCH*

by

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Introduction

I would like to explore with you the implications of some ongoing re-
search, because it seems to me that this work has some relevance for mana-
gers concerned with support for strategic planning their company's manage-
ment information system. From this base of factual research, we can sketch out the implications for management over the coming years.

Let me make it quite clear that this paper is concerned with the future. However, I have no wish to engage in vague handwaving so in an effort to make this a useful session I am going to base my discussion on what I see as the implications of some of the current research.

At the risk of a gross oversimplification, we can say that future man-
agement developments will be influenced by two major components. These are, firstly, technology and, secondly, man's comprehension and understanding of the decision-making process. Technology obviously shapes what is possible, and provides one set of constraints on what we can expect over the coming years. Historically in management settings, however, this has not often been the principle constraint. Much more significant in my opinion is man's comprehension of the processes in which he is engaged. At the re-
search level, a great deal has been going on in the last few years in an effort to understand the decision-making process more clearly. In fact, some of the systems I am going to describe have characteristics that will
make this research much more effective. Research progress so far has been limited by the lack of concepts, or theory, and while the developments I will be discussing have implications for the practice of management it may well be that they have even more profound implications for research and development of theory.

At the level of application of research to management's everyday task, we are at a different stage of development. There is probably no need to stress that there is a gap between what we know we can do and what in fact we are doing. The literature is full of interesting, effective, operational control systems and yet many, many companies have still to attack their problems at this level. My strategy today is to take the most advanced research of which I am aware in the States, and use this as an upper limit on the technological and conceptual changes I foresee in the coming years.

I am going to discuss first a framework in which we can think about management decision-making and the impact of computers. I will then briefly discuss the recent changes in technology, with a view to establishing the rough dimensions of what will be possible. Following that, I will expand on my three major predictions and provide some examples from research and, indeed, operational systems that are presently functioning. To close, I would like to raise what I see as being the implications of these efforts for managers and organizations.

Framework

I would like to establish, very briefly, a framework that will serve as
a reference point for subsequent discussion. The so-called management information systems literature is replete with predictions, examples and discussion of various different systems that their authors have been working with. However, none of this is very useful in the sense that each author has his own definition of what a management information system is or should be, and they all seem to be unwilling to read anybody else's articles! This results in a great deal of confusion, a great deal of duplication and very little progress as so few people build on anybody else's work. It is perfectly obvious that management is a broad field and that managers engage in a wide variety of tasks in any given day, week or year. It seems reasonable, therefore, that these different aspects of decision-making and the different kinds of decisions require different sorts of management information systems and different types of computer-based support for management decision making.

Professor Robert N. Anthony, presently the Controller of the United States Defense Department, has written a book entitled, "Planning and Control Systems - A Framework for Analysis." In this very readable book, he defines three levels of management decision-making:

1. Operational Control. This is the process of assuring that specific tasks are carried out effectively and efficiently.

2. Management Control. This is the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives.

3. Strategic Planning. This is the process of deciding on objectives of the organization, on changes in these objectives,
on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these resources.

A second author, Professor Herbert Simon of Carnegie-Mellon University has also written about the problems of developing adequate frameworks. He uses a simple framework in which he defines what he calls "programmed" or structured types of decisions and the "unprogrammed" or unstructured types of decisions, and he further breaks these down to a "simple" and "complex" category. (This framework is discussed in some detail in, The New Science of Management Decision, Harper & Row, 1965.) For purposes of this discussion, I would like to suggest that we think of a framework as in Figure 1.

This combines Anthony's types of management decisions with Simon's basic differentiation between the structured and unstructured management problems. For the former there are rules and procedures which allow the management problem or activity to be dealt with. For the latter, not only are there no formal rules to solve the problem but often a great deal of management effort is involved in finding the problem in the first place.

Impact to Date

Figure 1 contains a rough assessment of the impact computers have had to date on the various categories of management decision-making. The impact of computers has been quite significant on the whole range of structured problems. However, on the unstructured kinds of problems the impact
### Figure 1

**Current Impact of Computers on Management Decision Making**

<table>
<thead>
<tr>
<th>Operational Control</th>
<th>Management Control</th>
<th>Strategic Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Simple</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Structured</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complex</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Examples</td>
<td>Examples</td>
</tr>
<tr>
<td></td>
<td>Accounting-Payroll,</td>
<td>-Historical variance</td>
</tr>
<tr>
<td></td>
<td>Accounts Receivable</td>
<td>analysis and Budget</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reporting</td>
</tr>
<tr>
<td></td>
<td>(Size is main variable—not many systems that are complex and used)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Simple</strong></td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Unstructured</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complex</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>-computer based in-</td>
<td>-Warehouse location</td>
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<td></td>
<td>formation for de-</td>
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<td></td>
<td>cisions—but fixed</td>
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<td>format only</td>
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<td>(Research only)</td>
<td>(Research only)</td>
</tr>
</tbody>
</table>
of computers has been minimal indeed. From a management standpoint this is very significant as almost all of a manager's time, and certainly most of his significant problems, tend to fall in the unstructured management control and strategic planning areas. The operational control area lends itself to decentralization because the goals at this level can be made operational. As a result problems in this area are frequently well-structured and the responsibility of some first-line supervisor or lower level manager.

The reasons for our present level of development are in part due to the constraints of technology. Management information systems have been driven thus far by batch processing computers. If one examines the characteristics of these devices it is not surprising that they are only of real use with structured problems. Let me give a caricature of the manager's view of obtaining a new report from the data processing installation to support decision making on a new problem area. Information can typically only be obtained by managers through the intermediaries of systems programmers and systems analysts and immediately the manager has a communication problem. There is no common language and very little understanding of each other's area of expertise. Having finally specified the request to some systems analyst, he then goes away and has to write the program, only recently perhaps in a higher level language, to get the results. The programmers writing and debugging processes are slow and painful as he goes through the long turnaround time that is typical of many computer installations. When he finally comes back to the manager, anywhere from one week to three months later, with the first results of his program, it turns out that these are wrong! He misunderstood the request and it has to be explained again. He then goes away to make
the second pass! This sort of response is quite unacceptable if one has real, dynamic, management problems. Even if the manager struggles with this system it turns out, that by the time the new report system is in and running smoothly, the problems have shifted and he is now getting a useless piece of paper containing an analysis that is no longer relevant to this month's problems. This description is a little exaggerated, but nevertheless it characterizes many companies and managers' experiences with the systems and programming departments of their companies.

Coupled with this inflexibility of batch processing computers is the lack of understanding of the manager. Over the last few years systems designers have had to deal with the "black box" syndrome exhibited by many managers. That is, they either believed the "black box" was magic and could produce anything, or that it was an expensive waste of time and good for nothing more than printing payroll checks! This lack of understanding was not helped by the outpouring of jargon from the so-called systems experts who were meant to advise their managers.

The inflexibility of the system and the lack of understanding on the part of management and systems designers are two factors that have resulted in the major use of computers being in the "structured" area. Within the last year, two technical developments have proven to be both practical and economical in a management setting. These are the development of low cost multiple access computer systems, and the improvement of interactive visual display terminals. With these technical developments one can provide a system for management decision-making that does not suffer from the disadvantages, examples of which were cited above, that have limited the use of computer-based management information and control
systems. The importance of these developments cannot be overrated as they
directly overcome the major limitations of the systems we have been able to
employ in industry thus far.¹

I would like to suggest three major changes that I foresee in the coming
years. Let me reemphasize at this point that these are not changes that rep-
resent some wild guess about the future. In each case we have some concrete
evidence and examples before us of people who have already started to work in
this direction.

1. The manager will use an interactive computer system as an
active participant in the management decision-making process.
In short, the manager will find an interactive computer sys-
tem useful in the solution of many types of unstructured
problems.

2. Managers will be using systems that exhibit "intelligence."
That is, we will have been able to develop systems that can
make useful intelligent suggestions to the manager about
strategies or courses of action he might consider. Put in
other terms, the system could be thought of as monitoring
the problem-solving process of the user and suggesting al-
ternatives to him based on its prior experience and its
understanding of the manager's goals.

3. There will be significant changes in the style of managerial
problem solving, with the attendant problems of re-education,

¹For a fuller discussion of this point see Michael S. Scott Morton,
"Interactive Visual Display Systems and Management Problem Solving," In-
dustrial Management Review, MIT, Fall 1967.
and making changes in the organizational structure to effectively utilize the new technology.

The balance of this paper is concerned with laying out the technology that has given rise to these predictions and in discussing each of them in turn, together with an example of work going on in each of these areas.

Technological Developments

The rate of change of technology is very deceptive. In the computer field there has been a quiet but well-nigh irresistible wave of change from the first business computer installed in the United States in 1955 to the more than 50,000 installed in 1968. Costs have gone down and performance has gone up. A recent article in Datamation\(^1\) points out that in commercial computation the average increase in performance for the same dollar cost has been 160\% per year 1963 through 1966 against the earlier 87\% for the years 1950 through 1962.

Clearly, technological changes affect what is desirable and feasible in a management setting. At this point in time we have reached a critical point in the development of technology and would be justified in calling recent developments a breakthrough. We have reached a point where we can do certain tasks with computers in a significantly different way. As was mentioned previously, these technological impacts have been of two types:

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the development of time-sharing or multiple access computing and, secondly, the availability of low-cost visual display terminals.

**Multiple Access Systems**

The most flexible form of multiple access computer is a time-shared system. Time-sharing systems are no longer new, but the widespread availability of inexpensive remote computing is new. Time-sharing first became widely known when Project MAC at M.I.T. designed a system to provide a user with remote computing capability. One of their goals was to provide any user with computer power in such a way that he was unaware of any other user. In other words, to provide the user with the impression that he had his own personal computer. This was one of several goals that Project MAC set for itself at M.I.T. Using a hardware modified IBM 7094, they developed a system on which there were several hundred terminals around the University. This system supports 30 active users at any one time and is open 24 hours a day, seven days a week. Each typewriter terminal provides the user with access to the central system in such a way that he has available to him the full power of the computer and is normally unaware of any other users. This has been a very successful and widely used system at M.I.T. Project MAC is now busy with the final stages of development of the next generation time-sharing system. This will be larger, support more terminals and have more flexible software than its predecessors.

Time-sharing is based on the notion of allocating slices of time to
each of the active terminals. It is able to do this and be transparent to the user because of the tremendous difference in response times between humans, input-output equipment, and the central processing unit. That is, human response time is normally at least several seconds, input-output such as printing or reading information into the computer is at least hundredths of a second while the central processing unit's main logic and arithmetic capability is measured in millionths of a second. Time-sharing utilizes these thousandfold differences in speed to provide the apparently simultaneous service to several users. Each user thinks he has the entire system all to himself while for example there may be 30 users at any one time. Obviously, this is a gross oversimplification of the way in which time-sharing works but it should convey the principal notion.

A significant variation for management purposes of a pure "time-sharing" system is the "multiple access" system. With such a system each user is processed to completion before the computer shifts its attention to the next terminal. There is no sharing of time, each user takes his place in the queue. If processing time for each user is short then such a system can provide satisfactory support for certain types of management use. Clearly, there is a direct tradeoff between the length of the average request and the number of terminals the computer can support before the degradation of performance becomes too severe. For many classes of management use of a simple multi-programmed or partitioned system can provide quite adequate terminal support. This type of computing can be done on many third generation computer
systems and experience has shown that, in fact, such systems can support management terminal activity quite well. For example, one could use an IBM 360/30 system and support four terminals for scientific and management use. This is a relatively inexpensive system and can be very effective. Other small computers like the PDP/10 or the SDS/940 are specifically built for time-sharing and although limited in core storage can support terminals for some classes of decision-making.

The technology is here and proven. From an idea in 1964 we have moved to the point of having over 30 U.S. companies offering time-sharing services for sale. These companies offer remote scientific computing power to any user who wishes to install a typewriter terminal in his company office. With some of the third generation computer equipment specifically designed for time-sharing, the economics are such that this can be a very attractive means of obtaining computer power.

For management, as opposed to scientific, applications remote computing is only in the first stages of its infancy. It allows convenient access to computational power and permits data-bases to be maintained on a remote basis. This can lead to more accurate and complete data bases at a cost no greater than present systems. The manager then can draw on this common on-line data base for his decision-making purposes. Time-sharing and remote processing are clearly here, what remains to be done is to make effective use of them in a management setting.

Terminals

Terminals fall into two broad categories--the typewriter and the visual
display. Typewriter terminals are inexpensive, renting for about $75 a month, but in general they are not appropriate for managerial use. They are slow, fifteen characters a second, noisy and above all require the manager to type!

Visual display terminals also fall into two categories. The simplest is the alpha-numeric visual display terminal which operates in exactly the same fashion as the typewriter version but puts the characters out on a screen, instead of typing them on paper. These terminals are twenty times faster than the typewriter variety, they are quiet and their cost is roughly comparable to the typewriter version. They can be connected over regular telephone lines to a central computer and can display a page of text in approximately 2-4 seconds. Hard copy printout can be obtained in a variety of ways, the simplest of which is simply to have a typewriter terminal available when permanent copy is required.

However, the form of visual display terminal that offers the most potential for management use is the graphical terminal. That is, a visual display terminal that can display all the characters and numbers, but in addition has the ability to display lines or vectors. With this graphical capability, it then becomes possible to draw graphs, bar charts and other forms of display. Such graphical representation of data enables management to assimilate information and detect trends and significant points in the data very much faster than they can with tabular forms of information. A second

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1The ARDS II display, developed at MIT, is an example of such a terminal. Computer Displays Inc., Cambridge, Mass., manufactures and sells these terminals at a cost of roughly $15,000.
significant feature of graphical visual display terminals is the form of interaction that becomes possible with these. Such terminals can be equipped with light pens or Rand tablets which provide a simple flexible means of interaction between the manager and the computer system. These are described elsewhere, but they can be thought of as pencils which when pointed at the display screen allow the manager to specify his requests directly to the computer.

With the terminal in a convenient location the user can easily obtain computing support from any computer in the world. If adequate software is provided he can readily specify the types of data and computation he requires directly with the light-pen.

I would maintain that graphical display terminals provide three features of importance to management:

1. Their graphical capability allows a great deal of information to be presented rapidly and efficiently.

2. The light pen or Rand tablet allows easy flexible interaction with a great deal of power.

3. The response time of the system to a user request is measured in seconds.

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1 See for example, Morton, M. S. S., Impact of Interactive Visual Display Systems on Management Decision Making, Harvard Business School, Division of Research, forthcoming.

2 This response time is to be carefully distinguished from the currency of the data-base. The information the manager sees on the screen seconds after making the request may in turn be several seconds old or it may be several months old.
Future Impact on Management

The manager will use an interactive computer system as an active participant in the management decision-making process. In short, the manager will find an interactive computer system useful in the solution of many types of unstructured problems.

I would like to talk about the impact of the new technology and new concepts on management in terms of a specific example. I will sketch the outlines of a research project and some of the findings, details of the project are available in a forthcoming book.¹

The Laundry Division of the Westinghouse Electric Corporation has an interesting planning problem (see Fig. 2). On the one hand, their marketing division was anxious to have all models, in all colors in all the warehouses throughout the country, so that when one of their salesmen wanted to make a sale he would have the product available immediately. On the other hand, the manufacturing division wanted to make only white washing machines in very few models in nice well-planned economic order quantities. Thus, in some sense the production manager and the marketing manager were in conflict. For this reason, there was another managerial position, the market planning manager, whose responsibility it was to develop a plan that was best for Westinghouse over all. He used historical data, a simulation model of a simple sort, and input from both the marketing and production people as to their future plans.

¹Morton, op. cit.
Factors Affecting the Decision-making Process

Data Available—Computer & Manual:
Actual Sales History
Previous Production Schedule
Inventory Status
Previous Plan

Computer-generated Exponential Forecast

Marketing Manager (MM)
- Merchandising Plans
- Competitors' Performance
- etc.

Market Planning Manager (MPM)

Production Manager

Sales Plan
Production Plan (macro level)

Factory Status—Labour Situation—
etc.
Working with this information and the production and marketing people he then came up with the "best" plan for the division.

The former decision making process that was used to develop the plans of the division took place each month and was spread over roughly three weeks involving some six full days of meetings. In this process there were at least three major bottlenecks which led to serious limitations in the planning process. These were:

1. The data base was so large that it was hard for each participant to have a clear view of what had actually happened and what was projected.

2. If any member of the group suggested a strategy for a particular problem, then there was no easy way of seeing the implications of that strategy on the other variables. As a result, a great deal of time was spent arguing about what the "facts" were, and meetings were frequently adjourned to allow the staff time to work out the implications of a particular solution in detail. For example, the sales manager might suggest that an advertising campaign would affect sales by 10 per cent in a certain territory. The production manager might then be concerned with the impact of this on the levels of inventory available to meet this demand.

3. The criteria as to what constituted a problem was different in each time period and was rarely discussed explicitly. This multi-dimensionality of criteria for problems and solutions led to a great deal of discussion in the meetings which was disfunctional.

Characteristics of the New System

The managers were provided with an interactive visual display terminal.
This terminal had a light pen and keyboard and was connected via telephone lines to the Westinghouse Tele-computer center. The system was able to display all the data they had previously looked at but now both in tabular and graphical format. That is, they could look at cumulative and non-cumulative graphs.

Figure 3 is a sample of the specifications display. The manager hits any item in each row with the light pen and when he is finished the system provides him with a display having those characteristics. For example, the display in Figure 4 would appear if he was to hit the following: Cumulative Graph, Tumblers, Seasonal, January 1967, September 1967. Figure 4, a sample display, has the following features. On the right hand side at the top, there is a listing of a sample of the types of data available to the managers. Below that are a sample of the control points. These control points can be hit with the light pen and the computer will execute the command and produce a new display. For example, one could hit: July's expected sales for Tumblers (9,100), the control point "change points," type in a new number (say 10,900) and then hit the control point "proceed." A new graph would then be plotted with the changed number and the resulting inventory status.

Similarly one could hit October and November's months' supply of inventory (2.5 at the top of the display), type in the value 3, hit the control point "proceed" and the system would calculate the production schedule necessary to provide three months' supply of inventory, display the new numbers and replot the appropriate lines.
### Figure 3

**SPECIFICATIONS DISPLAY**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DATA</th>
<th>AXIS</th>
<th>FROM</th>
<th>TO</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUMULATIVE GRAPH</td>
<td>WASHERS</td>
<td>SEASONAL</td>
<td>JAN 1965</td>
<td>JAN 1965</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FEB 1966</td>
<td>FEB 1966</td>
</tr>
<tr>
<td>TUMBLERS</td>
<td>NORMAL</td>
<td></td>
<td>MAR 1967</td>
<td>MAR 1967</td>
</tr>
<tr>
<td>NON-CUMULATIVE GRAPH</td>
<td>AGITATORS</td>
<td></td>
<td>- 1968</td>
<td>- 1968</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>LAH 100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BAR CHART</td>
<td>LAH 200</td>
<td></td>
<td>DEC</td>
<td>DEC</td>
</tr>
<tr>
<td>TABULAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Impact of the Management Terminal System

The impact of this interactive terminal system on the decision making process was very marked. Again this is discussed elsewhere\(^1\) in more detail, but briefly there were four principal kinds of impact.

1. **Time**

The time for the problem solution process was reduced from, six full days of meetings over an elapsed time of some 25 days, to a half day. This sharp drop in time has obvious implications for the effectiveness of these managers. However, a more interesting effect of the time was the significant reduction in response time. In the previous process, if a strategy was suggested, the implications were worked out by the staff—and this would take anywhere from one hour to one day. The meeting then had to be reconvened and a great deal of time was spent by the managers trying to re-establish where they were when they had adjourned previously. With the management terminal system, a manager could suggest a strategy and this could be worked out on the screen within a matter of seconds, right in front of their eyes. This very rapid response time led them to experiment with different kinds of solutions. In the former process, the first time a solution was arrived at which was satisfactory to all concerned, everybody relaxed and the process was regarded as finished. It was a classic instance of satisficing behavior. With the new system, managers develop several possible solutions and make a conscious effort to select the best of those available.

\(^1\)Morton, op. cit.
To use Simon's terminology, they have moved from a satisficing solution to the point where they are selecting the best of the several alternatives they have generated.

(2) Problem Finding

The managers used the system for a constructive browsing operation. That is, they sit down with the system and use it to run through and display graphs of various aspects of the information. In their words, "this gives us a greater understanding of past performance and the kinds of things that have happened during the last month." In short, they find that the graphical portrayal of information is a very fast and useful way of gaining an understanding of what has been happening.

(3) Problem Solving

The problem solving process, as was mentioned under (1) above has resulted in the identification of a number of alternatives and the explicit choice among these of a final solution. This has occurred in part because the managers have had access to computational power in a form appropriate to their needs. They have been able to use simple models or algorithms to do the necessary computation. For example, they can use a forecasting model to project sales rate by simply pointing to that option on the screen.

(4) Communication

The system has considerably eased the communication problems between these three individuals, as each of them can make their point using the device and, essentially, expressing his thoughts through the medium of the display. In turn this led to some evidence of an increased sense of commit-
ment. That is, the implications of a particular strategy were clear to all, and if a particular manager said that it was a feasible strategy for him, then all concerned were explicitly aware of this commitment.

The discussion above has been a very brief presentation of one aspect of one of the systems that are presently in use. To my knowledge, no other company in the United States is quite as far advanced as Westinghouse in this particular aspect of displays and management problem solving. However, even if one does not have a market planning problem, there are obviously a large number of other areas which would benefit from the use of such a system. The implications of product mix on dollar profit, the problem of performance review of divisions or departments, the development of marketing strategies, budget development and a host of other possible applications at the managerial level.

The author has done some research and implementation on a terminal based costing system\(^1\) designed to allow managers to develop cost information that is relevant for the decision at hand. This interactive system is particularly useful where the manager's judgment is required, or where the standard cost system does not make the correct assumptions. Again this is a decision-making aid for use by managers and does not require any special accounting or computer knowledge.

Interactive terminal systems provide a flexible, simple, yet powerful

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tool that gives the manager immediate access to computational power to work out the implications of his suggestions and access to a data-base containing the relevant data for his particular problem. This computational power and data base is available with a fast response time, which leads to an inter-active mode of problem solving which in turn has implications for the final quality of decisions.

For high level staff people, as opposed to line managers, terminal sys-tems can also be of considerable benefit. There are languages such as OPS-3 developed at MIT that provide the capability of developing simulation models from a terminal. One then has the possibility of fast, flexible development of complex simulation models for management use. Similarly, project control, using Pert or CPM or some similar technique can also be done on a dynamic basis using such a terminal. Obviously the list is endless, limited only by the creativity of systems designers.

These examples have been designed to show that for certain classes of un-structured problems we have been successful in providing interactive management decision support. In the coming years I would expect to see this type use grow across a wide range of unstructured management problems. Concepts, hardware and software are available in varied stages of development. What is required now is active management involvement.

Systems with Intelligence

Managers will be using systems that exhibit "intelligence." That is, we will have been able to develop systems that can make useful intelligent suggestions to the manager about strategies or courses of action he might consider.
The systems suggested above, although useful for many kinds of purposes, suffer from one serious limitation. They only respond, they do not make suggestions. What would be much more useful for management purposes, would be a system that would be an "active participant" in the process, one that would suggest alternatives, detect trends and point out peculiar situations to the manager as he went through a particular decision-making process. For example, in the system above, it was necessary for the manager to look at the data and decide which situations were potential problem areas. Having decided that a particular area was a problem, he then had to think of a strategy or solution for solving that particular problem. What I am suggesting here, is that we can develop systems that not only will identify possible problems but will also identify possible solutions for these problems. We can then provide the system with the ability to learn or remember conditions and solutions. From this accumulated experience we can write software that will permit the system to modify its own rules on the basis of its actual experience. By this process of sequential modification we can develop systems that learn. In fact, I am suggesting that the next stage in the use of such terminal systems is to develop ones that have intelligence.¹

An obvious first step in this process, would be simply to have the system monitor the user. He does everything through the display anyway, and therefore the system can be programmed to monitor exactly what he does do. In this way, one can build in simple programs to detect trends, remember previous solutions and monitor what actually happens. The system can then

¹Professor Zenon S. Zannetos, Sloan School of Management, M.I.T., has suggested general systems with such characteristics in M.I.T. Working Papers numbers 229-66 and 210-66.
be programmed to remind the user of the fact, let's say, that last year or the year before there was a similar situation, and at that time he did the following sort of thing, with the following results. At the very least this monitoring process would force the manager to be consistent. As another example, after the manager had developed a plan for the coming months, the system could then suggest a production schedule that would optimize the manufacture of that particular plan. We are not yet very good at producing the best possible production schedule so the system could use those algorithms and heuristics which it had been given, but leave the manager the freedom to make changes at the margin to produce a realistic production schedule.

I am suggesting that once we have the terminal and it is being used in the way described above, it is a small step to start to have it monitor the user and remember the kinds of things that the user does. Watching the user it is possible to develop decision rules that he is implicitly using himself and if we can define these and put them into quantitative terms we can give them to the system and the system itself can use them. Essentially we would be taking an unstructured area that we presently regard as involving a high level managerial judgment and discovering which aspects of this are, in fact, programmed or structured, and giving those to the system. This in turn would leave time for even more unstructured material. Let me give a specific example of the kind of phenomena I am discussing.

Professor Geoffrey Clarkson\(^1\) in the early 1960's went to a large bank

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\(^1\)Presently at Manchester University.
in Pittsburgh to one of the senior trust officers and proposed that he build a simulation model that would make the portfolio investment decisions for the senior trust officer. The trust officer was very skeptical of any possible success, as he had spent many, many years gaining "experience" as to exactly what constituted good sound investment decisions. However, he agreed to cooperate and Clarkson observed him making his investment decisions over a period of some months. Using his observations, he constructed a simulation model embodying what Clarkson perceived as being the trust officer's decision rules. He then took a large set of historical data and ran it through the simulation model to see what portfolio selections the model would make. Even the trust officer was willing to admit that the model's selections closely matched his own. One of the most significant contributions that Clarkson made by his efforts, was the clear identification of the fact that many of the things that we regard as involving managerial judgment only attainable with forty years of experience, really involve quite explicit decision rules. Judgment may very well still be involved in part of the decision, but there is no point in using it where it is not needed. In the last few years, Professor Arnold Amstutz at the Sloan School of Management, MIT, has developed a system for a brokerage house in New York. He took much the same approach as Clarkson, namely carefully observing the senior brokerage management to see what kinds of decision rules they used. He then built these into an interactive simulation model and made a series of tests and changes. Working with the model, the brokerage management gradually began to realize that the system was performing
very well. As a result they gave the model authority to actually buy and sell on the marketplace with a portion of the firm's investment portfolio. Today the computer system buys and sells stocks in the marketplace and the brokerage management do not see what has transpired until the end of each week. At that point, of course, the trading has already taken place and can no longer be changed by the management; stocks have been physically bought and sold.

I do not wish to suggest that portfolio investment decisions are as complex as many of the decisions that managers must make. However, it is clear that at one time even portfolio investment decisions were regarded as being well beyond the scope of an investment decision model. We now have concrete tangible evidence that this is not so. I am suggesting that on the basis of our present research experience in both the management field and artificial intelligence, it is quite possible that we will be able to develop active decision models that will be of real help to managers in the decision-making process. In other words that we will be able to observe a similar phenomena as that that has taken place in the investment decision. I am quite confident that in the coming years, we will see widespread use of interactive terminal systems as active participants with managers in their decision-making tasks.

Management and Organizational Change

Quite obviously there are some important implications for managers in both of the above predictions. To make effective use of either of the above
notions, it is clear that we must change our way of thinking about decision making and the role of the computers in strategic planning. The situation now with interactive terminal systems, in many ways resembles that which existed when Batch Processing Computers were first introduced into companies. After four or five years of experience with Batch Processing Computers it became common to make the generalization that one could not expect success if one simply computerized the old manual methods— that to use a Batch Processing Computer effectively, one had to reorganize one's thinking about the task and the way of organizing to do that task. This in turn gave rise to such phrases as the "Total Systems Concept," which led people astray in a different way! However the basic point is valid and I would submit that we have to be very careful at this point to make sure that we learn from the lessons of the past. It seems quite clear that we cannot simply take our old decision-making processes and put on them interactive terminal systems. If we are going to make really effective use of interactive terminals we are going to have to restructure our thinking about the way decision making gets done in an organization and the kind of organizational structure that will be most useful for this. We recognize that we cannot "computerize" our old manual tasks and similarly we should recognize that we cannot "terminalize" our old decision-making tasks.

Let me give you a specific example of the sort of phenomena that I mean. In the Westinghouse example above, we discussed the role of the market planning manager in the old process as being one of coordination and communi-
cation and acting as a mediator between the other two parties. None of these functions are really necessary with the new process. The marketing manager and the production manager are both rational human beings, and with the system are able to do the job by themselves without the necessary mediation of a third party. The market planning manager can now spend almost all of his time worrying about longer run strategy, gaps in the market, methods of planning, organizing to make effective use of the information and techniques they are now developing. His role can shift to one of longer term planning, systems organization and these kinds of problems.

I think to argue, as some authors have, that interactive terminal systems will force centralization or decentralization is to miss the point. Interactive terminal systems allow more effective implementation of whichever management philosophy the senior executives wish to employ. However, it does place a premium on having managers who are flexible, have insight, and are willing to re-educate themselves to the requirements of the new technology. There is no doubt that interactive terminal systems force a certain degree of rigor on a manager and that therefore he has to be willing to learn how to make effective use of the additional power he now has available.

The central problem, then, is for any given company to face this issue and develop a time-phased plan to develop the people and concepts necessary if the changes in technology are to be utilized. There is no one simple answer for all companies, but if top management recognizes the implications and the resources necessary then it is quite possible to develop an evolu-
tionary plan. The essential ingredient is for management to get enough re-
education to really understand the role of interactive management decision
g systems. An interesting possibility is the opportunity available of util-
izing the experience of others and leapfrogging to the position where the
vestment in computer-based systems really begins to pay off.

Let me restate my three major points:

1. The manager will use an interactive computer system as
   an active participant in the management decision making
   process. In short, the manager will find an interactive
   computer system useful in the solution of unstructured
   problems.

2. Managers will be using systems that exhibit "intelli-
gence." That is, we will have been able to develop
   systems that can make useful intelligent suggestions
   to the manager about strategies or courses of action
   he might consider.

3. There will be significant changes in the style of mana-
gerial problem solving, with the attendant problems of
   re-education, and making changes in the organizational
   structure to effectively utilize the new technology.

The technology is available and cost effective, and the conceptual base
has been laid. The principle resource required if these predictions are to
be valid is the time and attention of management. If the responsible mana-
gers in any one company are willing to learn enough to lay out a plan and
devote enough attention to see it through then these predictions are almost
a certainty. We have enough evidence at hand to know it can be both feasible and desirable. The next step has to be taken by management in conjunction with the research community.