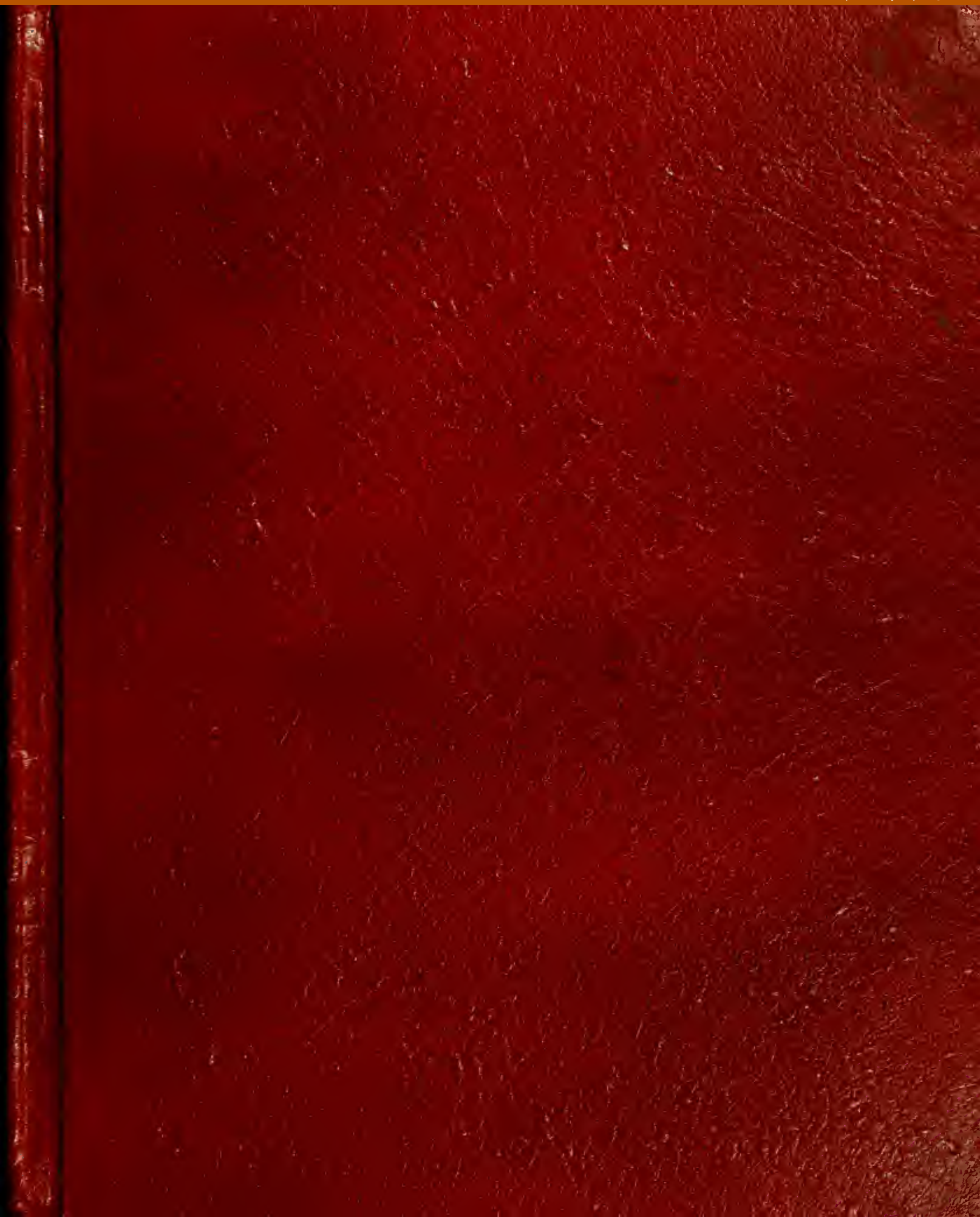

WORKING PAPER
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THE IMPACT OF INTERACTIVE VISUAL DISPLAY SYSTEMS ON THE MANAGEMENT PLANNING PROCESS

by

Michael S. Scott Morton and James A. Stephens

August 1968 356-68

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Abstract: A computer driven interactive visual display system is being used by line managers in an on-going business setting in the Westinghouse Electric Corporation. This use has allowed us to collect some evidence on the impact on management decision-making. The paper describes the components of the system, the problem area in which it is used, and the impact it has had on the planning process itself.

INTRODUCTION

Experience with prototype interactive display systems in an on-going management setting has convinced us that they can have a significant impact on the management planning process. This impact falls in a different area than that reached by those computers which only deal effectively with structured problems. Conventional data processing systems have typically been designed to perform tasks in functional areas such as inventory control and accounting, usually to replace clerical labor. Systems for direct use by management to support their decision-making processes are in their infancy. Interactive terminal systems have characteristics which allow them to be used effectively and efficiently on unstructured (3) management problems.

The emphasis with such terminal systems is on management decision-making. The system has to be designed and implemented with the objective in mind of supporting a particular decision-maker in solving his particular problems. This is in contrast to previous management information systems which have been typically based on batch-processing computers and have been functionally oriented. For example, we are not dealing with processing routine inventory transactions, but with one manager's problem-solving process based on his responsibility for inventory control.

From our experiments we would assert that interactive terminal systems can be used effectively to support managers in making their decisions on problems with the following characteristics:

1. Large data base. The management terminal system is useful when the data base is sufficiently large that it cannot be maintained or searched without disrupting the following problem-solving process of those involved.

2. High volume of manipulation. If the overall problem-solving process involves a large amount of computation and use of models, then a terminal can provide flexible and convenient access to this power.

3. Judgment required. For interactive terminal use the decision should be characterized by a considerable degree of judgment, both to determine what constitutes the problem as well as determining a satisfactory answer. Both these "problem finding" and "problem solution" processes require managerial judgment in most complex situations. In an unstructured problem the decision-maker does not have good algorithms or decision rules that allow him to arrive at the answer. Instead he is forced to apply his experience to the problem and arrive at an acceptable solution.

4. Multidimensionality. Complex problems have several dimensions along which one can measure performance. The relevant dimension is not always known in advance. In general, one can assert that the complete list of dimensions may not be known in advance. Under these conditions the terminal system becomes important as a means of giving the decision-maker the ability to evaluate alternative trade-offs.

If a manager has a problem having these characteristics, then it is well worthwhile exploring the use of an interactive terminal system as an aid in the problem-solving process.

This paper describes a system presently being used by some managers in the Westinghouse Electric Corporation. The discussion and description that follows is broken into three parts: the first deals with the components of the management terminal system; the

second with the problem area in which it is presently being applied; the third with the impact that the system has had on the decision-making process of the managers involved.

I. SYSTEM COMPONENTS

The Westinghouse Management Terminal System (MTS) has five basic components. They consist of: (1) the manager or the user with the problem, (2) the terminal, which forms the interface between the user and the system, (3) the central computer itself which drives the terminals involved, (4) the software system necessary to control the interaction between the users and the system and finally, (5) the data base necessary for the problem under consideration by the manager.

The manager and his environment, in the particular Westinghouse situation under discussion here, is described in the next section. The remaining four components are discussed below.

Terminal

A properly selected terminal is necessary to bring the computer and its manipulative ability, together with access to the relevant data, directly into the manager's hands. Graphic visual display devices offer several important characteristics.

Graphic capability is critical because such displays permit very much more rapid assimilation of large quantities of data by management. Pertinent variables, trends and interrelationships become more readily perceived when presented pictorially.

The availability of a light-pen or RAND tablet, in addition to a keyboard, is also necessary in managerial applications as this allows simple, yet powerful, interaction. Managers without any computer background are able to specify readily with the light-pen the complex retrievals and calculations they require to solve their problem.

In addition, these terminals offer the twin factors of convenience and speed to the user. Convenience because the user has access to the terminal at times when he is ready to use it. Speed because these terminals respond with a full dsplay within 2 to 5 seconds, some twenty times faster than typewriter terminals. These four characteristics of graphical visual display terminals, namely, vector capability, interaction, convenience, and speed combine to provide a tool of considerable power.

In the spring of 1966 Westinghouse took delivery of a terminal device from Information Displays Incorporated (model CM10009), which came closest to matching our needs at the time of purchase. When it was ordered, we felt it should have, as a minimum, the following kinds of characteristics:

a. The system had to have a light-pen and a keyboard. The light-pen is necessary to provide the simple interaction discussed above.

b. Remote connection. The connection from the central computer had to be by telephone to ensure a general remote capability.

c. The screen had to be capable of displaying 150-200 characters horizontally. This requirement is necessary to handle the frequent business situation where one is looking at 12 months of data plus totals and other statistics.

d. The screen had to remain flicker-free when displaying a complex graph of several variables.

e. The system had to have a fast response time -- five to ten seconds was considered an outside limit for a major display.

This terminal has proved to be adequate for our initial needs. However, in the two years since installation a number of hardware improvements have occurred. While no major manufacturer yet offers a satisfactory management terminal, there are a number of smaller firms which do. (1) On balance, hardware is not likely to be a constraining factor in the use of a management terminal system.

Central Computer

It is necessary that the central computer have multiple access capability. This does not mean to imply that it has to be fully time-shared as in the GE 645 or the 360/67. The term "multiple access" in this context implies a computer system that can drive several terminals at one time but on an interrupt basis, with each interrupt processed to completion. The multiple access capability is necessary for two basic reasons. One is simple economics, that is, reduction in the cost of computer power to drive the terminals, and the other is the requirement for remote access to the data base discussed below.

The central computer facility in the Westinghouse example is a pair of Univac 494 systems which have a multiple access interrupt

capability where the remote devices interrupt the processor whenever they are ready to send. With this system the response time is never greater than a second or two and more normally appears to be instantaneous. Processing time, of course, is in addition to response time, but with the present system this is approximately ten seconds for a large, complex display. The Univac 494's were not designed to support a management terminal system but have worked adequately thus far. It should be stressed that any form of multiprogrammed computer system could support management terminal activity -- this includes most third-generation equipment.

Software

The greatest single problem in the implementation of the management terminal system was the development of adequate software to support the interaction necessary in the system. Our goals for the software were five:

1. Simple to operate, so that an executive with no computer knowledge and a busy schedule could use it comfortably.

2. General purpose, in order to be applicable to many parts of the business.

3. Modular, to absorb changes in the software and allow for the addition of different forms of data.

4. Hardware independent, to allow change of terminals with advancing technology.

5. Interactive, so the system responds readily to user requests, and does not hinder the user's natural problem-solving process.

The implementation of this system is described elsewhere (2) and took some two man-years of design and coding to implement. In operational use the software has proved to be adequate and has met these five goals. A great deal more work could be done to improve it and we are far from being satisfied, but the system is operational and providing us with some useful experience.

Data Base

The data base has to be adequate for the decision task that the user is concerned with, and for many companies this may be a severe stumbling block to the use of management terminals. The use of a management terminal system, however, does not imply that the data base has to be maintained on a real-time basis. There are a great many complex decisions for which data two or three days old, or even several weeks old, is perfectly adequate. In fact, in the specific example we discuss below, the data base was at least one week old at the time the managers used it. However, it is important to recognize that the data base does have to be on-line to the system for interactive use. In other words, the response time has to be fast enough not to interfere with the decision-making process; however, the currency of the data base is purely relative to the particular decision.

II. APPLICATION AREA

Westinghouse is a large multi-product firm with sales in the billions of dollars. The company is decentralized by product group with some 70 divisions producing everything from large turbines to electric toothbrushes. The management terminal system was first developed for the Laundry Equipment Division, to help their management determine marketing and production plans for their products. There are several information inputs that affect the individuals responsible for producing the sales and production plans for the coming months. The system provides data on actual sales history, previous production schedules, inventory status and so forth. There is also a computer-generated forecasting model which provides a first approximation of future sales. This information is available to them on the management terminal system in several forms. A typical format is the cumulative graph shown in the Exhibits.

The marketing manager estimates the impact of merchandising plans, and provides evaluation of competitor's performance and the various other intangibles that he is best able to judge. Similarly, the production manager is well acquainted with the status of the factory, the labor situation and other manufacturing variables. These managers, working with the device and the data that they have available between them, develop a sales plan and production plan that is used as the specific goal for the coming periods. These managers have to balance four complex sets of variables. That is, they have to make trade-offs between the following:

a. Expected demand
b. Merchandising plans
c. Available inventory
d. Production availability

These four sets of variables have to be balanced to provide some form of "optimal"

olution for Westinghouse. This solution onsists of sales, production and inventory lans for each model and its various colors. he aggregate of the models is, of course, e overall plan. Each of the variables is onsidered at each level of aggregation. What ay seem "right" at the model level may seem wrong" at the overall level. For example, he aggregate sales level may appear unreasonble, the total inventory too high, production evels too variable or production capacity nder or over-utilized. This is a reasonably omplex planning process and space does not ermit elaboration here. (See (2) for details.) he Exhibits contain a simple example of the inds of interaction that are possible.

III. IMPACT

The management terminal system had a ery distinct and marked effect on the manageent decision-making process. The overiding effects evolved from the impact of the esponse time of the system. The time etween the manager's posing a question or oking for some information from the system nd the point at which the system came back ith the answer was so short (one to ten econds) that the managers were led to a ifferent form of problem-solving than the one hey had employed before. This was an interctive problem-solving process where the anagers tried many more solutions and mployed more analysis than before.

In addition, it stimulated a rethinking of he methods and process of analysis and creaed a desire on the part of the managers for dditional data and manipulation that they had ot considered in the pre-terminal situation. reviously, the quantity of data and manual ethods of calculation imposed serious imitations on the ability of the managers to odify their process or add more explicit odels. This flexible access to computaional power permitted the managers to use ome explicit, simple models. As they have ained familiarity with the system, they esired more complex models and, where ossible, the use of optimizing techniques.

We would assert that this access to computational power is useful in itself and that alistically it can only be provided to a manger through some form of terminal system. In addition, however, the stimulation to reevaluate the decision-making process provides a useful opportunity to improve the analytical techniques used.

Another way of looking at the impact is to use Simon's framework (4) of the decision-making process, namely, breaking it down into three phases: intelligence, design, and choice. The management terminal system affected the intelligence process in the sense that the managers were able to browse through the information, searching for problems. They had an easy flexible mechanism for scanning the data and digging down and looking at it from different angles as some thought or potential problem struck them. They were able to uncover more problem areas and through discussion of the data, were able to acquire a firmer understanding.

It affected the design process by presenting to the managers, in a clear and unambiguous form, the data from their operations. That is, the premises on which the managers based their strategies for solution were crystallized. For instance, the graphical ability made trends and deviations stand out clearly in the data.

The choice phase of the decision-making process was affected in that the managers would try several possible solutions for a particular problem. The manager remained the creative component of this system but he appeared to be able to visualize the status of the problem more clearly with this system and could then suggest one, or several, other alternatives and try these out in turn. The system implemented his suggested solutions and allowed him to see the impact quite specifically. This led to a sharp reduction in discussion among the participants as to the likely impacts of certain alternative stragegies and the time in the decision-making process itself was spent much more productively.

The impact of the management terminal system on the organizational structure is not particularly clear. However, the results of the use to date do suggest one or two features. The terminal has very good communication aspects. That is, the users are able to express their ideas to the others through the terminal and reduce the ambiguity in the discussion. This is important where different functional managers make decisions that affect each other's operating results. As a result, the need for some person in the middle to interpret and analyze seems to be reduced. For example, the duties of the staff man who acts as an analyzer of data and mediator between two line functions would change. The

SPECIFICATION DISPLAY

GRAPH NON CUM	TOTAL PRODUCT	ALL COLORS	FROM	TO
GRAPH CUM	PRODUCT LINE X	WHITE	JAN 1966	JAN 1966
TABULAR	MODEL 1	AVOCADO	FEB 1967	FEB 1967
RECONCILE	MODEL 2	COPPERTAN	MAR 1968	MAR 1968
	MODEL 3	GOLD	APR 1969	APR 1969
	MODEL 4	TURQUOISE	MAY	MAY
	MODEL 5	YELLOW	JUN	JUN
	MODEL 6		JUL	JUL
	MODEL 7		AUG	AUG
	MODEL 8		SEP	SEP
	MODEL 9		OCT	OCT
	MODEL 10		NOV	NOV
	PRODUCT LINE Y		DEC	DEC
	MODEL 1			
	MODEL 2			
	MODEL 3		SEASONAL AXIS	
	MODEL 4		NORMAL AXIS	
	MODEL 5			
	MODEL 6			
	MODEL 7			
	MODEL 8			
	MODEL 9			
	MODEL 10			

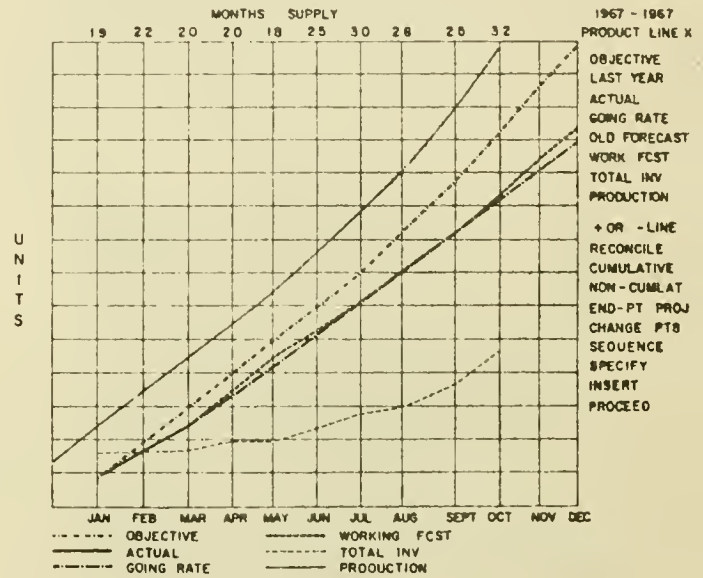
PROCEED

Exhibit 1 - Graph Specifications

This is a typical specifications display. The user selects one item in a column with the light-pen and then the action function PROCEED. If the user were to touch GRAPH-CUM, PRODUCT LINEX, ALL COLORS; JAN., 1967, DEC., 1967 and PROCEED, he would get the graph in Exhibit 2.

Exhibit 2 - End-Point Project

Suppose the user finds the year-end working forecast total units satisfactory. Instead, he would like to see what an increase to his year-end objective would do to his position, starting the increase in May. He touches the word MAY to indicate the starting month, WORKING FCST to indicate the data type, types in the new forecast, touches the control point for END-PT PROJ, and then PROCEED. This results in the display in Exhibit 3.



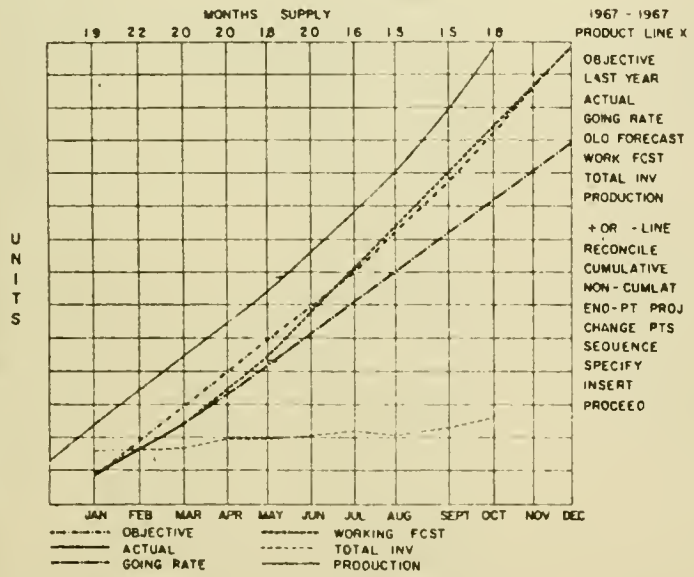


Exhibit 3 - New Working Forecast

The response to the previous request is a new working forecast line. As can be seen from the month's supp, y of inventory figures at the top of the graph, the inventory in October is now 1.8 months supply, down from the previous 3.2. The user might now want to alter the production schedule to bring his inventory to a higher level. This can be done using any relevant control points.

rucial emphasis now shifts to proper understanding of problem structure rather than the ata per se.

Systems people may well have to shift heir concern to the development of decision-upport systems as direct aids to line management. That is, move away from just designing nd implementing functional sub-systems that ncidentally supply data to management.

IMPLICATIONS AND CONCLUSIONS

From the applications in which we have been engaged in Westinghouse, it is clear that he management terminal systems are of considerable benefit for certain classes of problems. However, it is also true, as in the early days of computers, that one cannot simply put present applications onto a terminal without some serious analysis. There is little evidence to suggest that simply putting a present application, as is, onto a terminal will result in any better decision-making than before. The process of looking at the key decision areas, the variables involved in these areas, and the information necessary to make his decision -- this process of analysis is still necessary. A step beyond this is to decide how interaction can help. It must be realized that problem structure may well have to be refined to best take advantage of the capabilities of the interactive environment. People have learned to use intuition to cope with poorly structured situations and inadequate computational ability. With real-time "turnaround" and an adequate method of communicating with the system more complex and more useful problem-solving structures for existing decision areas may be made accessible to managers. Much more research is required in this particular area of terminal systems application before we can come out with a useful set of generalizations which have some research support.

Of course, it is critical that software be designed that is sophisticated and powerful enough to allow managers to use the system as a natural adjunct of their normal problem-solving activities. We have been relatively successful in Westinghouse on this first application but regard this more, perhaps, as a matter of luck than deliberate design.

We are expanding this particular application area and experimenting with a number of new ones. Our experience with our first year of operational use has been most encouraging and has convinced us that interactive terminal systems are useful to line and staff managers as aids in solving certain unstructured problems.

The first-stage systems discussed here have all been of the "reactive" type. That is, they respond to the user's questions. Research is in process (3) to develop "intelligent" terminal systems that monitor the user's problem-solving process and suggest alternatives to him. That is, the system becomes an active and intelligent participant in the process. This second-stage "intelligent" system offers the real challenge to the research community, but in the meantime there is probably ample challenge to the business world in making effective use of the "reactive" systems discussed here.

References

(1) For example, Computer Displays, Inc. offers an interesting visual terminal for approximately $15,000 purchase price.

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(3) Morton, M. S. S. and Zannetos, Z. S., Efforts Toward an Associative Learning System, Proceedings of the IFIPS Congress 1968.

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Date Due