SYSTEMS IMPLEMENTATION:

A GAMING APPROACH

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Growth in the size, complexity, and diversity of operations of industry places an increasing demand on the use of quantitative techniques and computerized systems. In response to this demand, the fields of mathematics, operations research, and management science continue to develop sophisticated quantitative techniques.

Unfortunately, in developing quantitative techniques researchers have overlooked problems that can occur in translating a developed technique into an operational system. Literature in the field indicates that a gap exists between the development of many quantitative techniques and their successful translation into practical and profitable implemented systems. This research attempts to develop a game-implementation process that can aid in resolving some translation problems. The process explores the use of a functional business game during the conceptualization of a system.

To translate a conceptualized technique into an operational system requires the integration of factors associated
with three major areas—the acceptance and use of quantitative techniques by managers and users; the education, direction, and motivation of people associated with the different systems activities; and the employment of a systematic approach to conceptualization, development, and installation activities. Much of the previous research in the area, however, focuses only on problems relating to the acceptance and use of techniques; only a limited number of researchers attempt to interrelate all three areas.

The proposed game-implementation process attempts to interrelate the three areas. By employing a gaming activity in the initial formulation phase of a system, factors related to acceptance and use of techniques can be integrated before the system is developed; likewise, an early game activity provides a means for educating, directing, and motivating people associated with the system. The process reorganizes the traditional systems process (that associated with management information systems and system engineering fields) by shifting to the conceptual stage many activities that normally occur in later stages. Also the approach alters the traditional decision cycle associated with the conceptualization of a system. The process was shown to involve activities such as identification of system objectives, development of abstract games, identification of current systems, comparative analysis, and the development of a game-system simulator; these activities provide inputs for a feasible study.
To evaluate the game-implementation process, an industrial case study, questionnaire-interview surveys, and generalized game sessions were performed. The organization in which the research was made had previously employed a game as a systems training aid. Results from the case study indicated that, though system usage can increase from a training activity, usage can be retarded by design constraints. Questionnaire-interviews with managers, systems staff personnel, and users (production line supervisors, process engineers, and marketing analysts) revealed that a majority believed that many constraints could be avoided by employing the proposed game process—a majority of the interviewees expressed support for the process. Results from generalized gaming sessions demonstrated that biases and an imbalance in understanding can exist among users, managers, and analysts at the conceptualization of a system—if left unresolved, these biases and imbalances can create implementation problems. The increase in feasibility cost, resulting from using the approach, was the only negative reaction voiced by a majority of interviewees.

Based on the organization studied, it was concluded that the game-implementation process is a useful approach to developing and implementing a quantitative based system. However, because of its quantitative base, and increased conceptualization cost use of the concept will depend upon management's understanding and willingness to support it.
SYSTEMS IMPLEMENTATION:
A GAMING APPROACH

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CHAPTER I

INTRODUCTION

Growth in the size, complexity, and diversity of the operations of modern industry places an increasing demand on the use of quantitative techniques and computerized systems. In response to this demand, the fields of computer science, systems analysis, mathematics, operations research, and management science continue to develop sophisticated mathematical techniques and systems. Since the late 1940's, techniques such as linear programming, dynamic programming, inventory theory, and queuing theory have emerged. Such techniques and concepts have successfully solved problems concerned with blending of materials, distribution and transportation, production scheduling, air traffic scheduling, and hospital operations. The successes, however, do not convey the total results. Literature in the field indicates that a gap exists between the development of many quantitative techniques and the successful translation of these into practical and profitable implemented systems.¹ Implementation appears to be a key problem.

The Implementation Problem

Literature on the history of the growth of quantitative management indicates that, during the early development of the field, implementation was viewed as a mundane problem (a view that is still held by many in the field). It was generally felt that efforts should be directed toward developing the more theoretical solutions. Implementation was assumed to involve only a simple task of specifying the physical changes that were required in the organization in order to install a technique or system. This approach to implementation, however, had only a modicum of success, and in most cases the task was not a simple process. The lack of success, however, had little impact on the implementation philosophy. As a result, the field evolved into a pattern in which researchers either presented system alternatives to management concerning selection and implementation or concentrated on developing techniques to support other staff groups.

Current philosophies on implementation have changed somewhat as a result of experience. Many researchers in the field have come to realize that key problems exist which cannot be resolved by a mere physical specification process. For example one author states that

As systems have become more widely dispersed and more complex, they have created serious economic, political, social, and psychological problems in addition to technological problems of design and feasibility. The most important problem relating
to systems has arisen from the necessity to organize people, to acquire them as system components, to select and classify them, to train them, to keep them working for the system's goals and to bring their performance to a peak to achieve the systems goals.\(^2\)

Human factors, however, are not the only source of the implementation problem. To cover the full spectrum of the problem, researchers have begun to examine organizational factors, management needs and characteristics, needs of the systems staff group, as well as the problem areas and the solution approach. A summary of the findings by Allan Harvey\(^3\) highlights some of the current knowledge.

**Management Characteristics**

In those areas where successful implementation has resulted, a high correlation exists between the degree of success and the level of management support. This support is most often displayed by the confidence which management places in the capabilities of its systems staff group to develop successful solutions to company problems and management's willingness to commit time and resources.

Successful implementation is more likely to occur in an innovative atmosphere. Therefore, management's attitude toward innovation is important.


\(^3\)Harvey, p. B315.
Most management science techniques require more time and effort to implement them than do less effective and simpler techniques. Thus, many cases of successful system implementation have occurred only when management recognized that additional time and resources were required.

**Problem Characteristics**

The characteristics of the problem for which a system is designed have a significant bearing on the ease with which the system can be implemented. When management can ascertain that the objectives of a system are of major importance to the objectives of the business or when sufficient resources have already been committed for solving a given problem, implementation problems are substantially reduced. However, when a problem is one that lends itself to more conventional approaches, a sophisticated system solution may reduce the positive influence of the problem characteristics. Likewise, when the solution approach is too narrowly conceived or too global in terms of solving the problem, implementation problems result.

**Group Characteristics and Solutions**

Successful implementation is also dependent upon the systems staff group. The group should recognize the difficulties to be expected in implementing a system and should accept the responsibility for implementation. Difficulties expected should include technical problems in converting
the solution into an operating system, skills and disciplines required for organizational change, and behavioral problems. It should also be recognized that the operating system ought to reflect a sensitivity to the motivations and priorities that exist in the organization.

Human and organizational factors, management needs, the solution approach, and the problem characteristics are all problem elements that relate to the implementation of quantitative systems. As a result, successful implementation is dependent upon integrating these elements into the logic and philosophy of a system. To date, however, much of the primary research on implementation has focused on the problems only in an isolated mode. Some studies have noted the interrelationship of the problems, but there has been little research on integrating these into a system. It is highly improbable that a universal approach exists which integrates all the problem elements, but an approach should exist which integrates some of the key elements.

One possible approach is the use of gaming. Historically, gaming has served as a training device for studying

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human behavior, as a means for evaluating strategies (war games), as a training device for management, and as a teaching aid in university business schools. It should, however, be possible to extend the use of gaming. By structuring a game to parallel the philosophy and logic of a system, ways of identifying problem elements may be ascertained. The objective of this study is to develop such a game approach.

Specifically, the research objective is to demonstrate that a game-implementation process can serve as a means of solving some key implementation problems and for integrating the components associated with developing a quantitative based system. Thus, the study has the following objectives:

1. To demonstrate by means of a case study example that gaming can be successfully employed as a systems implementation tool.

2. To identify a game-implementation approach which would be useful in developing and implementing a quantitative based system.

Hypotheses

Two basic hypotheses will be tested in the research. These are summarized as follows:

1. Gaming is a valid implementation tool that is useful as a training aid during the installation of a system.
2. Gaming can be employed during the conceptualization of a system to interrelate the problem area which the system addresses, the solution approach, and the ideas and needs of users, managers, and systems analysts; and by employing a gaming activity during conceptualization, many implementation problems are resolved prior to development and installation of the system.

Scope and Limitation of the Study

The primary analysis of this study is limited to the implementation problems associated with systems. More specifically, the analysis is directed to computer based quantitative systems. It is beyond the scope of the study, however, to examine all problem areas associated with every technique that has been developed within the computer systems or management science/operations research fields. Rather, the analysis and findings of such studies as those of Michael Radnor and David Mylan\(^6\) and Radnor, Albert Rubenstein, and David A. Tansik\(^7\) will serve as a basis for identifying implementation problems. The objective is to identify what impact the game-implementation process will have on these problems.


problems. It will be necessary to explore all the literature in this area in order to identify the problem adequately.

Although much of the current documentation regarding quantitative based systems is found within the journals of operations research and management science, the research will not be limited solely to these sources.

The implementation problem is common to systems in general. For example, Perry E. Rosove\textsuperscript{8} devotes a complete chapter to examination of implementation problems associated with computer-based information systems. Examination of this type of source will help one to avoid being totally biased by the operations research/management science literature and should identify implementation problems common to the systems field in general.

Since gaming is the basic framework for the study, a historical survey of the area will be included in the research. An in-depth examination of the area will be made, but it is beyond the scope of this study to survey all phases of gaming. For example, the birth and growth of game theory will not be examined, even though this field is related to the general field of gaming. The basic areas to be explored will include management, business, and operational games. Specific attention will be directed to computer-based games.

Definitions and Clarification of Terminology

**Implementation**—Numerous definitions exist in the literature. For example, the term has been used to imply acceptance by management of a recommended solution to a problem. Likewise, it has been used to refer to the manner in which the results of operations research/management science efforts are used by management. Within this study the term will refer to activities and/or steps that are involved in transforming a conceptualized system into a fully operating entity.

**System**—This term can be defined as a set of objects with relationships between the objects and their attributes designed to accomplish a particular objective according to a plan. Objects are the components or elements of the system; attributes are properties used to describe the elements, and relationships tie the system together. (See Chapter III for an in-depth description of a system).

**Gaming**—This consists of a simulated environment in which an individual interacts within the simulator to affect

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9Harvey, p. 331.


the outcome of the process. The simulated game environment in this case parallels the logic and philosophy of a given system.

Data Collection and Analysis

Primary and secondary sources are employed during the study. A detailed case study and interviews serve as the source for the industrial game analysis, while an in-depth literature search supports the examination of the implementation problem and gaming.

Direct experience associated with the development and installation of systems within a large electronics firm provided an opportunity to view many of the problems associated with systems implementation. The case study analysis flowed from this experience and from interviews with individuals in the systems environment.

The particular case included in the study dealt with the implementation of a computerized production control system. Interviews with individuals directly involved in the project were used to identify the major problem areas and a previously developed game-training activity. A game-session questionnaire was used for measuring the effectiveness of the game activity. Certain production indices were also monitored on a sample group of production operations preceding and following the game presentations. This initial work formed the foundation for much of the research, and the
game-implementation concept resulted from an extension of this initial research.

The second phase of the research involved the development and evaluation of the game-implementation concept. The concept was developed from the in-depth literature search and the case study analysis. Specific hypotheses concerning the concept were examined by means of interviews with managers, operating personnel, and systems analysts within the firm. Some additional aspects of the game concept were evaluated by developing a generalized game. The TYMSHARE Corporation provided time on their time-sharing computer system for this development and evaluation work.

The specific data collection process involved the following steps:

1. **Literature search.**—An in-depth search of books, periodicals, indexes, abstracts, and bibliographies to acquire an insight into the implementation process, implementation problems, and gaming.

2. **Industrial case study.**—Exploration of a game currently existing in a large industrial firm. This case study analysis included the collection of data concerning (a) actual game output reports (as a result of player interaction) before and after game seminars, (b) seminar session critiques for measuring game effectiveness, and (c) production operation indices before and after the game-training activities.
3. **Personal interviews.**—Interviews with various individuals within an industrial systems environment in order to substantiate problems identified in the literature search and to evaluate specific hypotheses relating to the proposed game-implementation concept.

4. **Generalized game.**—Actual game outputs associated with two separate groups of game participants.

Organization of Presentation

The research is divided into three major divisions. Chapters II, III, and IV give the background material for the research, while Chapter V develops the game-implementation concept. The research results, which include an analysis of the game concept, are presented in Chapter IV.

The research material specifically is organized as follows:

Chapter II is involved with the examination of implementation problems. This review examines factors associated with the acceptance and use of quantitative techniques and relies heavily on the operations research/management science literature. During the latter portion of the chapter, the focus is on showing that a systematic approach is needed for developing and implementing quantitative systems.

Chapter III identifies and develops a systems process. This work includes a detailed examination of the activities involved in moving a conceptualized system into an operational
system. The framework developed within the chapter is the basis for integrating the implementation factors identified in Chapter II. Included also in the chapter is an examination of the problem associated with each stage of the systems process. Literature from the systems field supports much of the analysis of the chapter.

Chapter IV presents a historical survey of gaming along with an examination of types and uses of games. Included also is an examination of factors which have limited the use of gaming.

Chapter V is devoted to the development of the game-implementation concept. This concept involves the integration of the factors associated with the development and implementation of a system and is structured from the findings presented in the previous chapters.

Chapter VI presents the research results for the study. An in-depth presentation is made of the industrial case study, including an analysis of the game-training activity and evaluation of the production operation indices. Also results from the interview activity used to evaluate the proposed game concept and results from the generalized game activity are presented.

Chapter VII contains the summary and conclusions of the research.
Significance of Writing in the Field

A significant amount of literature exists which examines the implementation problem. Likewise, much has been written concerning the field of gaming. Very little, however, has been written on the relationship between the two fields. Much of the helpfulness of gaming in bridging the implementation gap has been inhibited because of cost and lack of facilities.\(^\text{12}\) However, with recent advances within the computer area, such as low cost time-sharing, some of this potential can be unleashed. This research, although not a panacea for the problem, does suggest an approach which takes advantage of developments within the computer field and demonstrates some of the potential of gaming.

CHAPTER II

IMPLEMENTATION PROBLEMS

Many of the problems associated with the implementation of a quantitative based system result from the quantitative nature of the system. The objective of Chapter II is to examine the problems associated with the acceptance and use of quantitative techniques. An understanding of these problems is a prerequisite for the design, development, and installation of a quantitative system.

Section one examines factors that have been identified as being related to the implementation of quantitative techniques. It should be pointed out that implementation in this sense implies acceptance and use of a technique. Implementation has been defined as being the activities and/or steps associated with transforming a conceptualized system into a fully operating entity. However, this definition is meaningful only when the activities that are being examined relate to the definition, development, and installation of a system. Since the analysis in this chapter explores only a subset of these system activities, the traditional definition of implementation, namely, management's acceptance and use of a recommended solution on
technique, is more appropriate. The former definition of implementation will be used in Chapter III and in the ensuing chapters.

Section two reveals how the relevance of different implementation problems is changed by particular events or activities. The impact of the changing demands of the organization is viewed. Also examined is how the impact of implementation problems varies depending on the stage that a project or activity has reached in its life cycle.

The interrelationship and integration of implementation factors is presented in section three. Included are several models drawn from the literature.

The final section of the chapter identifies the need for a development plan or systems approach for developing a project and carrying forward its implementation.

Factors Relating to Implementation

A review of the literature within the operations research/management science field reveals that several sources explore areas relating to implementation problems. For example, David R. Heiman\(^1\) explores factors which predict the potential success or failure of quantitative

activities, and D. G. Malcolm\(^2\) examines factors which further the usefulness of operations research projects. Louis T. Rader\(^3\) comments on roadblocks within the quantitative area. The findings identified in these and other studies can be grouped into the following categories:

1. Organizational factors
2. Management factors
3. Factors associated with the quantitative group
4. Client or User factors
5. Factors relating to the problem and solution approach
6. Other related factors

While it is desirable for study purposes to group the factors explored in the different studies in this manner, it does not imply a lack of interdependence of some of them. Interdependencies do exist and have a significant effect on implementation. This point is developed in the latter part of the chapter.

**Organizational Factors**

An appropriate and accurate solution technique does not guarantee successful implementation. Certain factors


such as the organizational environment and the need for organizational change can have an impact on the degree of success of implementation. These factors can be described as follows:

**Organizational environment.**—The type of environment in which the project or activity takes place is significant in relation to implementation success. If the environment is such that organizational goals and outputs are not well defined, then implementation problems may result. Also the influence of an operations research/management science project may be difficult to demonstrate. In comparing a business and a government organization, one would expect that the problems associated with the governmental groups would have a different order of magnitude since most such groups appear to have less well-defined goals and outputs.

If the environment is such that it becomes difficult to measure the results of operations research/management science activities, then the client-researcher or user-analyst relation becomes critical. In order to convince the user of the benefits of the activity, the analyst must seem to be reputable and trustworthy.

**A need for organizational change.**—The installation of a new system or technique may require a change of goals for different elements in the organization. For example, a

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4 Radnor, Rubenstein, and Tansik, p. 976.
solution may require that one part of the organization operate at less than total efficiency in order for the flow of work between functions to be optional at the total system level. Such a requirement must be made explicit at all levels of the organization if problems are to be avoided.

New operating procedures may also be associated with a new system. If such procedural changes are not explicitly disseminated to all members of the group, then problems can result. For example, if a new system has more automated controls and more extensive instrumentation than the previous operating system, then operating procedures may have to be altered to accommodate the system. If these new procedures are not adequately communicated then implementation problems result. Also if the reasons why the new system is preferable are not conveyed, implementation may be unsuccessful.

Major organizational changes may be required for implementation success. Design, development, and implementation of a computerized quantitative system require design and development activities that are integrated with programming and data processing activities. In most cases, however, these activities are under two separate management responsibilities, each having a different objective. The data processing

function is generally oriented toward efficient data processing, high computer utilization, and a flexibility of outputs to meet unexpected demands with little interest in how the data are used in the decision process. The management science function (the design and development activities) is directed toward development of a system which requires specific outputs with easy access to the computer and timeliness of output reports. If an incompatible working relationship exists between the design and development area and the data processing area as a result of the organization structure, then implementation problems may result. To alleviate this disharmony, it may be necessary to make organizational changes. For instance, a centralization under one particular area may be necessary in order to achieve a unified objective.  

Management Factors

The manager is often a key decision maker or at least a key element in a project or activity. Thus implementation is affected by the knowledge, capabilities, and actions of the manager.

Parameters relating to or associated with the management element of implementation fall into one or more of the following areas:

6Ibid., p. B57.
Characteristics.--Particular management characteristics can be correlated with the implementation of quantitative techniques. From an examination of thirty-one companies, Harvey identifies several factors which tend to be associated with management's decision to accept and use a given technique or system. The first to be noted is that those managers who have previous success with developing and implementing sophisticated approaches to problem solving are receptive to applying new techniques to problems. Conversely, in many instances of failure to implement new techniques, it is noted that the manager, in advance of the study, lacks conviction that management science is likely to lead to a solution to their problem. A second factor, closely associated with the first, relates to management's attitude toward innovation. In cases where projects are implemented, it is often noted that management creates, throughout the organization, a climate that encourages innovation. In examining companies which fail in implementing particular projects, it is generally noted that a negative attitude toward aggressive actions exists.

7Harvey, p. B317.
In examining a group of characteristics which can be termed "management style," Harvey states,

...in the majority of implementation success cases future-oriented managements exist. That is, management attaches high importance to where they wanted to be at various points in the future.\(^8\)

In exploring characteristics of decision making by management, Harvey concludes that the ability to see solutions in terms of trade-offs is critical to successful implementation:

In examining those companies who failed to implement projects, a very low, positive or negative rating existed in managements' ability to recognize the importance of interrelationships between activities as well as the significance of trade-offs.\(^9\)

Another significant factor, and one often showing a high correlation, is management's confidence in the capabilities of its management science group. In many successful implementation cases, a correlation is noted between managements' willingness to implement a project or activity and its confidence in the quantitative staff. In Harvey's study such a high correlation existed that the decision was made to eliminate from the sample those companies which had an impressive history of successful implementation of management science solutions to problems.

\(^8\)Ibid.

In exploring some of the negative characteristics of management, Rader concludes that the unwillingness and inability of many managers to develop and communicate an explicit objective for the business is a major roadblock to implementing quantitative systems. Management often fails to recognize that without a clear and concise objective the ability of the quantitative staff is limited. On the other hand, with a clear identity of the business objective, aggressive and dynamic actions can be pursued. According to Rader, "Any model of a business constructed without consideration of management's vision of the business is likely to be a creation that responds only defensively to the environment."\(^{10}\)

Another factor which can be described as a negative characteristic of management is the tendency of some managers to use a performance ratio as a measure of an individual's level of contribution to the organization. Employing such measures gives the management scientist very little freedom in which to operate. Generally, most management science techniques require additional time and efforts to implement than less effective techniques; thus a performance indicator may be meaningless as a measure of contribution. If a manager relies on some day-to-day

\(^{10}\)Rader, p. C4.
measures as an indicator of the performance of his staff group, he may find that the group's actions are directed toward meeting these criteria rather than toward solving the desired problems or tasks.

Exposure to management science and computer science area.--One of the most frequently discussed requirements for successful implementation of quantitative techniques is that of exposing management to the management science area. Without proper knowledge and understanding of the concepts and techniques associated with the field, management cannot expect to comprehend the objectives of its quantitative group. Also with the increased utilization of computers within the quantitative environment, management is not only expected to comprehend the quantitative concepts, but it is also expected to understand how they integrate into a computerized system. In a presentation to The Institute of Management Science Meeting in Minneapolis in 1965, Rader pointed out that one of the major obstacles that retards progress within the quantitative area is management's education deficiency in management and computer sciences.\footnote{Ibid., p. C3.}

With the widespread utilization of computers and the emphasis by the academic area toward developing decision science programs within business curriculums, the level of management exposure has changed somewhat within recent years.
In the examination of sixty-six firms, Radnor found that a significant percentage of high-level management had some exposure to the management science area. Radnor's conclusion, however, was that there is a continuing need for introducing management to the techniques and concepts as they develop.

Level of management support.—Management's support appears to be a key variable affecting the success of a management science activity. In a study by Radnor, Rubenstein, and Bean it was found that a strong relation exists between the support of sponsors and the success of the operations research/management science group. Examination of the effects of the loss carried with it the probability that the activity, as well as the group, would not maintain its position in the organization. By contrast, activities which retain their sponsors are generally more stable and somewhat more successful.

The level of management support also has an effect upon specific problems of implementation as well as upon the overall success of the activity. Examination of both business and government data indicates that a correlation may exist between management's support of a project or

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12 Radnor, Rubenstein, and Tansik, p. 978.

activity and the client or users' willingness to implement the project. Endorsement of the operations research/management science group by management or even pressure brought to bear by managers on users influences the implementation of projects within the user organization.

Factors Associated With the Quantitative Group

In addition to organizational and management factors, implementation is also affected by factors associated with the operations research/management science group. Factors such as the attitudes and interests of the group and the group's capabilities, knowledge, and reputation can influence implementation. These factors can be described as follows:

Attitudes and interests of the group.--Harvey indicates that a strong relationship exists between the extent to which implementation occurs and the willingness of the management science group to assume implementation responsibility. Assuming that successful implementation is dependent upon the support of the management science group, then certain attitudes and interest factors must be altered if the group is adequately to support implementation. In

14 Radnor, Rubenstein, and Tansik, p. 982.
15 Harvey, p. 3319.
general, the interest of most quantitative groups is in developing theoretical solutions to particular problems, with the attitude that operational implementation of the concept or technique should be the responsibility of the user organization. For example, concerning an examination of forty-eight case studies, Ackoff comments, "many cases of unsuccessful implementation resulted but not a single case of technical failure occurred."\(^{16}\)

To support the implementation activity successfully, the management science staff must develop and accept a broader view of its responsibility for a project or system. In this process, efforts must be extended to assure that the group gives continual support to the project or system throughout its life cycle. A basic problem that often must be overcome, however, is retaining the interest of the management scientist. Paul Stillson expresses the problem in this manner:

During implementation other interesting problems were assigned the operations research group. As each implementation problem was encountered, it required more and more diversion from the "real" work of the group. There was less and less inclination to fight the operational fires.\(^{17}\)


Capabilities and knowledge.—A technical knowledge and capability is required of any quantitative group, but organizational knowledge is also a necessity. Most management science groups have the technical knowledge required for a theoretical solution to a given problem. A deficiency, however, generally exists in the group's knowledge of the organization requirements and activities associated with implementing the theoretically developed technique. 18

The required depth of knowledge of organizational requirements and activities will vary with different types of projects. Development of a statistical forecast may require only a superficial knowledge of organizational requirements. In contrast, development of an inventory control system for a total corporation necessitates an in-depth knowledge of many organizational factors. In the latter case, the management scientist must be knowledgeable concerning the individual managerial responsibilities required, achievement possibilities with existing systems, system activities necessary at each level of operation, the behavioral effect of personnel on these activities, and the sensitivity of the proposed system to the current organizational operations.

Many implementation problems which are associated with the lack of knowledge of organizational requirements result

from the attitude and interest of the management science group. With an interest directed toward the theoretical end of problem solving, organizational requirements are of little concern to most management scientists.

Reputation and prior level of success.—Successful implementation requires a strong interaction between system users (clients) and the management scientist. Such interactions are affected by previous levels of success with other project activities and by the reputation of the management science group. In exploring client relations, Radnor, Rubenstein and Bean found that a key element which contributes to poor receptivity of a management science group is poor prior project results. In similar examinations, other studies indicate that a poor reputation on the part of management science groups is a negative implementation factor, regardless of pressures brought to bear by top management in support of an activity.

Definition of results.—Because of the highly technical nature of most quantitative projects or activities, there is a tendency on the part of the management scientist to use sophisticated approaches and technical terminology throughout the activity. One of the key problems that results from such practice is that the manager and/or client is unable to comprehend the actual results that should occur from employing

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19 Radnor, Rubenstein, and Bean, p. 135.
the technique or system. In the study by Radnor, Rubenstein and Tansik, a key factor underlying implementation problems was the need of the operations research group to identify and define explicitly the results or impact of a given project.20

Client or User Factors

The client plays a key role in the implementation of a project; he is the user of the technique or the system. Several factors relate to the role he plays in the process and these can be classified into the following categories:

Client relations.—In the study by Radnor, Rubenstein and Tansik of both business and governmental organization, it was found that activities which show high implementation problems tend to be associated with reports of bad relations with clients.21 Conversely, good client relations tend to be associated with low levels of implementation problems. Warren Bennis places primary importance on client relations as is obvious from his comment that "implementation is the problem, and the relationship between researcher and the user is its pivotal element."22

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20 Radnor, Rubenstein, and Tansik, p. 972.
21 Ibid., p. 980.
Several factors interact to affect client relations. Radnor, Rubenstein and Bean explored this problem and identified the following ones:

1. Poor prior project results
2. Use of highly technical terminology
3. Unsatisfactory experience with outside operational research consultants.
4. Identification of the management science staff with a highly specialized functional area.
5. Inability to demonstrate cost effectiveness.
6. Methods employed by the management science group of allocating project costs.
7. Differences in planning horizons.23

Norman R. Baker explored the client relation problem and concluded that prior project results have a significant impact on the receptiveness of the client.24 Unfavorable project results generally change receptive clients into unreceptive ones. Likewise, the quality of personal relationships decreases as unfavorable project results increase.

23 Radnor, Rubenstein, and Bean, p. 135.
Therefore, to retain the client's support and receptiveness, it becomes important to disseminate continually the accomplishments of the management science group in other areas of the organization.

The client's receptivity to the management science group is an important factor in establishing the environment within which the management science activity operates. Baker states that "the management scientist must have the freedom to select projects, gather data, and test and implement proposals." Without this freedom of operation, the capabilities and activities of the group are limited. The level of receptivity from the client controls the extent of the management science group's action and thus controls the level of implementation.

Urgency of results.—Most operations research/management science techniques require more time to develop and implement than the less sophisticated and less efficient techniques need. If the client fails to recognize this fact and places a high demand on "results," then implementation problems can occur.

The urgency with which the client needs results places a burden on the management scientist. With a high demand placed on "action and results," the management scientist is often forced into the situation of attempting to fit the

25 Ibid., p. 3516.
problem into a pre-structure technique. Similarly, if the client has a preconceived solution to the problem, a high demand for results may force the management scientist into accepting the recommended solution approach. In many cases such action results in solving only superficial problems rather than in eliminating the real source of the problem, and the project or activity is deemed unsuccessful.

Commitment of resources.—The development and implementation of a quantitative technique or system requires a commitment of resources on the part of the client. Such resources include facilities, manpower, and money as well as the willingness of the client to participate in all stages of the project. Russell L. Ackoff identifies one of the key problems in implementation as the willingness of the client to commit his time and efforts throughout the life cycle of the project. Participation is a necessity at the beginning of a project, but it is equally necessary that the client stay abreast of developments in the project and be attuned to any problems and variances that occur.

Factors Relating to the Problem and Solution Approach

Client relations play a key role in the implementation activity, but likewise, factors relating to the problem itself and to the solution approach have a significant

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impact on implementation success. Factors falling under this heading can be classified into the following subheadings:

Problem characteristics.—The kinds of problems to which management science techniques are applied and the objectives which are defined play an important part in implementation. Implementation is more likely to occur when management recognizes the objectives of the activity as being of major importance to the objective of the business. Complementing this particular point, it has been found that if substantial resources have previously been committed to a given activity, then lack of support does not become a limiting factor. If the problem, however, is one that readily lends itself to more conventional approaches requiring more modest management commitments, then an attempt to apply a sophisticated technique may result in opposition and lack of support from management.

Support alone does not guarantee successful implementation; explicit identification of problem objectives is also a necessity. If the objectives are too narrowly conceived or too global, then it becomes difficult to measure the impact of the management science efforts. Harvey

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27 Harvey, p. 3318.

28 Ibid.
states that "in the examination of 'success' cases, a realistic scope of the objectives was a very positive factor supporting implementation."\textsuperscript{29}

Projects.--During the first decade of the operations research/management science activity, efforts were generally directed toward well-structured problems. Since that period, the field had tended to gravitate toward a blend of structured and less than tailor-made problems.\textsuperscript{30} Both type problems play a key role in the activity of the management scientist.

Generally, relatively few implementation difficulties result in cases where the problems are well-structured. From his knowledge of tools and techniques that are available in the field, the management scientist can quickly identify a solution technique. An evaluation of the returns against the outlay of resources can also be explicitly determined. In many cases, however, these type problems are solvable by more conventional techniques; consequently, a more sophisticated quantitative technique is difficult to justify financially.

Those problems that fall into the category of being less than tailor-made are generally those which potentially have a large payback. In this case, though, the solution to the problem is generally not a simple process of fitting the

\textsuperscript{29}\textit{Ibid.}, p. B319.

problem with the techniques of the management scientist. Explicit evaluation and control are necessities throughout the life cycle of the activity, and interaction with the client is a must. Projects of this nature are also of much longer range than are the well-structured type problems. Successful implementation requires a continuing effort of keeping the client as well as management enthusiastic and motivated.

In examining the portfolios of projects, Malcolm states that it is essential that the management science group select projects which represent a blending of long-range and short-range problems. Such a mixture is required in order to meet two needs. First there is a need for producing results quickly enough to satisfy management. Second, the capabilities of the quantitative staff in solving the more complex problems must be demonstrated. It is necessary, however, that management recognize the complexity of long-range type problems and be willing to commit the additional time and resources necessary for developing and implementing solutions.

The criteria for selection of the proper mixture of long-range and short-range projects cannot be based solely on the benefits that either the client or the management science group will accrue. It is appropriate to consider

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31 Malcolm, p. 355.
a range of parameters. Malcolm states that it is important to consider the following factors:

1. Impact on user's goals, such as savings in operating cost, manpower, and equipment and improvement in quality and quantity of service.

2. Cost of the project, including implementation and operation.

3. Estimate of pay-off period, including estimates of time to achieve specific results.

4. Ability of the management science group in solving the problem.

5. Effect on the group's growth and development process.

6. Interrelatedness with other identified problems.  

Solution to the problem.--A solution technique that theoretically solves the problem and is cost-effective does not guarantee implementation success; other factors related to the solution approach are also important. First, if the complexity of the computation needed to implement and use the solution technique deviates extremely from the norm of the client's operations, there may be a tendency to reject the technique. Second, if the procedures required to implement the technique are such that extreme organizational changes are necessary, then a planning and educational

32 Ibid., p. 357.
process will be required in order to convey the need for change and to inform each individual of his role in the new system. Finally, if the solution approach is structured so that its accuracy requires a rigid control of the operating environment, a strong opposition may result from the increased burden that the system places on the operating people.

Other Related Factors

In addition to organizational, management, and solution-related factors, two remaining factors are associated with implementation. These fall under the headings of communication and cost of implementation.

Communication.—Good communication is a necessity for development and implementation of a quantitative technique. This is particularly true at the beginning of a project. A key problem that often results during the initial stages of a project is the misunderstanding of specifications. With a poor client-management scientist interaction, improper specifications result which, if left unaltered, ultimately lead to the development of inaccurate and inefficient techniques. A good communication feedback network must exist if a technique is to be developed and installed.

Poor communication can also result in a lack of understanding of the objectives in a given project or system. In many cases negative reactions on the part of management and/or misuse on the part of the client are the result of such a
lack of understanding of the basic goals of a project. This does not necessarily imply total rejection on the part of management of the client. This type situation, however, can easily lead to implementation failure. This is illustrated by a case example of a large semiconductor firm which developed a quality control system to aid in controlling overproduction of low quality devices, but after eighteen months of operation and thousands of dollars expended, the system was declared a failure.\(^{33}\) Analysis of the case showed that in the initial stages management strongly supported the project and the clients were enthusiastic about the potential of the system. After the system was developed and placed in operation, the clients discovered that it failed to produce and serve all the desired functions that had originally been envisioned; also there were some operations of the system that did not appear logical in terms of normal operations. Analysis by the management science group indicated that the clients did not fully comprehend the system and that the lack of success that had occurred was due to improper use; however, the management science group was unable to convince the clients of their misuse of the system. After a period of time, since the system performance was less

\(^{33}\)Scott A. Gaulding, Interview, Texas Instruments Incorporated, February 19, 1971.
than expected, the clients' interest and support declined and management support dwindled. After eighteen months the system was rejected, and the previous system was again adopted. Lack of communication was identified as a major problem throughout the project's life cycle.\textsuperscript{34}

**Cost of implementation.**--The cost of implementation is often either completely neglected or minimized. Malcolm contends that this action results from the budget process.\textsuperscript{35} A tight budget impedes operations research/management science activities by delaying studies until a new fiscal period or by requiring that the proposed studies be placed in competition with other uses of the resources. This type action tends to force the proponents of a project to understate the expected cost in order for the project to be approved. In most cases the one area which is purposely minimized during this costing process is the cost of implementation of results.\textsuperscript{36}

Following a policy of neglecting implementation cost can only result in problems. Client relations are quickly placed in jeopardy when it becomes apparent that implementation and operating cost far exceed original estimates. Management confidence in its quantitative staff is likewise

\textsuperscript{34} Ibid.

\textsuperscript{35} Malcolm, p. B50.

\textsuperscript{36} Ibid.
diminished when projected profits or savings fail to materialize as a result of unforseen implementation costs.

Stillson contends that one criterion for evaluation and selection of a project is the project cost, including implementation and operation.\textsuperscript{37} Such a sum should include the cost for development and analysis, the estimated cost for implementation (including training), and the estimated operating cost (including both manpower and equipment).

Relevance of Factors

Implementation of a quantitative project or activity depends upon an abundance of factors; some, however, are more relevant than others. That is, the degree to which a technique is accepted and used is largely affected by some key factors. In a literature survey of fifteen articles relating to the conditions which affect the success of operations research/management science activities, David R. Heiman identified five key factors which are identified in Table I. In a similar but more detailed study, Radnor, Rubenstein and Tansik identified seventeen factors as described by fifteen literature sources. These are listed

\textsuperscript{37} Stillson, p. 145.
TABLE I

SOME KEY FACTORS RELATING TO IMPLEMENTATION PROBLEMS*

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of Authors Maintaining This Factor (N=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Understanding</td>
<td>6</td>
</tr>
<tr>
<td>Working with Management</td>
<td>9</td>
</tr>
<tr>
<td>Measurable Project Savings</td>
<td>6</td>
</tr>
<tr>
<td>Project Urgency</td>
<td>4</td>
</tr>
<tr>
<td>Relevance of Techniques</td>
<td>4</td>
</tr>
</tbody>
</table>


in Table II. These two studies in no way establish a ranking of the necessary and sufficient condition for implementation of quantitative activity. Assuming, however, that the frequency with which a factor appears in the literature is a measure of its relevance, these sources bear some weight in identifying the relevance of a given factor.

The Impact of Change

In addition to the specific factors explored in section one, two remaining partial factors are associated with implementation. First, the changing demands of the organization create a dynamic environment in which implementation must occur. Second, the relevance of some implementation factors is affected by changes that occur in the operations research/
<table>
<thead>
<tr>
<th>Factor number</th>
<th>Description</th>
<th>Literature sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Need by OR to define results</td>
<td>Accoff [1]</td>
</tr>
<tr>
<td>2</td>
<td>Impact on users' goals</td>
<td>Accoff [1], Chu and R. Schmalensey [2]</td>
</tr>
<tr>
<td>3</td>
<td>Communications (understanding, timeliness, etc.)</td>
<td>Crane [3], Hann [4], Hurn [5], Hicks [6], Hitch [7], Huygens [8], Malcolm [9]</td>
</tr>
<tr>
<td>4</td>
<td>Client involved (time, money, participation)</td>
<td>X, X, X</td>
</tr>
<tr>
<td>5</td>
<td>Implementation costs and time</td>
<td>X, X, X</td>
</tr>
<tr>
<td>6</td>
<td>Low-level resistance to change (failure to participate)</td>
<td>X, X, X</td>
</tr>
<tr>
<td>7</td>
<td>Client requests for help</td>
<td>X, X, X</td>
</tr>
<tr>
<td>8</td>
<td>Urgency of results</td>
<td>X, X, X</td>
</tr>
<tr>
<td>9</td>
<td>Measurable savings</td>
<td>X, X, X</td>
</tr>
<tr>
<td>10</td>
<td>Improved information</td>
<td>X, X, X</td>
</tr>
<tr>
<td>11</td>
<td>Availability of trained people to implement</td>
<td>X, X, X</td>
</tr>
<tr>
<td>12</td>
<td>Reporting level of OR/MS</td>
<td>X, X, X</td>
</tr>
<tr>
<td>13</td>
<td>Availability of detailed implementation plan</td>
<td>X, X, X</td>
</tr>
<tr>
<td>14</td>
<td>Complexity of computations needed to implement and use</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Changes in management structure</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>'Mutual understanding'</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Cognitive style of managers</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Radnor, Rubenstein, Tansik, p. 972.
management science group and in the project as the project moves through different stages of its development.

Time is a critical element within any systems activity, particularly within the design, development, and implementation of a quantitative system. The critical nature of time results from the organizational changes that occur concerning time. In turn, these changes can impede implementation. For example, Stillson found in the development and implementation of a maintenance system for service station equipment that the time lapse between "selling" the system and obtaining a fully operational system was a critical factor.\textsuperscript{38} The enthusiasm which existed during the early stages of the study waned after several development problems occurred, and this extended the length of the development process. When the finalized system was complete, it was discovered that many of the basic factors of the system had changed and many of the initial operational personnel who supported the system were no longer associated with the operational area in the earlier assignments.\textsuperscript{39} A second example highlighting the impact of organization change and likewise paralleling the findings of Stillson is exemplified in the comments of a systems manager in a large industrial firm:

\textsuperscript{38}Ibid., p. 144.

\textsuperscript{39}Ibid., p. 145.
One of the major problems that we have experienced in our implementation efforts has been organizational change. Before we can develop and implement a system, organizational changes have occurred that impact the operating priorities of the group and in most cases change the responsibilities of the operating managers. In one particular case, our operating group experienced twelve organizational changes (these changes affecting some of the key people associated with the systems effort in the area) within a period of thirteen months. With such an erratic environment it is very difficult to establish an operating base from which to implement a system.\(^4\)

In exploring the impact of change, one group of authors identifies how the relevance of implementation factors vary depending upon the stage that the management science group has reached in its life history in the organization.\(^4\) The findings of these authors indicates that the group's activities seem to pass through several phases in its life cycle, and the relevance of implementation factors are qualitatively distinct within these phases. These phases are identified and defined as follows:

1. **Pre-birth phase.**--Interest exists in the organization for exploring management science activities; but no formal activity exists, and no resources are officially devoted to such work.

2. **Introductory phase.**--A "charter" has been granted to perform some management science work. This is temporary

\(^4\) Carl Hopper, Interview, Texas Instruments Incorporated, Dallas, Texas, February 5, 1971.

and may be specific to a project or program. Resources have been officially allocated for such activities.

3. **Transitional phase.**—A long-term commitment has been made to management science activities. Management and/or clients have indicated the intention of using quantitative systems in the decision-making.

4. **Maturity phase.**—The management science group as well as some key systems have been accepted as a permanent part of the organization. The resistance to a commitment of resources and the acceptance of recommended quantitative activities as an essential part of the decision-making process is at a minimum.

5. **Death phase.**—Progress of the management science group or of an activity has been terminated. Termination can occur in any of the preceding phases and can be defined as complete discontinuance of activity or the return to phases I or II.42

These life cycle phases embody such factors as management’s and clients’ behaviors and attitudes, the availability of resources, the relevance of a given project or system, and the level of commitment from both management and the client. The importance of each of these factors depends upon the particular phase which is operative. Factors relevant in the introductory phase may be of little importance

42 Rubenstei and others, p. B512.
during the maturity phase. Specific events and actions, however, can cause the management science activity to progress or regress through the various phases. Thus, the relevance of implementation factors can increase and decrease as the group or activity moves through the life cycle phases.

The Interrelationship and Integration of Implementation Factors

The foregoing sections identified and examined implementation factors from a somewhat isolated perspective. These factors are, however, interrelated and they interact in all phases of a project.

Several researchers have examined the interrelationship and interactions of some of the key implementation factors. For example, Figure 1 is an implementation model identified by Heiman in developing a procedure for predicting the potential of a management science activity. This particular model attempts to interrelate management and client factors as well as those associated with the problem area and the solution approach. There are, however, some limitations to the model in that it does not include all the factors relevant for implementation. Heiman points out that this model is not adequate for large scale systems.

Client Relationships

factors influencing management's decision:

1. Is management working with the OR/MS group in such areas as problem definition, model development, data gathering or evaluation?
2. Is the OR/MS group acting as a competitor towards other organization members?
3. Were past results beneficial to the client?

Perceived Significance of Solutions

factors influencing management's decision:

1. What is the actual saving to be achieved through?
2. Can an accountable saving be predicted?

Perceived Relevance of Solutions

factors influencing management's decision:

1. Is the project urgently required?
2. What degree of technical methodology was used?

Fig. 1—A model of implementation. Source: Rubenstein and others, "Some Organizational Factors Related to the Effectiveness of Management Science Groups in Industry," Management Science, XIII (April, 1967), p515.

projects but is useful for distinct projects which are completed and then offered to management for implementation.\footnote{Ibid.}

Figure 2 is a somewhat generalized model relating some global implementation factors. This particular model relates factors which affect the performance of a management science
group. However, if effectiveness is assumed to imply the extent to which a project or system is implemented, then the model is also representative of those factors associated with implementation of a project or system. The model attempts to link the attitudes and behavior of management, clients, and others with specific events and conditions. The model

\[
\text{EFFECTIVENESS} \quad \downarrow \\
\text{CONDITIONS} \\
\text{PHASES IN LIFE CYCLE} \\
\text{BEHAVIOR OF CLIENTS \& OTHERS TOWARD OR/MS} \quad \text{MANAGEMENT BEHAVIOR TOWARD OR/MS} \quad \text{SPECIFIC EVENTS} \\
\text{ATTITUDES OF CLIENTS \& OTHERS TOWARD OR/MS} \quad \text{MANAGEMENT ATTITUDES TOWARD OR/MS} \\
\]

Fig. 2--A generalized implementation model. Source: Albert H. Rubenstein and others, p. 3510.

can be described as follows:

1. The attitudes of management, clients, and others depend upon their perception of specific events such as the prior level of success of the management science activity, the relevance of a project, and the impact of organizational changes.
2. The attitudes of management, clients, and others influence the behavior of these groups. In addition, the behavior of clients and other people tend to be influenced by each group's perception of managerial behavior toward the management science activity.

3. External events and conditions also affect attitudes. For example, managerial support may increase or decrease because of a top executive's attendance at a course on data processing.

4. Existing conditions also partially determines the degree to which a system can be developed and implemented. For example, the lack of appropriate personnel and resources can retard the effectiveness of an activity.\(^4^5\)

The detailed model in Figure 3 is an attempt by Radnor, Rubenstein, and Tansik to integrate a majority of the factors relating to implementation. The model can be described as a series of modules (numbered 1, 2, 3, . . ., 24) linked by propositional nodes (numbered I, II, III . . . XIII).\(^4^6\) The nodes within the model consist of a dependent variable and a set of independent variables. Independent variables, however, are not always considered fixed; certain independent variables become dependent and certain dependent variables become independent as each ensuing node is described. The

\(^4^5\) Rubenstein and others, p. B514.

\(^4^6\) Randnor, Rubenstein and Tansik, p. 975.
Fig. 3--A detailed implementation model. Source: Radnor, Rubenstein, Tansik, p. 973.
thirteen nodes linking the mode can be described as follows:

1. The level of implementation of a project depends upon the clients' willingness to support implementation, his ability to perform any new tasks, and the availability of money and personnel to implement the project.

2. The client's willingness to support implementation depends upon his willingness to change ongoing work patterns; his perception of project results, cost benefits, and threats; and the level of top-management support of the project.

3. The availability of money and personnel for implementation depends upon the level of top-management support of the project and organizational and external environmental conditions.

4. Top-management support of the project is dependent upon organizational and external environmental conditions, top management's system of variables, and relevant past outcome.

5. The client's perception of project results, costs, and benefits depends upon his involvement in pre-project conditions, his orientation and goals, his attitude and confidence in the research techniques, his perception of self-interest, the perceived relevance of the project, and the project characteristics (in terms of technical and organizational aspects).

6. The client's willingness to change ongoing work patterns depends upon his involvement in pre-project
conditions, his orientation and goals, his attitude and confidence in the research techniques, and his perception of self-interest.

7. The relevance of the project as perceived by the client depends upon the project characteristics (in terms of technical and organizational aspects) and the recognition of a "need" by the client.

8. The project's characteristics (in terms of technical and organizational aspects) are determined by the researcher's perception of the client's needs, the level of the researcher's abilities—both technical and organizational, the researcher's orientation and goals, the client's behavior with respect to the project, the researcher's willingness to satisfy the client's needs, and the researcher's perception of self-interest.

9. The client's recognition of a need (in terms of technical and organizational aspects) depends upon the level of the client's abilities, his orientation and goals, his attitude and confidence in the research techniques, his perception of self-interest, his actual needs, and the level of interaction between the client and researcher.

10. The client's behavior with respect to the project is determined by the organizational and external environmental conditions and by the client's recognition of a need (in terms of technical and organizational aspects).
11. **The researcher's perception of the client's needs** (in terms of technical and organizational aspects) depends upon the level of the researcher's technical and organizational abilities, the researcher's orientation and goals; the client's actual needs, and the level of interaction between the client and researcher.

12. **The level of client-researcher interaction** depends upon organizational and external environmental conditions; the client's orientation and goals, his attitude and confidence in the research techniques, and his perception of self-interest; the researcher's orientation and goals; and the pre-existing relations of trust and confidence between client and researcher.

13. **The pre-existing relations of trust and confidence between client and researcher** depend upon the client's orientation and goals, his attitude confidence in research techniques, and his perception of self-interest; the history of client-research interaction; and the researcher's orientation and goals. ⁴⁷

These three models are not the only possible implementation models, nor do they represent a universal approach for integrating all implementation factors. No general model or method has been found so far for successfully linking all factors under all conditions.

⁴⁷Ibid., pp. 974-975.
A Need for a Systems Approach

From an examination of the literature, it is apparent that numerous researchers have made an extended effort to identify and evaluate factors relating to the implementation of quantitative techniques. Little effort, however, has been expended in developing a systems approach for resolving implementation problems. Although numerous studies explore particular factors and attempt to identify their interrelated impact on implementation, most of these fail to identify any systematic approach to the development and implementation of a system. This is exemplified in Monroe's comment that "most design and implementation efforts are based on the classical approach... a great deal of intuition, some superannuated techniques and a relatively limited amount of planning and analysis." 48

What is desired is a systematic approach such as a planning and control process. This process would serve as a means for planning the development and implementation activities and could control such activities throughout the total life of the system. Malcolm recognized the necessity of such an approach as is exemplified in his comment:

there is a need for identifying the time-ordered steps and responsibilities required to make the proffered alternative an organic part

of the decision-response pattern of the organization. Such an implementation plan and schedule is required. 

In attacking the planning and control problem, Malcolm conceptualized what is described as an operations research and development process. Malcolm envisioned the process as containing such possible steps as problem definition, selection of the method of analysis, presentation of alternatives, selection of an alternative, preparation for implementation of chosen alternative, pilot implementation, measurement of results of system against established criteria, development of program for full-scale implementation, execution of full-scale implementation, and finally review and update of the system as required. Malcolm's efforts, however, were not directed at developing the process; rather he only recognized the need for such a systematic approach and suggested a possible approach. He was also more concerned with developing a total operations research and development program which placed a heavy emphasis on proper project selection for emphasizing the total operations research efforts within a firm. In suggesting the operations research and development process, Malcolm failed to recognize that problems also exist within the process itself. That is, execution of the process involves more than a mere


50 Ibid., p. B54.
sequential carrying out of process steps. Each step involves many substeps, each being a possible potential problem. Additional requirements also result from the interactions that exist between substeps and between the steps themselves.

A systematic and structured approach to implementation is thus needed; however, it must be recognized that, in employing the approach, problems will likely occur. The next chapter, therefore, is directed at developing a systems approach to implementation and exploring problems relating to it.
CHAPTER III

ANALYSIS OF IMPLEMENTATION
(A SYSTEMS PERSPECTIVE)

Three major areas of activity associated with quantitative systems have emerged over the past decade. First, there has been a significant growth in the use of quantitative techniques within the management process. Second, there has been an accelerated growth in the systems field itself. Finally, following along with these has been the growth of the computer field. To develop and install a quantitative based system successfully requires the integration of these areas. Certain problems, however, exist within each of these respective areas which hinder the integration process. Many of these problems may be resolved by taking a systematic approach to development and implementation. Thus, the objective of Chapter III is to identify a systems approach for implementation and to highlight some problems relating to the approach.

The first section of the chapter identifies and defines implementation from a systems point of view. A systems process, which is employed throughout the remainder of the study, is identified, and implementation is defined with respect to this process.
Section two of the chapter describes the systems process. Each phase is examined in detail in order to highlight the process and identify problems.

An overview of problems associated with the computer field appears in the third section of the chapter. The objective of this section is to highlight the human problems that have resulted from the impact of the computer. This section concentrates on behavioral factors associated with the employment of computers as opposed to exploring man-machine systems or human factors in systems engineering.

The final section of the chapter identifies the need for an approach that can integrate problems associated with the acceptance and use of techniques, the use of the computer, and employment of the systems process. Gaming is suggested as a possible approach.

A common trend throughout the chapter and the remainder of the study is an emphasis on the human factors inherent in implementing a system. Some of the current problems within implementation have resulted from the lack of proper consideration of the human element.¹

Overview of Implementation

Implementation can be considered from several points of view. First, it can be looked upon as the manner in which the results of operations research/management science efforts are used by management (as was the case in Chapter II). Second, it can be viewed as the organizational change or adaptation required to adopt a system successfully. Finally, it can be viewed as a process that is continuous along successive stages of a systems process. This latter view is the approach adopted for this study and is in contrast with the concept of implementation as taking place after a system has been designed and developed. This concept of implementation is represented pictorially within the system process of Figure 4.

Analysis of the systems process shows that implementation is defined as evolving from the conceptual phase. This becomes apparent when the subprocesses associated with the conceptual phase (decision stage) are examined. These subprocesses can be identified in four basic steps. First is recognition that a problem exists which may require the necessity of a system. Second is identification of possible

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3 Radnor, Rubenstein, and Tansik, p. 969.

solution approaches and a probability of various outcomes for each approach. Third, a utility or value assessment is made for all outcomes. Fourth, a decision rule or criterion is employed to select a possible solution approach. The primary output resulting from the conceptual phase should be an analysis that summarizes the origin and nature of the problem and a concept of the solution approach.  

conceptual phase does not define the system in detail, nor does it involve system design. Rather, it provides sufficient facts and a concept to make possible the decision to proceed with implementation. Systems implementation can thus be defined as those phases associated with moving a system from a conceptualized stage into an operating reality.

Systems Problems

The systems process consists of four phases. Implementation has been defined as evolving from the conceptual phase of the process; however, factors associated with this phase as well as the three remaining phases affect implementation. Particular attention is paid to the conceptual, definitional, and operational phases since it is within these areas that many implementation problems occur. These are also the areas in which it is hypothesized that gaming can have an impact.

It should be pointed out that this examination of the systems process is not a complete step-by-step procedure for definition, development, and installation of a system. Rather, the objective of this portion of the study is to develop the area in sufficient enough detail to provide a base for developing a game-implementation analysis.

It should also be pointed out that the identity of the boundaries between the phases of the system process is not as exact as that portrayed by Figure 4. While it is desirable for study purposes to separate the process in this
manner, in reality the process is a continuum, thus making it difficult to identify the end of one phase and the beginning of the next.

Another item of importance to be cognizant of is the human factors associated with the process. Numerous individual and human interactions are involved in the systems process. (These are many of the same interactions identified in Figure 3 of Chapter II). Each phase of the process involves two or more individuals or a group of individuals. For example, conceptualization most often involves a decision-maker (manager) management scientist (analyst) interaction; the definition phase involves manager-analyst-programmer-client interactions. Though these interaction groups may often be difficult to identify in association with any one particular phase of the process, the point that should be remembered is that human interactions are involved throughout each phase. (This area is discussed in detail in section 3).

A search of the literature concerning quantitative based systems reveals little published work which describes a systems process. From the presentation in Chapter II, it can be noted that most of the literature in the quantitative area is directed toward problems associated with the acceptance and use of quantitative techniques. Many of the

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^ Radnor, Rubenstein, and Tansik, pp. 967-991.
problems and phases associated with quantitative based systems, however, parallel those of management information systems and the systems development process of system engineering. Therefore, by borrowing from the literature within these areas, the systems process can be developed. In particular, concepts and problems identified by Rosove in his work at the Systems Development Corporation are presented in describing different phases of the process. Likewise, reliance is placed on the work of Wilson in his text, Information, Computers, and System Design. Literature from the area of systems analysis is also employed in identifying many problems.

Conceptual Phase

During the conceptual phase, the preliminary plan for the system is formulated. As has been noted, this can be viewed as a decision cycle which involves four basic steps: definition of the problem or objective, identification of possible solution alternatives, determination of a criterion for evaluating alternatives, and finally selection of a system solution approach. Drawing from a process commonly used in the defense community, this decision cycle can be defined as systems analysis.

7 Rosove, pp. 179-310.

In concept, the conceptual phase appears simple, but in actual practice many problems exist. The first of these is defining the "right" problem. A great deal of effort should be invested in thinking about the problem, exploring all the facts, and trying to discover the appropriate objectives. A serious pitfall is the failure of management to allocate sufficient time to decide what the problem really is. In most cases the manager-analyst interaction occurs after the manager has a preconceived idea of both the problem and the solution approach. The analyst thus falls into an environment where the manager is eager to begin. Under these circumstances the analyst may become so saturated with the decision maker's ideas that he loses his independent viewpoint. The role of the analyst should be to sharpen the intuition and judgment of the manager. Therefore, what is desirable is a means for evaluating the available facts and relationships in view of the problem. The resulting action either should verify the problem, or it should identify a direction for reformulating the problem. In any event, unless the problem is properly identified, a system may be designed, developed and installed which does not solve the "real" problem. In most cases implementation failure will result in the operational phase when the system's deficiency becomes most apparent.

9E. S. Quade, "Some Problems Associated with Systems Analysis,"*Electronic Industries Association Symposium on Systems Analysis in Decision Making*, II (June, 1966), 83.
The second problem that results during conceptualization is restriction of the range of solution alternatives. Narrowing the range of possible solution approaches makes evaluation easier, but this may be a high price to pay if some key approach has been excluded. Quade states that the most frequent cause of failure to explore the full range alternatives is an "attention bias." Failure to explore all alternatives is generally associated with the preconceived ideas (bias) of the decision-maker, in this case with reference to the solution approach. However, attention bias on the part of the analyst can also be a problem factor. The analyst may recognize a weakness in the preconceived solution approach of the manager, but he may fail to recognize his own bias in terms of "fitting" the problem into a preconceived technique or solution approach. That is, it is easy for the analyst to develop an interest in particular solution techniques and thus limit his viewpoint by attempting to fit problems into these preconceived techniques.

The first step in eliminating bias is to recognize that it exists. The second step is to have the solution analysis

10 Ibid., p. 80.
11 This problem appears in the development of any system, but is more prevalent in a quantitative based system because of the quantitative nature of the system. Cox explores this problem in his study: An Information Theory Approach to the Allocation of Resources (Phoenix, Arizona, 1970).
criticized by individuals other than the manager or analyst. A third party analysis may easily identify some technical point that had previously been ignored.

The selection of a criterion for evaluating alternatives is a third problem associated with the conceptual phase. Traditionally, factors such as length of time required for development and cost of executing are used as evaluation criteria.\textsuperscript{12} Although these are key factors, other elements should also be considered. Quade suggests that a sensitivity analysis be employed.\textsuperscript{13} That is, an analysis should be made to determine how sensitive the solution approach would be to changes in particular system variables. The environment, as well as the problem for which the system is to be designed, never remains static. It is desirable therefore, to select a solution approach in which variable fluctuations are unimportant. A sensitivity analysis can provide this capability. Factors such as the degree of adaptability with other systems and the amount of system growth each solution approach would allow should also be considered as criteria for evaluation.

There are no set criteria for measuring the effectiveness of a system. Quade states that "it is essentially an art, a

\textsuperscript{12}Rosove, p. 103.
\textsuperscript{13}Quade, p. 74.
matter of trial and error and good judgment. It is hopelessly impossible to think out a good measure in advance.\textsuperscript{14}

It is safe, however, to assume that a solution approach should not be evaluated solely on cost and time factors.

The final step within the decision cycle of the conceptual phase is the selection of the system solution approach. This selection process is not a simple action of applying an evaluation criterion to the alternative approaches. Intuition and judgment must be applied in determining what factors are relevant and in interpreting the results of the analysis. Factors such as boundaries of the system under consideration, relationship of the system to its environment, interaction of the system with other associated systems, both existing and preconceived, and constraints under which the system will operate should also be viewed during the decision process.\textsuperscript{15} The presence of uncertainty should also weigh into the analysis, this weighing process being determined by the sensitivity analysis.\textsuperscript{16} A final factor of importance is that preconceived ideas and partisan biases should bear no weight on the analysis.

In summary, the conceptual phase is an iterative process that should result in providing facts associated with

\textsuperscript{14} Ibid., p. 72.

\textsuperscript{15} Rosove, p. 79.

\textsuperscript{16} Donald M. Port, \textit{System Analysis as an Aid to Air Transportation Planning} (January, 1966), p. 41.
the problem and objectives and a concept of the solution approach. Borrowing from the field of systems analysis, Figure 5 can be described as representing the iterative process of the conceptual phase. This particular figure represents what Quade describes as the systems analysis process for military decisions, but it is representative of steps and procedures associated with the conceptual phase of a systems process.

**Definition Phase**

The objective of the definition phase of the systems process is to detail a conceptualized system and to provide
plans and specifications for the development phase. To accomplish this objective, one must identify the tasks required to accomplish the system objectives and to integrate these into an interrelated whole. Rosove identifies four steps associated with this action:

1. A preliminary analysis of the system's objectives must be made.

2. These objectives are then divided into sub-objectives at one or more levels until specific tasks have been reached.

3. Successive refinements of tasks are made to the point where the analyst can infer the data inputs, outputs, and processing that the system will require.

4. Action is associated with tasks integrated into an interrelated system. The difficulty encountered at each step will depend a great deal on the complexity of the system under consideration. Most systems, however, will at least involve the following activities:

1. Identification of system elements and specification of their attributes.

2. Definition of user requirements and the desired outputs.

3. Identification of system task requirements.

17Fernsternaker, p. 8.

4. Integration of system elements.

5. Evaluation of defined system.\(^{19}\)

To understand the definition phase better, each of these activities can be examined in detail.

**Identification of system elements and their attributes**—

From the definition of a system given in Chapter I, it can be seen that a system's elements depend a great deal upon the system's objective. There are, however, several elements that are common to most systems. The first basic element of any system is data. A system can function only by acquiring and transforming data. Jaffe states,

> no matter how simple or complex a system may be, data ultimately is transformed into information about one or more of the following states:
> 1. The environment with which the system and its users are concerned.
> 2. The resources the user controls.
> 3. The system itself.
> 4. Commands to the system.
> 5. Commands to the user's resources.\(^ {20}\)

The attributes of the data element describe the system data requirements on a more explicit basis. These can be described as follows:

1. There must be a rationale which makes explicit the relationship between each class of data and the system task that requires it.


\(^{20}\) Jaffe, p. 106.
2. The classes of data and the units employed must all be expressed in a language common to the users and designers of the system. There must be no ambiguity of terms.

3. All data must be characterized in the system by source as well as destination.

4. All data relationships must be specified. Failure to associate proper items can cause major systems problems.

5. It must be determined whether each class of data will be either saved or destroyed.

6. The processing requirement associated with each class of data must be identified.\textsuperscript{21}

The form and timeliness of data are also data attributes. These are also closely related to the attributes of user requirements and output documents. It is necessary to be aware of this dual existence between data form and timeliness; such interactions require attention during the system's elements integration activity.

A second element common to most systems is personnel. Various concepts of personnel subsystems appear in the literature. Generally, these view personnel attributes in terms of man-machine interactions. It is necessary, however,\textsuperscript{21}

to extend the personnel element beyond this level. In many situations people not only monitor and use information from a system but inject instructions into the system in the form of computer requests; these are instructions to which the system must respond. Therefore, in addition to man-machine attributes, it is necessary to identify personnel attributes such as the following:

1. Specifications must be established for the location, skill, and number of people who have the responsibility and authority for taking various types of possible actions available within the system structure.

2. Individuals exhibit abilities to learn; therefore, it is desirable to structure the system so that it can be changed as a result of knowledge gained through training and operational evaluation.

3. In defining the system requirements, one should not assume that every possible system action should be computerized. In many cases it is more economical for an individual to perform certain functions.²²

The personnel element is a component of the organization as well as the system. System structure and organizational structure must be complementary for successful system implementation.

²²Jaffe, pp. 115-116.
The equipment element is a third component of most systems. Typically, in a computer-based system, equipment is assumed to imply the computer and its associated hardware. Efforts should be made, in viewing the equipment element in this manner, to identify the limitations and capabilities of the computer as well as its associated input/output media. The third generation of computer equipment offers such features as mass direct-access storage, a variety of on-line terminal devices, time-sharing systems, and substantial, remote processing capabilities. Lower costs and better equipment, however, will expand these capabilities in the near future. As the costs of direct-access storage equipment becomes increasingly available and as limitation of current input/output devices are reduced, system design characteristics and procedures will be changed. Therefore, when exploring equipment trade-offs, attributes such as capacity, compatibility, reliability as well as adaptability should be examined in detail.

User requirements and desired outputs—Before the system's elements can be combined into an operational system, it is necessary to identify user requirements and specifications. During conceptualization, global objectives were identified; during the definition phase it becomes necessary to define these in detail.

Definition and specification of requirements should involve all levels of personnel within the user organization. Many of the requirements can be defined through interaction with the decision makers who were involved with the conceptualization of the system. However, if the conceptualized system includes several levels of personnel, then each of these users must be interfaced, and their requirements must be specified. Every objective and subobjective of the system must be identified and defined.

A major factor associated with system requirements is the user's desired output. The reason for emphasis of this factor is caused by the form and timeliness requirements. Current computer capabilities are such that volumes of information can be generated. The problem with many systems results from indiscriminately exercising this capability. The manager or user is flooded with too much information in a form that conveys little real knowledge. System success from the user's point of view results when complete and timely information is available in the desired form. Therefore, definition and specification of user requirements must include form and timeliness of outputs.

Identification of system tasks requirements—User requirements are system objectives or goals; system tasks are the ways of reaching the goals. Thus, to achieve the

\[24\textit{Ibid.}, \ p. \ 24.\]
identified system objectives, all necessary task requirements must be identified.

To determine the task requirements certain actions should occur. Jaffe suggests that the following questions be asked and answered:

1. What are the tasks? (What action is necessary to achieve each defined goal?)

2. Why is each task performed? Are all the tasks necessary, or are there redundancies in the task?

3. What resources are necessary for performing the task?

4. What is associated with each task performed? (Formulas, computational routines, data, user input decisions, and so on.)

5. When is each task performed, that is, under what conditions; at what times? What happens to initiate, continue, terminate, or reiterate the task performance?

6. How is each task performed? (How do all the actions associated with the task fit together?)

In answering these questions, control must be exercised to assure that all task requirements are identified. If the conceptualized system embodies several levels of objectives, then there will be several levels of tasks. Because of the relationship between task levels, there is often a tendency

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\(^{25}\) Jaffe, p. 120.
to overlook certain task requirements. To avoid this oversight, an effort should be made to relate task requirements directly to each objective and subobjective.\textsuperscript{26} Although task interrelationships cannot be ignored, the emphasis should be on identifying all task requirements.

Integration of system elements--The breakdown of system objectives itemizes the system requirements on a task basis. The identity of system elements and their associated requirements emerges from fulfilling these task requirements. During the initial stages of the definition phase, these task requirements are usually generated relatively independent of one another; little effort is made in these early stages to integrate requirements. It must be recognized, however, that this state in which there is seemingly no interaction can only exist during the task analysis process since all the system's elements are in someway interrelated.\textsuperscript{27} The desired objective during the latter stages of the definition phase is to integrate the system elements in an optimal manner while meeting the task requirements. The extensiveness of this integration effort is a function of the system's elements and their associated attributes, but it depends also upon the system design methodology.


\footnotesize{\textsuperscript{27}Jaffe, p. 129.}
Integration of the system elements is not necessarily a simple process. Often exchanges must be made between different system elements and/or task requirements. An iterative action is involved at this stage of the process, and it should be recognized that a considerable amount of time may be involved in this effort. Personal judgment can play a large role at this point; however, other methods do exist for exploring these trade-offs. These fall into the activities of evaluation of the defined system.

**Evaluation of the defined system**--At the end of an iteration of the system elements integration activity, it is desirable to determine whether the specified system can perform all the necessary tasks. Jaffe suggests the following techniques for evaluating the system:

1. Mathematical modeling and model exercising.
2. Functional simulation.
3. Non-mathematical analysis; personal judgment.
4. Field testing the defined system.\(^\text{28}\)

Each of these approaches has advantages as well as disadvantages depending upon the size and complexity of the system. Moravec states that the latter two techniques will reduce the total time required for system design and development and thus decrease cost by making the analysis task an

applied science. The important point is to recognize that an evaluation activity must occur during the definition phase.

As is the case during the conceptualization phase, there is a tendency to overlook the evaluation activity during the definition phase. Time and cost factors place restrictions on the analysis, but preconceived bias also results in neglected analysis. In many cases the same individuals are involved with system definition as well as development. If management support has been granted, the tendency is to move from the conceptualized system to the developed system in one integrated definition-development phase. Thus, unrecognized problem areas and bottlenecks are not discovered until the system reaches the operational phase. As was conveyed by Figure 4, the desired approach is to analyze each phase of the process.

Fernstern's global conception of the activities associated with the definition phase is presented in Figure 6. The integration-evaluation activity is described by the iterative trade-off loop. Output from the phase should be a set of plans and specifications which provides a baseline for a decision as to whether to proceed with development. This baseline results from the iterative action of the

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phase and provides not only a means for determining whether system requirements are met but also whether management's objectives are being met. Baseline refers to the documents that describe the outputs from each phase of the process (See Figure 4). In this case it describes the design requirements resulting from the definition phase.

Development Phase

The development phase, the third in the systems process, has as its prerequisites the plans and specifications prepared during the definition phase. The activity of this phase, however, is not a mere transformation of specification into computer programs. The design and development of computer programs is a necessary activity, but, likewise,
identification and development of system procedures and
design and development of orientation programs are required.
Many of the problems that result within the phase stem from
the lack of consideration of activities other than the
generation of computer programs. This does not imply that
computer program generation is a minor activity since each
activity plays a specific role.

Development of system procedures and orientation pro-
cgrams is not the only additional activity associated with
the development phase. Output from the phase includes a
complete documented system design, all necessary computer
programs, detail procedures for the operation of the system,
input document formats, output report formats, training
manuals as well as personnel and equipment requirements.
The three activities, computer program generation, system
procedure development, and orientation program development,
are included in order to convey some basic requirements of
the development phase. But these activities are not all
inclusive requirements for the phase.

Generation of computer programs--System specifications
flowing from the definition phase are transformed into com-
puter programs during this activity. To perform this function
within a desired time frame and at lowest cost requires an
orderly "production process." J. J. Connelly, in describing
such a process, identifies five basic steps as follows:
1. Requirement documents are translated into programming terminology. At this step, programmers study the requirements, identify and resolve any inconsistencies, and arrange the requirements so that they are logically grouped from a programming point of view.

2. Detail design of the required programs are worked out and clearly specified. The purpose of this step is to structure the program tasks required to produce the most efficient and lowest cost system. Experience demonstrates that inefficient task design results in redundant efforts in design, coding, and verification; extensive rework in coding and verification; and low programmer morale.

3. Detailed flow-charted programs are transformed into coded computer programs.

4. Coded programs are tested for accuracy of coding and for adherence to both design specification and original system requirements. A verification test plan is necessary in order to avoid oververifying some areas and under-verifying others.

5. Tested and verified programs are released. This consists of releasing of program decks, listings, tapes, and documents and delivery of them to the appropriate groups. There is some overlap in the activity of this step and that of system installation which occurs during the latter part of implementation. Thus the importance of the release step.
cannot be over emphasized. Careful planning is required in order to make a smooth transition into system operation.\textsuperscript{31} 

\textbf{Identification and development of system procedures—} Delivery of verified programs to the user does not set a system in operation. There still are certain procedures which must be followed in order for the computer based system to receive, generate, process, and display information. Typically these actions are viewed in terms of user requirements; however, Friedman states that system procedures should exist for the following functions:

1. The \textit{operation} of computers and computer-related equipment. These procedures contain the decisions and actions for operating the hardware associated with the computer programs.

2. The \textit{preparation} of the system for operation and use. Procedures should be included which describe data input formats and times. Included also within the function should be procedures which relate to the diagnosis of software difficulties. That is, if the computer program is not performing properly, procedures should exist which prescribe the diagnostic and maintenance activities necessary for ensuing normal operations.

3. The \textit{utilization} of the system to achieve the task and objectives of the user. The utilization procedures should

include all the descriptions and instructions necessary for operating the system. A few such procedures include system capabilities, options, and limitations; the way to start, stop, or recycle programs; the method for recovering from errors, and the consequences to operation if critical steps are not taken.\textsuperscript{32}

The detailed documentation of system procedures occurs during the development phase. Many of these procedures, however, are developed during earlier steps of the systems process. System operating requirements, which include interactions between system programs, equipment, and users, are determined by the basic structure and design specifications. These system requirements and specifications, generated during the conceptualization and definition phase, establish many basic operating procedures. During the development phase it is necessary to consolidate all such requirements and develop an integrated set of documents. In such an action a check should be made to assure that all procedural requirements are specified since proper system documentation is a necessity for successful implementation.

Design and development of orientation programs--The development of appropriate orientation programs is a third requirement of the development phase. Rosove states,

"Experience has shown that user personnel must have an opportunity to attempt to comprehend a system intellectually before they undertake efforts to make the system work in an operational environment."^33 System procedures alone cannot meet this requirement; appropriate techniques must be developed to complement these procedures.

The actual design and development of the orientation program should follow the basic logic of the systems process in general. First, there is a study of orientation requirements. Second, orientation program content and structure are defined. Third, orientation program and materials are developed and produced (lecture courses, games, models, briefings, manuals, films, slides, and so forth). Finally, the actual program is conducted or installed.

Time and cost factors often delay or reduce the development of appropriate orientation programs. The tendency thus exists to minimize the necessity of the orientation effort. In order to avoid such action, it should be realized that costs and time can be minimized by employing facilities and findings established during the earlier phases of the system process. For example, a simulation facility employed for experimental purposes during conceptualization may also serve to introduce the system to the user during the

^33 Rosove, p. 294.
orientation activity. This is a major factor that should make a game-implementation process a reality.

Appropriate orientation programs, detailed procedures for operation of the system, and all necessary computer programs should appear as outputs from the development phase. Each of these is a necessity for stepping into the next phase of the process. Minimizing the necessity of any one of these activities may result in major problems during system installation.

Operational Phase

The final phase of the systems process is the operational phase, often referred to as the installation phase. As the term implies, this is the period in which the components of the system, in conjunction with the user, are placed in the operational environment. In other words, this phase is that period of time during which activities associated with the development phase are completed and the system becomes a successful operating reality. The length of time associated with the phase will depend upon the size, complexity, and nature of the system. Likewise, the occurrence of problems associated with the activities of the phase depends a great deal upon the given system.

The first problem associated with the operational phase results from the difficulty in identifying where development activities end and operational activities begin. With the absence of such a decision point, there often is an inclination
to slip into the operational activities with inadequate preparation; deficiencies in equipment, personnel, or training; or partially documented operating procedures. This does not say that a sharp line of demarcation should exist between the two phases. Rather, it should be recognized that activities of both phases merge, and successful installation results when the proper sequence of activities is conducted. Rosove suggests the following sequence of activities:

1. Instruction of the users in the characteristics of the system.
2. Conducting a period of trial use of the system by the users.
3. Detection and correction of errors, inadequacies, and gaps in system operations.

Each of these activities forms a big part of the operational phase; however, before these are examined in detail, it is necessary to discuss what has traditionally been referred to as the "turn key" concept to system installation. Rosove describes the concept in this manner: "the completed system, after it has met its acceptance tests, is presented by the developer to the user who, on some predetermined date,

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34 Fernstermaker, p. 12.
35 Rosove, p. 280.
turns the system on."\textsuperscript{36} Such a concept, although somewhat mundane, is basically the philosophy for installation that developed during the nineteen fifties in association with quantitative based systems.

Recalling the basic nature of the systems process, it can be seen that a "turn key" concept is irrelevant, even within a quantitative based system. Human interactions exist throughout the systems process. During conceptualization, decision maker-analyst interactions occur. Similarly, decision maker-analyst-client interactions appear during system definition, while analyst-programmer-client interactions occur during development. Therefore, it is a fallacy to believe that interactions can cease when development is complete. It is more than likely that the opposite result will follow, that is, maximum interaction and interdependence should occur during the operational activity. Thus, a "turn key" philosophy to system installation can only result in failure because it ignores a basic concept of the systems process. A more realistic approach to installation is the sequence of activities suggested by Rosove.

Instruction of users in system characteristics.—One of the basic problems that must be overcome during the operational phase is user acceptance of the system. It is important that both high-ranking and lower ranking personnel
\textsuperscript{36}Ibid.
within the user organization accept the system since planning and managerial operations must occur during this phase. If such activities as a systems test (under operating conditions) are to occur, all levels of personnel must be knowledgeable concerning the objectives of the system.

If proper planning and development has occurred during the development phase, then orientation programs will exist for conveying system concepts and objectives to the user. The necessity of a formal orientation program depends upon the system and the particular level of personnel. Regardless of the orientation structure, three factors are important during the orientation activity. First, different types of user organization personnel require different levels of system exposure. Some individuals have been involved in different phases of the systems process (definition, design, development of orientation programs) while others are being exposed to the system for the first time. The orientation program must meet these different user requirements. Second, it is necessary to convey an operational capability; that is, user personnel must understand the nature and structure of the system.\footnote{Rosove, p. 288.} Depending upon the particular user, this understanding should include knowledge of structure of computer programs, functions performed by each group, functions of the system, and its associated elements, kinds
of system information output, kinds of system requests that can be made, and so on. The important element is to convey as completely as possible the system's operational nature and requirements. Finally, close control should be exercised over the orientation program to assure that the system is not over sold since lack of confidence can develop rapidly if the orientation program conveys capabilities beyond those of the system.

Conducting a trial use—In order to provide a means for operational tests and verification, it is desirable to establish a period of trial use for the system. One objective of this trial operation should be to facilitate a convergence between the expectations of the user and the actual system capabilities. It is likely that system performance may deviate from specification and that user expectations may deviate from reality. These discrepancies, however, can only be identified by exposure of all levels of user personnel to the actual operating system.

Detection and correction of errors—During the trial use period, errors and inadequacies appear that necessitate change. Changes which do not affect computer programs, such as changes in operational procedures and changes in organizational responsibilities, may possibly be made with relatively little difficulty. Changes which do affect computer programs, however, require a systems study before alterations are made, and many required changes may affect the total system structure.
If such changes are made without proper evaluation, then the system's performance and operation may easily deviate from that anticipated with the end result often being system implementation failure.

It is necessary to recognize and correct errors which exist in the system; however, control must be exercised to assure that each requested change is valid and necessary. Often many requests for changes result from lack of understanding on the part of the user. If a policy for making design changes is developed, control can be assured and deficiencies in systems operations can be identified.\textsuperscript{38} Such policies can be employed during both the operational test period and during full operation.

Proper performance of the orientation, trial operations, systems test, and detection and correction of errors activities should make the transition into full operation rather smooth. Also, the problems associated with moving into operational activities with inadequate preparation in the development phase should be resolved. It will be necessary to continue the orientation, test, and error correction activities after the trial operations. The level of action at these activities should diminish, however, as the system reaches its full operational or implemented state.

\textsuperscript{38}Rosove identifies a formal design change process associated with an information system of the Air Defense Command, p. 307.
Human Problems

Successful systems implementation requires a systematic approach, but there is also a need for resolving human problems inherent in the computer system. This is exemplified by the comments of a manager of a large systems department:

Computer technology was such a boom in the early years that no matter how badly systems were managed they had a positive payoff. It has been customary to accept failure and mismanagement as part of the new technology. This is now taking its toll. . . the economic payoff on new applications. . . is rapidly losing momentum. . . . The problem is not one of hardware or technology. The capabilities of hardware and technology have far outstripped our expectations. . . . We do not have technological problems; we have people problems. During the first decade of our experience with computers we emphasized the management of hardware. . . its design, acquisition, operation and maintenance . . . rather than the people associated with these functions.39

A major source of problems has been a lack of understanding by the people who are part of computer systems.

First, the manager often does not possess a firm knowledge of the capabilities of the computer, and in many cases places reliance on systems people to resolve any problem. As Marvin Kornbluh states,

operating managers seem to have trouble distinguishing between the capabilities of the computer and their influences. Although managers know that they are unlikely to be displaced by a computer system, they may experience it as a significant threat to their self-image, especially if their intuitive judgment and their years of experience are suddenly not sought after and appear to be

irrelevant. In addition, many managers are "over awed" by the physical appearance and operational speeds of a computer system. Unconsciously, they tend to envision it as something "all-knowing" and affecting, significantly, their time-honored way of doing things. They become fearful about their ability to adapt to automated data processing and decision-making.40

Some of the typical problems that result from the manager's insufficient knowledge of the computer and its systems are identified in a study by Michael D. Moore:

1. The manager most often expects nearly impossible results regarding real time, flexibility, cost, and efforts required.

2. There is a tendency on the manager's part to relate what other companies are doing without regard for the organization itself.

3. The manager requests impossible tasks for solving temporary problems that could be solved without the computer.

4. In most cases the manager expects a lot of data output from the system. The tendency is to associate volume of information output with the capabilities of the system.

5. In many cases the manager develops a negative attitude when his recommendations are ignored, especially if he believes that the computer system should be able to

40 Marvin Kornbluh, "Who's the Master of Your System?," Proceeding of AFIPS. (Maryland, 1970), p. 3.
comprehend his recommendation and views the rejection as a lack of concern on the part of the system's people.41 Such unrealistic actions and expectations on the part of unknowledgable managers can lead to major system problems.

Second, many operational personnel or users also have inadequate knowledge. The problems that result in this area are generally those associated with operation and use of the system, such as data inputs. Stillson found that one of the key problem areas in implementing a maintenance system is in convincing the operating personnel of the necessity of timely and accurate data.42 According to Gary L. Richardson, a major problem associated with implementing a relatively simple assembly tracking system is the lack of a data input discipline on the part of the worker.43 And Scott A. Gaulding believed that the major factor leading to the failure of a quality control system is the operational personnel's lack of knowledge of basic computer systems.44 In most cases such problems do not stem from the user's lack of knowledge of system objectives but rather from the user's

42 Stillson, p. 144.
deficiency of knowledge of the basic capabilities of the system and of the operation of the computer in conjunction with the system. Thus, it becomes a necessity in many cases to educate users in these basic concepts before identifying system objectives and operations.

All the human problems inherent in systems are not necessarily a result from the lack of skill in dealing with behavioral aspects. Warren expresses it in this manner:

As computer applications come to have more direct impact on the activities of every organization, management attention must be focused on the people aspect of computer systems... designers, programmers, users and recipients of computer-provided service... or there will arise a strong reaction against the continued application of computers to the solution of problems.⁴⁵

One of the basic problems resulting from the mismanagement of people is the tendency to related implementation failure to weaknesses of the system or deficiencies in the computer hardware. This is illustrated by a case example of a large industrial firm that experienced problems in implementing a resource allocation system.⁴⁶ Analysis of the case showed that management supported the system and agreed that it was desirable for reducing production costs. In implementing the system, however, excessive time delays (resulting from excess volume or load on the computer) caused output reports to be less than timely. As a result,

⁴⁵Warren, p. 50.
⁴⁶William Downs, Interview, Texas Instruments Incorporated, October, 17, 1971.
operating managers complained that the system could not be successfully used owing to the system's inefficiency in delivery of timely reports. After a period of time the excessive time delays were resolved by the addition of extra computer capacity (in addition, a backup computer was allocated in order to increase the reliability of the system). Resolving the timeliness of output data, however, failed to resolve the implementation problem within the system. Operating managers then complained that the historical data carried within the system really could not be used as a valid data base for the system; it was contended that a real-time updating capability was needed to support the data base. Analysis of the implementation problems by the systems groups indicated that failure on the part of operating managers in using the system was due to lack of direction, motivation, and control. The department manager, who initially endorsed the system, left the operating managers with the decision to use or reject the system. The department manager suggested adoption of the system but gave no direct motivation in this respect to his operating people. Also no departmental controls were established for managing the total implementation effort. The system analysts also expressed the opinion that many of the operating managers opposed the system as a result of the lack of knowledge; they (the managers) did not comprehend how the system operated and thus were skeptical of using it in their decision-making
functions. After eight months of unsuccessful use, the decision was made to drop the system. Failure in use of the system was attributed to system weaknesses as opposed to lack of direction, motivation, and control of the people associated with the system.

Successful systems implementation thus requires a resolution of the human problems inherent in computer systems. Managers and operation personnel must become knowledgable concerning computer and system capabilities, but also it is necessary to direct the people associated with system activities. This final requirement is true at all phases of a systems process not just at the operational phase.

A Need for an Integrated Approach

In order to develop and install a quantitative based system, the integration of factors associated with three major areas is required—namely, the acceptance and use of quantitative techniques, the employment of a systematic approach to the integration process, and the education, direction, motivation, and control of people associated with the process. Numerous problems exist in each of these areas. A major problem within the integration process itself which can lead to implementation failure is the tendency to overlook one or more of these major areas during the implementation activities. For example, as noted in Chapter II, a majority of the literature stressing the acceptance and use of techniques fails to include both a systematic approach to
the implementation problem and a recognition of the necessity for education and management of the people associated with the implementation activities. Similarly, it would be a serious error to overstress the education and management of the people element and overlook the necessity for a systematic approach to the total problem. The desired approach is that which integrates the needs in each of the major areas and resolves some of the associated problems. One possible approach is through the use of gaming.

A properly structured game, paralleling the logic and philosophy of the identified system, should serve both as a tool for research and evaluation as well as training. Such an approach is not unrealistic as exemplified by one author's comments:

Any business game could be used for some form of research; the obverse of the coin is that any simulation could be used for training. . . . a model primarily designed to search for and evaluate decision rules can also provide training. . . . A simulation, used as a game, can serve as an orientation device.\(^7\)

By integrating such an approach with the system process, a framework should emerge that addresses the implementation problem in a systematic manner.

Before such an approach can be established, it is appropriate to review the previous developments within the field of gaming. The objective of Chapter IV is to present

such an overview of the gaming area. In addition, the chapter will attempt to explore factors which have previously limited the use of gaming and at the same time attempt to establish some reasons for the emergence of the proposed game approach for the study.
During the past two decades there have been significant developments in the use of gaming. Games have become increasingly popular as training devices for management, as teaching aids in the university, and as experimental and operational devices. Before exploring the types of games and their uses, however, it is helpful to examine their historical development. Although the first business game was not developed until late 1956 (The AMA Game), the actual birth of gaming can be traced back to military war games. It is recognized that some relationships may exist between the mathematical theory of games and business gaming. Such theory provides some rather illuminating concepts of strategy and game value. It is also evident, from the amount of work that has transpired in the field, that such theory has stimulated interest in problems of a gaming nature. It is, however, beyond the scope of this study to explore the relationship of game theory with business gaming.

Historical Evolution of Gaming

**War Games**

Business games are a direct outgrowth of war games; the actual origin of war gaming is difficult to identify. Several authors have explored the early developments within gaming, each forming an opinion as to the origin of the field. In general, the conclusion is that chess was the earliest form of war game.

More important than the origin of these early games was their basic structure which was the basic foundation for the games that followed. In regard to structure, Weiner made this comment:

> Although it is not possible to be definite about the origin of war games, it seems that the games very early took on a formal and abstract character.

By formal is meant that there were definite rules covering what the players could do and what the immediate outcomes of each action would be. By abstract is meant that the rules, the playing board, the pieces, etc. were not specific representative of real life phenomena.

By 1798, the form of these early games had progressed to the point that maps were employed to replace the older kinds of game boards.

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3 Weiner, p. 132.

4 Cohen and Rhenman, p. 133.
By the latter part of the nineteenth century, the development of war games had branched out in two directions. First, there was the "rigid kriegspiel" or the rigid-play games. These games were characterized by formal rules that reflected the nature of the military exercise being simulated. Extensive charts, tables, and calculations were used to incorporate details such as troop movements and effect of fire and to make the games more realistic. The second variety of game, the "free kriegspiel" or free play, was less structured than the rigid variety with human referees, rather than formal procedures and rules, playing a major role.

The popularity of both the rigid and free varieties of war gaming during the latter part of the nineteenth century is reflected in the interest that grew in numerous countries. The early development of gaming occurred in Prussia, but by 1872 war games were used in the British army. Shortly thereafter, the United States began to explore the use of war gaming. Extensive work was done at West Point to further the variety of war games by the introduction of new technical apparatus and extensive tables based on data from the American Civil War and the Franco-Prussian War.

5 Ibid.
6 Thomas, p. 68.
7 Ibid.
By 1940 knowledge of war games existed throughout the world. The United States had established a Naval War College at Newport, Rhode Island, whose objective was to pursue the development of military games. Japan had established the Naval War College of Japan and the Total War Research Institute and was also engaged in the development and use of war games. The extent of Japan's development and use of war gaming during this period is reflected by the efforts that were expended in preparing for World War II. Robert D. Specht summarizes these efforts as follows:

In August 1941, a game was written up in which the two year period from mid-August 1941, through the middle of 1943, was "lived through" in advance and, of course, at an accelerated pace. Players represented the Italo-German Axis, Russia, United States, . . . Japan was played, not as a single force, but as an uneasy coalition of Army, Navy, and Cabinet, with the military and the government disagreeing constantly . . . Disagreements arose and were settled . . . in the course of an afternoon, at the pace of this game . . . with the military group, by the way, as the more aggressive one, winning arguments.

Measures to be taken within Japan were gamed in detail and included economic, educational, financial, and psychological factors. The game even included plan for the control of consumer-goods. . .

The development and use of military gaming continued throughout the 1940's and 1950's with interest existing in both the rigid-play and free-play varieties. Support for

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the free-play games continued because of their versatility in dealing with complex problems of tactics and strategy and because of the ease with which they could be adapted to various training, planning, and evaluation ends. Rigid-play games received continued support because of the consistency and detail incorporated in their structure. Strong support for the rigid variety of gaming was enhanced by the development of the computer in the late 1940's. With the aid of the computer, detailed computations could be quickly performed; thus some of the previous constraints of the rigid-play game were relaxed.

During the early developments of military gaming, the primary use of the tool was for planning and instructing. By the middle 1950's, however, there were some groups that felt its use could be extended. A comment by Alexander M. Mood highlights this view:

War gaming is the traditional final step after the preparation of the war plan; it is universally regarded as the best peace time test of a plan. Recently, the technique of war gaming has been modified to make it a method for solving problems previously thought to be beyond analysis and answerable only by appeal to the judgment of experts. By the mid 1950's extensive developments had been made in military gaming; at this same time the business community

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9 Weiner, p. 133.

began to question whether the concepts that had been applied to the military environment could be equally applicable to the business environment. The results of such curiosity brought on the birth of business gaming.

**Business Gaming**

The first business game was developed by the American Management Association as a result of experience drawn from the military war games. This is exemplified in the following comments by Franc M. Ricciandi and his associates:

> In the war games conducted by the Armed Forces, command officers of the Army, Navy, and Air Force have an opportunity to practice decision-making creatively in a myriad of hypothetical yet true-to-life competitive situations. . . . Why then shouldn't businessmen have the same opportunity? Why shouldn't a vice-president, say, in charge of advertising have a chance to play the role of company president for fun and practice? Why not a business "war game". . . . From these questions grew AMA's Top Management Decision Simulation. After an exploratory visit to the Naval War College, a research group was formed, and work began on a game which would eventually become part of an AMA course in decision making.\(^{11}\)

Paralleling the business environment, the American Management Association game was structured to represent five companies competing in a single product market. Each company was represented by a team of players who assumed responsibility for certain functions in their company, such as director,

sales manager, or production manager, and who made decisions for each quarter of a year on the following issues: the sales price of the product, expenditures on marketing and on research and development, rate of production and plant capacity, and finally purchase of detailed market research information about competitive behavior.12

The first American Management Association game, a computerized game, was first programmed and run on an IBM 650. The simplicity in the structure of the game did not require the use of a computer; however, the accuracy and the rapid computational capability of the computer made a computerized game more desirable.12

As a result of the success of the Top Management Decision Simulation game, other groups became interested in the field. Two off-shoots from the American Management Association game were the International Business Machines Management Decision-Making Laboratory and the University of California Executive Game No. 1.13 The International Business Machines game extended the American Management Association game somewhat by adding complexity in the market structure. The newer game divided the market into four sections. Three companies were placed in three separate sectors, each company having the majority of the market in his resident sector. Competition

13 Cohen and Rhenman, p. 136.
was defined to exist in the fourth common market sector as well as across resident sectors. The University of California Game No. 1 (Game No. 1 was obsolete with the development of Game No. 2) differed from the American Management Association game primarily in the financial area. Financial constraints were relaxed; net cash flow was allowed to fall below zero, which meant that firms could, in effect, borrow money for operations. Loan negotiation charges, interest, and factoring expense were also incorporated as part of the financial area.

By 1960, interest in the development of business gaming had broadened to include many academic institutions and industrial firms. Extensive work had been done in developing both computerized as well as non-computerized games. Some of the institutions and firms which developed computerized management games include the University of California, Carnegie Institute of Technology, Westinghouse Electric Corporation, the University of Washington, Pillsbury Mills, the University of Oklahoma, Indiana University, and McKinsey

\[14\] Ibid., p. 137.
and Company—International Business Machines.\textsuperscript{15} Some of the non-computerized games include Boeing Aircraft Corporations' "Operation Interlock," Esso Standard Oil Company's "Petroleum Industry Simulation," McKinsey and Company's "Business Management Game," and Herron's "Executive Action Simulation."\textsuperscript{16} The complexity of these management games ranged from relatively simple (Executive Action Simulation) to extremely complex (Carnegie Tech Management Game). Likewise, there were different variations in the structure of the games. For example, some games included stochastic elements in order to...


make them more realistic, and in many cases the games were
designed to be representative models of particular industries
(the Carnegie Tech game represented a packaged detergent
industry; the McKensey-IBM Bank Management Simulation
represented a commercial bank operation).\textsuperscript{17}

In addition to the group of general and top management
games that had been developed by the early 1960's, an array
of functional type games had also emerged. These games were
developed to focus attention on specific problems of decision-
making, in particular functional areas such as manufacturing
or marketing. One of the first games of this nature to
emerge was the "Materials Management Simulation," developed
by the American Management Association.\textsuperscript{18} This particular
game was designed to demonstrate management concepts associ-
ated with a firm's material flow activity which included
raw material purchasing, inventory control and production
scheduling, and finished goods distribution.\textsuperscript{19} The objective
of the game was to minimize the total cost of overall com-
pany operations subject to meeting product sales requirements.
Two factors that were characteristic of the game were that
no competition existed between firms (even though the game
consisted of two firms) and no interaction existed among
players (several teams could play simultaneously).

\textsuperscript{17}Cohen and Rhenman, p. 138.

\textsuperscript{18}J. Clifford Craft and Lois A. Stewart, "Competitive
Management Simulation," \textit{The Journal of Industrial Engineering},
XX (September-October, 1959), 362.

\textsuperscript{19}Ibid., p. 363.
Interest in the development of functional type games, though it emerged later, was almost as strong as that in the development of general management games. And numerous universities as well as industrial firms contributed to the development of functional games. Such games include General Electric's "Dispatch Game," Tulane University's "Production-Manpower Decision Game," University of Pennsylvania's "Smart," Kroger's "Supermarket Decision Simulator," and Burrough's "Steps." These functional games, in contrast to the general management games which were so encompassing that an optional solution was impossible to identify, were generally directed toward the use of particular techniques for arriving at the desired solution. For example, Tulane University's "Production-Manpower Decision Game" was designed to demonstrate the use of linear decision rules. Similarly, Jay R. Greene and Roger L. Sisson's "Materials Inventory Management Game" was designed to illustrate the concept of economic order quantity. In terms of complexity these functional games


21 Cohen and Rhenman, p. 142.

somewhat paralleled the general management games; thus some
of the games required the use of a computer, while others
were designed specifically for manual operations. (Greene
and Sisson's complete text is directed towards manual oper-
ations).

Though significant progress in game development had
been made in the United States by the early 1960's, other
countries had not been dormant. Both computer and non-
computer general management and function type games had
been developed in such countries as France, Sweden, and
England. For example, a computer manufacturer in France,
Compagnie des Machines Bull, had developed a top management
game that was comparable in complexity to the Carnegie Tech
Management Game. Similarly, an array of functional type
games such as English Electric Company Limited's "A Computer-
Based Manufacturing Game," Eilon's Inventory Control Games," and Kodak Limited's "A Business Game for Supervisors," had been developed in England. The extent of this foreign
development activity was significant in that at least two

23 Many of these games are described in C. West Churchman
and M. Verhulst, Management Sciences Models and Techniques

24 See F. D. Robinson and P. R. McKee, "A Computer-Based
Manufacturing Game," (abstract) Operations Research Quarterly
cited in Eilon, p. 145; S. Eilon, "Inventory Control Game,"
(abstract) Operations Research Quarterly, cited in Eilon,
p. 148; J. D. Croston and A. K. Soper, "A Business Game for
Supervisors," (abstract) Operations Research Quarterly cited
in Eilon, p. 146.
major international conferences reflected many of these developments.²⁵

The total level of game activity that existed in the early 1960's did not carry forward into the 1970's;²⁶ however, a significant amount of activities continued to flourish and still exists. An examination of the current literature reveals that gaming activities have now spanned a variety of industries and business activities. At least one company, the Didactic Game Company,²⁷ has been established for the purpose of designing games, simulations, and a variety of participative training materials for industry, educational institutions, and the government. During the past fifteen years business games have been recognized both as a tool for instruction and as a means for research.


²⁶As of the middle of 1960, there were over 100 different business games in use, as estimated by Max D. Richards and Fred W. Kniffin, "Business Decision Games--A New Management Tool," Pennsylvania Business Survey cited in Cohen and Rhenman, p. 142. A publication by Paul S. Greenlaw, Lowell W. Harren, and Richard H. Rawden, Business Simulation (Englewood Cliffs, 1962) summarizes eighty-nine business games. Only a representative sample of these games has been included in this historical overview. The current literature reflects that this same volume of game activity has not occurred for the past five years.

Types of Games

Two types of games, functional and general management, have been identified; however, to be fully cognizant of the area a more in-depth exploration in the structure of games is required. In order to establish a basic framework, Eilon states that a game-type classification can be made by examining the design characteristics of a game, and he suggests three such characteristics. First, a game is designed to be total enterprise or functional. Second, a game is either interacting or non-interacting. Finally, a game is either computerized or non-computerized.²⁸

A total enterprise (general management) game is designed to give game participants exposure to decision making at a top managerial level within a simulated organization. Games of this nature are structured so that several managerial functions are brought together. Players thus have an opportunity to view how several functions interact to further policy decisions. In general, most total enterprise games parallel the logic of the first American Management Association game, that is, a team of players, allocated with specific functional responsibilities, interact to establish a company's policy decisions (normally set as a group of decisions that are input on a quarterly basis). The complexity of such a game is dependent upon the number of functional areas

²⁸Eilon, p. 138.
(players) included in the game, on the number of decisions to be made each quarter, on the interrelationship of various game parameters, and on the competitive market structure for the game.29

Functional games are designed to demonstrate problems encountered in a single functional area, such as marketing, inventory control, or production scheduling. In most cases functional games are much simpler than total enterprise games. For example, most functional games are structured for individual participation as contrasted to the team play that is characteristic of total enterprise games.

The interactive design characteristic of a game describes the relationships between game participants. In interacting games several teams of participants play in competition. The nature of these games is such that the performance of one team is affected not only by the decisions taken by its members but also by the performance of the other teams.30 Non-interacting games are void of participant interaction; that is, simultaneous play of a game by more than one participant has no bearing on any one individual's performance. Most functional games are non-interacting.

The large number of variables and interactions associated with most total enterprise games becomes so complex that

29 Ibid.
30 Ibid., p. 139.
often a computer is required. In contrast, most non-
computerized games are not so sophisticated in detail and
in the number of variables that are used. Complexity and
computational rigor alone, however, should not be a sole
criterion for a decision concerning computation. Many
advantages may result from computerizing even a simple
functional game.

Using Eilon's game classification scheme, several re-
representative examples can be noted. First, the Carnegie
Tech Management Game can be identified as a total enterprise,
interacting, computerized game. And Esso Standard Oil
Company's "Petroleum Industry Simulation," can be described
as a total enterprise, interacting, non-computerized game.

Purpose and Use of Games

Game use also has a bearing on game structure. Thus,
game classification can be extended by establishing a classi-
fication based on game use. Numerous examples of game use
exist in the literature. Broadly classified, these examples
describe the use of games for both teaching and research.

Games for Teaching

Games in one form or another have been used in both the
academic and industrial environment for teaching purposes.
(Although games have been employed in other disciplines such
as psychology, political science, and sociology, the use in
these areas has primarily been for research). The Carnegie
Tech Management game has for several years been incorporated into the graduate academic program at Carnegie Tech (now Carnegie Mellon University). Likewise business games have become regular parts of the business curriculum at such schools as the University of California, Michigan State University, and the University of Pennsylvania. Many large industrial firms such as International Business Machines, Westinghouse, General Electric, and Esso Standard Oil Corporation have in the past employed business games as part of their internal executive training program. In addition, the Systems Development Corporation has made extensive use of gaming for training purposes in the development of large military systems.

In attempting to assess the objective of employing games for teaching purposes, Martin Shubik identified three game-use categories, namely

1. The teaching of principles.
2. Training and teaching skills or facts.
3. Supplementary support for course instruction, such as a dynamic case study.

These particular sub-classifications highlight the key usage of most business games (for teaching purposes).

31 "In Business Education, the Game's the Thing," Business Week (July, 1959), p. 56.
32 Rosove, pp. 235-277.
33 Shubik, p. 631.
The teaching of principles.—One advantage of gaming is that participants develop some skills by playing an active part in the game proceedings; however, the basic objective of many games is not to teach skills. As an example, in discussing the Carnegie Tech game, K. J. Cohen and his associates commented that

...the emphasis is not on teaching managers skills; it is limited to reminding experienced specialists that the functions and the people of a business are interdependent and that many decisions must be made under time pressure by the cooperative judgments of several individuals.34

Generalizing, it can thus be said that the major objective of most general management games has been to demonstrate to the participants that upper level managers must have the ability to organize and use information from a complex and diffused environment and must be able to forecast and plan while interacting with numerous functional areas.

The primary teaching objective of most functional games has been to demonstrate the need for formulating an optional policy. Through repeated play in a feedback type environment, it has been found that participants can identify with and appreciate the need for formulating an approach for resolving functional problems.

Teaching skills and facts.—Military science has been chiefly responsible for the employment of gaming for teaching skills. In many cases elaborate simulations of radar and

sonar exercises, link trainers, and communication networks have been designed. Such simulated operations have provided game participants the opportunity to gain experience which could not be obtained otherwise without acting in the actual situation. One disadvantage of such activity, in terms of employment by the business community, is that considerable time and expense is most often associated with developing the gaming operation.

Supplementary support for course instruction.—After some experience with business games was gained it became obvious, particularly to the academic community, that a possible extension to gaming was to incorporate it into the traditional case study teaching method. Such game-case studies have been developed and employed. The general opinion concerning these is that they enhance the case study analysis by providing a more dynamic type environment through an information feedback network. A disadvantage of the approach had been the resource requirement. In many cases extensive costs have resulted in developing an appropriate game that adequately supplements the case study.

It should be emphasized at this point that, while games have been successfully employed as a means for teaching concepts and principles, as a training aid, and as case study

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35 An extensive analysis of a game-case study approach is presented by Cohen and Rhenman, pp. 153-158.
supplement, there is no unanimous support for the employment of gaming. It has been argued by some educators that too much of a "game" perspective pervades the use of gaming and that this destroys the possibility for serious analysis. Similarly, it has been argued that economically gaming is an inefficient method of instruction, particularly if the initial cost of the game is considered. Likewise, criticism has resulted from the fact that improperly administered games can misrepresent facts and principles.

All arguments concerning gaming, however, are not negative; there are those who strongly support it. In particular Cohen and Rhenman identify several positive factors in support of gaming as a teaching aid. These are as follows:

1. In general management games, the participants become vividly aware that the various functional specialties of a business are closely interrelated. While this fact is stated in most business courses, it does not seem to have the forceful impact that participants receive through participation in management games.

2. General management games place participants in an essentially dynamic situation. Decisions at any point in time are affected by past actions (including the competitor's actions) and the alternatives available in the future. This dynamic situation is absent in many other forms of instruction.

36Shubik, p. 634.
3. The risk and uncertainty that is characteristic of most business environments can be incorporated in both the functional and general management games. The importance of risk and uncertainty is often overlooked in other instructional approaches.

4. The necessity of systematic collection and analysis of information is strongly emphasized in most games. The feedback of results from input decisions reinforces the necessity of decisions based on proper information and analysis. This feedback of result is often voided in the case study type analysis.

5. The total task situation, which a game imposes upon a participant, provides an opportunity for learning or reinforcing a variety of analytical tools. Functional type games emphasize the necessity of an optimal analytical approach. Statistics and probability theory are emphasized in connection with general management games, such as in purchasing marketing information and attempting to forecast certain variables.

6. Many institutional facts can be presented through the use of gaming. For example, by designing output reports (which come to the participants from the computer) to conform to standard operating forms, participants can learn a great deal about the meaning of the report form. A game structured to parallel a given business environment can thus enhance operations by reinforcing familiarity with the operations.
7. Playing a game may focus the participant's attention on the importance of establishing policies and on making long-range plans. This fact too is often stated in many business courses; however, business game play strongly reinforces this necessity. This is particularly true in the case of functional games where an optimal approach is desirable. 37

No empirical evidence is presented which proves or disproves these factors; however, the authors refer to cases throughout the examination which are in support of several factors.

Games for Research Purposes

Games have been useful not only for teaching purposes but also for research. Under the category of research, games have been utilized for both experimentation and operational purposes. Significant activity has occurred in both of these areas.

Operational gaming.--Operational gaming in a true sense is not a subclassification of business gaming. Like business gaming it has roots in war gaming; however, it has more direct roots in the theory of games. Operational games seek to find an optimal solution or strategy by repeated play of the game. Thomas and Deemer define operational gaming and develop its historical base with the theory of games. 38

37 Cohen and Rhenman, pp. 145-151.
Operational gaming has been employed more within the disciplines of economics and political science in terms of attempting to find optimal solutions to competitive environment. Employment within the business environment has been more in terms of exploring behavioral patterns and evaluating the behavior of systems. Much of the work within the business environment falls more under the heading of simulation.

If the structured environment simulated by a management game is sufficiently realistic and if game participants react in a realistic manner, then gaming can be employed in several operational modes. First, it has been found that operational gaming can be employed as a means of practice for operations or plans. For example Shubik stated,

"Field maneuvers," "shake down cruises," and "dry runs" have been used by the armed forces for many years. Political, diplomatic, and economic "shake down cruises" are of more recent origin. . . . Individuals lacking experience usually tend to seriously underestimate the costs, time, and difficulty involved in carrying out a new operation involving many or even several participants. . . . This methodology of operational gaming for "debugging" is possibly the most important contribution of gaming.39

Some groups are of the opinion that operational games can also be employed to study the behavior of systems. Eilon expresses it in this manner:

. . . in a game the human element is always present and the game usually represents a system in which human decisions have a significant effect on the course of events. The purpose, then, is to study

39Shubik, p. 635.
the characteristics of the system as a whole and its reaction to varying conditions or to test the sensitivity of certain rules of behavior. 40

A third area of operational application is in exploration and planning. A large volume of the work in this area has appeared in the military and political sciences. For example, Herbert Goldhamer and Hans Speier have explored some operational aspects of politics through gaming. 41 Similarly, Robert D. Specht as well as others have examined the use of gaming in planning and analysis within the military environment. 42 Some operational applications, however, do exist in the business environment. For example, Norman N. Barish and Frederick H. Siff have examined the use of operational gaming in exploring the functions of the stock market. 43 Following along similar lines, the Carnegie Tech Management Game has been employed to explore the effects of changing organizational structures and communication patterns.

From such exposure in the operational area, it has been found that a realistic game-simulation is often difficult to

40 Eilon, p. 142.
43 Norman N. Barish and Frederick H. Siff, "Operational Gaming Simulation With Application to a Stock Market," Management Science, XV (June, 1969), B530-B541.
achieve; however, the benefits that can accrue often justify the activity. Many authors agree that one of the key benefits resulting from an operational activity is the detailed rigor and analysis required in constructing the game. One author expresses it in this manner: "The mere attempt to build a formal game representation of any phenomenon provides a discipline that has for the most part been lacking in subjects such as economic theory or political science."^44

Experimental gaming^45^Games involving the study of the decision-making processes of individuals can be classified as experimental games. As such, games of this nature have been employed in psychology and economics as well as in organization theory. For example, the study of oligopoly theory, the development of a behavioral theory of the firm, the functioning of teams, and the establishment of organization and communication patterns have all been subjects of experimental games.^46

To date most experimental games have been of a non-computerized variety. For example, S. Siegel and L. E. Fouraker employed a highly controlled non-computerized game to investigate hypotheses concerning competitive behavior and

^44 Shubik, p. 636.

^45 Since it is beyond the scope of this study to explore the total field of experimental gaming, only a brief look at the area is made in order to give the reader exposure to this particular use of gaming.

^46 Shubik, p. 638.
the roles of a reward system and communication and information patterns.\(^47\) Similarly, numerous non-computerized games have been used in studying competition and bargaining. In contrast to complex business games, most of these non-computerized games have been simple and in many cases have only involved a minimum of tasks.

In addition to the simple non-computerized games, experimental gaming has employed complex business games. For example, the Carnegie Tech game has been used to study organizational behavior. In studying changes in the external environment of a firm and other aspects of the organization, Charles P. Bonni employed a somewhat sophisticated computerized game.\(^48\) Similarly, International Business Machines in the mid-1960's developed a complex computerized game for experimental purposes.\(^49\)

Some of the more recent literature has been directed toward identifying behavioral patterns associated with formulating strategies. In some of these experiments, games have been structured in which the participants play against the system. Performance and learning processes are observed


during the game activity as the participants are supplied more data. Findings from work of this nature have been important in the construction of man-machine systems in which an individual is placed in a learning environment. One necessity of system design is to structure the system so that it is adaptive to individual learning processes.

Limiting Factors

Although various types of games exist which have numerous uses, there are several factors which have limited their development and use. For example, game activities have been limited by the fact that the design, development, and operation of a game may require many months of development work and many thousands of dollars in computer time and facilities. It is, therefore, desirable at this point to examine this area in some detail. Even though it is beyond the scope of this study to present an in-depth coverage, an overview of such factors as game construction and computer and facility requirements should give some insight into gaming limitations.

50 In an analysis of forty-eight responses from game-developers Shubik (pp. 639-650) identifies some limiting factors associated with the development and use of games. Some of these findings are summarized here to give the reader an understanding of problems associated with the area.
Game Development

Game development may require a few man-hours or as much as several man-years of effort. Much of the difference is, of course, accounted for by the differences in size, complexity, and purpose of the game under construction. Also a complex game may require several additional man-months of checking before it becomes operational.

With the exception of the most basic experimental game, requirements for construction of a game are closely related to those of systems development and model building. Shubik identifies the following four basic skills required in computerized game construction:

1. The ability to formulate an abstract representation of the phenomena to be considered.

2. Skill in the construction of a viable model that is amenable to control, to manipulation, and to analysis.

3. Programming skill, especially with respect to the modification of the programs and the flexibility of input and output.

4. Skill in the design of experiments and the general design of data processing procedures. \(^{51}\)

From this basic framework it can be noted that gaming development requires a knowledge of techniques and procedures of data processing and modeling. It should be emphasized,

\(^{51}\)Shubik, p. 645.
however, that the requirements associated with the construction of some games are substantially less than others. For example, time and costs of developing a game for operational purposes (and for some experimental purposes) are usually much greater than those needed for teaching purposes.

Regardless of requirement differences, many authors express the opinion that one of the key benefits resulting from game construction activity is the detailed analysis required. Many dormant relationships and variable interactions that are key elements to the operations within the area under investigation are often identified during game development.

Paralleling the systems development activity, game development often requires a substantial period of time for "debugging" before a game can be placed in operation. In most games constructed for teaching purposes, this does not represent a serious problem; actual trial runs can be made with game participants. Much of value in terms of game use results when users find errors or flaws in the game. Operational games pose more problems in terms of "debugging;" in most cases relatively high level participants must be employed for a somewhat extended period of time in order to test the game. In the case of large operational games, substantial expense may be incurred both in terms of manpower and computer time.52 Experimental games do require checking,

52Cohen and Rhenman, p. 160.
but most games of this nature are relatively simple in construction so that validation of the game logic as well as the program is somewhat easy.

Computer and Facility Requirements

In addition to the burdensome constraints of design and development, many games require both extended computer capabilities and facility support. For example, the Carnegie Tech Management Game requires an extremely large computer facility; in addition, facilities are needed for clerical work and for the organization and storage of special subroutines and analysis programs. Size alone, however, does not dictate these added requirements. To understand the nature of such additional game requirements, it is desirable to examine computer and facility requirements in detail.

Computer requirements.—Many simple games employed for experimental purposes do not require the use of computers, but simplicity alone is not a sole criterion for determining computerization. Although the complexity of a game may necessitate the use of a computer, there are negative sides to this. First, many computerized games which require excessive capacity may virtually tie up the computer; this means that the size and cost of the computer become important. Second, many computerized games for the most part are immobile in the sense that gaming operations must be performed in the locale of the computer facility. Finally, since in most gaming operations participants do not have direct access to
the computer facility (much of computer input is in the form of game sheets which are submitted to an administrator) the level of comprehension of the total operation is not as great as is desirable.

Though all these problems have not been resolved, current technology has reduced these to a manageable few. Of prime importance are the current capabilities within computer time-sharing.\textsuperscript{53} With the past technological growth in this area, it is now possible to automate games completely to the extent that a participant may interact with a game directly by way of an input-output console. In addition, telephone data reception and transmission can be linked to a variety of input-output devices. Thus, many prior game-computerization constraints have been resolved. With the exception of large computerized games which may require access to a laboratory facility, it is now possible to construct a variety of games that require interaction and mobility as well as medium computer capacity.

Facility requirements.—Though time-sharing has made gaming operations more flexible, it is not a panacea for all such activity. Many games require more formal facilities

\textsuperscript{53}It is recognized that computer time-sharing is almost a decade; however, the current capabilities within the area such as high speed data transmission and reception (30-60 characters per second), interactive operation, unlimited computer capacity through chaining operations, and graphical output devices have extended the capabilities with the area.
than mere access to a computer. This is especially true of some games used for operational and experimental purposes. For example, the Navy Electronic War Simulation Laboratory at the Rand Corporation has required millions of dollars of special apparatus in the creation of simulated environments for large tactical war games and logistics exercises.\textsuperscript{54}

Similarly, the Systems Development Corporation has expended several million dollars in the construction and use of gaming facilities where experiments in psychology, small group behavior, and business gaming activity have been run. In addition, many large universities such as Carnegie-Mellon University, the University of Michigan, and the University of California employ games requiring special laboratories as well as clerical and administrative support. Thus, depending upon the use as well as complexity, game facilities and support requirements may range extremely high.

It should be pointed out, however, that all games do not necessitate such facilities; many can be operated with a minimum of resources. But this does not imply that facilities can be overlooked; negligence in terms of facility requirements can result in the failure of a well-structured game. Just as the development and implementation of a system requires a systematic process, game development and implementation require proper evaluation, planning, and control.

\textsuperscript{54}Shubik, p. 643.
Though gaming may be limited by development and facility requirements, it should be useful in resolving some systems development and implementation problems, particularly since these activities may be involved. Chapter V, therefore, will explore a possible approach for using a game in a systems framework—the game-implementation process. This discussion will be directed towards integrating the findings of the previous two chapters with some of the ideas discussed in this chapter; however, it will be done from a conceptual point of view. No attempt will be made to take a step-by-step approach in resolving all implementation problems, nor will the discussion necessarily be in the sequential order of the systems process (as identified in Chapter III). Rather, the approach will be to employ the findings of the chapters as supportive bases for explaining or justifying the analysis.
CHAPTER V

THE GAME-IMPLEMENTATION PROCESS

The purpose of Chapter V is to identify the game-implementation process and to discuss the merits of adopting such an approach. It is, however, necessary first to delimit the field of application within which the process is meaningful. Without realistic operational constraints, additional implementation problems can be created. Thus, a secondary objective of the chapter is to identify the area of applicability for the process.

Section one of the chapter explores the area of applicability for the process. A planning and control framework is identified and examined in detail. The planning and control framework in this case should not be confused with that suggested in Chapter II in regard to implementation of a computer system. Here, planning and control activities will be used to subdivide the organization in order to identify where a game-implementation process is most applicable. A distinction is made between strategic planning, management planning and control, and operational control. With the game approach demonstrated to be more meaningful when applied within the operational control area.
Section two discusses some of the benefits that could result from the game-implementation process, particularly, with reference to resolving behavioral problems and some problems associated with the acceptance and use of quantitative techniques. The third section develops the game approach. Although, traditionally, gaming has been employed as a training aid during the operational phase of systems implementations, it is here suggested as a systems analysis aid during conceptualization.

The concluding section of the chapter, which summarizes the process, makes an attempt to show how the game approach affects each of the phases of the systems process.

The Delimited Framework

Earlier, it was noted that the organizational environment as well as the level of management support are key variables affecting systems implementation. For example, the statement was made that, if the organizational environment is such that organizational goals and outputs are not well defined or if management is unable to develop and communicate explicit objectives for the organization, then implementation problems may occur. However, all implementation problems are not necessarily created by these failures. Rather, they often result from the systems group's inability to recognize that each of the different management or organizational groups within the organization requires a different approach to the systems process. For example,
at the top level the strategic planning process is involved with major goals and policies of the organization such as product definitions, desired market objectives, means for financing operations, as well as profit objectives. Thus, a systems approach within a strategic planning environment should differ somewhat from that within an operational environment where the focus of attention is on day-to-day operational problems and on assuring that specific tasks are executed effectively and efficiently.

Although different approaches to the systems process may be required in the different organizational environment, this does not imply that a game activity is irrelevant within these. On the contrary, games have been developed which emphasize concepts relevant to the total organization (management games) as well as to the lower operating entities of an organization (functional games). The point that must be recognized is that, because of the differences in structure, objectives, data and information requirements as well as in the type of individuals involved, it is unrealistic to propose a game-implementation process which would be applicable at all levels of an organization. Instead, the process must be structured for a specific organizational environment or management group.

The necessity for delimiting the game-implementation concept to a particular environment or group can be perceived by examining the different organization or management
functions, particularly the planning and control functions, that can exist in an organization. A framework identified by Robert N. Anthony which consists of three processes—strategic planning, management planning and control, and operational control—is helpful in understanding these planning and control functions. In the framework, planning as well as control activities occur within each major process. The key planning functions, however, occur within the strategic planning and management planning and control processes, while the majority of the control activities occur within the latter two areas. Activities relevant to each of the processes are highlighted in Figure 7.

Within this framework, the emphasis of the quantitative and management science activities has occurred primarily in the operational control area. A heavy emphasis on modeling and game activity within the operational control area. However, before examining the relevance of modeling and game activity within the operational control area and within the other planning and control areas, it is necessary to identify and characterize each of those areas in more detail.

1Robert N. Anthony, Planning and Control Systems: A Framework For Analysis (Boston, 1965), p. 15; Anthony uses the term "management control" in his text; however, for discussion purposes here the term "management planning and control" will be employed.
### Fig. 7--A planning and control framework

Source: Anthony, p. 19.

#### Strategic Planning

Within any organization a key requirement is the identification and definition of the objectives or goals and the major policies and plans for achieving these goals. Numerous terms appear in the literature describing such activity. For example, Tead Ordway identifies the activity as "administration," and Bill E. Goetz uses the term "design of the enterprise."² On the other hand, Anthony uses the term

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"strategic planning" to label the activity. His definition of the activity is as follows:

strategic planning is the process of deciding on objectives of the organization or 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.3

In order to gain insight into the strategic planning process, one must understand certain characteristics such as the scope, complexity, degree of structure, the nature of information and organizational relationships. These are defined as follows:

Scope.—Strategic planning does not necessarily embrace all aspects of a company's operations. Even though it is necessary that the analysis of a proposed plan take into account all the significant consequences that the proposal may have throughout the organization, this does not imply that the total organization is affected by a given strategic plan.

Complexity.—Although the strategic planning process does not necessarily embrace the total organization, it generally is complex. Social and political as well as economic matters must be dealt with. Similarly, since the strategic planning activity must set the framework and guide lines for the organization, it is invariably more

complex than working within guidelines, which is the case at the lower levels within the organization.

Degree of structure.—Strategic planning is essentially irregular. Problems, opportunities, and ideas do not necessarily arise according to a set timetable. As a planning aid, techniques such as technological forecasting can be employed during the planning process, but because of the social, economic, and political factors associated with the area, even these techniques often do not regulate the planning activity.

Nature of information.—Information used in strategic planning is considerably different from that used in other areas of the organization. First, heavy reliance is placed on external information, such as market analyses and technological developments. Second, much of the planning information is imprecise. Often the strategic planner must make projections covering a rather long time period; thus a degree of uncertainty often exists in some planning information. Finally, data requirements change, depending on the nature of the problem being studied. Owing to the varied and unpredictable nature of the data required, it is thus somewhat unrealistic to conceive of designing an all-purpose, strategic planning information system.

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4 Ibid., p. 38  
5 Ibid., p. 38  
6 Ibid., p. 45.
Organizational relationships.—Top management, supported by a staff group, is involved with strategic planning; line managers are not usually major participants in the process. Since much investigation and analysis are needed as a basis for making strategic decisions, it is often necessary to seek information, ideas, and advice from the operating line managers, but the responsibility of the planning effort resides in the staff area of the organization.

End results.—The desired output from strategic planning is objectives and policies that can serve as a framework and guideline for the lower operating entities within the organization.

Management Planning and Control

Given that organizational objectives and policies are established, management planning and control is the process which directs and guides the operations in accomplishing the established objectives. This process, which differs significantly from the strategic planning process, is, however, carried on within the guidelines established by strategic planning; facilities, the organizational structure, product lines, plant location and capacity, and some financial factors are more or less accepted as given factors. Characteristics that describe this area are as follows:

Scope.—Whereas strategic planning may affect only a segment of the organization, management planning and control

7Ordway, p. 101.
embraces all aspects of an organization's operations. In order to assure that all operations are in balance with one another, the scope of this level of management activity must encompass the total organization. Thus, control within the organization's operations necessitates information about each aspect of the business.

**Complexity.**—Management planning and control is less complex than strategic planning. Management activities within the process take place within a framework of policies and plans already decided upon. These constraints thus simplify such management tasks as preparing an operating plan and operating in accordance with the plan.

**Structure.**—The structure of the management planning and control process tends to be rhythmic; that is, it follows a definite pattern or timetable, which is repeated. The budgeting activity of the organization is an example of such rhythmic action. Anthony's description of the budgeting activity highlights some of the rhythmic actions associated with the area:

Certain steps are taken in a prescribed sequence and at certain dates each year: the dissemination of guidelines, the preparation of original estimates, the transmission of these estimates up through the several echelons in the organization, the review of these estimates, final approval by top management, dissemination back through the organization, and the reporting and appraisal of performance.  

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8 Anthony, p. 39.
Although the general activities of management planning and control are rhythmic, specific actions are taken when required. In some cases the control activity for the process may warrant some discrete actions. This, however, does not invalidate the generalization that the process as a whole can be viewed as a recurring flow of activities.

**Nature of information.**—In contrast to strategic planning, the information requirements for management planning and control vary somewhat. First, a heavy reliance is made on internal, as opposed to external, data. Second, most information has an underlying financial base; reporting is expressed or equated with monetary units. Other quantitative measures such as yields, turnover, and productivity, and nonquantitative expression such as quality, ability, and cooperation are a necessity and are thus employed. But, because of the necessity for coordinating and controlling the total organization, it is generally necessary to reconcile nonmonetary information with monetary information. Finally, owing to the rhythmic nature of the process, the data that are used are usually collected and organized in the same manner monthly.

**Foundation.**—Whereas the basic foundation for strategic planning has roots in economics, the management planning and control process has a social psychology as well as financial base. The operating manager is concerned with financial
matters, but concern must also exist for the individuals associated with the planning and control activities.

Control.--Management planning and control involves a mixture of both planning and control activities; thus control is important. Since time horizons are shorter and since activities occur rhythmically and according to prescribed procedures, control within the process is somewhat easier than within the strategic planning environment. Size, complexity, and differing data requirements, however, complicate control activities.

End results.--Effective and efficient action within the prescribed policies of the organization is the objective of management planning and control.

Operational Control

In operational control the focus of attention is on execution, that is, on action and control activities rather than the planning function; a minimal of planning activities occur. Anthony, in defining the process, expresses it in this manner: "it is the process of assuring that specific tasks are carried out effectively and efficiently."9

The specific tasks associated with operational control involve such activities as scheduling and controlling individual jobs through a shop, controlling inventory, and specifying the optimal material requirements for a production

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9Ibid., p. 74.
process. This is in contrast with management planning and control which assumes responsibility for the total production and inventory management for the organization.

Characteristics which describe the operational control process are as follows:

Scope.--The focus of operational control is on specific tasks, and in most cases activities associated with the tasks occur within a set of defined procedures and rules derived from strategic planning and management planning and control. This, however, does not necessarily imply that the process or activities associated with the process are simple or that they are restricted to a small area. For example, production scheduling in an automotive company, which involves a nationwide network of assembly plants, parts plants, and supplier facilities, is a rather large and complex process.¹⁰

Structure.--The structure of the operational control process is essentially objective. The process is thus principally concerned with activities for which correct decisions can be determined objectively. In many cases a valid decision can be stated by mathematics or by a set of logical rules. Much of the activity within the process thus falls into the category which Herbert A. Simon calls "programmed control."¹¹ In contrast, the management planning

¹⁰ Ibid., p. 76.

and control process is more subjective, and in many cases psychological factors are dominant elements.

**Information requirements.**—Data requirements for operational control differ significantly from those needed for management planning and control. First, operational control data are often expressed in such terms as man-hours, number of items, units of output, and number of rejects rather than in financial terms. Second, in most cases operational control data are in real time and related to individual events, not retrospective in summarized form. Finally, whereas management planning and control requires only approximate data, operational control activities require exact data. For example, material is ordered and scheduled in specific quantities, and output is expressed in specific numbers or volumes.

**Process foundation.**—Whereas strategic planning draws upon economics, and management planning and control draws upon the areas of social psychology and finance, the operational control process relies heavily on the physical sciences. Techniques of inventory control, production control, and other related areas of the management sciences are an important part of the logical and technical base for the area.

**Systems importance.**—The role of systems within the operational control process is a key function while in the strategic planning and management planning and control
processes systems form more of a framework for activities that occur within the processes. For example, in the management planning and control process, systems can provide information which aids in making decisions and which can often identify the need for exploring certain activities within the organization. However, success or failure within management planning and control depends a great deal on the judgment, knowledge, and ability of the manager employing the system and the manner in which the system is used. In the operational control process, the system most often functions in the process to state what actions should be taken, and in the case of a fully automated operation the system will make the decision and take the appropriate actions. The degree of management involvement in the operational control area is thus at a minimum; the system is a key aspect of the process.

Relevance of Modeling and Game Activity

Regardless of the differences between the different planning and control processes, modeling and gaming activities are relevant within these. For example, in strategic planning, a modeling activity is useful for exploring different decision alternatives. In many cases it may also identify the need for a strategic decision. Similarly, a strategic game designed to interrelate some environmental and economic variables may serve as another useful tool for identifying the need for strategic planning. An organization model,
developed mathematically by interrelating many of the key variables within the organization, can serve to analyze probable consequences for alternate management planning and control decisions. Likewise, general management games can be of aid in conveying to managers that many variables within the organization are related and thus interact to affect the outcome of the organization. In the more structured areas of the organization, functional games can serve as training aids. In many cases models such as inventory control, resource allocation, and production scheduling complement the structured environment. Thus, in general, modeling and gaming are relevant within the different planning and control processes.

The question that should be addressed next is how relevant are the activities to the processes? John D. Little examined some of the more recent modeling activities and concluded that, owing to scope, number of variables included, and the often unstructured environment of the area being modeled, most modeling efforts are unrealistic; thus the results from many modeling activities are seldom or never used.\(^1\) Because of the complex and unstructured environment of strategic planning and because of the wide focus and large number of behavioral and judgmental variables associated with

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management planning and control, it can be concluded that modeling activities within these processes may be of limited benefit. It is thus reasoned that, with the rigid structure and the quantitative base of the operational control area, modeling and game activity have a higher degree of relevance within the area than within the former planning and control processes.

If one assumes that modeling and gaming have a high degree of relevance within the operational control area, the question of necessity can then be raised. In other words, since the focus of the operational control process is on specific tasks that occur within a defined set of constraints and since the structure of the process involves a set of logical decision rules, it would appear that the need for modeling or gaming would be limited. Thus, what necessitates a game-implementation activity within the area?

In addressing this question of necessity, two points are significant: First, the importance of a system within the process and, second, the implementation of the system. In characterizing the operational control process, it has been noted that systems are a key aspect of the process itself. A system, with few exceptions, is thus a necessity in the process. In terms of implementation (the definition, development, installation, and operation of the system), the defined characteristics of operational control convey the idea that implementation activities are somewhat routine and
simply involve identifying the mathematical relationship or logical set of rules that can control the specific task under question. This, however, is far from the truth, as proved by the high failure rate of system implementation in the operational control area.\textsuperscript{13}

Thus, because of the necessity of using a system and because implementation problems exist within the area, a game-implementation activity is relevant to the operational control area. The remainder of the study, therefore, will be limited to developing the game-implementation approach that is meaningful within an area which could be characterized as an operational control process.

The Impact of Gaming on Systems Variables

Earlier it was stated that to successfully develop and install a quantitative based system requires the integration of factors associated with three major areas, the acceptance and use of quantitative techniques; the education direction, motivation, and control of the people associated with the system activities; and finally the employment of a systematic approach to conceptualization, development, and installation activities. The objective of this section is to examine how

gaming can impact the first two of these areas (the third area is examined in the section to follow). More explicitly, this section addresses these questions: How does a game, placed at the conceptual stage of a systems process, affect the problems associated with acceptance and use of the system, and how are the behavioral problems reduced or minimized?

**Impact on Acceptance and Use Problems**

Problems associated with the acceptance and use of quantitative techniques can be categorized as relating to the problem area, to the different individuals who must interact in the process, and to the solution approach or technique employed. In employing a system within an operational control area, problems will most likely be encountered because of the quantitative or technical base of systems. These problems must be resolved if successful systems implementation is to occur. Placing a functional game at the early stages of the systems activities (during conceptualization and definition) should impact some problems, since the design, development, and operation of a game necessitates an interfacing of all three problem areas (assuming that the game is designed and developed to be representative of the area of the organization being studied and the game logic employs the proposed solution technique or techniques). Thus, the question that should be asked
is how would a game activity impact particular implementation problems?

At this stage of the study, no data have been presented which can validate the impact of gaming during the initial system activities; however, hypotheses can be made as to the probable impact on specific problems. For example, gaming should impact such factors as management's confidence in the solution approach, management's ability to develop clear operational objectives, the attitudes and interests of the management science group, interaction between users and the management science staff, and the definition and explanation of the solution approach and results.

Explicitly stated, the probable impact of gaming can be categorized and described as follows:

The problem area.—In many instances the failure of management or users in accepting and using a system results from a mismatch in the problem that the system addresses and the "real" problem. Harvey identifies several cases in which users and management were unwilling to accept and use a developed system; a key factor identified as contributing to their lack of acceptance was that the system failed to address the proper problem.\(^{14}\) Placing a game at the initial stages of system activities should resolve some of the lack in

\(^{14}\)Harvey, p. 3319.
understanding of the objectives of a project or system. A game addressed to a given problem area should identify objectives and specification problems in the early stages of system definition and design. Since game development and operation brings together both the addressed problem and the individuals associated with the problem, misunderstood objectives or specification should become apparent during the initial system stages rather than at the end of the system process when the attempt is made to place the system in operation.

Early game activity should also highlight problems in the adopted solution approach. Since many of the areas of systems application within an operational control area fall into particular categories such as inventory control, resources allocation, and production scheduling, there is a tendency for the management scientist to fit the problem area into some traditional solution approach. In many cases, however, such action results in systems problems. Different industries as well as different areas of an organization have variant system requirements owing to production process differences, data requirement differences, and market differences. Often a traditional solution approach must be modified or adapted to fit the given problem area. If the need for such modifications are not recognized in the early stages of the system work, then an inadequate system may be designed and developed before the problem is recognized. A
game designed to incorporate the adopted solution approach should focus on needed modifications or adaptions.

**Management, user, and analyst problems.**—Since gaming necessitates individual involvement as well as some degree of game knowledge, some related problems associated with the acceptance and use of a system may be resolved through gaming. For example, several management related problems should be affected by the gaming activity since it is able to identify the system's output or results. Thus management should be convinced that the system can identify a solution to the particular problem being addressed. Similarly, repeated play of a game aids management in identifying trade-offs between interrelated system variables. Gaming should likewise emphasize for management the necessity for developing and communicating clear operational objectives. A fundamental benefit that should result from the game activity is management's exposure to the concepts and techniques employed in the system; this, in turn, will broaden management's understanding of the system's mechanics and logic. The gaming approach should also improve management's confidence in the capabilities of its management science group, assuming the game activity results in some degree of success.

Implementation problems associated with the management science staff should also be affected by the gaming activity. In particular, two factors should be of importance. First,
the game activity should provide the management scientist
with typical results that will occur from employing the
system. Because of the quantitative nature of many projects
or activities, particularly within an operational control
environment, there is a tendency for the management scientist
to use highly sophisticated approaches and technical termi-
nology in developing a solution approach. A key problem
that often results from such action is that the manager
or users are unable to ascertain the result that should
occur from use of the system. Through the game approach,
the management scientist should be able to resolve some of
these difficulties since the game involves a direct inter-
face of the manager and/or users and the proposed solution
approach. Second, a game activity should aid the management
scientist by providing information relating to organization
requirements and activities necessary for implementing the
system. Construction and operation of a game necessitates
an interface between the management scientist, users, and
management. Therefore, before system definition and develop-
ment the management scientist should understand the re-
quirements that will be necessary for system implementation.
Also since many of the game activities are the responsibility

15 In Table II of Chapter II this particular factor was ranked as the most significant problem area affecting im-
plementation.
of the management scientist, a broader view of the responsibility for system implementation should result.

Because the user plays a key role in the implementation of a system, the impact of gaming on the user is of importance. A principal requirement that must be met, if successful system implementation is to occur, is user involvement; gaming most likely will affect this area. In the study by Radnor, Rubenstein, and Tansik, it was shown that significant implementation problems were associated with poor user or client relations, and in many cases such relations resulted in the user's unwillingness to commit time or resources to the system's activities. Employing a game before system development (and thus before the commitment of excessive resources) should resolve some user related problems. If the game identifies and demonstrates some of the benefits that can accrue from use of the system, the user can evaluate more realistically the expected results before the commitment of resources. In addition, the game activity should develop the initial steps for user involvement; thus poor client relations (if they exist) should be improved.

The solution approach.—Though the developed solution approach may be properly structured and may address the desired objectives, system implementation problems may still

16 Radnor, Rubenstein, Tansik, p. 980.
result. If the procedures required to implement the system necessitate extreme organizational changes or if the solution approach is structured so that its accuracy requires a rigid control of the operating environment, then strong opposition to implementing the system may result. In many cases problems of this nature do not become apparent until the systems activity has reached the operational phase, at which point excessive resources have been expended. Thus, it is desirable to identify such problems in the early stages of the systems work. Gaming may be of importance in accomplishing this objective. Game play may identify some of these problems, but of equal importance is development and construction of the game itself. The activity associated with development of the game may identify factors that would otherwise remain dormant until the systems operational activities triggered the problem. Game activity could thus be viewed as part of the feasibility study of the system, particularly if the activity identifies critical problems that may affect a decision concerning the continuation of the systems work.

**Gaming costs.**—Gaming may be relevant in several areas of the systems activities and may affect several implementation problems; however, the question of game cost cannot be overlooked. Thus, the question that will likely be asked is how does one cost justify committing resources toward the development of a game when implementation cost (training cost) is often completely neglected in attempting
to minimize a project budget? In addressing the question, three points are significant. First, implementation cost cannot be neglected. Following a policy of neglecting implementation cost can only result in implementation problems. Since a game constructed during system conceptualization can be employed as a training aid during the operational phase (before trial use of the system), game construction cost can be labeled as development and training cost (the cost will be incurred regardless of when the game is constructed or whether it is constructed; some form of training aid must be developed). Second, if a game activity identifies critical problems that result in significant saving in cost as well as time, then game construction can be justified from the saving alone. Third, gaming cost can be considered a feasible study cost. It is generally desirable to identify implementation problems in the early stages of systems activities, preferably by means of a feasibility study. Though the gaming activity in no way replaces the need for a feasibility study, gaming can be viewed as a means of complementing the feasibility study.

**Impact or Behavioral Problems**

People are an important element of most systems; and, in general, they play a key role in systems implementation. One author expresses the people-system relationship in the following manner:
People's attitudes, degree of participation, and level of perception are the most significant factors that relate to a system's success or failure. Stated explicitly, a system is effective and succeeds when people understand the system and are willing to participate in its development and use, see how desirable goals can be achieved through the system, and are able to obtain timely results from the system. In the reciprocal respect, a system is ineffective and fails when people fail to understand the purpose of the system or its mechanics, disagree with its purpose, interpret the system as a threat or an infringement on their rights, or see the system as a source of oppression or as a needless burden.17

Successful systems implementation thus necessitates people's being knowledgeable of each aspect of the system and being involved with the system.

To define, develop, and operate a system successfully requires perception and participation from management, the management scientist, and the users. Traditionally, these people have been involved in a segregated sense in system activities. System conceptualization has involved a management-management scientist interaction with minimal inputs from users. Similarly, system installation and operation has involved analyst-user interactions with little management intervention. The desirable approach is integrated individual involvement in all areas of systems activity.18 To accomplish


18Harvey N. Shycon, "Perspective on MS Applications," The Institute of Management Science-Interfaces. II (August, 1971), 31.
this objective, the trend has been toward adoption of a team approach with team members being drawn from each of the different groups. This approach, however, has not always been successful; participation still appears to be a problem. Placing a functional game at the early stages of systems activity may resolve some of these problems.

Since the design, development, and operation of a functional game requires management-analyst-user interactions, a game activity before system design and development should resolve some systems involvement problems. In addition, the game activity should be relevant as a means for introducing computer concepts and capabilities, particularly if a time-sharing computer system can be employed. Use of an on-line, time-sharing computer complements the individual involvement factor, since the system gives direct contact with the computer on a "real-time" basis. In addition, basic concepts and techniques can easily be demonstrated by such a system. Some of the problems that result from a lack of understanding, lack of involvement, or from a mere oversight on the part of management (oversight in term of disregarding the human element in a system) should thus be resolved through the game activity.

\[^{19}\text{Ibid.}, \text{p. 33.}\]
The Game Approach

An event that must occur during the systems process is user acceptance of the system. Traditionally, gaming has been employed as an aid during the operational phase to accomplish this objective. Since a functional game can convey a system's operational nature and can identify typical system input requirements and information outputs, it lends itself well to being an instructional aid in identifying system characteristics. However, regardless of how well a game may convey a system's characteristics or operations, if the system addresses the wrong problem or fails to comprehend specific user requirements or needs, then system acceptance may never occur.

The conceptual stage of the system process is of primary importance in accomplishing the objective of user acceptance. The primary benefit from the conceptual stage should be an analysis that summarizes the origin and nature of the problem being addressed and the proposed system solution approach. Since the problem area is characterized and the solution approach is identified during this initial systems stage, it is important that the right problem is being addressed and that the solution approach is realistic in solving the given problem. Otherwise, an unrealistic or undesirable system may be developed.

In exploring the activities associated with the conceptual stage, it has been noted that problems such as the
manager's preconceived ideas of the problem area and solution approach, the analyst's tendency of fitting the problem into a preconceived technique or solution approach, and the adoption of time and cost factors as sole system evaluation criteria have often resulted in the conceptualization and development of unrealistic systems. In identifying these problems, a minimum amount of attention has been directed at identifying possible solutions to problems. In particular, a solution to the problem of identification and definition of the right problem has practically been overlooked. This, however, is not a unique oversight; a survey of the literature within the quantitative field will reveal that most of the literature identifies techniques or approaches for solving management problems. The process by which the problem should be formulated is generally left totally unspecified. Thus a key activity that must occur during systems conceptualization is problem identification.

Problem Identification

Several conventional approaches to problem identification appear in the management information systems literature. For example, R. H. Gregory and R. L. Van Horne identify an approach which involves interviewing individuals associated with the

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problem area, studying process operations, observing activities in the operation, and collecting sample data that define and describe the operations. A. F. Moravec, on the other hand, describes a comparative modeling approach in which the events or activities associated with the problem area are simulated on a computer, followed by a study, analysis, and synthesis activity. In addition, Thomas P. Gerrity, Jr. discusses another approach (although he does not advocate it) which involves a study of the current system and an in-depth examination of the information needs of the individuals associated with the area. The fallacy in most of these approaches is that they fail to identify with the problem. They result in either computerizing a manual operation or process, making all "desired" data available to users with little attention being directed at identifying "required" data, or they simply result in developing a theorized problem which is solvable by some solution technique.


24 Ibid.
There are other approaches to problem identification; a possible one is a game-based system study. The structure and basis for a game-approach can be identified by first examining the "process of problem finding" as identified by Pounds. Pounds describes the process in this manner:

The word "problem" is associated with the difference between some existing situation and some desired situation. The manager defines differences (problems) by comparing what he perceives to the output of a model which predicts the same variables. A difference might be defined by comparing a ten per cent reject rate in a department to a budgeted rate of two per cent. In this case the budget is the model.

Pounds continues the analysis by suggesting that four types of models are used by managers in identifying problems, namely, historical models, planning models, other people's models, and extraorganization models. Problems are identified when significant differences are seen between the actual situation and these models. By taking a Poundsian problem-finding view of the conceptual stage of the systems process, a game-based system study may identify the problems associated with the study. That is, by viewing the response or result of a game activity as an abstract goal or objective, a model is identified; by comparing game results with the current operations or activities, differences can be noted; thus problems are identified. The game serves as a norm for the

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25 Pounds, p. 5.
idealized system; problems are defined as the differences that exist between the game output and the current system or current situation.

The Approach

The game-based system study should be more than a means for identifying problems. There is a need for resolving the differences (problems) that exist between the game output and the current system or environment. Equally, the means for system evolution must be provided; the game-approach serves as a basis for identifying and defining system specifications, but the long run objective is development and implementation of the system. To accomplish these objectives, a framework is required that relates such activities as identification of system objectives, abstract game development, analysis and definition of the current system, identification of problems, and development of a game-system simulator for resolving problems. Figure 8 outlines such a framework.

The methodology for the game-based study can be identified by examining the specific activities of the framework. These activities can be described as follows:

Identification of system objectives.--Before any attempt can be made to identify specific problems, the objectives of the system must be identified. This should not be confused with identification of problems. System objectives are the goals or desired results sought from the systems
Fig. 8—A game-based system study framework.
activity, such as increased performance levels, increased rate of productivity, reduced process cycle time, or reduced inventories without loss of product delivery time. Fortunately, the focus of the operational control area is on specific tasks; thus the task of identifying system objectives is minimized.

In most cases system objectives are identified through interaction with the operating personnel or managers within the problem area. As a result, it is easy for the analyst to be influenced by the manager's or user's preconceived definition of the problem. This should be avoided; the objective is to identify system goals or desired system results. While it is necessary to identify the boundaries of the problem area, problem definition should be of little concern at this point.

Abstract game development.—Much of the traditional literature on systems analysis emphasizes the necessity for an early detailed study of the problem area and the existing system; contrary to these approaches, it is proposed that the game development activity occur during the early part of the conceptual stage before the detailed study. By developing the game early in the process, the management scientist can avoid being swayed by management's or user's hypothesis of the problem and solution approach. Following similar logic, if the game is developed before a detailed study is made, the
management scientist is free to think in terms of "what should be" as opposed to being biased by "what exists."  

In terms of game definition and development, it is desirable that the game parallel the problem area and employ the proposed solution approach. It is not necessary, however, that the game be a valid simulation of the problem area. The game serves as an idealized system solution and, as such, is a model toward which systems activities should evolve. The objective of the game is to assist the user in gaining a perspective of all aspects of the problem area. Through a comparative analysis of the existing system with the game output, the user can often perceive overlooked factors. Thus, even though the game may be abstract, it can serve as a basis for analysis. Viewed from a modeling perspective, John F. Rockart identifies a case study in which an industrial job shop model was used in the analysis of a medical clinic appointment system; in this case the industrial model served as an abstract model. This degree of abstraction is not proposed here. But it should be recognized that some degree of abstraction in the game does not invalidate its usefulness.


Though the game development activity occurs before the detailed systems study, it is not developed autonomously to the current environment. Key environmental and operating variables should be included in the game or at least should be represented in some form. Thus, game development does require certain inputs from the existing operating area.

**Definition of the current system.**—In order to provide a basis for comparative analysis, it is necessary to define the current system. This is not to say that the identified and described system will be used as a basis for the analysis; rather, the described system will be used as an operating base or anchor point from which to validate and measure specific problems which will appear during the game play—comparative analysis activity. In many cases problems (differences) will appear because of the user’s lack of understanding of the current system. For example, Bodenstab identifies a case in which a manager sought a computerized statistical inventory control system in order to solve his inventory control problems.\(^{29}\) On analysis and definition of the current system, it was discovered that the existing product lines did not have a system of unique numbers for each product, nor was there a defined system of information flow. The problem was solved not by computerization but by development of an authorized stock list and a well-defined product

\(^{29}\) Bodenstab, p. 65.
information flow. Thus, definition of the current system is a necessity.

Definition of the system should be fairly detailed and should reflect the unbiased findings of the analyst. Frequently, interviews with the managers and users within the operating environment will be the most fruitful means for identifying details of the system. It should be recognized, however, that bias can easily be injected into the system discussion by the interviewee if poor pre-existing relations exist between the managers or users and the analyst. In many cases, therefore, it may be necessary that the analyst directly observe activities in the operating area and collect sample data.

Comparative analysis.—Comparative analysis provides the means for problem identification. Though the approach here is unique, comparative analysis as such is not a new technique for identifying problems. As Pounds has indicated, managers traditionally have identified problems by perceiving differences that exist between organization models and the current situation. Similarly, S. L. Optner identifies a test of correspondence models in which a modeled activity or process

30 Rockart, p. 3.
31 Pounds, p. 8.
is compared against output from the process.\textsuperscript{32} In a more recent study, Rockart describes a comparative modeling approach to identifying systems analysis problems.\textsuperscript{33}

Though successful use of comparative analysis has occurred in some areas, use of the concept has not achieved its full potential in the systems analysis area. One of the weaknesses in previous approaches has been the exclusion of the individuals involved with the system activities, particularly the users. Most previous approaches have relied on the judgment of a limited number of individuals such as the manager or analyst or both. In many cases the analyst becomes burdened with the task since he has a better understanding of the models.\textsuperscript{34} Here it is suggested that the comparative analysis activity involve individuals associated with all areas of the systems process, particularly the users.

The structure of the comparative analysis activity involves game-play followed by a critique session. The objective of game-play is to assist the player in gaining a perspective of all aspects of the problem area. This is done by removing the player from the current environment and placing him in the abstract game environment. This step is based on the premise that people tend to overlook the importance or the


\textsuperscript{33}Rockart, pp. 1-14.

\textsuperscript{34}Gerrity, p. 64.
existence of certain factors as a result of their residence within the environment. By removing the individual (player) from the process which he is analyzing, the environmental constraint should be minimized.

The critique session is designed to give the player a means for comparative analysis. The structure of the session involves both verbal group discussion and a game questionnaire. The objective of the questionnaire is four-fold. First, the questionnaire serves as an aid to the analyst by revealing the player's understanding of the game and the employed solution approach. Second, a pre-structure portion of the questionnaire gives player-inputs to the analyst's perception of problems. Third, in contrast with the current system, an unstructured portion of the questionnaire provides a means for the player to express the game-play results. Finally, the questionnaire serves, in general, as a means for gaining the data of individual participants; the premise here is that an individual will more readily express criticism in writing than he will in a verbal group discussion.

Analysis of the questionnaire and verbal comments provide the basis for identifying differences between the abstract game-play and the current system. Primary use is made of the questionnaire as well as of some of the game output results. To form some logical basis for the analysis, identified problems are weighed, based on two criteria: the frequency of occurrence and the understanding of the game
participant. A high frequency of occurrence of an identified problem connotes the possible existence of the problem. However, if the game results indicate poor player performance, then the identified problem may stem from the game participant's lack of understanding. Thus, in analyzing identified problems, one sees that the two criteria interact; consequently, a weighing factor should be employed so that those participants achieving the high degree of game success have a heavier impact on problem identification. The basis for placing a heavy emphasis on successful game participants is drawn from Pounds conclusion that the more successful participant is the richer source of information. The game-play weighing factor can also be employed in supporting or disproving the analyst's input of preconceived problems.

The problem analysis may not always result in conclusive support of particular problems. In some cases the abstract game may parallel the wrong problem, while in others the game participants may have insufficient knowledge of the current system. Results of the problem analysis must then be confirmed against the previously defined current system and the developed game, since the game employs the proposed solution approach. In cases where there is little conclusive evidence which confirms particular problems or where results indicate a significant difference between the current system and the

\[35\] Pounds, p. 4.
game, it may be necessary to re-examine the game development and system identification activities. Thus, before the game-system simulator activity can begin, it is necessary to iterate the abstract game development, current system identification, and comparative analysis activities until conclusive support substantiates problems or until it is evident that the game addresses the proper problem and the proposed solution approach is appropriate.

**Game-system simulator development.**—The objective of the game-system simulator activity is to resolve problems flowing from the comparative analysis activity and, at the same time, to simulate the problem area in conjunction with the system solution approach. In accomplishing this objective, the analyst plays a key role. The activity, however, requires more interactions and more inputs than that of the analyst, though some authors contend that the analyst is the key problem solver. Gerrity expresses the role of the analyst as a problem-solving agent in this manner:

> the mark of a good systems analyst is his ability to choose functions that have a high probability of alleviating problems. . . the process primarily depends upon the analyst's experience with systems, his ability to generalize from an experienced situation to an analogous situation, and his ability to predict the behavior of the modified system. 36

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36 Gerrity, p. 64.
However, just as manager-analyst, analyst-user, and user-manager interactions occur during the earlier activities, the development of the game-system simulator requires multiple individual interactions. Also inputs flowing from the analysis and identification of the current system are important in developing a valid simulator.

In developing the game-system simulator, the game evolves into a simulation of the problem area; thus, much of the activity involves steps which are characteristic of the definition phase of the system process. For example, it is necessary to identify particular system elements, such as data requirements, relationships and roles played by different individuals within the system, and the functions performed by machines or automated elements. User requirements such as desired output reports must also be specified. In addition, the interrelationship of all system elements and how they relate to the proposed solution approach must be identified. In performing these particular functions, the analyst must again interact with the individuals within the operational area. If a mutual relationship has been developed during the earlier activities and if there has been common agreement during the comparative analysis activity as to the source of particular problems, then the hesitancy of users or managers in becoming involved should be at a minimum.

In some cases many of the requirements for developing the simulator will have been identified in the earlier
activities; however, in order to keep all individuals involved with the systems activities abreast with the latest developments, it is desirable to validate all requirements before they are incorporated. The most meaningful manner of validation, particularly in terms of maintaining user acceptance, is to demonstrate that the simulator can produce results parallel to those of the current operating area. If it can reproduce past performance activity under the previous operating conditions based on the previous input decisions, then there is a high probability that it will be accepted.

Though the simulator is structured to parallel the problem area and to demonstrate the function of the solution approach within the area, it can be employed in a game activity. That is, it should be possible to operate the simulator in a game mode similar to that of the abstract game; the difference in the two being is the latter is a valid reproduction of the problem area. The simulator employed in a game mode should enhance player involvement since the results of game play should be representative of activity in the operational area.

System specifications.—Results from the simulator activity form the basis for identifying system specifications. Since the simulator demonstrates the solution approach adapted

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to the modeled operational problem area, it provides a means for identifying system specifications. In addition, since the development of the simulator involves an integrating of facts and specifications which were identified in earlier activities, many system specifications should be readily apparent at the conclusion of the simulator activity.

System specifications do not define the system in detail; rather they describe its nature and complexity. A prime input to the feasibility study is the specification of the complexity of the problem area and solution approach. Sufficient facts must be provided before a decision on whether to proceed with implementation can be made. Though the system specification activity should not involve system design, it should be identified and described in enough detail to access the requirements necessary for implementing the system. In particular, specifications should describe the necessary events and activities that must occur in order to transform the simulated system into an operational system. Included in the specifications should be a list of the resource requirements such as computer facilities, manpower, and facilitating or supporting equipment.

Feasibility study.—A solution approach or system can be described as feasible if it provides a sufficient solution to the given problem. As noted earlier, a key result of the game study approach is the specification of a solution approach. The feasibility study, however, must involve more than
evaluation of the specified system. Other factors such as total cost of the project, including implementation and operation, estimated time required to achieve specific results such as reduced cost or improved service, and specific manpower and equipment requirements are also important in terms of the decision to proceed with implementation.

Though the prime objective of the game study approach is to identify a feasible solution approach and to demonstrate its usefulness, other results should flow from the study activities, many of which are complementary. The feasibility study requires an estimate of the cost of implementing the system, including training; if the game study activities have been properly performed, then information necessary for a cost estimate is available. Many of the requirements associated with the definition phase of the system process such as data requirements, output reports, and interrelationship of system elements are also specified in developing the game-system simulator; thus systems cost estimates can be made by expanding on these requirements. The estimated cost of operating the new system can also be made by expanding on the cost associated with the operation of the simulator. Since the philosophy of the solution approach has been identified and exposed to management and users, estimates of potential problems and estimates of the time required to achieve the fully operational system can be made at the conclusion of the game study.
The Process

The systems process has been described in detail as consisting of the conceptual, definitional, developmental, and operational phases; the game approach alters this process somewhat. To understand and appreciate the process changes and the potential impact of the game approach, it is necessary to examine it in relation to the total process.

The traditional approach to systems conceptualization has been pictured as a decision cycle involving four basic steps: definition of the problem, identification of solution alternatives, determination of a criterion for evaluating alternatives, and selection of a system solution approach. The game approach revolutionizes the cycle by means of the abstract game, system definition, and comparative analysis activities. The major difference in the cycle is a logical framework for identifying problems and for including all individuals in the cycle activities. The approach does not destroy the cycle but rather reorganizes and complements it. The abstract games provide the means for exploring different solution alternatives. Problems are identified, and different alternatives are evaluated by means of the game-play comparative analysis. Selection of a solution approach results from iteration of the game, system definition, and comparative analysis activities.

The game approach also alters the definition phase of the systems process. Some of the basic activity and steps
traditionally associated with definition of the conceptualized system are performed in development and operation of the game-system simulator. Two reasons justify such action. First, it is desirable to test and evaluate the solution approach in a pilot operation or a simulated operation before the decision concerning whether to proceed with implementation is made. Malcolm expresses the desirability of evaluating the solution approach in this manner: "Adaption of the solution to meet practical considerations should have been made during the course of the operations research study and before implementation was recommended." Second, if control is to be exercised over the implementation activities, a coordinated implementation plan must be developed as part of systems conceptualization. Before this can occur, however, it is necessary that the basic framework for system definition be identified. Data requirements, desired output reports, and the interrelationship of system elements must be identified. The implementation plan should be concerned with identifying the action and events that must occur in order to transform a valid systems approach into an operational system. Implementation should not be concerned with validating a solution technique or integrating a theoretical solution technique into the operational environment; this should occur

before the implementation decision is made. This does not imply that systems problems will not be encountered during the implementation activities, nor does it imply that control can be minimized as the system moves through the different stages of implementation. Problems will be encountered, and control is a must. But if the validity of the system has been demonstrated before implementation and if all individuals associated with the system activities are cognizant of the objective of the system, the roles and relationships that each plays within the system, and the benefits that can accrue from employment of the system, then control and systems problems should be at a minimum.

The game approach does not alter the necessity of a feasibility study. All requirements pertaining to implementation cannot be identified during the game-study activities; other inputs are necessary. Factors such as the relationship of the proposed system with existing systems, the remaining life or potential growth of the operational area in which the system will reside, and the urgency of results from the system are all valid questions that should be raised and answered. The game-study is an integral part of the feasibility study, but only a part; other questions and points should be examined, and the results should become inputs to the feasibility study.

Development and operation of the game-system simulator involve many of the steps associated with the definition
phase of the systems process; the simulator, however, is not a finalized system. Detailed system specifications and operating characteristics must be established. Timeliness and organization of data inputs and outputs must be specified. Many of the factors that could be minimized during the development of the simulator must be specified in detail during the system definition phase. Also, if the simulator is structured and developed for operation of an on-line time-sharing computer system, while the finalized system is to reside on a different computer system because of company policies or operational constraints, then controls must be exercised to assure that all necessary system specifications are made and that they are in compliance with the capabilities of the computer.

Activities associated with the development phase of the systems process, with the exception of the development of orientation programs, are generally not directly affected as a result of the game approach. Many of the tasks, however, can be minimized by use of the simulator. For example, operating system procedures can be identified and evaluated; questions associated with the system logic can be evaluated; and, in addition, the actual function or operation of different facets of the system can be tested before incorporating these into the system. The necessity for developing an orientation program during the development phase is avoided since the activity occurs in the development and operation of the
game-system simulator. But it is important that the simulator and the activity associated with its use evolve as system changes occur. That is, if the development activities identify the need for specific system changes, then changes should occur within the simulator, particularly if the system resides on a different computer.

Though the direct impact of the game approach occurs during conceptualization, some impact occurs during the operational phase. First, trial use of the system should probably occur in order to provide a means for operational tests and verification. However, if the game approach and simulator capabilities have been adequately employed, then a minimum of system discrepancies should exist, and there should be little divergence between the expectations of users and the actual system capabilities. Second, the trauma associated with operational tests and verifications of system design should be minimized. Because verification of system logic occurs during the operational test of the simulator, operational test of the system is necessary only to detect error in computer programs or operating procedures. Finally, since the simulator output should be representative of the systems operational nature, detection and correction of errors can be controlled by comparing the systems operation with that of the simulator.

The gaming approach thus affects directly or indirectly each of the phases of the systems process. The major impact
occurs during conceptualization when the game is employed as a means of problem identification and of testing different solution alternatives. The game approach reorients the systems process by pulling some of the activity from the latter phases into the conceptualization phase. (It also provides a means for individuals to become involved in the initial system activities). The objective of conceptualization is to identify and characterize the problem area, to develop a valid solution approach, and to obtain individual involvement. Implementation is concerned with transforming a valid system approach into an operational system. The revised system process thus can appropriately be labeled a game-implementation process.

Next, Chapter VI will present some basic research that suggests that a game approach to conceptualization and implementation is valid and that many individuals (users, managers, and management scientists) would support the use of the concept. In addition, the chapter presents an industrial case study which demonstrates the use of a game as a training aid.
CHAPTER VI

APPLICATION OF THE APPROACH
(RESEARCH RESULTS)

Introduction

Chapter VI presents results from an industrial case study, questionnaire-interview surveys, and a generalized game activity. The hypotheses of the study are evaluated using these results.

The first section of this chapter describes the industrial case study which served as the basis for evaluating the use of a game as a training aid. The hypotheses as stated in Chapter I was that gaming is useful as a training aid before the installation of a system. This section describes and evaluates the results from a game-training activity and a game-questionnaire survey in order to test this hypothesis. The training activity and questionnaire survey are the key elements of the case study; to place the study in perspective, however, foundation material is presented which describes the structure of the industrial organization, the nature of the system in which the game-training activity was employed, and other systems which existed with the organization at the time of the study.
In Chapter I it was also hypothesized that gaming can be employed during the conceptualization of a system in order to interrelate the problem area which a system addresses, the solution approach, and the ideas and needs of users, managers, and analysts. In Chapter V a game-implementation process was proposed which involved some of these interrelationships. The second section of this chapter tests this original hypothesis and evaluates the proposed implementation process. Specifically, this section presents the results of questionnaire-interview surveys and a generalized game activity. The questionnaire-interview—which involved users, managers, and systems analysts—were used to evaluate the primary hypothesis for the research. In addition, they were used to explore some secondary hypotheses made in Chapter V concerning the probable impact of the proposed game-implementation approach. The results of the generalized game activity were used to study specific aspects of the proposed implementation approach and to give further support to the primary hypothesis.

The Case Study

The industrial case study which served as a primary data source for the research was conducted within Texas Instruments Incorporated, a large electronics firm that has a reputation for being aggressive in seeking to use quantitative techniques and systems. Specifically, the study was conducted in a large computer systems department (hereafter referred to as the systems department) within a decentralized operating...
division of the firm. The game-training activity occurred within a section of the department which was responsible for the development of production control systems.

This activity was developed in order to help the systems department convey the basic concepts and logic employed in a previously developed system. The system, around which the game was structured, was designed for use in a large production control operation. Although usage of the system was expected to be extensive, this did not prove to be the case. Managers within the systems department hypothesized that the reason for this lack of usage was that some of the concepts and logic employed were not fully understood by potential users. The game was thus developed as a training aid.

To test the hypothesis concerning the use of a game as a training aid, a group of game-training sessions were sampled. Before exploring and evaluating the game-training activities, however, it is first necessary to identify some basic aspects of the case study. For example, the organizational structure and operational activities of the firm are identified. Also as foundation material, some of the systems which had been developed before the game-training activity are described.

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1 At the request of managers within the organization, anonymous titles and descriptive names will be employed throughout the research in referring to specific departments or computer systems that were identified during the case study.
The Organization

The systems department, which had a professional staff of more than ninety members at the time of the study, operated on a staff function basis with several operating departments within the division. This department had partial responsibility for the payroll and personnel systems for the division; otherwise, the primary responsibility for the department was to give professional computer systems support to the production and operational departments. This support partially involved multiplant operations as well as some international operations. However, the majority of the support for the production operations occurred within the Dallas, Houston, and Sherman, Texas, plants.

Computer facilities for the decentralized divisional operations were provided and supported by a centralized corporate data processing center. The corporate facilities consisted of a centralized IBM 360 complex with remote 360 Model 20 terminals located in the decentralized divisions. In addition, the centralized complex supported on-line inquiry and data collection terminals; approximately ninety of these terminals were located throughout the corporation. The corporate operations did not support on-line time-sharing

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2The corporation's organizational structure actually is built on the concept of group level entities, division level subentities, and profit centers within the divisions. However, for explanation purposes the traditional terms of division and department are used.
operations; instead, this service was supplied by a computer firm outside of the corporation.

Thus computer systems operation within the corporation involved three groups. The corporate systems group was the prime supplier of hardware and facilities. The divisionalized operating departments were the prime users of the computerized systems. Finally, the divisionalized systems department served as a computer staff support group, responsible for the development and implementation of new systems and for the maintenance and support of on-going systems.

As a divisionalized staff support group, the systems department was responsible only for systems operations within the division. Similar systems groups existed, however, in other divisions in support of operations for the respective division. For example, a chemical division had a systems staff group which supported its operations; similarly, a military products division was supported by a separate group. The semiconductor products division, the division examined in the study, was supported by the systems department. The necessity for having such differential divisionalized operations resulted from at least two factors. First, the corporation stressed decentralization; second, each division was involved with a different type of manufacturing process. This second factor was important in terms of the systems department's activities, for it determined the type of systems support required within the division.
Systems Support Activities

Manufacturing operations within the semiconductor division were primarily a continuous or assembly line type production. Operations thus involved the flow of material through assembly stations along a production line. Many of the typical problems associated with a continuous production process, such as excess or delinquent finished goods inventories, excess work-in-process inventories, less than optimal material utilization, and poor inventory control, were prevalent within the operating departments. In an effort to resolve some of these problems, numerous systems had been developed over a period of several years. Some of these addressed such problems as inventory control, production scheduling, production planning, production control, and resource allocation. Some of these systems which were available to users at the time of the study can be described as follows:

Inventory Control.—This was an off-line inventory system designed to provide users with a daily summary of finished good inventories by product type. Included also in the reports were the manufacturing costs associated with the inventories.

Production scheduling.—Two systems were available for scheduling customer orders. First, an on-line selection system provided the capability of identifying the semiconductor product family from which the customer's semiconductor device could be produced. Second, an on-line status inquiry system was available for determining the production schedule for the
order. This latter system gave the user the capability to update the production schedule on a real-time basis; that is, the uncommitted portion of the planned production could be committed to a given customer's order.

Production planning.--The objective of the production planning system was to provide up-to-date daily information concerning the production process. The system was designed to monitor work-in-process, inventories, production cycle times associated with different products and processes, and material utilization. In addition, it made projections of anticipated product output quantities and their completion dates. Daily reports could be generated from the system. System designers contended that judicious utilization of the system could result in shorter billing cycles and improved product scheduling.

Production control.--A production control system, which stressed the minimization of product cycle time and the control of work-in-process inventories, was available to the operating departments. This system was designed to furnish daily reports that specified machine and personnel utilization requirements necessary for meeting required production outputs. Reduction and control of work-in-process inventories, efficient utilization of production capacity, increased production output, and reduced product cycle times were projected as probable benefits resulting from use of the system.

Resource allocation.--The link between product marketing and the production process was made in the resource allocation
system. This system was designed to optimize the material requirements associated with producing given products. Furthermore, the system was directed at tailoring the production process so that it could meet the projected demand rather than just the firm orders. Projected product demands were first made by means of a forecasting system; based upon these demands, a linear programming routine was employed to optimize the material required in production. It was expected that the utilization of this system would lead not only to a more efficient utilization of resources but also to an increased market effectiveness. Since products were to be built to projected market demands, the organization's response time to customer's demands could be significantly reduced.

Other systems.--In addition to systems directed at improved inventory control, production control, and resource utilization, several other systems had been developed by the systems department. First, a capacity utilization system was developed for monitoring manufacturing capacity in terms of people, equipment, and space. The system was designed to aid management in planning and controlling required production capacity based in changing market demands. Second, a product quality control system had been developed for evaluating the production process. Through use of the system, product parameter statistics could be gathered and analyzed. Finally, there was a data collection network in support of all the systems; this was designed to provide an efficient means for
on-line collection and entry of production data. Data were to be collected on-line in the production environment, transmitted to a central processor, and recorded on magnetic tape. The input tape could then be used on a daily basis for updating all associated systems.

Though numerous systems were available to users within the operating department, only a portion of these were employed. Also, in every department where systems were utilized, the heaviest usage occurred with the production planning, production scheduling, and capacity utilization systems. Minimum usage was made of the production control and resource allocation systems. This limited usage, particularly with reference to the production control system, was difficult for the systems department to explain. Some data files used in the system were common to those employed in other systems; thus only a minimum of data input was required. The data collection network also supported the production control system; consequently, daily production information could easily be collected and used to update the system. Upon examining the situation, the system department identified one key difference that existed between the control and allocation systems and those systems being used; the planning, scheduling, and capacity utilization systems were primarily management information systems whereas the control and resource allocation systems were quantitative systems, designed to optimize
the production operations. One systems department analyst expressed the situation in this manner:

The operating people use the planning and scheduling systems because the systems complement the production process with which they are familiar. It provides them useful planning information. The line managers do not understand the concepts associated with the production line balancing and allocation systems; these systems alter the production process. Most managers are unable to visualize how the systems can aid their operations.3

To resolve some of the problems associated with the quantitative systems and thus increase the use of the systems, the decision was made to develop a quantitative game that would serve as a training aid in teaching the concepts used in a given system's logic. The production control system was selected as the system to be emulated. It was also decided that the game should be developed on a time-sharing computer, since the interactive nature of time-sharing was amenable to a gaming activity.

In taking the gaming approach for resolving systems problems, management's objective was not only to convey concepts used within particular systems but also to develop an interactive atmosphere between the systems department and the operating departments. It was the opinion of some managers that problems associated with the acceptance and use of the quantitative system were not exclusively a result of lack of understanding on the part of users; rather, some problems

3 Statement by A., September, 1970 (anonymity requested).
were a result of poor management scientist-user relationships. Most of the poor relationships, which had developed several years earlier, resulted from the systems department's lack of concern for implementation. By involving the users in a game training session, it was reasoned that some of these poor relationships could be improved.

The Game-Training Activity

Eleven game-training sessions were sampled over a four-month period in gathering data on the production-control gaming activity. The time period in which the sample data were gathered extended from August, 1970, through November, 1970. One hundred and thirty-six individuals were involved in the sessions which were staged at plan sites in Houston, Sherman, and Dallas. All game sessions were identical in structure and content with the exception of the latter sessions which incorporated suggestions from the earlier ones.

The actual game session involved a short lecture on the theory of production control, an explanation of the objectives of game-play, actual game play, and finally a critique of the game and game session. An overview of the theory presented during the sessions, a sample of the game output, and a copy of the game critique questionnaire are presented in Appendix A.

\[4\] Interview with C. D. Hopper, Texas Instruments, Incorporated, Dallas, Texas, August, 1970.
Game-Training Analysis

To evaluate the effectiveness of the game-training activity, two steps were taken. First, the game session questionnaires were analyzed; second, production indices were monitored on four production operations to determine if the indices changed after game-training sessions were administered. Results from both steps tended to confirm the hypothesis that gaming is useful as a training aid.

Specific results from the respective steps are as follows:

Game session analysis.--Results from the game session questionnaires indicated that the game-training activities were informative and meaningful. Eighty-seven per cent of the one hundred and thirty-six sampled game participants rated the sessions with a score of four or higher out of a possible five in expressing the meaningfulness of the session; similarly, 83 per cent expressed the feeling that the objectives were met. Specific comments in terms of improving the sessions were primarily directed at the mechanics of the presentations; however, several of the participants

5 The production control game questionnaire was developed by the systems department. The primary objective of the questionnaire was to measure the participant's response to the session and to identify ways to improve the game or session. Though many of the questions did not directly complement the objectives of the study, some meaningful data were extracted from the sampled sessions. The analysis thus explores only a portion of the questions appearing on the questionnaire. See Appendix A for the specific questions included in the questionnaire and the rating procedure employed.
expressed the opinion that the sessions could be enhanced by having a second game which was more related to a specific in-house operation. Several game participants also expressed the feeling that interaction among players would increase the level of understanding within the sessions and would give exposure to the problems that different individuals had previously encountered in their respective areas.

Reactions to the game-play portion of the sessions were also positive. Eighty-five per cent of the participants rated the meaningfulness of the game with a score of four or higher. A majority of participants, however, did express the feeling that the game could have been improved by increasing the length of time for game-play which would allow more exploration of the ideas and concepts presented in the theory. The more reactive comments were made in response to the question, "What did you like most about the game?"

Some of these responses were as follows:

1. The game brings out the actual conditions a line supervisor is faced with daily.

2. This is a good way to communicate systems to users. I would like to see more of the same sort of communication on other systems.

3. The results you get are on a real-time basis.

4. The fact that one variable could be changed is helpful and the effect of the change on the rest of the line could be evaluated.

5. It makes one aware of cycle time and work-in-process inventories and how they affect operations.
6. It demonstrated that the concepts presented in the theory do hold in an actual situation.

7. The game gives one the chance to try the system.

8. It helps one understand the problems in production control and develops a better understanding of the part the system plays.  

A change in the attitude of managers and users was revealed by reactions to the portion of the questionnaire relating to the session leaders. In all eleven sampled sessions more than 90 per cent of the participants rated the session leader's degree of effectiveness, open-mindedness, cooperativeness, and level of enthusiasm with a score of four or higher. This positive reaction to the session leaders was important in that it indicated that the game sessions were not only meaningful in terms of conveying a level of confidence and an effective degree of communication between the systems department and the operating departments. The change in attitude reflected in the game session was apparent after the session in a more relaxed interactive working relation between the systems department staff and individuals in the operating departments who had been game session participants.

The game participants' reactions to the theory presented in the sessions were also favorable. Specific comments from

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6Identity of the game participants responding to the questionnaire was not requested. This approach was taken based on the assumption that more candid responses would result.
the participants, however, revealed that, although there was
a high degree of acceptance of the theory, all individuals
were not convinced that the system was practical. Some of
the more negative comments were as follows:

1. I am not totally convinced it can be used for
more than a guide or trouble spotter in my manufacturing
operation.

2. Implementation will require blood, sweat,
and tears.

3. The approach still seems a little too ideal-
istic.

4. The concept is believable, but I must be con-
vinced by a practical application before I accept the
system.

5. I need to see a trial run in our area before
I will be convinced it will work.

6. It is good in theory, but I am not sure about
a practical application.

Even though there were some negative reactions concerning
the practical application of the theoretical concepts, there
were participants who appeared to have a more positive
attitude. Some of their responses were as follows:

1. If the approach were applied with the full
cooperation of all levels of management, then results
would pay off.

2. The system looks great for my particular area,
but I am not sold on the idea that every department can
go this way.

3. I think it is an excellent method and would
like to see it implemented in my area.

Identity of respondents was unavailable.
4. It will work but will require involvement of line workers as well as line supervisors.

5. It will require considerable dedication of time and efforts to get it operative; however, I am convinced it can be done.

6. The approach would probably work in many areas but will require support at all levels.

7. I would like to see the system tested in my area before making a total commitment, but I am convinced it can work.8

**Impact of the game-training sessions.**—In order to measure the effect of the game-training activity on the use of the production control system, the activities of four production operations were selected from the different areas exposed to the gaming sessions. Data were collected both before and after the gaming sessions concerning production indices such as levels of work-in-process inventories, number of production operators involved in the operations, production output, and cycle time of the process. Table III summarizes the data collected in the four areas.

An analysis of the production indices data indicates that the game sessions did affect the production operations; an improvement was noted in all four operations. Operations A and C showed a significant change in work-in-process inventories, cycle time, and productivity. The work-in-process inventories in operation A were reduced from the prior three months average of 634,100 units to 138,800 units 

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8Ibid.
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**Data have been adjusted upon the request of the managers within the respective operations.
over the five-month period, while production output increased from 669,800 units to 1,175,500 units. The large increase in output required only a small increase in the number of production people; thus productivity increased significantly from 18,500 units per person to 45,200. The production cycle time was reduced from 8.3 days to 2.3 days. In Operation C work-in-process inventories were reduced from an average of 315,100 units to 223,500 units. Production output in the operation increased from an average of 760,200 units per month to 916,600 units per month with the number of required operators being reduced from 320 to 284. Production cycle time changed from 14.6 days to 9.2 days. Operations B and D also showed improved changes in work-in-process inventories, production cycle time, and productivity; changes in the indices in these operations, however, were not as distinct as those in Operations A and C.

In discussing the game sessions and use of the production control system with managers in the four observed production areas, it was determined that the game-training activity was a key factor relating to changes in the areas. In Operations A and C, which reflected the most distinct changes, use of the production control system occurred after the game sessions; in both cases use of the system became standard practice in the operation. In Operation B, use of the system also followed the game-training session; however, in this area the system was employed only on a periodic basis.
The manager in Operation C expressed the view that, while the system was useful for bringing operations under control, on a daily basis much of the control function could be handled by a manual process. In Operation D, the system was not employed, but a manual form of the control process did exist. In discussing the game activity, the manager of Operation D agreed that the use of the production control concept resulted from the stimulus of the game sessions.

Interviews with the managers in the sampled operations thus confirmed that the changes in the production indices in the respective areas were a result of usage of the production control system (with the exception of Operation D) and that the use of the system was stimulated by the game-training sessions. These results, along with the general acceptance of the game-training sessions as expressed by the game participants, thus support the hypothesis that gaming is a useful training aid for installing a system.

Gaming During Systems Conceptualization

Preface

Phase II of the research was involved with testing the second hypothesis of the study—namely, that gaming is not only useful as a training aid during installation of a system but can be used to aid in the conceptualization and design

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9Telephone conversation with C., January 21, 1971 (anonymity requested).
of a system. However, before discussing specific aspects of this area of the research, it is first necessary to pose the following question: If a game-training activity is useful for installation of a system and if usage of the system increases as a result of the activity (which was the results in three out of four of the operations examined in the case study), why is it necessary to consider use of the game during conceptualization and design of the system?

A broad examination of the outcome of the game-training activity gives one answer to the question since some key results did occur. First, there was an increase of interest in the production control system; second, a more relaxed, interactive atmosphere existed between the systems department and the operating departments after the game sessions; finally, there was an increase in the usage of the production control system. However, initially increased usage of the system occurred only in a small portion of the departments which were exposed to the gaming sessions. A major increase did not occur until a redesign of the system was made. A smaller and less sophisticated version of the system was developed after it was recognized that some design constraints prevented many operating departments from using the system. Had these constraints been recognized during the initial development of the system, then the time and costs lost in redesign could possibly have been avoided.

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10 Interview with F. F. Eichman, Texas Instruments Incorporated, Dallas, Texas, October 21, 1970.
Using a game during the conceptualization and design of the system could possibly have identified design constraints. Thus, exploring the possibility of broadening the use of gaming beyond that of a mere training aid is justified.

To evaluate the hypothesis that gaming can be used in the conceptualization and design of a system, reliance was made on the proposed game-implementation process developed in Chapter V. The assumption was made that acceptance of the process would validate the hypothesis. Consequently, specific research activities were directed at evaluating the acceptance of the process by users, managers, and analysts. Questionnaires for soliciting opinions and views were developed in order to explore different aspects of the process. These questionnaire-interviews thus served as the primary data source for the second phase of the study.

As a follow-up step to the questionnaire surveys, a generalized game activity was used to evaluate further the hypothesis and to explore some additional aspects of the proposed game process. The specific objective of the game activity was to show that a game or some similar activity is needed at the conceptualization stage of developing a system in order to interrelate the problem area, the solution approach, and ideas and needs of users, managers, and analysts. A secondary objective was to demonstrate that an abstract game is desirable for this interrelating function.
The second phase of the research thus involved two activities: questionnaire-interview surveys and generalized gaming session. Results from these activities appear in the subsection that follows.

**The Questionnaire-Interview Activity**

The interview activity, directed at exploring the use of games during the conceptualization of a system, primarily occurred after the case study phase of the research, with the exception of interviews with systems staff personnel which occurred in conjunction with the case study. The time period involved in the interview cycle spanned from September, 1970, to May, 1971. Managers within the operating departments, department members (users), and staff personnel within the systems department were contacted during this period. Because of the nature of the study, the groups of individuals interviewed were limited to those within the corporation.

A total of forty-one individuals within the organization were contacted during the interview cycle. Categorized in terms of individual classes, the interview group consisted of six managers within operating departments, fourteen systems staff personnel, and twenty-one operating department members (users). The operating department members interviewed consisted of production line supervisors, process and evaluation engineers, and product marketing analysts. In 78 per cent of the cases, the individuals interviewed had previous exposure to the game-training sessions. In
soliciting opinions and views, questions similar to those in Appendix B were posed.

The interview activity was conducted in pursuit of specific objectives; however, an informal and unstructured approach was found to be the best method for gathering data. This approach made the analysis of particular questions somewhat difficult when individual comments were compared. But, it was believed that the interviewee would be more candid in his comments in an informal approach.

Results in general from the interviews tended to support the hypothesis; users, managers, and analysts all expressed support for the proposed game-implementation process.\textsuperscript{11} Likewise, results from specific portions of the different questionnaires supported many of the hypothesized impacts of the process (these hypotheses were made in Chapter V). Specific results from the different interviews were as follows:

**User interviews.**—The strongest supporters of the proposed process were in the user group. Over 70 per cent of these individuals expressed the opinion that employment of a game activity before development of a system would be of aid in resolving some systems problems. They also believed this to be a meaningful approach for integrating the ideas of the various groups involved in a system as it is

\textsuperscript{11}See Appendix B for the questionnaires used in the interview activity.
developed and implemented. The number of individuals from the user group expressing an interest in the concept was somewhat greater than anticipated, particularly since 33.0 per cent of the group had not participated in the game-training seminars. Somewhat surprising also was the fact that 55.5 per cent of the individuals in the group who had no exposure to the game sessions expressed a positive interest in the proposed approach.

In discussing the proposed approach with individuals from the user group, several key facts emerged. Most frequently mentioned as contributing to systems problems was the lack of understanding on the part of managers, the systems department staff, and the users themselves. Of the twenty-one individuals interviewed, twelve expressed the opinion that the managers within the operating departments did not fully understand the systems that were available for use. In defense of their opinion, many of the interviewees said that often the manager's lack of understanding stemmed from a belief that operational systems were only of minimal importance in terms of the department operations; the manager thus took little or no interest in the existing systems. One user expressed the view in this manner:

Many of the managers do not support the systems because they feel the systems are really not very useful in their particular operations. Many of these people have grown up in the area
and feel that they can adequately control the operations; they have little interest in the systems.¹²

Sixteen members from the user group expressed the view that the systems department staff did not fully understand the operations in the production departments. Although 75.0 per cent of these sixteen members felt that the systems staff was competent in its area of expertise, they believed that problems resulted when the systems department, with only a minimum amount of operating knowledge, developed a system and then attempted to force it on the user. Several individuals from the group also felt that many of the systems department personnel believed that the production operations should be adapted to fit the system rather than that the system should be designed to meet the needs of the operation.

According to members of the user group, the traditional argument used by the systems department in supporting their philosophy is that changing the system to meet the desired approach to the production operations would invalidate the system's logic. Though criticism was made of the systems departments' philosophy, a majority of the user group did, however, reveal recognition of a changing attitude within the department. For example, 53 per cent of the group said that within the past year individuals within the systems department appeared to be more willing to work with the users.

Response from the users also indicated a lack of understanding with reference to the existing systems. Over 47 per cent of the ones interviewed had only minimum knowledge of the systems that had been developed by the systems department. The most frequent reasons given in defense of this lack of knowledge was that the systems department seldom interfaced with the users in developing systems; primary contact was made with managers within the department. One product engineer expressed the view as follows:

I am not familiar with many of the systems, although I have heard different comments in reference to some of them and am familiar with what some of the other areas have done or are doing with the systems. One of the problems we have is that we seldom have the opportunity to view the systems work. The systems department normally works primarily with the managers within the department.13

Though many of the interviewed users expressed strong criticism of some system activities and procedures, in general the user group supported the use of gaming. For instance, 75 per cent of them expressed positive support for the use of a game activity as opposed to a team approach for integrating the ideas and needs of users, managers, and the systems staff. Several of the individuals, in indicating support for the "game activity," stated that the team approach was really not effective in terms of integrating ideas. This lack of effectiveness was caused by the fact that the team did not necessarily include those individuals

13Statement by W., December 17, 1970 (anonymity requested).
who were knowledgeable concerning the operations and because in most cases managers and the systems staff played more of a leading role. The game activity would give more exposure to a larger number of individuals; thus more than a select group of users would have an opportunity to be heard.

Over 78 per cent of the interviewees who had been exposed to the game-training sessions expressed the opinion that the game session fostered a better understanding of the production control system. This supportive group also voiced the feeling that the sessions were helpful in terms of identifying the probable benefits that could accrue from use of the system. These two facts seemed to support the earlier conclusion that a game session would be meaningful in terms of conveying concepts and facts. In elaborating on the game sessions, a majority of the interviewees indicated that the time-sharing base of the game session was a key factor contributing to its meaningfulness. Many of the game interviewees also expressed the opinion that some of the existing systems could be improved significantly by converting them to a time-sharing mode.

Several disadvantages of the proposed game-implementation approach were voiced by some of the interviewees. First, more than 20 per cent of the user group expressed the opinion that employing an abstract game to present systems concepts would not be meaningful. In defending their view, these users indicated that, unless the game were a true
simulation of an actual operation, it would be of little use. Several of the users voiced the opinion that, unless the game addressed actual problems encountered in the productions, most users would be unable to relate to it. In general, it appeared that the dissenting users viewed the abstract game approach as another attempt by the systems department to force a preconceived system onto the operating department.

A second disadvantage identified by the user group, and a somewhat unexpected response, was the probable increased time and costs that could be associated with the game approach. Over 78 per cent of the user group believed that this approach would probably require a longer period of time to develop because of the number of people involved. The resulting increase in time could cause cost to increase; as a result it would be difficult to sell the concept to management. One member of the user group, however, expressed a possible solution to the dilemma:

The approach is very good for getting users, and managers involved. However, with more people being involved, the resulting system will probably take longer and cost more to develop. It would probably be difficult to sell the concept to management. If the game could be designed around a typical operation, then it might be possible to convert the game into a system; this would allow saving in time and cost.14

Though there is some question as to whether the approach would require additional time with resulting increased cost, this particular response was unexpected for the following

reason. A key point that was emphasized in developing the proposed game approach was that, if the game-system simulator were properly structured, then the time required for development of the final system should be minimized.

Manager interviews.—The management group also indicated positive support for the proposed game approach. However, the indicated level of support from this group was less than that from the user group. Sixty-seven per cent of the managers interviewed indicated that they would support the approach, at least on a trial basis. This level of support was somewhat greater than anticipated, since only 33 per cent of the group expressed the opinion that operational systems had a high degree of importance in the area; 67 per cent of the managers expressed a greater need for informational type systems. In exploring the situation, it was determined that some of the reasons for the greater-than-anticipated level of interest resulted from the game-training sessions. Several of the managers who expressed the need for informational type systems had attended the game-training session for the production control system. Each of these managers indicated that they were favorably impressed with the seminars and, as a result, would be willing to try using a game for conceptualization and study of a system. In the interview discussions, each manager also said that the game session had significantly increased his interest in the use of operational systems.
Several comments and opinions were expressed by the managers which complemented the views of the user group. For example, over 60 per cent of the management group indicated minimal familiarity with most of the systems that had been developed by the systems department. Only 33 per cent believed that the previously developed systems adequately met the needs of the operational departments. However, over 83 per cent of the managers indicated that, even though some system problems did exist, the corporation was not over-emphasizing the use of systems. As was true of the user group, the management group felt that some system problems were a result of the level of understanding and the philosophy of the system department. Over 60 per cent of them stated that the system department did not fully comprehend the operating environment or the operating problems before developing a system. Similarly, the same managers indicated that the systems department was often guilty of fitting a problem into a predetermined solution approach rather than attempting to adapt the system to meet the requirements of the problem area.

More than 60 per cent of the management group supported the idea of using a game activity rather than a team approach for developing a system. However, the expressed reasons for supporting the concept differed from those of the user group. A majority of the managers indicated that the game activity appeared to have a great deal of potential for conveying
ideas and concepts. Further, the degree of involvement necessary in a game session made the game activity more desirable than a team or committee approach. But most managers said that it was not necessary to involve a large number of users in the initial game sessions. Primary user involvement should occur during installation of the system; the game would be beneficial at that time for use as a training device. This view concerning terms of user involvement concurred with that expressed by the users who generally had little opportunity to voice their ideas or needs until the system was designed and developed.

A frequently mentioned factor in support of the proposed game approach was the increased interaction that could occur between the systems staff and the management group in employing the approach. Over 60 per cent of the management interviewees believed that the approach would foster increased interaction between groups. As a result of this increase, such differences as the systems staff's view of particular operations and procedures and managements' view of the operations could be resolved. The approach would also be helpful in exploring and evaluating different solution alternatives before they were incorporated into a system. One manager voiced this general view:

The approach looks very good for achieving better interaction with the systems department. Based on my experience with the game-training session for the production control system and from some of our general conversation today, it appears that the approach would give us a chance to really work
with the systems fellows. We should be able to avoid some of the problems we have had in the past.\textsuperscript{15}

Opposition was expressed concerning the higher conceptualization and validation cost that would be associated with the game approach. Eighty-three per cent of the management group indicated that they would be cautious in using the approach because of possible increased development costs. Several of the managers also indicated that one disadvantage of the approach was the excessive time that could be expended in attempting to refine a desired solution approach particularly if adequate guide lines were not established. One member of the management group expressed this view: "If some adequate checks and controls are not established, a lot of time could be wasted in studying and refining different solution techniques, rather than getting on with the business of developing the system."\textsuperscript{16}

A second disadvantage voiced by several of the interviewees was the possibility that the approach would increase the total time required to conceptualize, develop, and install a system. Over 60 per cent of the group believed that this approach would require longer time, if properly executed, than would the traditional approach. Several managers, however, expressed the opinion that some disadvantages of the

\textsuperscript{15} Statement by James T. Lineback, Texas Instruments Incorporated, February 20, 1971.

increased development and installation time could be minimized if the game-system simulation could be developed as a small interim system before development of the final system. This would allow a pilot line test of the system and would provide management with some results which could justify the commitment of required resources for the final system. This particular view paralleled a similar opinion expressed by a member of the user group.

Systems staff interviews.—The proposed game-implementation approach received the lowest level of support from the systems group; only 62.2 per cent of this group expressed positive support of the concept. However, in evaluating the responses of the interviewees based upon a categorisation by area of responsibility, it was noted that 87.5 per cent of the interviewees with responsibility in the area of operational systems expressed support of proposed concepts, while only 18.6 per cent of those with information systems responsibility supported the concept. All of these interviewees had been exposed to the game-training sessions.

The low percentage of positive response in support of the concept appeared to have little correlations with the response on some other questions posed to the interviewees. For example, a high positive response was noted when the question of implementation responsibility was discussed. Eighty-six per cent of all system staff interviewees expressed the opinion that the systems department should assume
primary responsibility for the implementation of systems. This particular level of response, however, was not surprising since the department manager’s philosophy included a strong emphasis on implementation. The question concerning management support also received a strong positive response. Over 93 per cent of the group indicated that the support of the respective managers within the operating departments was important for a good working relationship between the operating department members and the systems staff. If this response were interpreted to imply that the systems would work closely with the managers in order to gain their support and if the response were indicative of the systems department’s reaction in total, then this would partially explain the reaction voiced by the user group; that the systems department’s primary interaction activity was with the managers within the operating departments.

A majority of the interviewees indicated that some of the problems associated with the use of systems resulted from a lack of understanding of concepts and techniques. Over 75 per cent of the group responded negatively to the question: "Do the operating managers as well as users really understand the concepts and techniques used in the different operational systems?" In discussing the question further, 40 per cent of the interviewees said that many of the members of the operating departments had a general overview knowledge of some of the techniques and concepts. But the interviewees added that in most cases the level of understanding was a
detriment. The managers and users assumed competency in the area when in reality they had only a superficial knowledge; this often led to misuse of the systems.

Some differences of opinion were expressed by different interviewees in discussing what constituted an implementation problem. In general, though, the group agreed that more implementation problems were associated with operational systems rather than informational systems. Over 68 per cent of the interviewees replied with an affirmative response.

Interviewees also expressed differences of opinion in discussing the use of technical jargon. Only 46.6 per cent of the group voiced the opinion that the systems department often used technical jargon in discussing ideas and concepts with members of the operational departments. On the other hand, 39.9 per cent of the interviewees expressed the view that the systems department did not employ sophisticated terminology in discussing systems, but instead the members of the operating department often tended to use confusing operational terminology.

Though all the system staff interviewees did not endorse the proposed game-implementation concept, the group in general did express positive support for the basic use of gaming. Over 79 per cent said that gaming was a meaningful approach for conveying concepts and techniques. Thus, the use of gaming as a training aid was generally accepted.
Reactions of the interviewees toward specific aspects of the proposed game concept, such as the use of a game for identifying specification and operating problems, again tended to be correlated with the area of responsibility with which the interviewee was associated. More than 87 per cent of the individuals with operational systems responsibility felt that a game activity should be a useful approach for identifying specifications and operation errors or problems; They also believed it would be helpful in gaining the support of management. Likewise, the same individuals expressed the view that a game activity before systems development would identify problems that normally would not be apparent under other analysis and design approaches. This was because the activity involved managers, users, and the systems staff and because there was a common base for analysis.

On the other hand, over 70 per cent of the interviewees in the area of information systems stated that use of a game for other than training purposes would really be overextending the capabilities of the tool. Further comments were made that the abstract nature of a game was a key element limiting the usefulness of the tool in an analysis and design function. In defense of this point of view, several individuals voiced the opinion that a more realistic approach to resolving systems problems was through establishment of strong working
relationships with the managers within the operating departments. One interviewee expressed the view in this manner:

If you are going to resolve system problems, then you first have to develop the confidence of the managers. If you can demonstrate to the manager how some information systems can aid him in his operations and if you work with him to get some of the systems installed and operating, then you have made the first step toward bringing some of the operational systems into the area.\(^1\)

This particular view reflected the bias of some of the systems group interviewees.

As was true of the management group and the user group, a majority of the systems staff believed that the increased cost of conceptualization and feasibility study was a disadvantage of the approach. Over 80 per cent of the group indicated that the operational department managers would probably oppose the concept because of cost and time factors.

In retrospect, several general conclusions can be drawn from the interview activity. First, though it was not a direct objective to explore implementation problems, response from many of the interviewees indicated that the organization was experiencing or had experienced many of the typical implementation problems faced by other organizations as identified by the literature. Second, responses in general confirmed the conclusion, gathered from the case study, that gaming is a meaningful training aid for resolving systems problems relating to misunderstood concepts. And, finally,

\(^{17}\) Statement by D. E. Glinka, Texas Instruments Incorporated, September, 1970.
over 50 per cent of the interviewees supported the proposed game-implementation concept, thus confirming the hypothesis that gaming is also a useful tool for the conceptualization and design of a system.

The Generalized Game Activity

The generalized game activity, which followed the questionnaire interviews, sought to confirm further the primary hypothesis of the study by demonstrating that a game activity or some similar activity is required at the initial stages of developing or redesigning a system. Development or redesign of a system requires coordination and unification of the ideas and needs of analysts, users, and managers; however, before this can occur, there must be a common understanding of the problem area which the system addresses and the solution approach used in solving this problem. The objective of the generalized game activity was to demonstrate that in many cases a basic imbalance in understanding exists between analyst, users, and managers at the conceptualization or redefinition phase of a system process, even when a professed or expressed degree of knowledge or understanding has been indicated.

A further objective was to show that an abstract game can be used at the conceptualization stage for coordinating and unifying ideas and that it provide a means for interrelating the solution approach with the problem area. Two modes of reasoning supported this second objective: First,
a game provides the means for the interface of managers, users, and analysts and as such provides a common starting point for a systems study or analysis; second, by employing an abstract game, individuals are removed from the bias of their current environment, thus allowing them to concentrate on the relationship of the solution approach and problem area as suggested by the game. The secondary objective of the generalized game activity was thus to justify use of an abstract game as the first step of conceptualizing or redefining a system.

The game.—The computerized game found in Appendix C was employed in the game sessions of phase II. Though the game was generalized and abstract and was designed to be representative of several industries, it employed concepts that paralleled the resource allocation system that had been developed by the systems department. The game was structured to be characteristic of the allocation system in order to provide a sample of players for the study. Two groups of individuals were selected to play the game. The first group consisted of individuals who expressed knowledge of the resource allocation system but who were not currently using the system; the second group comprised individuals who had either limited knowledge of the system or none at all but who could have benefited from using the system.

The necessity for employing two different game groups was to allow the exploration of some basic assumptions
concerning the development or redesign of a system. These assumptions were as follows:

1. Different groups of users and managers, each having a similar problem that can be solved by a common system, can exist within an organization.

2. The differences in the groups are determined by the group's degree of knowledge of the problem, previous exposure to solutions to the problem, and educational or experience background.

3. Prior experience can strongly bias an individual's actions, particularly if he is placed within the prior environment or a similar environment.

The anticipated results from the game sessions thus were that the two groups would react differently to the game activity. It was hypothesized that the group of individuals with previous exposure to the allocation system would voice the strongest positive or negative reaction to the game depending upon their previous knowledge of and experience with the system.

Twelve individuals were selected to play the game. Six of the individuals had previous exposure to the allocation system and expressed knowledge of the concepts used in the system, while the remaining six individuals had no previous exposure to the system. Twelve single-player game sessions were conducted, with each player allowed to iterate the game as many times as desired. On completion of the game, the
results were discussed with the player. Each participant was also asked to express an opinion concerning the usefulness of the game in identifying problems that might exist in the system and for linking the problem area with the solution approach. Each participant had been told before he played the game that the system was being evaluated by means of the game.

Game session results and analysis.—Game performance from the first group of participants (that group consisting of individuals who expressed knowledge of the system) was lower than expected. Only one game participant performed reasonably well during the game; three participants or 50 per cent of the group had poor game performance, while two participants performed satisfactorily. Results from the sessions thus tended to support the assumption that an expressed level of understanding is not necessarily indicative of a true understanding and that often individuals have only a superficial knowledge of a concept while assuming full or complete knowledge. This result reinforced the hypothesis that a game activity or some similar activity is needed during the conceptualization or redefinition of a system. Had the allocation system been redefined by this first group of game participants, then additional or similar implementation problems might have resulted after redevelopment since a majority of the participants did not completely understand the existing system.
Reasons given for poor game performance tended to occur as anticipated. In general, the participants were defensive concerning their prior understanding of or experience with the system. Over 60 per cent of the group or four out of the six participants indicated that the reason for their low performance level was the structure of the game; they felt that the game was not realistic or that it was not a true simulation of the problem area. One player expressed his opinion in this manner:

The game is really unrealistic; things just do not occur that way. . . . If you are really going to make the game useful, then you need to parallel one of our operations. . . . The game does employ a forecasting and allocation, but the inventory policy is just totally different from our operations. . . . I could have done much better if the game had been more in parallel with our operations.18

These reactions tended to support the necessity for an abstract game. From the actions of most participants during play of the game, it was apparent that decisions were based upon past modes of operations rather than upon the results of the game and they way in which the quantitative techniques interrelated with the game. Thus, it can be concluded that some means such as an abstract game should be provided in order to remove a player from the bias of his current environment.

In general, the first group of participants criticized the game activity; some players, however, expressed support

18Identity of game participants was unavailable; anonymity was granted upon the participant's willingness to play the game.
for the approach. Two participants indicated that the game really helped them gain a better understanding of how the forecasting and allocation techniques worked conjunctively, which was somewhat different from the participants' original understanding.

Results from the second group of game sessions (this group of participants had no previous exposure to the allocation system) were rather poor, as was expected; however, a difference in attitude was noted in the participants' reactions to the sessions. In general, a more receptive attitude existed, even in the cases where poor game performance resulted. In a discussion of the game with the participants, 66 per cent of the group expressed support for the activity. One player expressed his view in this manner:

I had a problem in the beginning relating to the inventory control policy in the game, since it is difficult from our operations. However, I think the game is great in terms of pulling all the areas and techniques together. Also, by using the example from another organization it gives you fresh look at things. Maybe we need to change some of our operations to be more compatible with the way the game is tied together.19

Reactions from the second groups of participants, thus, tended to reinforce the necessity for the abstract game.

Though the sample sizes were small in both game groups, results in general from the sessions reinforced the primary hypothesis of the study and likewise supported the secondary

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19Identity of participants was unavailable (anonymity requested).
hypotheses concerning use of an abstract game. Results from the sessions demonstrated that a game activity or some similar activity is needed during the conceptualization or redefinition of a system because of the imbalance of understanding that most often exists between different groups of users and managers and because of the superficial level of understanding that users and managers may have. (A team approach to conceptualization or redefinition has traditionally been used to resolve some of these problems). The game activity likewise demonstrated that it is desirable to employ an abstract game as the first step of systems conceptualization, since the game should remove some of the participant's bias toward his current environment.
CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

Literature in the quantitative field indicates that a gap exists between the development of many quantitative techniques and the successful translation of these into practical and profitable implemented systems. The objective of this research has been to identify and develop a game-implementation process that could aid in resolving some of the translation problems.

In Chapter I, the general problem area, the specific objectives of the research, and the overall plan of the paper were defined. Defining the general problem area revealed that organizational factors, management needs, user requirements, the solution approach, and problem characteristics are all elements that relate to the development and implementation of a quantitative system. Successful implementation of a system thus depends upon the integration of these elements into the logic and philosophy of the system. To date, however, much of the primary research concerning implementation has focused on the elements in an isolated mode; only a narrow perspective has been taken of the implementation
factors. For example, extensive research has been made regarding the acceptance and use of given quantitative techniques, while only a limited number of researchers have explored the implementation problems related to the translation of a developed technique into an operational system.

In developing the game-implementation concept, it was stated that a broad view would be taken. The concept would be concerned with acceptance and use factors as well as translation factors relating to implementation. This broad view was defined as a systems approach to implementation. It was hypothesized that within this framework a computerized game could be used to interrelate many of the elements.

Previous research relating to implementation was discussed in Chapter II. Here, implementation was defined as managers' and users' acceptance and use of a given technique, and problems which related to this were examined. For instance, it was noted that implementation success is related to the type of environment in which a project takes place; if the environment is such that organizational goals and outputs are not well defined, then it may be difficult to demonstrate the usefulness of a quantitative technique. Similarly, organizational changes may be required in order to employ a given technique; if management is inflexible or if required changes are not fully explained to members of the organization, then problems can result.
Several management factors related to implementation were also reported; for example, there is a high probability that a quantitative technique will be employed if management has had success with previous quantitative methods, has an aggressive creative attitude toward innovation, has confidence in the capabilities of its management science group, and understands the concepts and methods that exist within the field. The attitude and interests of the management science group, the group's capabilities and knowledge, and their reputation within the organization were also identified as important. Of particular significance is the willingness of the management science group to accept a broad view of its responsibility for a project; it was noted that, if the group gives support beyond the mere formulation of a technique, then users and managers tend to be more willing to use or at least explore the use of the technique. Elements such as the client's (user) receptiveness of the management science group, the urgency with which the client needs results, and the willingness of the client to commit his time and resources were also identified as critical. The type of problems to which quantitative techniques are applied must also be considered; it was noted that use of a given technique is more likely to occur when management recognizes that the need for solving a given problem is of major importance to the objectives of the business.
The results from previous research, which had explored the interrelationship of implementation factors, was also presented in Chapter II. Several models were identified which attempted to link such factors as the attitudes and behavior of management, requirements of users, characteristics of the management science group, and characteristics of the organization or environment. This section concluded by identifying the need for a systematic approach to implementation which would provide a framework for the development of a technique and would also provide a means for translating the technique into an operational system.

Chapter III outlined the structure for a systematic approach to implementation which was defined as a "systems process." In an overview, presented in the first section of the chapter, the process was described as consisting of four major phases—conceptual, definitional, developmental, and operations. Implementation was then defined with respect to the process as activities and/or steps that are involved in transforming a conceptualized system into a fully operating system (a broadening of the definition used in Chapter II).

In the discussion of the different phases of the process, certain other problems, in addition to those associated with the acceptance and use of a technique, were noted. For example, during the conceptual phase, identification and definition of system objectives, identification of solution alternatives, selection of an evaluation criterion, and
selection of the proper system solution approach are prominent problems. In the definitional phase, problems occur as a result of the transformation of the system requirements into functional requirements associated with the system elements (personnel, equipment, and data). During the developmental phase, problems occur in defining and developing system procedures, in developing orientation programs, and in transforming the system specifications into computer programs. Some of the major problems during the operational phase occur when the system is subjected to the fully operational environment. In the analysis of these problems, it was pointed out that the systems process had a key characteristic—the feedback relationship and the baseline checkpoints associated with each phase of the process provided a systematic way for resolving some implementation problems.

In addition to identifying a systematic approach for implementation, Chapter III also explored some behavioral factors relating to implementation. A key point was that the source of many systems problems is the lack of understanding by the people who are part of the system. For example, because management often does not possess a firm knowledge of the capabilities of a given system or of the computer, it may expect impossible results. Or it may have the tendency to relate what other companies are doing—in terms of developing and using systems—without regard for the organization itself. Similarly, problems such as improper use of the system or
inappropriate data inputs often result from the users' inadequate knowledge of the system or computer. All human problems inherent in systems, however, are not necessarily a result of a deficiency of knowledge; the discussion of behavioral factors pointed out that many problems result from management's lack of skill in directing, motivating, and controlling the people associated with the systems process.

In the final section of Chapter III, which focused on the need for an integrated approach to implementation, it was stated that more than a systematic approach was required in order to implement a system. Rather, what was required was a systematic approach which could resolve some of the problems related to the acceptance and use of techniques (those identified in Chapter II) and which could provide a means for educating, directing, and motivating the people associated with the system. It was hypothesized that one possible approach would be a game-implementation process, structured by placing a gaming activity in the initial phase of the systems process.

Chapter IV provided the background of and supportive material for gaming, and it also outlined in some detail the scope of gaming. The first section which was concerned with an analysis of the evolution of gaming, showed that business gaming has a historical link with the early activity in military war games. Much of the structure of current games grew out of these earlier ones. In tracing the game evolution
activity, some key developments, particularly those within the late 1950's and the early 1960's, were identified in both general management and functional games. It was noted that numerous universities, industrial groups, and governmental groups contributed to this development activity; a significant volume of gaming activity also occurred in other countries, such as France, Sweden, and England.

The second section of the chapter pointed out that numerous uses have been made of the different types of games that have emerged. Games have been employed for both teaching and research. Typically, most general management games have been used in the academic community and in the industrial training environment where their employment has served as a teaching aid and as a training device. Functional games have served both as an experimental device and for operational purposes. Activity in experimental gaming has been directed towards such areas as the investigation of competitive behavior and the role of communication patterns, the study of competition and bargaining, and the exploration of behavioral patterns and learning processes within a simulated organizational environment. A key fact noted was that in at least one case operational gaming has been used in studying the characteristics of a systems activity in an operating environment. This fact lends support to the hypothesis that gaming can serve as a meaningful approach to resolving some systems implementation problems.
The final section of Chapter IV identified factors, which have limited the development and use of gaming. For instance, some gaming activities have been limited because of the design, development, and operation requirements; many months of development work and many thousands of dollars in computer time and facilities are often required. All games, however, do not necessarily require excessive resources; the size, complexity, and purpose of the game largely determine its development and facility requirements. The requirements for games employed for teaching purposes usually are nominal whereas those for operational and experimental games may be excessive. Thus, some gaming activity in the experimental and operational areas have been limited by their requirements.

In exploring the facility requirements associated with gaming, it was suggested that some of the recent developments within the computer field, particularly within the time-sharing area, have broadened the possibilities of gaming. Time-sharing computers now provide capabilities such as human interaction, real-time processing, mobility, and medium computer capacity.

Next, Chapter V focused on the development and analysis of the game-implementation process. Before the actual structure of the process was described, an organizational framework was identified in order to delimit the field of application in which the process was meaningful. It was shown that the process is more amenable to the development
and installation of systems within an operational control area of an organization than at the higher levels of the organization such as the strategic or management planning and control areas. Because of the rigid structure and quantitative base of many operational activities, a functional game is useful for identifying the use of quantitative techniques such as linear programming, economic order quantity, and job shop scheduling. Because of the necessity of having systems within the operational control area and because of the implementation problems that have resulted in developing and using systems, a game-implementation activity is relevant to the area.

Chapter V also discussed some effects that could result from the game process. Though no direct data were presented, hypotheses were made as to the probable impact of placing a functional game at the conceptual stage of the systems process. It was shown that a game activity should affect the problems associated with acceptance and use of quantitative techniques and the problems of individual involvement (behavioral problems).

The game approach was developed in detail in the third section of the chapter. The structure for the approach was shown to involve activities such as identification of system objectives, development of abstract games, identification of current systems, comparative analysis, and development of a game-system simulator. Projected results flowing from the
game approach were a means for problem identification; a means for individual involvement of users, managers, and management scientists; and a means for identification of a valid solution approach. These were shown to be meaningful inputs to a feasibility study.

Also examined was the relationship of the game approach to the systems process. The approach reorganizes the process by shifting to the conceptual stage many of the activities that traditionally occur during later stages. More directly, it was shown that this approach alters the traditional decision cycle associated with the conceptual stage and shifts some of the basic activities that are associated with systems definition to the conceptual stage. It was also pointed out that some of the activity of user training and pilot implementation occurs during the conceptual stage in the re-organized approach.

A brief subsection of the chapter addressed the question of gaming cost. It was submitted that game costs could be justified for three reasons. First, the cost can be viewed as a training and development cost. Second, if the game activity identifies critical problems, then the cost of gaming can be offset by the saving. Finally, the cost can be viewed as a necessary feasibility study cost. A point that should be recognized is that the game approach to the system process will most likely result in a higher feasibility cost. Since some activities of other stages are performed during conceptualization, it can be expected that additional costs will
be incurred. Traditionally, the feasibility activity of the systems process results in less than 5 per cent of the total systems cost.¹ The expected feasibility cost for the game approach could be as high as 15 per cent.

In exploring and developing the game implementation process, a minimum of attention was directed at examining computer facility requirements. It was recognized, however, that one of the key elements that makes the approach most meaningful, particularly in terms of individual involvement, is the capabilities of on-line computer time-sharing. Many of the comments concerning the probable impact of the game approach were made under the assumption that the game activity and the game-system simulator employed a time-sharing computer system.

Finally, Chapter VI presented the research of the study. An industrial case study, questionnaire-interview surveys, and a generalized game activity were described and evaluated in order to test the research hypotheses and to evaluate the proposed game-implementation process. The first section of the chapter, which described the case study, presented the results from eleven sampled game-training sessions and four production operations; these were used in evaluating the hypothesis concerning the use of a game as a training aid. Foundation material describing the case study was presented

before the results were given. This is summarized as follows:

The study was conducted in a large computer systems department within a decentralized operating division of a large electronics firm. The department operated on a staff-function basis with several operating departments in the division; the department's primary responsibility was to give professional computer systems support to these operating departments. The primary problems faced by the operating departments were noted as excess or delinquent finished-good inventories, excess work-in-process inventories, and less-than-optimal utilization of resources. In an effort to resolve some of these problems, several systems had been developed. In examining the usage of these systems, however, the systems department noted that the heaviest usage was made of the management information type systems; minimum use was made of the quantitative systems. It was the opinion of some managers within the department that this lack of usage was a result of managers and users within the operating departments not fully understanding many of the systems. Game-training sessions were developed in an attempt to resolve some of these problems. The eleven game sessions described in the case study were a representative sample of these game-training sessions.

The results from game session questionnaires collected during the game-training sessions were described and analyzed in order to evaluate the training activity. These results tended to indicate that the sessions were effective. For
example, a large majority of the game participants felt that the sessions were informative and meaningful. Specifically, many of the participants expressed the feeling that the gameplay portion of the sessions was a meaningful way to communicate systems to users; several individuals also indicated that it was helpful in understanding problems in systems and in understanding the role that systems play in the production operations. Game participants also expressed a high degree of acceptance of the theory presented in the game sessions; a majority of the participants stated that the game was helpful in gaining an understanding of the theory employed in the system. All games participants, however, were not sold on the system; there were negative reactions to the sessions. For example, some felt that the approach was too idealistic, that the system was good in theory but would not work in an actual operation, and that it was useful only as a guide to how the production operations should perform.

In order to measure the effect of the game-training activity on the use of the production control system (the system around which the game-sessions were structured), data were collected on production indices from four production areas. This data indicated that usage of the system had increased after the game-training sessions; improvements in operations were noted in all four areas.

The second section of Chapter VI was concerned with the primary hypothesis of the study—namely, that gaming can be
employed during the conceptualization and design of a system to interrelate the problem area, the solution approach, and the ideas and needs of users, managers, and analysts. The proposed game-implementation process developed in Chapter V was used as a framework for analysis; the assumption was made that acceptance of the process would validate the hypothesis. Two specific activities were used in exploring the hypothesis. First, questionnaire-interviews (concerned with the proposed process) were used to solicit opinions and ideas from users, managers, and analysts; second, a generalized game activity was used to demonstrate that a game or some similar activity is needed at the conceptualization stage of a system.

A total of forty-one individuals within the organization were involved in the questionnaire-interviews; this group was comprised of managers from the operating departments, systems staff personnel from the systems department, and users from the operating departments (production line supervisors, process and evaluation engineers, and product marketing analysts). The results of the questionnaires revealed that users, managers, and analysts all expressed support for the proposed process; the expressed level of support, however, differed among the groups. For example, over 70 per cent of the individuals from the user group expressed the opinion that the employment of a game activity before the development of a system would aid in resolving some systems problems. Similarly, over 75 per cent of the
group felt that the game activity, as opposed to a team approach, was more useful as a means for integrating the ideas of users, managers, and analysts.

Sixty-six per cent of the managers interviewed indicated that they would support the game approach at least on a trial basis; this level of support, however, was greater than anticipated, since 66 per cent of the management group expressed the opinion that informational type systems had a higher degree of importance than operational systems. This high level of support for the approach resulted from the group's previous exposure to the training sessions. The management group also expressed support for the idea of using a game activity rather than a team approach for developing a system, but over 60 per cent of the group felt that only a small number of users needed to be involved in the initial development activities. A factor frequently mentioned by the management group was that the game approach would increase the level of interaction between the systems and management groups; a majority of the managers felt this would aid in resolving differences in the understanding of operations both of the proposed system and of the production operations.

A majority of the systems group interviewees, 62.2 per cent, supported the proposed game approach. It was noted, though, that their responses tended to be correlated with the area of responsibility with which the interviewee was associated. Over 85 per cent with responsibility in the
area of operational systems expressed support for the concept. There was a common agreement that a lack of understanding was the cause of many systems problems; however, while a majority of the interviewees with operational system responsibility felt the game approach would resolve some of these problems, a majority of those who had informational systems responsibility felt that the problem could be resolved only by a close working relationship with management. A negative response, common among all groups of interviewees, concerned the cost of the game approach; users, managers, and systems analysts all expressed the opinion that the increased cost of conceptualization (an increase in cost of the feasibility study) was a disadvantage of this approach.

The generalized game activity followed the questionnaire-interview surveys. The primary objective of this activity was to demonstrate that an imbalance in understanding can exist between users, managers, and analysts at the conceptualization or redefinition phase of a system, and thus a game activity or some similar activity is needed if the imbalance is to be resolved. (This imbalance can create implementation problems if overlooked). A secondary objective was to show that an abstract game can be used at the conceptualization stage for unifying ideas and achieving a balance in understanding, particularly if the different individuals involved are biased by their environment. The game (found in Appendix C) employed in the generalized game
sessions was structured to be characteristic of an allocation system that existed in the organization. Twelve individuals within the organization were involved in the game sessions. The individuals were categorized into two groups; the first group (six individuals) consisted of persons who expressed knowledge of the allocation system but who were not using it; the second group (six individuals) had no knowledge of the system. In analyzing the results from the twelve game sessions, only a slight difference in performance was found to exist between the two groups, with the exception of one participant from the first group who performed well. A notable difference in attitudes, however existed between the two groups; the first group of participants, defensive of their prior understanding of or experience with the system, were critical of the game; a more receptive attitude existed among the second group, even when poor game performance resulted. Results from the sessions thus tended to indicate that a game activity or some activity is needed during the conceptualization of a system because of the imbalance of understanding that can exist between the different individuals involved and because of the superficial level of understanding that some of the individuals may have. An abstract game is preferable since it is not affected by a participant's bias.

Conclusions

The major conclusions of this study can be drawn from an evaluation of the results in Chapter VI since this chapter
relates the research activities to the hypotheses of the study. Before examining these results, however, supportive conclusions can be made by relating some secondary results to the problem areas and to the systems process that were focused upon in the early stages of the study. The approach taken in this section, therefore, is first to highlight some supportive conclusions, second to identify the conclusions relating to the hypotheses of the study, and finally to draw some general conclusions regarding the potential use of the proposed game-implementation process.

Supportive Conclusions

A review of the quantitative literature shows that extensive research has been made of the factors that relate to the acceptance and use of quantitative techniques; the interrelationships among different factors have also been explored. The literature suggests that knowledge of these factors and their interrelationships should result in additional usage of quantitative techniques and should resolve the major implementation problems that occur in transposing a technique from theory into practice. A review of the current literature, however, reveals that many implementation problems have not been resolved and that the acceptance and use of developed techniques have not increased drastically. Likewise, though it cannot be assumed to be true of industry as a whole, results from the questionnaire-interview surveys made in the research confirm that some key implementation
problems still exist in actual practice. For example, over 50 per cent of the users, managers, and analysts interviewed in the surveys indicated that such problems as the use of confusing technical jargon in discussing systems, forcing a problem into a pre-determined solution approach, lack of understanding of concepts and techniques, and the lack of management support existed in the organization. It must be concluded, therefore, that knowledge of factors relating to the acceptance and use of techniques has not resulted in their increased usage.

Examination of the literature within the management information systems field, particularly that literature relating to a systems development-implementation framework (such as the systems process identified in Chapter III), reveals that many authors view behavioral problems associated with the field as linked with the selecting and training of appropriate personnel. Results from the game-training sessions and the generalized game sessions indicate that, in developing and implementing a quantitative system, behavioral problems are much broader. Specifically, results from the sessions indicate that people must be motivated and controlled as well as trained and that the biases of users, managers, and analysts can create major implementation problems if ignored. Thus, it is concluded that in developing and implementing a quantitative system a broad perspective must be taken of behavioral problems.
Examination of the literature on gaming shows that some of its potential usage has been limited by costly computer and facility requirements (see Chapter IV). It is concluded, however, that, as the cost per hour of computer time is reduced and as time-sharing computer systems become more widely available, the magnitude of this problem will be reduced.

**Primary Conclusions**

Literature from the fields of systems engineering and from the management information systems indicates that gaming can be employed as a training aid in installing a system. In this study the hypothesis stated that the use of gaming as a training aid is likewise applicable to the installation of a quantitative system. Data collected from the game-training questionnaires indicate that a game participant's level of understanding does increase as a result of a training activity. For instance, 83 per cent of the one hundred and thirty-six game participants indicated that training sessions were informative and meaningful (see questionnaire in Appendix A). Likewise, data collected on production operating indices reveal that the usage of a system can increase after a training activity—Table III shows that positive changes occurred in the indices of the four monitored production operations after training sessions were administered. It is concluded, therefore, that gaming is a valid implementation tool which is useful for installing a quantitative system.
The results from the case study also show that a more relaxed, interactive working relationship can exist between individuals after a game-training activity. Thus, it can be concluded that attitudinal changes can also result from a game-training activity.

The changes in production operating indices data, which were collected in the case study, indicate that the usage of a system can increase as a result of a game-training activity. The thesis could thus be developed that a training activity will result in increased usage of a system. Additional results collected from interviews during the case study, however, challenge this thesis; results show that operational constraints, which limit a system from functioning effectively, can retard a potential increase in usage. Specifically, an interview with a systems manager during the case study revealed that usage of the production control system did not increase after the training sessions until a redesign of the system corrected some operational constraints. Consequently, it is concluded that this thesis has little validity.

Data collected from users, managers, and analysts during the questionnaire-interview surveys reveal that gaming can also be useful as an aid during the conceptualization and design of a system, since over 50 per cent of the individuals interviewed during the questionnaire-interview surveys expressed support for the proposed game-implementation process.
Though differing levels of support for a game-implementation approach can exist, in general users, managers, and analysts would support the concept. The questionnaire-interview surveys indicated that some managers would be cautious concerning the cost and time factors of the game approach; however, over 66 per cent of the managers interviewed indicated that they would support the approach, at least on a trial basis. Responses from the analysts who were interviewed disclosed that over 85 per cent of those with informational systems responsibility agreed with the proposed concept. As a group, though, over 60 per cent expressed support for the concept. Responses from the users interviewed indicated that, in general, this group felt that the approach allowed them a more interactive role in the design and development of a system with over 70 per cent of them expressing support for the concept. From these results, therefore, it is concluded that gaming can be employed during the conceptualization of a system.

The general opinion, as revealed by the questionnaire-interview survey, is that employing a game activity during the conceptualization of a system will increase the total cost of the system—over 70 per cent of the users, managers, and analysts interviewed expressed this belief. There are, however, two strong arguments in support of the opposite point of view: First, the cost of conceptualization will increase with the addition of a game activity, but since a
game-implementation approach only reorients the steps and activities of the traditional systems process, the total cost of developing and implementing a system should not increase. Second, current literature shows that implementation cost and training cost are usually ignored in the initial cost determination of developing a system. Consequently, it is not surprising that an increase in the cost of conceptualization is viewed as an increase in total systems cost. It is, therefore, the conclusion of this study that in using the game implementation approach the total cost of developing and implementing a system will not increase.

An analysis of the results from the generalized game sessions of the study reveals that the use of a game activity or some similar activity during the conceptualization of a system is particularly desirable. The twelve game sessions demonstrated that differing levels of understanding existed among the users, managers, and analysts involved with the game and that these individuals' actions and decisions during game-play were affected by personal biases. The results suggest that implementation problems can be created if differing levels of understanding and personal bias are not resolved before a system is developed. The questionnaire-interview surveys indicate that the team approach to resolving such problems may not be fully effective—over 50 per cent of the individuals interviewed expressed this opinion. It is concluded, therefore, that suggesting the use of a game-implementation approach to conceptualization and implementation
of a system is not unrealistic and that in the future, approaches to the conceptualization of a system (particularly a quantitative system) will be employed which involve more interactions among users, managers, and analysts.

The data compiled in this study show that the examined industrial organization experienced implementation problems similar to those identified in the literature. Second, data indicate that a number of members of the organization would support the game-implementation process as a means for resolving some of these problems. The thesis could thus be developed that the game approach is applicable for most industries or most areas within an industry that experience such problems. However, without taking a statistical sample of the members from all areas of an organization (those in which quantitative techniques are applicable) and a similar sample from all industries, the broad applicability of the proposed process can only be hypothesized. It is concluded, therefore, that broad applicability of the proposed process cannot be established without further research.

**General Conclusions**

Research data from the study show that, within the industrial organization studied, a potential use of the game-implementation process exists; if one assumes that equal or similar results will occur in other organizations which have similar implementation problems, then an extended potential usage of the concept exists. Two factors exist,
however, which can retard much of the potential usage. First, research data from the study suggest that the increased cost of conceptualization will be viewed with caution since managers interviewed expressed the opinion that the concept could result in excess costs if not adequately controlled. Second, a review of the quantitative literature indicates that the number of cases of successful application of quantitative techniques is less than the number of failures. Thus, since the game-implementation concept had a quantitative base, it can be assumed that it will be viewed with caution. It is concluded, therefore, that the use of the concept will depend upon management's willingness to support it and the degree of success which results from the initial use; failure or mediocre success in the initial use of the concept could result in management's decision to discontinue.

The primary objective of this research was to identify an approach which would be useful in developing and implementing a quantitative based system. The game implementation process was developed as a possible implementation approach that would meet this criterion (development of the approach was the major contribution made by the study). Based upon data from the research, it is concluded that the proposed concept is a useful development implementation approach. This conclusion is supported by data which show that a game activity is useful in installing a quantitative system, that users, managers, and analysts within the organization studied would support the game-implementation concept, and finally that a
game activity during conceptualization is needed if individual differences and biases are to be resolved. Specifically, the conclusion is based on the following: First, the assumption that some of the gaming success demonstrated during the game-training activity of the case study will occur during the conceptualization phase of the game-implementation process since it involves similar activity. Second, the fact that over 50 per cent of the users, managers, and analysts interviewed during the questionnaire-interview surveys indicated that they would support the concept, even when it was noted that higher conceptualization-feasibility cost would result. And, finally, the fact that the generalized game activity indicated that superficial levels of understanding and individual biases can exist among users, managers, and analysts but that through the use of an abstract game some of these biases and differences of understanding can be resolved. It is further concluded, however, that a key determinant of the usefulness of the game approach to developing and implementing a system will depend on the support and understanding of all individuals involved, particularly management, and their recognition that the concept is not a panacea.
APPENDIX A

CASE STUDY - SUPPORTIVE MATERIAL

Preface

The problem area for which the production control system was developed was line balancing. The functional game and game-training sessions thus were directed at presenting the basic theory of line balancing and exposing the user to the logic (algorithm) employed in the system. Samples of the game output reports and a copy of the game session questionnaire are included in this section; before presenting this material, it is, however, worthwhile to examine the basic theory of line balancing.

The theory presented here has neither the form nor the depth of coverage used in the game sessions; likewise, the algorithm presented here is not necessarily the one that was employed in the system. Because of proprietary constraints, most of this information was unavailable.

Theory

Basic Concepts and Relationships

Two key points are of significance in understanding the basic theory of line balancing; first, the definition of line
balancing; second, the relationship between the speed of the line and the length of the line. These relationships are described as follows:

**Line balancing.**—The balancing of operating in terms of equal times, and in terms of the time required to meet the desired rate of production, is the problem of line balancing. It is part and parcel of line production. The desired rate of production is converted to a time per work station; this is called by various engineers the balancing factor, balancing time, station cycle time, or station time. This balancing factor, or station time, is equal to the reciprocal of the rate of production; i.e., it equals one divided by the rate of production.

Perfect balance is rarely achieved; there is always some extra time in at least one operation. However, an operator with idle time to balance may often be assigned additional work not necessary to this operation: handling material to the line; extra inspections of his work; and even more lengthy operations when the work is allowed to bank up at his work station. Because of the difficulty of dividing machine operations, it is far harder to balance forming or fabrication lines that assembly lines, where the assembly time can be split at many places and the workers moved readily.

The term bank is commonly used for the accumulation of material waiting for an operation. The use of banks is common where parts are put over a line, and with irregular amounts of work to be done on each part. They are also used where parts are handled as a lot or batch on the line and, again, where materials are delivered to or removed from the line at irregular intervals, or where a given machine or work station is also used for some other part or product periodically.

Banks may be located directly in the line. Examples of this are hoppers between punch presses into which parts from the previous operation are elevated, and additional lengths of chute or roller conveyor on which parts can accumulate but index themselves forward by sliding. Or the bank may be beside the line on a shunt, over-the-line shelf, or spare conveyor. These arrangements are far better than removing the bank to a separate storage point.

Where banks are held for protection rather than balancing, they must be adequate to protect the operations subsequent to the point of interruption of flow. This means that the anticipated interruption or delay time divided by the station time or balancing time per piece will determine the number of pieces in the bank. This can be expressed analytically in the following manner:
Bank Size (No. of Pieces) = \[
\text{rate of production (pcs/hr) \times time of interruption or delay (hr)}
\]

Bank Size (No. of Pieces) = \[
\text{time of interruption or delay (hours) balancing factor or station (hr/pc)}
\]

Line speed and length.—Speed of flow bears a direct relation to rate of production and space per work station. This is expressed as follows:

\[
\text{Speed of Line (ft/hr) = rate of production (pcs/hr) times station length or space per piece (ft/pc) = station length or space per piece (ft/pc) balancing factor or station time (hr/pc)}
\]

The station length or space is dependent on the size of the part or unit, the room required by workers and equipment, and the amount of work to be performed there. Expressed analytically this is as follows:

\[
\text{Length of line = station length of space X number of stations = station length or space (ft) \times overall time for completing the piece or unit (total line (hr/pc) + the balancing factor or station time (hr/pc))}
\]

Methods of Obtaining Balance for Fabrication Operations

Several methods exist for balancing a line that is characterized as a fabrication (machine) operation. These are described as follows:

Improve the operations.—This is the best way to balance material-forming lines. Concentrate attention on the bottleneck operations; bring the methods and tool engineers in to

---

work on them. By changing the method—through improved tooling, mounting two pieces at one time, eliminating extra handling time, and many other ways—one can bring machine times down to a rate that will fit in with the desired rate of production.

Change machine speed.—Changing the speed of the machine is sometimes easy and practical. Where you can bring a slow operation up to the line rate by this device, you solve the problem right away. Slowing down machines to meet the same rate as other operations may even be practical. This is especially true where you have fast operations and parts that will not stack easily, as in many draw-press lines. Usually it is easier to let the fast machine stand idle a little and have the operator do some miscellaneous bench-work, stock handling, or the like.

Bank material and operate the slower machines overtime or on extra shifts.—This sacrifices floor space and increases material-in-process at the bottleneck operations. It involves supervision problems and may interfere with maintenance routines. It is a simple procedure when you have only one or two machines out of balance on the high, or long, side. It is not possible three-shift operation.

Divert excess pieces to other machines not in the line.—This is practical also when you have one or a few constriction points. Here you let surplus pieces accumulate. These are the ones the long operation cannot do in time. Then you move them to another machine and do them on a job-lot basis, bringing them back to the line when finished.

Frequently, one costly machine can be located so it is common to two or three lines, provided it is fast enough and the tool changing is quick.

Multiple items or combination lines.—Sometimes it is possible to group similar items and produce them on a combination line. The theory here is to spread the idle machine time of one product against that of another. The first operation may be the same for three parts—one machine for all three parts. Operation two may be one-third as fast—three machines, one for each part. The third operation may take one-half, one and one-half, and two times the time of operation two. This means four machines with one alternation back and forth on one part. This kind of ingenious balancing is receiving more attention every day.

^Multiple items or combination lines.—Sometimes it is possible to group similar items and produce them on a combination line. The theory here is to spread the idle machine time of one product against that of another. The first operation may be the same for three parts—one machine for all three parts. Operation two may be one-third as fast—three machines, one for each part. The third operation may take one-half, one and one-half, and two times the time of operation two. This means four machines with one alternation back and forth on one part. This kind of ingenious balancing is receiving more attention every day.

2Ibid., pp. 7-103 - 7-104.
Methods of Obtaining Balance for Assembly Operations

The methods and operations associated with balancing an assembly line operation are slightly different from that of fabrication operation. Some of the methods for balancing an assembly operation are as follows:

Divide operations and apportion the elements.--This is the most common way of balancing assembly operations. Since assembly operations usually can be easily divided, a high degree of balance with little idle time is attained.

Combine operations and balance groups.--Many times it is not practical to divide an operation further. This is true especially on short lines. Here you can spread a group of five workers over three operations and let them alternate on the operations they cover. This means balancing the idle time of one operation against the idle time of another without subdividing either. Some workers will have to change places to cover two operations.

Have operators move.--When operations take relatively less time than the station or balancing time, a worker may move with the work doing several operations. Sometimes he may even work on two different lines. Or he may go to tight work stations and help out there. In small groups, workers with the light operation normally get the material-handling work.

When the operations take longer than the cycle or balancing time, balance by having one worker move with the work through, say, six operations. If he moves back up the line and picks up each fourth unit, you will have balanced four men against six operations.

In other cases, have workers move up to the head of the line at the beginning of each shift. They will get enough pieces started through the unbalanced operation for the shift; then they will return to their regular place in the line.

Improve operations.--Where an operation is longer than the station time or balancing time, balance it by improving the method. If you cannot divide the operation, put extra study into reducing its time. Many industrial engineers will spend costs far beyond the saving possible in that one operation if they can reduce a bottleneck to the balancing time.

Bank material and do slower operations on extra time.--This sacrifices floor space and increases material-in-process at the bottleneck operations. It requires extra time of
supervision and may interfere with maintenance work. It is not possible with three-shift operation. But it is simple and often used, though less in assembly work than in forming or treating.

Improve operator performance.—Sometimes you can balance an operation by identifying a bottleneck operation as such and seeing that the group leader gets better performance on it. He may give an added bonus for anyone on the tight operation who keeps pace with the other operations. He may assign extra help there, a utility operator during rest or lunch period or a material handler to position work exactly.

Mechanics of Balancing

Balancing a production line involves establishing a relationship among several key factors, namely the rate of production, the operations necessary and their required sequence, and third, the time necessary to perform each operation. These factors are a necessity. For the line to be set up, it must be designed for a given rate of production; for it to operate as a unit, the operation times must be such as to let the material flow evenly. Time study, predetermined motion times such as methods-time measurement, standard data, and machine capacity come into their own here. They are fundamental to establishing a balanced line, except in those cases where an overall time is estimated and the workers are left to balance out the operations themselves. This latter can be done on simple, man-paced operations when there is room for banking material between operations and when there is some form of group incentive. While it works in some situations, it usually results in overly large protective banks and cannot be considered a precise method of organizing the line.

Expressed as a sequence of steps, balancing involves the following:

1. List the required operations or elements thereof.
2. List them in sequence, noting beside each the limiting operation or element it must precede or follow.
3. Show the operation or elemental time for each, indicating which is the controlling or bottleneck operation.
4. Adjust operations by combining or dividing operations or changing the methods indicated above so as to get a total time for each operation that is equal to the balancing factor or station time.\(^3\)

\(^3\)Ibid., pp. 7-104 - 7-106.
Balancing Logic (Algorithms)

Several algorithms have been developed which determine either the exact or approximate solution for the line-balancing problem. Edward J. Ignall\(^4\) summarizes several computerized techniques that have been developed. Similarly, John Mariotti\(^5\) presents four manual approaches to the line-balancing problem. Though these techniques differ somewhat in the solution approach, each basically involves the interrelating of the same general factors. That is, basic factors such as the breakdown of the operation into elements, specification of time required to perform each element, efficiency of operators, sequence of operations, and the required rate of production are determined and their interrelationships specified. No attempt will be made at this point to explore any particular one of these solution approaches in detail. A quick and much more in-depth view of the field can be gathered by referring to one of the specific references.

The Production Control Game

The following is an example of the output from the production control game:


Hi, this is the Production Control Game. The problem area for this game is that of assembly line balancing. You are playing the game in order to gain some appreciation for the difficulties involved in line balancing and to gain a perspective of how the production control system arrives at a solution to the problem.

The production process for the line involves a metal brazing operation. The process consists of six activities. First, it is necessary to assemble four ring assemblies into a metal housing. The assembly is then placed on a moving belt conveyor furnace in which the brazing process occurs. After passing through the furnace the assemblies are unloaded and inspected. Rejects are thrown out. The acceptable assemblies then pass through a cleaning activity followed by a ream activity in which an inner portion of the assembly is reamed to a given diameter. The assemblies then pass through a second and final inspection and packaging operation.

The current situation of the line is as follows:

<table>
<thead>
<tr>
<th>Station</th>
<th>Operation</th>
<th>Operator No. of Operators</th>
<th>Work in Allowed Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Output (Per HR)</td>
<td>Yield (Units/HR)</td>
<td>Standard EFF.</td>
</tr>
<tr>
<td>ASSEMBLE</td>
<td>267.4</td>
<td>1.00</td>
<td>37.0</td>
</tr>
<tr>
<td>FURNACE</td>
<td>267.4</td>
<td>1.00</td>
<td>0.0</td>
</tr>
<tr>
<td>UNLOAD</td>
<td>246.0</td>
<td>92</td>
<td>91.0</td>
</tr>
<tr>
<td>CLEAN</td>
<td>246.0</td>
<td>1.00</td>
<td>54.0</td>
</tr>
<tr>
<td>REAM</td>
<td>246.0</td>
<td>1.00</td>
<td>28.0</td>
</tr>
<tr>
<td>INSPECT</td>
<td>214.0</td>
<td>87</td>
<td>11.0</td>
</tr>
</tbody>
</table>

Total No. of Operators = 44.5
Total Cycle Time = 8.5 hours
THIS IS THE WAY THE LINE HAS BEEN RUNNING FOR SOME TIME NOW. AS YOU CAN SEE, THERE IS TOO MUCH WORK IN PROCESS ALL ALONG THE LINE AND THE CYCLE TIME SHOULD BE A FRACTION OF WHAT IT IS NOW.

YOU HAVE JUST BEEN PUT IN CHARGE OF THIS LINE, AND IT IS YOUR JOB TO ASSIGN OPERATORS TO ALL STATIONS SO AS TO REDUCE BOTH CYCLE TIME AND EXCESS WORK IN PROCESS. WE'RE CURRENTLY WORKING AN 8 HOUR SHIFT AND YOU HAVE TO TRY TO REBALANCE THE LINE IN THAT TIME.

NOTE THAT NO OPERATORS ARE REQUIRED AT THE FURNACE, BUT THE FURNACE SPEED MAY BE VARIED IN ORDER TO REBALANCE THE LINE. AT PRESENT IT IS RUNNING AT ITS MAXIMUM SPEED - 267.4 UNITS PER HOUR.

IN REBALANCING THE LINE YOU ARE REQUIRED TO MAINTAIN THE CURRENT OUTPUT OF 214 UNITS PER HOUR. YOU MAY TRY AS MANY SOLUTIONS AS YOU LIKE, BUT REMEMBER ALL SOLUTIONS REFER BACK TO THE CURRENT SITUATION.

LET'S PLAY.

FIRST, ENTER YOUR CHOICE FOR THE NUMBER OF OPERATORS; SEPARATE YOUR INPUTS WITH COMMAS. YOU MAY USE FRACTIONS OF PEOPLE. SECOND, ENTER THE SPEED OF THE FURNACE. AFTER EACH ENTRY PRESS THE 'RETURN' KEY SO THAT THE COMPUTER WILL ACCEPT THE INPUT.
ENTER THE OPERATOR DATA:
? 6.5, 2.9, 4.7, 5.8, 21.8
NOW ENTER THE SPEED OF THE FURNACE:
? 267

SOLUTION NO. 1

<table>
<thead>
<tr>
<th>STATION</th>
<th>OPERATION</th>
<th>OPERATOR</th>
<th>NO. OF WORK IN ALLOWED CYCLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OUTPUT</td>
<td>YIELD</td>
<td>STANDARD EFF. OPER. PROCESS WIP TIME</td>
</tr>
<tr>
<td></td>
<td>(PER HR)</td>
<td>(UNITS/HR)</td>
<td></td>
</tr>
<tr>
<td>ASSEMBLE</td>
<td>269.4</td>
<td>1.00</td>
<td>37.0</td>
</tr>
<tr>
<td>FURNACE</td>
<td>267.0</td>
<td>1.00</td>
<td>0.0</td>
</tr>
<tr>
<td>UNLOAD</td>
<td>250.1</td>
<td>92.0</td>
<td>91.0</td>
</tr>
<tr>
<td>CLEAN</td>
<td>243.6</td>
<td>1.00</td>
<td>54.0</td>
</tr>
<tr>
<td>REAM</td>
<td>246.4</td>
<td>1.00</td>
<td>28.0</td>
</tr>
<tr>
<td>INSPECT</td>
<td>214.9</td>
<td>0.87</td>
<td>11.0</td>
</tr>
</tbody>
</table>

TOTAL NO. OF OPERATORS = 44.7
TOTAL CYCLE TIME = 8.6 HOURS

GOOD GRIEF. WHAT ARE YOU DOING?

LET'S TRY AGAIN

NOTE THAT ALL SOLUTIONS ALWAYS REFER BACK TO THE ORIGINAL STATEMENT OF THE PROBLEM.

ENTER THE OPERATOR DATA:
? 6.0, 2.9, 4.7, 3.8, 21.8
NOW ENTER THE SPEED OF THE FURNACE:
? 260

SOLUTION NO. 2

<table>
<thead>
<tr>
<th>STATION</th>
<th>OPERATION</th>
<th>OPERATOR</th>
<th>NO. OF WORK IN ALLOWED CYCLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OUTPUT</td>
<td>YIELD</td>
<td>STANDARD EFF. OPER. PROCESS WIP TIME</td>
</tr>
<tr>
<td></td>
<td>(PER HR)</td>
<td>(UNITS/HR)</td>
<td></td>
</tr>
<tr>
<td>ASSEMBLE</td>
<td>245.6</td>
<td>1.00</td>
<td>37.0</td>
</tr>
<tr>
<td>FURNACE</td>
<td>260.0</td>
<td>1.00</td>
<td>0.0</td>
</tr>
<tr>
<td>UNLOAD</td>
<td>250.1</td>
<td>92.0</td>
<td>91.0</td>
</tr>
<tr>
<td>CLEAN</td>
<td>243.6</td>
<td>1.00</td>
<td>54.0</td>
</tr>
<tr>
<td>REAM</td>
<td>246.4</td>
<td>1.00</td>
<td>28.0</td>
</tr>
<tr>
<td>INSPECT</td>
<td>214.9</td>
<td>0.87</td>
<td>11.0</td>
</tr>
</tbody>
</table>

TOTAL NO. OF OPERATORS = 44.2
TOTAL CYCLE TIME = 8.0 HOURS

GOOD - YOUR CYCLE TIME IS IMPROVING.

LET'S TRY AGAIN
**SOLUTION NO. 3**

<table>
<thead>
<tr>
<th>STATION</th>
<th>OPERATION</th>
<th>OPERATOR</th>
<th>NO. OF WORK IN ALLOWED CYCLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OUTPUT</td>
<td>YIELD</td>
<td>STANDARD EFF. OPER. PROCESS WIP TIME</td>
</tr>
<tr>
<td></td>
<td>(PER HR)</td>
<td>(UNITS/HR)</td>
<td>(HRS)</td>
</tr>
<tr>
<td>ASSEMBLE</td>
<td>269.4</td>
<td>1.00</td>
<td>37.0</td>
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<tr>
<td>FURNACE</td>
<td>267.4</td>
<td>1.00</td>
<td>0.0</td>
</tr>
<tr>
<td>UNLOAD</td>
<td>250.1</td>
<td>0.92</td>
<td>91.0</td>
</tr>
<tr>
<td>CLEAN</td>
<td>295.5</td>
<td>1.00</td>
<td>54.0</td>
</tr>
<tr>
<td>REAM</td>
<td>246.4</td>
<td>1.00</td>
<td>28.0</td>
</tr>
<tr>
<td>INSPECT</td>
<td>223.8</td>
<td>0.87</td>
<td>11.0</td>
</tr>
</tbody>
</table>

**TOTAL NO. OF OPERATORS = 46.6**
**TOTAL CYCLE TIME = 8.0 HOURS**

**GOOD - YOUR CYCLE TIME IS IMPROVING.**

**LET'S TRY AGAIN**

**SOLUTION NO. 4**

<table>
<thead>
<tr>
<th>STATION</th>
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<th>OPERATOR</th>
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</thead>
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<tr>
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<td>OUTPUT</td>
<td>YIELD</td>
<td>STANDARD EFF. OPER. PROCESS WIP TIME</td>
</tr>
<tr>
<td></td>
<td>(PER HR)</td>
<td>(UNITS/HR)</td>
<td>(HRS)</td>
</tr>
<tr>
<td>ASSEMBLE</td>
<td>33.2</td>
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<td>37.0</td>
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<td>60.0</td>
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<td>UNLOAD</td>
<td>112.1</td>
<td>0.92</td>
<td>91.0</td>
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<tr>
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<td>1.00</td>
<td>54.0</td>
</tr>
<tr>
<td>REAM</td>
<td>226.8</td>
<td>1.00</td>
<td>28.0</td>
</tr>
<tr>
<td>INSPECT</td>
<td>214.9</td>
<td>0.87</td>
<td>11.0</td>
</tr>
</tbody>
</table>

**TOTAL NO. OF OPERATORS = 35.8**
**TOTAL CYCLE TIME = 1.9 HOURS**

**NO, YOU HAVE LOWERED THE WORK IN PROCESS TOO FAR.**

**LET'S TRY AGAIN**
ENTER THE OPERATOR DATA:
? 6, 1, 2, 4, 10

NOT ENTER THE SPEED OF THE FURNACE
? 125

SOLUTION NO. 5

<table>
<thead>
<tr>
<th>STATION</th>
<th>OPERATION</th>
<th>OPERATOR NO. OF WORK IN ALLOWED CYCLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSEMBLE</td>
<td>248.6 1.00</td>
<td>37.0 1.12 6.0 45. 45. .16</td>
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<td>FURNACE</td>
<td>125.0 1.00</td>
<td>0.0 0.00 0.0 1469. 63. 11.49</td>
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<tr>
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<tr>
<td>CLEAN</td>
<td>103.7 1.00</td>
<td>54.0 .96 2.0 600. 31. 5.54</td>
</tr>
<tr>
<td>REAM</td>
<td>112.0 1.00</td>
<td>28.0 1.00 4.0 198. 57. 1.37</td>
</tr>
<tr>
<td>INSPECT</td>
<td>98.6 .87</td>
<td>11.0 1.03 10.0 265. 140. 1.36</td>
</tr>
</tbody>
</table>

TOTAL NO. OF OPERATORS = 23.0
TOTAL CYCLE TIME = 26.2 HOURS

GOOD GRIEF. WHAT ARE YOU DOING?

LET'S TRY AGAIN

ENTER THE OPERATOR DATA:
? 6, 5, 2, 2, 4, 7, 3, 3, 21, 7

NOT ENTER THE SPEED OF THE FURNACE
? 135

SOLUTION NO. 6

<table>
<thead>
<tr>
<th>STATION</th>
<th>OPERATION</th>
<th>OPERATOR NO. OF WORK IN ALLOWED CYCLE</th>
</tr>
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<tr>
<td>ASSEMBLE</td>
<td>269.4 1.00</td>
<td>37.0 1.12 6.5 45. 45. .17</td>
</tr>
<tr>
<td>FURNACE</td>
<td>135.0 1.00</td>
<td>0.0 0.00 0.0 1555. 63. 11.29</td>
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<tr>
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<td>54.0 .96 4.7 791. 31. 3.24</td>
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<td>246.4 1.00</td>
<td>28.0 1.00 8.8 243. 57. .99</td>
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<tr>
<td>INSPECT</td>
<td>213.9 .87</td>
<td>11.0 1.03 21.7 279. 140. 1.13</td>
</tr>
</tbody>
</table>

TOTAL NO. OF OPERATORS = 44.6
TOTAL CYCLE TIME = 15.9 HOURS

NO. YOU HAVE LOWERED THE WORK IN PROCESS TOO FAR.

LET'S TRY AGAIN
ENTER THE OPERATOR DATA:
? 5.2, 3.3, 7.1, 14.36

NOW ENTER THE SPEED OF THE FURNACE:
? 267.4

SOLUTION NO.

<table>
<thead>
<tr>
<th>STATION</th>
<th>OPERATION</th>
<th>OPERATOR NO.</th>
<th>OF WORK</th>
<th>IN ALLOWED CYCLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSEMBLE</td>
<td>215.5</td>
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<td></td>
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<tr>
<td>FURNACE</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNLOAD</td>
<td>234.6</td>
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</tr>
<tr>
<td>INSPECT</td>
<td>354.9</td>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>OUTPUT</th>
<th>YIELD</th>
<th>STANDARD</th>
<th>OPER.</th>
<th>WIP</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>(PER HR)</td>
<td>(UNIT/HR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASSEMBLE</td>
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<td>1.12</td>
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<td>45.</td>
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<tr>
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<td>.00</td>
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<td>1.00</td>
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<td>74.</td>
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<td>11.0</td>
<td>1.03</td>
<td>36.0</td>
<td>148.</td>
</tr>
</tbody>
</table>

TOTAL NO. OF OPERATORS = 65.6
TOTAL CYCLE TIME = 2.2 HOURS

CONGRATULATIONS - YOU HAVE BALANCED THE LINE.

HOWEVER, IN REBALANCING THE LINE YOU HAVE EXCEEDED THE DESIRED OUTPUT OF 214.0 UNITS PER HOUR. ALSO THIS BALANCE REQUIRES AN ADDITIONAL 20.6 OPERATORS.

WOULD YOU LIKE TO SEE THE SOLUTION THAT BALANCES THE LINE AT THE DESIRED OUTPUT RATE? ••• 'YES' OR 'NO'

? YES
WE HOPE YOU HAVE ENJOYED PLAYING THE GAME. BY NOW YOU PROBABLY REALIZE THAT A TRIAL AND ERROR APPROACH TO LINE BALANCING COULD BE A DISASTROUS IN A PRACTICAL SITUATION. THE PRODUCTION CONTROL SYSTEM CAN HELP YOU AVOID SUCH A SITUATION. A BALANCE OF THE LINE IS POSSIBLE AT THE RUNNING RATE OF 214.0 UNITS PER HOUR. FIRST, YOU MUST IDENTIFY THE CURRENT WORK IN PROCESS AT EACH STATION, INCLUDING THE FURNACE. INPUT THESE VALUES NOW; SEPARATE YOUR INPUTS WITH COMMAS.

? 45, 480, 360, 740, 265, 275

SOLUTION WITH A LINE OUTPUT OF 214.0

<table>
<thead>
<tr>
<th>STATION</th>
<th>OPERATION</th>
<th>OPERATOR NO. OF WORK IN ALLOWED CYCLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OUTPUT YIELD</td>
<td>STANDARD EFF.</td>
</tr>
<tr>
<td></td>
<td>(PER HR)</td>
<td>(UNITS/HR)</td>
</tr>
<tr>
<td>ASSEMBLE</td>
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</tr>
<tr>
<td>FURNACE</td>
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<td>1.00</td>
</tr>
<tr>
<td>UNLOAD</td>
<td>114.5</td>
<td>0.92</td>
</tr>
<tr>
<td>CLEAN</td>
<td>203.1</td>
<td>1.00</td>
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<tr>
<td>REAM</td>
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<td>1.00</td>
</tr>
<tr>
<td>INSPECT</td>
<td>214.0</td>
<td>0.87</td>
</tr>
</tbody>
</table>

TOTAL NO. OF OPERATORS = 35.9
TOTAL CYCLE TIME = 0.6 HOURS
Game Session Questionnaire

The following is a condensed copy of the questionnaire used in the game sessions:

SESSION CRITIQUE

Your evaluation of the Seminar can aid us in determining how to further improve it. You are asked to make a judgment on each question, and after each question your comments are invited. For each rating scale, circle the number that best describes your view.

I. My reaction to the session:

1. Fully Rewarding Unrewarding
   5  4  3  2  1
2. Objectives Met Objectives Not Met
   5  4  3  2  1
3. Too Long Too Short
   5  4  3  2  1
4. What suggestions can you make to improve the Session?

II. My reaction to the Game:

1. Fully Rewarding Unrewarding
   5  4  3  2  1
2. What did you like most about the game?
3. What suggestions can you make to improve the game?
4. Did you win the game?
5. How many solutions were you able to try?

III. My reaction to the Session leader:

1. Fully Effective Ineffective
   5  4  3  2  1
2. Open-minded Dogmatic
   5  4  3  2  1
3. Cooperative Defensive
   5  4  3  2  1
4. Comments

4Source: Management Systems Department, Texas Instruments Incorporated, Dallas, Texas (unpublished document).
IV. My reaction to the theory and logic of line balancing:

1. Believable
   5 4 3 2 1

2. Comments in regard to solution approach

3. Any other comments
APPENDIX B

GAME - SYSTEM
INTERVIEW QUESTIONNAIRES

Typical User Questionnaire

Questions similar to the following were posed to the systems users within the operating department of the firm in soliciting opinions and views of the proposed game approach:

1. In your opinion do operational systems have a high degree of importance in terms of your daily activity?

2. Are you familiar with most of the systems that have been developed to support the operating departments?

3. Have you participated in the game-training seminar that was developed as a training aid in support of the production control system?

4. In the past the systems department has experienced some problems of developing systems that failed to fully accomplish users needs and objectives. In your opinion, could a game approach to developing systems aid in identifying system objectives as well as system specifications? Would this also minimize misunderstandings between groups?

5. In your opinion has the systems department been guilty of "fitting" the user's problem into a predetermined solution approach and/or forcing a system on the user without fully understanding the user's problem or problem area? Would a game activity before the development of a system resolve or minimize some of these problems?

6. Do the managers within your department fully understand the currently available operational systems, such as the production control system? Do they support the use of systems?
7. A "team approach" has been suggested as one means for integrating the ideas and needs of users, managers, and the systems staff; do you feel that a "game activity" that involves each of these groups would be more meaningful in accomplishing this objective?

8. After participating in the game-training activity for the production control system, did you have a much better understanding of the probable benefits that could accrue from the use of the system? Did they appear to be realistic?

9. What disadvantages do you visualize that could result from using a game-implementation approach to developing systems?

Typical Operating Manager Questionnaire

Questions similar to the following were discussed with the operating department managers in soliciting opinions and views of the game approach:

1. In your opinion do operational systems have a high degree of importance in your area of responsibility? Do you have a greater need for information type systems such as the inventory control system or the production planning system?

2. Are you familiar with most of the systems that are currently available and are supported by the systems department? Do these systems adequately meet your needs? Is there too much emphasis placed on systems within the corporation?

3. Have you or your people experienced problems in using some of the operational systems? Have you participated in the game-training seminar that was developed as a training aid in support of the production control system? What is your opinion of the seminar?

4. In the past, the systems department has experienced some problems of developing systems that failed to meet particular needs of users and/or failed to accomplish user objectives. In your opinion, would a game approach to developing systems aid in identifying system objectives as well as user needs? Would a game be of aid to you in evaluating different strategies or exploring trade-offs between different variables? Could you identify these without the use of a game?
5. A "team approach" has been suggested as one means for integrating the ideas and needs of users, managers, and the system staff. In your opinion, would a "game activity" that involves each of these groups be more meaningful in terms of accomplishing this objective?

6. What disadvantages do you visualize could result from using a game-implementation approach to developing systems?

7. Realizing that a game-implementation approach would more than likely result in higher conceptualization and validation costs, since some of the later system activities occur during the initial systems study and evaluation, would you support the approach?

Typical System Staff Questionnaire

In discussing the game approach with systems staff personnel, questions similar to the following were posed:

1. Should the systems department assume prime responsibility for the implementation of systems?

2. Generally, are more implementation problems associated with operational systems as opposed to informational systems?

3. Is the support of the managers within the operating departments critical to a successful working relation between users within the departments and the systems staff people?

4. Do the operating managers as well as the users really understand the concepts and techniques used in the different operational systems?

5. Does the systems department tend to use highly technical jargon in discussing systems or techniques?

6. Is gaming a meaningful approach to resolving problems, such as lack of management support, misunderstood concepts or techniques, and improper or insufficient definition of system objectives?

7. Should not the game activity occur before development of the system as opposed to the traditional approach of using the game as a training aid after the system is developed?
8. Would a game activity before system development identify problems that normally would not become apparent under other analysis and design approaches?

9. Assuming that a game-implementation approach to developing systems is adopted, can the increased cost of conceptualization and the feasibility study be justified? Would most managers accept this increased cost, even though the total cost of the system would probably not increase?
APPENDIX C

THE GENERALIZED GAME*

The generalized game employed in the research was designed to demonstrate the concepts of resource allocation and inventory control. The game is somewhat self-explanatory; however, a basic understanding of the problem area addressed by the game and the game structure is helpful for developing an overall view of the game. The material presented here is that discussed with the players during the game sessions.

Problem Area

The problem area addressed by the game is basically that of allocating a limited supply of resources to the production of products while maintaining control of the inventories of the products. The problem is common to such industries as petroleum-refining operations, manufacturing of paints and associated by-products, food production (mass production farming), and semiconductor manufacturing. The problem results owing to the nature of the business and the demand for the products. For example, a petroleum refinery may have the capability of producing a multiple number of products such as premium and regular motor fuels, aviation fuel.

*Source: Adapted from a specialized game—"The Production Planning Game," Texas Instruments Incorporated, February 23, 1971.
various fuel oils, and lube oils. The output of each of the products, however, is dependent upon the type of crude oil or the mix of crudes used in the process. Thus, the quantities produced depend upon the raw material mix. Material inputs, however, are not the only factors affecting the producer's decision. The demands for the different products may vary from period to period; and, similarly, the selling price of the products may change; thus production decisions are affected by product volume and price changes. If the producer had a limited storage capacity or if company policy is to maintain a certain level of inventory of each product, then production decisions are affected by the required inventories for each product. The optimal decision is one which results in production output that meets the demand for each product, maintains the desired inventory level for each product, and employs the proper combination of raw material input so that profits are maximized for the period.

Several quantitative techniques exist which can aid the decision maker faced with problems of defining product demand and producing to meet the demand. Forecasting techniques can be employed to project anticipated demand. Linear programming is useful for determining the proper raw material or crude mix required to meet defined production levels. The use of these concepts is demonstrated in the game.
Structure

The game is structured so that it can be played in two phases. The first phase involves direct game play without the aid of quantitative techniques. Phase two provides forecasting and allocation techniques that can be employed to aid in the decision-making activities. Identical product demand curves are employed in both phases of the game; likewise, the inventory policies and production output ratios are repetitive in the two phases. Thus, the only factors that differ between the phases are the forecasting and allocation techniques which appear in phase two.

Both phases of the game should be played. The first phase allows the player to become familiar with the game and explore different decisions and actions. From the play of phase one, the player should also become conscious of the complexity of the problem area and the resulting impact of wrong decisions. Phase two demonstrated how forecasting and allocation techniques, designed to function as a system, can affect the problem area. The system maintains a status of the inventory levels, makes a forecast of anticipated demand, and recommends the raw material inputs that should be used in the production process.

Game Play - Phase I

The following is a typical example of the game play output from the first phase of the game:
HELLO! ... WELCOME TO THE 'RESOURCE ALLOCATION' GAME.

THIS GAME REQUIRES THE GENERATION OF PRODUCT DEMAND CURVES PRIOR TO 'PLAY'.

HAVE YOU PREVIOUSLY GENERATED YOUR DEMAND DISTRIBUTIONS? 

... 'YES' OR 'NO' 

YES

DO YOU WISH TO HAVE INSTRUCTIONS PRIOR TO BEGINNING 'PLAY'? 

... 'YES' OR 'NO'  

YES

THIS IS A 'RESOURCE-ALLOCATION, INVENTORY CONTROL' GAME. YOU ARE PLAYING IN ORDER TO GAIN SOME APPRECIATION FOR PROBLEMS ASSOCIATED WITH THE AREA AND TO IDENTIFY HOW A 'FORECASTING-ALLOCATION' SYSTEM CAN AID IN SOLVING SUCH PROBLEMS.

FIRST, LET'S LOOK AT YOUR OPERATIONS. YOU ARE CURRENTLY MANUFACTURING FIVE PRODUCTS (PRODUCTS A ... E). THE STRUCTURE OF THE BUSINESS IS SUCH THAT THESE PRODUCTS CAN BE JOINTLY PRODUCED FROM A GIVEN RAW (CRUDE) MATERIAL. SEVERAL RAW MATERIALS EXIST FROM WHICH YOU CAN PRODUCE YOUR PRODUCTS. THE OUTPUT RATIO (RATIO BETWEEN RAW MATERIAL INPUT AND FINISHED GOODS OUTPUT) ASSOCIATED WITH THREE SPECIFIC MATERIAL TYPES ARE AS FOLLOWS:

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>WASTE</th>
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<tr>
<td>MATERIAL 1</td>
<td>.090</td>
<td>.155</td>
<td>.175</td>
<td>.215</td>
<td>.000</td>
<td>.350</td>
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<tr>
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<td>.210</td>
<td>.195</td>
<td>.000</td>
<td>.130</td>
<td>.325</td>
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<tr>
<td>MATERIAL 3</td>
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<td>.060</td>
<td>.000</td>
<td>.280</td>
<td>.150</td>
<td>.380</td>
</tr>
</tbody>
</table>

COMBINATIONS OF DIFFERENT QUANTITIES OF THESE INPUT MATERIALS WILL
RESULT IN DIFFERENT PRODUCT OUTPUT QUANTITIES.

RECORDS SHOW THAT YOU HOLD A CONSTANT SHARE OF THE MARKET FOR YOUR PRODUCTS. THE DEMAND FOR EACH PRODUCT, HOWEVER, IS IN DIFFERENT STAGES OF ITS LIFE CYCLE. YOUR SHARE OF EACH PRODUCT DEMAND CAN BE EXPRESSED AS FOLLOWS:

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>AVERAGE WEEKLY DEMAND</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>200 UNITS/WEEK</td>
</tr>
<tr>
<td>B</td>
<td>400 UNITS/WEEK</td>
</tr>
<tr>
<td>C</td>
<td>500 UNITS/WEEK</td>
</tr>
<tr>
<td>D</td>
<td>500 UNITS/WEEK</td>
</tr>
<tr>
<td>E</td>
<td>100 UNITS/WEEK</td>
</tr>
</tbody>
</table>

THE DECISION HAS BEEN MADE TO CONTINUE TO COMPETE IN ALL PRODUCT AREAS.

PREVIOUS OPERATING PROBLEMS HAVE BEEN 'EXCESS' INVENTORIES AND 'HIGH' MATERIAL-MANUFACTURING COST. PRICES ARE STABLE, HAVING BEEN SET BY COMPETITION IN THE MARKET. PROFITS ARE THEREFORE MAXIMIZED BY MINIMIZING COST AND CONTROLLING INVENTORIES. A MANAGEMENT POLICY HAS ESTABLISHED MAXIMUM FINISHED GOODS INVENTORIES AT ONE MONTH'S AVERAGE DEMAND (PER PRODUCT). INVENTORIES IN EXCESS OF AVERAGE MONTHLY DEMAND ARE RETAINED IN A WAREHOUSE. A 'HOLDING COST' IS CHARGED FOR THESE INVENTORIES (10% OF STANDARD COST). IF A PRODUCT INVENTORY EXCEEDS 200% OF AVERAGE MONTHLY DEMAND, WRITE-OFF CHARGES RESULT. YOUR OBJECTIVE, THEREFORE, IS TO SELECT THE PROPER MIX OF RAW MATERIALS (ON A WEEKLY BASIS) SUCH THAT YOU MEET WEEKLY DEMAND FOR YOUR PRODUCTS, MAINTAIN FINISHED GOODS INVENTORIES, AND MAXIMIZE PROFITS (GPM).
SEVERAL FACTORS ARE IMPORTANT IN PLANNING YOUR WEEKLY MATERIAL REQUIREMENTS. FIRST, A DIFFERENT COST AND CYCLE TIME (TIME LAPSE FROM MATERIAL 'START' TO OUTFLOW OF FINISHED GOODS) IS ASSOCIATED WITH EACH DIFFERENT MATERIAL TYPE. THESE CAN BE EXPRESSED AS FOLLOWS:

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>MANUFACTURING COST</th>
<th>CYCLE TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATERIAL 1</td>
<td>$3.60/UNIT</td>
<td>5 +/- 1 WEEK</td>
</tr>
<tr>
<td>MATERIAL 2</td>
<td>$4.80/UNIT</td>
<td>6 +/- 1 WEEK</td>
</tr>
<tr>
<td>MATERIAL 3</td>
<td>$5.20/UNIT</td>
<td>7 +/- 1 WEEK</td>
</tr>
</tbody>
</table>

SECOND, ORDERS ARE FILLED FROM FINISHED GOODS INVENTORY (WEEKLY).

THIRD, THE OUTPUT RATIOS DETERMINE THE QUANTITIES OF FINISHED GOODS THAT RESULT FROM THE ASSOCIATED MATERIAL 'STARTS'. FINALLY, PLANNING IS ON A MONTHLY BASIS; THEREFORE, YOU MUST DETERMINE YOUR WEEKLY MATERIAL REQUIREMENTS AT THE BEGINNING OF EACH MONTH.

A 'FORECASTING-ALLOCATION' SYSTEM IS AVAILABLE TO AID IN YOUR PLANNING FUNCTION. THIS SYSTEM WILL FORECAST PRODUCT DEMAND AND DETERMINE MATERIAL 'STARTS' BY EXAMINING THE CURRENT OPERATING SUMMARY AND THE FORECASTED DEMAND. IT IS RECOMMENDED THAT YOU FIRST PLAY THE GAME WITHOUT THE SYSTEM. THIS APPROACH SHOULD IDENTIFY SOME OF THE OPERATING PROBLEMS PRIOR TO EMPLOYING THE SYSTEM. DO YOU WISH TO EMPLOY THE SYSTEM DURING THIS PARTICULAR GAME?

NO
NOW LET'S LOOK AT THE STATUS OF YOUR OPERATIONS:

OPERATIONS SUMMARY - BEGINNING MONTH 1 (WKS 1-4)

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>400</td>
</tr>
<tr>
<td>B</td>
<td>800</td>
</tr>
<tr>
<td>C</td>
<td>1200</td>
</tr>
<tr>
<td>D</td>
<td>1000</td>
</tr>
<tr>
<td>E</td>
<td>300</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>3700</strong></td>
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</tbody>
</table>

FINISHED GOODS INV.

<table>
<thead>
<tr>
<th>WORK-IN-PROCESS INV.</th>
<th>2807</th>
<th>3835</th>
<th>3437</th>
<th>4884</th>
<th>2405</th>
<th>17418</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUE OUT IN WEEK 1</td>
<td>441</td>
<td>631</td>
<td>582</td>
<td>764</td>
<td>334</td>
<td>2752</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 2</td>
<td>441</td>
<td>631</td>
<td>532</td>
<td>764</td>
<td>334</td>
<td>2752</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 3</td>
<td>405</td>
<td>569</td>
<td>512</td>
<td>678</td>
<td>334</td>
<td>2493</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 4</td>
<td>385</td>
<td>547</td>
<td>504</td>
<td>764</td>
<td>282</td>
<td>2482</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 5</td>
<td>405</td>
<td>569</td>
<td>512</td>
<td>678</td>
<td>334</td>
<td>2493</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 6</td>
<td>373</td>
<td>545</td>
<td>512</td>
<td>566</td>
<td>274</td>
<td>2270</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 7</td>
<td>322</td>
<td>71</td>
<td>233</td>
<td>335</td>
<td>334</td>
<td>1486</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 8</td>
<td>95</td>
<td>71</td>
<td>0</td>
<td>335</td>
<td>179</td>
<td>680</td>
</tr>
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</table>

BACKLOG

<table>
<thead>
<tr>
<th>BACKLOG</th>
<th>620</th>
<th>1630</th>
<th>1370</th>
<th>1830</th>
<th>380</th>
<th>6330</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELINQUENT:</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

NON-DELINQUENT:

<table>
<thead>
<tr>
<th>NON-DELINQUENT:</th>
<th>620</th>
<th>1630</th>
<th>1370</th>
<th>1830</th>
<th>380</th>
<th>6330</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUE IN WEEK 1</td>
<td>260</td>
<td>410</td>
<td>470</td>
<td>570</td>
<td>110</td>
<td>1320</td>
</tr>
<tr>
<td>DUE IN WEEK 2</td>
<td>50</td>
<td>380</td>
<td>540</td>
<td>510</td>
<td>40</td>
<td>1520</td>
</tr>
<tr>
<td>DUE IN WEEK 3</td>
<td>220</td>
<td>430</td>
<td>390</td>
<td>500</td>
<td>110</td>
<td>1650</td>
</tr>
<tr>
<td>DUE IN WEEK 4</td>
<td>90</td>
<td>410</td>
<td>470</td>
<td>250</td>
<td>120</td>
<td>1340</td>
</tr>
</tbody>
</table>

THIS 'OPERATIONS SUMMARY' IDENTIFIES YOUR FINISHED GOODS INVENTORIES,
WORK IN PROCESS INVENTORIES, AND 'FIRM' ORDERS (AS OF THE BEGINNING
OF THE MONTH). YOUR OPERATING DECISIONS SHOULD BE BASED ON THIS
SUMMARY AND THE ANTICIPATED DEMAND FOR NEXT MONTH (SINCE YOUR AVERAGE
MANUFACTURING CYCLE TIME IS 6 WEEKS).

REALIZING THAT YOU ARE NEW IN THE AREA, YOUR SUPERVISOR HAS
PREVIOUSLY MADE THE DECISIONS FOR MATERIAL 'STARTS' FOR MONTH 1.
HIS DECISIONS FOR WEEKS 1-4 ARE AS FOLLOWS:

MATERIAL 1: 600 600 600 600
MATERIAL 2: 400 400 400 400
MATERIAL 3: 200 200 200 200

LET'S LOOK AT THE RESULTS OF HIS DECISIONS. REMEMBER, YOU WILL BE IN THE DRIVER'S SEAT BEGINNING IN MONTH 2.

PERFORMANCE FOR MONTH 1:

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NET UNITS SHIPPED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DELINQ. TO CUST. REQ.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PER CUSTOMER REQUEST</td>
<td>900</td>
<td>1630</td>
<td>1890</td>
<td>2070</td>
<td>540</td>
<td></td>
</tr>
</tbody>
</table>

| NET SALES ($) | 8775 | 13855 | 14741 | 20906 | 6047 |
| PER CUSTOMER REQUEST | 8775 | 13855 | 14741 | 20906 | 6047 | 64324 |

| COST ($) | 4089 | 5736 | 5082 | 5782 | 3632 |
| INV. WRITE-OFF COST | 0   | 0   | 0   | 0   | 0   |
| WAREHOUSE HOLDING COST | 0   | 0   | 0   | 0   | 0   |

| GROSS PROFIT MARGIN | 4685 | 8118 | 9659 | 15124 | 2415 |
| OPERATING EFFICIENCY (%) | 53.4 | 58.6 | 65.5 | 72.3 | 39.9 | 62.2 |
## OPERATIONS SUMMARY - BEGINNING MONTH 2 (WKS 5-8)

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINISHED GOODS INV.</td>
<td>1172</td>
<td>1548</td>
<td>1490</td>
<td>1900</td>
<td>1044</td>
<td>7154</td>
</tr>
<tr>
<td>WORK-IN-PROCESS INV.</td>
<td>1627</td>
<td>2251</td>
<td>1981</td>
<td>2646</td>
<td>1441</td>
<td>9946</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 5</td>
<td>458</td>
<td>661</td>
<td>616</td>
<td>806</td>
<td>334</td>
<td>2875</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 6</td>
<td>481</td>
<td>720</td>
<td>693</td>
<td>694</td>
<td>325</td>
<td>2913</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 7</td>
<td>262</td>
<td>322</td>
<td>233</td>
<td>335</td>
<td>334</td>
<td>1486</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 8</td>
<td>256</td>
<td>338</td>
<td>285</td>
<td>591</td>
<td>230</td>
<td>1700</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 9</td>
<td>30</td>
<td>22</td>
<td>0</td>
<td>110</td>
<td>58</td>
<td>220</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 10</td>
<td>70</td>
<td>94</td>
<td>77</td>
<td>55</td>
<td>30</td>
<td>376</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 11</td>
<td>55</td>
<td>83</td>
<td>77</td>
<td>0</td>
<td>51</td>
<td>266</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 12</td>
<td>15</td>
<td>11</td>
<td>0</td>
<td>55</td>
<td>29</td>
<td>110</td>
</tr>
<tr>
<td>BACKLOG</td>
<td>720</td>
<td>1310</td>
<td>1140</td>
<td>1570</td>
<td>500</td>
<td>5240</td>
</tr>
<tr>
<td>DELINQUENT:</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NON-DELINQUENT</td>
<td>720</td>
<td>1310</td>
<td>1140</td>
<td>1570</td>
<td>500</td>
<td>5240</td>
</tr>
<tr>
<td>DUE IN WEEK 5</td>
<td>230</td>
<td>390</td>
<td>380</td>
<td>500</td>
<td>120</td>
<td>1620</td>
</tr>
<tr>
<td>DUE IN WEEK 6</td>
<td>130</td>
<td>140</td>
<td>390</td>
<td>570</td>
<td>170</td>
<td>1400</td>
</tr>
<tr>
<td>DUE IN WEEK 7</td>
<td>240</td>
<td>360</td>
<td>370</td>
<td>200</td>
<td>150</td>
<td>1320</td>
</tr>
<tr>
<td>DUE IN WEEK 8</td>
<td>120</td>
<td>420</td>
<td>0</td>
<td>300</td>
<td>60</td>
<td>900</td>
</tr>
</tbody>
</table>

**NOTE**

YOU ARE CURRENTLY CARRYING INVENTORIES ABOVE AVERAGE MONTHLY DEMAND.

THESE EXTRA INVENTORIES ARE AS FOLLOWS (PRODUCT A ... E):

```
272
0
0
0
504
```

YOU WILL INCUR A WAREHOUSE 'HOLDING' COST FOR CARRYING THESE EXTRA INVENTORIES.
Based on the above information and your keen knowledge of operations, input the following information:

Enter your material 'starts' for month 2.

Specify weekly quantities (units) separate your inputs with commas.

Material Type 1: 125, 300, 455, 431
Material Type 2: 194, 600, 900, 732
Material Type 3: 321, 420, 108, 110

Verify your inputs.

Material Type 1: 125, 300, 455, 431
Material Type 2: 194, 600, 900, 732
Material Type 3: 321, 420, 108, 110

Is this data correct? Yes

Performance for month 2:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net units shipped</td>
<td>810</td>
<td>1670</td>
<td>1690</td>
<td>2130</td>
<td>630</td>
<td>8790</td>
</tr>
<tr>
<td>Delinquencies to cust. req. per customer request</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Net sales ($)</td>
<td>7897</td>
<td>14195</td>
<td>13181</td>
<td>21512</td>
<td>7055</td>
<td>63840</td>
</tr>
<tr>
<td>Delinquencies to cust. req. per customer request</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>3619</td>
<td>4856</td>
<td>4350</td>
<td>4372</td>
<td>3422</td>
<td>20619</td>
</tr>
<tr>
<td>Material - manufacturing cost</td>
<td>3422</td>
<td>4356</td>
<td>4350</td>
<td>4372</td>
<td>3007</td>
<td>3007</td>
</tr>
<tr>
<td>Inventory write-off cost</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Warehouse holding cost</td>
<td>197</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>415</td>
<td>415</td>
</tr>
<tr>
<td>Gross profit margin</td>
<td>4278</td>
<td>9337</td>
<td>8831</td>
<td>17140</td>
<td>3633</td>
<td>43220</td>
</tr>
<tr>
<td>Operating efficiency (%)</td>
<td>54.2</td>
<td>65.8</td>
<td>67.0</td>
<td>79.7</td>
<td>51.5</td>
<td>67.7</td>
</tr>
</tbody>
</table>
OPERATIONS SUMMARY - BEGINNING MONTH 3 (WKS 9-12)

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINISHED GOODS INV.</td>
<td>1819</td>
<td>1919</td>
<td>1627</td>
<td>2196</td>
<td>1637</td>
<td>9193</td>
</tr>
<tr>
<td>WORK-IN-PROCESS INV.</td>
<td>696</td>
<td>973</td>
<td>851</td>
<td>765</td>
<td>673</td>
<td>3958</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 9</td>
<td>30</td>
<td>22</td>
<td>0</td>
<td>110</td>
<td>58</td>
<td>220</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 10</td>
<td>107</td>
<td>159</td>
<td>150</td>
<td>145</td>
<td>80</td>
<td>641</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 11</td>
<td>82</td>
<td>123</td>
<td>114</td>
<td>0</td>
<td>76</td>
<td>395</td>
</tr>
<tr>
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<td>205</td>
<td>288</td>
<td>254</td>
<td>241</td>
<td>193</td>
<td>1181</td>
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<td>DUE OUT IN WEEK 13</td>
<td>116</td>
<td>150</td>
<td>116</td>
<td>117</td>
<td>139</td>
<td>633</td>
</tr>
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<td>DUE OUT IN WEEK 14</td>
<td>46</td>
<td>72</td>
<td>75</td>
<td>122</td>
<td>16</td>
<td>331</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 15</td>
<td>110</td>
<td>159</td>
<td>142</td>
<td>30</td>
<td>111</td>
<td>552</td>
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<tr>
<td>DUE OUT IN WEEK 16</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<td>1540</td>
<td>2230</td>
<td>640</td>
<td>6960</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NON-DELINQUENT:</td>
<td>980</td>
<td>1570</td>
<td>1540</td>
<td>2230</td>
<td>640</td>
<td>6960</td>
</tr>
<tr>
<td>DUE IN WEEK 9</td>
<td>210</td>
<td>330</td>
<td>350</td>
<td>540</td>
<td>190</td>
<td>1670</td>
</tr>
<tr>
<td>DUE IN WEEK 10</td>
<td>240</td>
<td>330</td>
<td>380</td>
<td>530</td>
<td>100</td>
<td>1580</td>
</tr>
<tr>
<td>DUE IN WEEK 11</td>
<td>250</td>
<td>390</td>
<td>480</td>
<td>510</td>
<td>160</td>
<td>1790</td>
</tr>
<tr>
<td>DUE IN WEEK 12</td>
<td>280</td>
<td>470</td>
<td>330</td>
<td>650</td>
<td>190</td>
<td>1920</td>
</tr>
</tbody>
</table>

** NOTE **
DECLINING DEMAND AND/OR CONTINUED OVER PRODUCTION HAS CREATED EXCESS INVENTORIES IN SOME OF YOUR PRODUCT AREAS.

YOU MUST NOW WRITE OFF AT LEAST THE FOLLOWING QUANTITIES:
(PRODUCT A ... E) -    179  0  0  0  425

SPECIFY YOUR WRITE-OFF (PRODUCT A ... E)
180, 0, 0, 0, 425
PLEASE VERIFY YOUR INPUTS

INV. WRITE-OFF (PRODUCT A ... E) : 180 0 0 0 425

IS THIS DATA CORRECT?
YES

** NOTE **

YOU ARE CURRENTLY CARRYING INVENTORIES ABOVE AVERAGE MONTHLY DEMAND.

THESE EXTRA INVENTORIES ARE AS FOLLOWS (PRODUCT A ... E):

819 246 0 116 606

YOU WILL INCUR A WAREHOUSE 'HOLDING' COST FOR CARRYING THESE EXTRA INVENTORIES.

BASED ON THE ABOVE INFORMATION AND YOUR KEEN KNOWLEDGE OF OPERATIONS,
INPUT THE FOLLOWING INFORMATION:

ENTER YOUR MATERIAL 'STARTS' FOR MONTH  3.

SPECIFY WEEKLY QUANTITIES (UNITS); SEPARATE YOUR INPUTS WITH COMMAS.

MATERIAL TYPE 1 ? 0,0,300,400
MATERIAL TYPE 2 ? 300,225,400,515
MATERIAL TYPE 3 ? 0,0,0,0

VERIFY YOUR INPUTS.

MATERIAL TYPE 1 0 0 300 400
MATERIAL TYPE 2 300 225 400 515
MATERIAL TYPE 3 0 0 0 0

IS THIS DATA CORRECT?
YES
PERFORMANCE FOR MONTH 3:

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NET UNITS SHIPPED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DELING. TO CUST. REQ. PER CUSTOMER REQUEST</td>
<td>980</td>
<td>1710</td>
<td>1670</td>
<td>2330</td>
<td>760</td>
<td>9520</td>
</tr>
</tbody>
</table>

| NET SALES ($) | | | | | | |
| DELING. TO CUST. REQ. PER CUSTOMER REQUEST | 9555 | 14535 | 13025 | 23532 | 8511 | 69158 |

| COST ($) | | | | | | |
| MAT'L.-MANUF. COST | 2543 | 3665 | 3315 | 2372 | 2277 | 6232 |
| INV. WRITE-OFF COST | 1305 | 0 | 0 | 3506 | 8511 | 6232 |
| WAREHOUSE HOLDING COST | 593 | 164 | 0 | 91 | 499 | 6232 |

| GROSS PROFIT MARGIN | 5114 | 10704 | 9710 | 21069 | 2230 | 48827 |

| OPERATING EFFICIENCY (%) | 53.5 | 73.6 | 74.5 | 89.5 | 26.2 | 70.6 |

Game Play-Phase II

The following is a typical example of the game play output from the second phase of the game:
HELLO! ... WELCOME TO THE 'RESOURCE ALLOCATION' GAME.

THIS GAME REQUIRES THE GENERATION OF PRODUCT DEMAND CURVES PRIOR TO 'PLAY'.

HAVE YOU PREVIOUSLY GENERATED YOUR DEMAND DISTRIBUTIONS?
... 'YES' OR 'NO'

YES

DO YOU WISH TO HAVE INSTRUCTIONS PRIOR TO BEGINNING 'PLAY'? ...

NO

DO YOU WISH TO EMPLOY THE 'FORECASTING-ALLOCATION SYSTEM'? ...

YES

LET'S LOOK AT THE STATUS OF YOUR OPERATIONS.

OPERATIONS SUMMARY - BEGINNING MONTH 1 (WKS 1-4)

<table>
<thead>
<tr>
<th>PRODUCT TYPES</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINISHED GOODS INV.</td>
<td>400</td>
<td>800</td>
<td>1200</td>
<td>1000</td>
<td>300</td>
<td>3700</td>
</tr>
<tr>
<td>WORK-IN-PROCESS INV.</td>
<td>2807</td>
<td>3885</td>
<td>3437</td>
<td>4884</td>
<td>2405</td>
<td>17418</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 1</td>
<td>441</td>
<td>631</td>
<td>582</td>
<td>764</td>
<td>334</td>
<td>2752</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 2</td>
<td>441</td>
<td>631</td>
<td>582</td>
<td>764</td>
<td>334</td>
<td>2752</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 3</td>
<td>405</td>
<td>569</td>
<td>512</td>
<td>678</td>
<td>334</td>
<td>2498</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 4</td>
<td>385</td>
<td>547</td>
<td>504</td>
<td>764</td>
<td>282</td>
<td>2482</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 5</td>
<td>405</td>
<td>569</td>
<td>512</td>
<td>678</td>
<td>334</td>
<td>2498</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 6</td>
<td>373</td>
<td>545</td>
<td>512</td>
<td>566</td>
<td>274</td>
<td>2270</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 7</td>
<td>262</td>
<td>322</td>
<td>233</td>
<td>335</td>
<td>334</td>
<td>1486</td>
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<tr>
<td>DUE OUT IN WEEK 8</td>
<td>95</td>
<td>71</td>
<td>0</td>
<td>335</td>
<td>179</td>
<td>680</td>
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<tr>
<td>BACKLOG</td>
<td>620</td>
<td>1630</td>
<td>1870</td>
<td>1830</td>
<td>380</td>
<td>6330</td>
</tr>
</tbody>
</table>

DELINQUENT:
| DUE IN WEEK 1 | 260 | 410 | 470 | 570 | 110 | 1320  |
| DUE IN WEEK 2 | 50  | 380 | 540 | 510 | 40  | 1520  |
| DUE IN WEEK 3 | 220 | 430 | 390 | 500 | 110 | 1650  |
| DUE IN WEEK 4 | 90  | 410 | 470 | 250 | 120 | 1340  |

NON-DELINQUENT:
| DUE IN WEEK 1 | 260 | 410 | 470 | 570 | 110 | 1320  |
| DUE IN WEEK 2 | 50  | 380 | 540 | 510 | 40  | 1520  |
| DUE IN WEEK 3 | 220 | 430 | 390 | 500 | 110 | 1650  |
| DUE IN WEEK 4 | 90  | 410 | 470 | 250 | 120 | 1340  |
This 'Operations Summary' identifies your finished goods inventories, work in process inventories, and 'firm' orders (as of the beginning of the month). Your operating decisions should be based on this summary and the anticipated demand for next month (since your average manufacturing cycle time is 6 weeks).

Realizing that you are new in the area, your supervisor has previously made the decisions for material 'starts' for month 1.

His decisions for weeks 1-4 are as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
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</thead>
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<tr>
<td>Material 1</td>
<td>600</td>
<td>600</td>
<td>600</td>
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<tr>
<td>Material 2</td>
<td>400</td>
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<td>Material 3</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

Let's look at the results of his decisions. Remember, you will be in the driver's seat beginning in month 2.
PERFORMANCE FOR MONTH 1:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NET UNITS SHIPPED</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DELING. TO CUST. REG.</td>
<td>900</td>
<td>1630</td>
<td>1890</td>
<td>2070</td>
<td>540</td>
<td>8770</td>
</tr>
<tr>
<td>PER CUSTOMER REQUEST</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **NET SALES ($)**      |       |       |       |       |       |       |
| DELING. TO CUST. REG.  | 8775  | 13855 | 14741 | 20906 | 6047  | 64324 |
| PER CUSTOMER REQUEST   |       |       |       |       |       |       |

| **COST ($)**           |       |       |       |       |       |       |
| MAT'L.-MANUF. COST     | 4089  | 5736  | 5082  | 5782  | 3632  | 24321 |
| INV. WRITE-OFF COST    | 0     | 0     | 0     | 0     | 0     | 0     |
| WAREHOUSE HOLDING COST | 0     | 0     | 0     | 0     | 0     | 0     |

|                        |       |       |       |       |       |       |
|                        |       |       |       |       |       |       |

| **GROSS PROFIT MARGIN**| 4685  | 3118  | 9659  | 15124 | 2415  | 40001 |

| **OPERATING EFFICIENCY (%)** | 53.4 | 58.6 | 65.5 | 72.3 | 39.9 | 62.2 |
## Operations Summary - Beginning Month 2 (Wks 5-8)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Finished Goods Inv.</strong></td>
<td>1172</td>
<td>1548</td>
<td>1490</td>
<td>1900</td>
<td>1044</td>
<td>7154</td>
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<tr>
<td><strong>Work-in-Process Inv.</strong></td>
<td>1627</td>
<td>2251</td>
<td>1981</td>
<td>2646</td>
<td>1441</td>
<td>9946</td>
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<tr>
<td>DUE OUT IN WEEK 5</td>
<td>458</td>
<td>661</td>
<td>616</td>
<td>806</td>
<td>334</td>
<td>2875</td>
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<tr>
<td>DUE OUT IN WEEK 6</td>
<td>431</td>
<td>720</td>
<td>693</td>
<td>694</td>
<td>325</td>
<td>2913</td>
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<tr>
<td>DUE OUT IN WEEK 7</td>
<td>262</td>
<td>322</td>
<td>233</td>
<td>335</td>
<td>334</td>
<td>1486</td>
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<tr>
<td>DUE OUT IN WEEK 8</td>
<td>256</td>
<td>338</td>
<td>285</td>
<td>591</td>
<td>230</td>
<td>1700</td>
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<td>30</td>
<td>22</td>
<td>0</td>
<td>110</td>
<td>58</td>
<td>220</td>
</tr>
<tr>
<td>DUE OUT IN WEEK 10</td>
<td>70</td>
<td>94</td>
<td>77</td>
<td>55</td>
<td>30</td>
<td>376</td>
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<tr>
<td>DUE OUT IN WEEK 11</td>
<td>55</td>
<td>83</td>
<td>77</td>
<td>0</td>
<td>51</td>
<td>266</td>
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<tr>
<td>DUE OUT IN WEEK 12</td>
<td>15</td>
<td>11</td>
<td>0</td>
<td>55</td>
<td>29</td>
<td>110</td>
</tr>
<tr>
<td><strong>Backlog</strong></td>
<td>720</td>
<td>1310</td>
<td>1140</td>
<td>1570</td>
<td>500</td>
<td>5240</td>
</tr>
<tr>
<td><strong>Delinquent:</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Non-Delinquent:</strong></td>
<td>720</td>
<td>1310</td>
<td>1140</td>
<td>1570</td>
<td>500</td>
<td>5240</td>
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<tr>
<td>DUE IN WEEK 5</td>
<td>230</td>
<td>390</td>
<td>380</td>
<td>500</td>
<td>120</td>
<td>1620</td>
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<tr>
<td>DUE IN WEEK 6</td>
<td>130</td>
<td>140</td>
<td>390</td>
<td>570</td>
<td>170</td>
<td>1400</td>
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<tr>
<td>DUE IN WEEK 7</td>
<td>240</td>
<td>360</td>
<td>370</td>
<td>200</td>
<td>150</td>
<td>1320</td>
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<tr>
<td>DUE IN WEEK 8</td>
<td>120</td>
<td>420</td>
<td>0</td>
<td>300</td>
<td>60</td>
<td>900</td>
</tr>
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### Forecasted Demand:

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<th>C</th>
<th>D</th>
<th>E</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEMAND IN WEEK 9</td>
<td>186*</td>
<td>415*</td>
<td>445*</td>
<td>464*</td>
<td>165*</td>
<td>1678*</td>
</tr>
<tr>
<td>DEMAND IN WEEK 10</td>
<td>181*</td>
<td>420*</td>
<td>441*</td>
<td>457*</td>
<td>169*</td>
<td>1663*</td>
</tr>
<tr>
<td>DEMAND IN WEEK 11</td>
<td>176*</td>
<td>421*</td>
<td>437*</td>
<td>450*</td>
<td>173*</td>
<td>1657*</td>
</tr>
<tr>
<td>DEMAND IN WEEK 12</td>
<td>171*</td>
<td>423*</td>
<td>434*</td>
<td>443*</td>
<td>177*</td>
<td>1647*</td>
</tr>
</tbody>
</table>
**NOTE**

YOU ARE CURRENTLY CARRYING INVENTORIES ABOVE AVERAGE MONTHLY DEMAND.

THESE EXTRA INVENTORIES ARE AS FOLLOWS (PRODUCT A ... E):

272  0  0  0  504

YOU WILL INCUR A WAREHOUSE 'HOLDING' COST FOR CARRYING THESE EXTRA INVENTORIES.

BASED ON THE ABOVE INFORMATION AND YOUR KEEN KNOWLEDGE OF OPERATIONS, INPUT THE FOLLOWING INFORMATION:

ENTER YOUR MATERIAL "STARTS" FOR MONTH 2.

SPECIFY WEEKLY QUANTITIES (UNITS); SEPARATE YOUR INPUTS WITH COMMAS.

MATERIAL TYPE 1 ? 181, 645, 1422, 407, MATERIAL TYPE 2 ? 0, 1541, 1954, 524
MATERIAL TYPE 3 ? 0, 0, 0, 0

VERIFY YOUR INPUTS:

MATERIAL TYPE 1  181  645  1422  407
MATERIAL TYPE 2  0  1541  1954  524
MATERIAL TYPE 3  0  0  0  0

IS THIS DATA CORRECT?

YES
### PERFORMANCE FOR MONTH 2

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<th>TOTAL</th>
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<tbody>
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<td><strong>NET UNITS SHIPPED</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Delinquencies to Cust. Reg.</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Per Customer Request</td>
<td>810</td>
<td>1670</td>
<td>1690</td>
<td>2130</td>
<td>630</td>
<td>8790</td>
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<td><strong>NET SALES ($)</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delinquencies to Cust. Reg.</td>
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<td>0.</td>
<td>0.</td>
<td>0.</td>
<td>0.</td>
<td>0.</td>
</tr>
<tr>
<td>Per Customer Request</td>
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<td>14195</td>
<td>13181</td>
<td>21512</td>
<td>7055</td>
<td>63840</td>
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<td><strong>COST ($)</strong></td>
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<tr>
<td>Material-Manuf. Cost</td>
<td>4375.</td>
<td>6655.</td>
<td>6420.</td>
<td>4194.</td>
<td>3142.</td>
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<td>Warehouse Holding Cost</td>
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<tr>
<td></td>
<td>4572.</td>
<td>6655.</td>
<td>6420.</td>
<td>4194.</td>
<td>3557.</td>
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<tr>
<td><strong>GROSS PROFIT MARGIN</strong></td>
<td>3324.</td>
<td>7538.</td>
<td>6761.</td>
<td>17318.</td>
<td>3498.</td>
<td>33439</td>
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<tr>
<td><strong>OPERATING EFFICIENCY (%)</strong></td>
<td>42.1</td>
<td>53.1</td>
<td>51.3</td>
<td>80.5</td>
<td>49.6</td>
<td>60.2</td>
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</table>
# Operations Summary - Beginning Month 3 (Wks 9-12)

<table>
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<tr>
<th>PRODUCT TYPES</th>
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<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>FINISHED GOODS INV.</td>
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<td>1919</td>
<td>1627</td>
<td>2196</td>
<td>1637</td>
<td>9198</td>
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<tr>
<td>WORK-IN-PROCESS INV.</td>
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<td>1463</td>
<td>1399</td>
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<td>740</td>
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<td>22</td>
<td>0</td>
<td>110</td>
<td>58</td>
<td>220</td>
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<tr>
<td>DUE OUT IN WEEK 10</td>
<td>86</td>
<td>122</td>
<td>108</td>
<td>93</td>
<td>80</td>
<td>439</td>
</tr>
<tr>
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<td>402</td>
<td>437</td>
<td>443</td>
<td>51</td>
<td>1573</td>
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<tr>
<td>DUE OUT IN WEEK 12</td>
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<td>334</td>
<td>300</td>
<td>55</td>
<td>229</td>
<td>1148</td>
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<td>DUE OUT IN WEEK 13</td>
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<td>63</td>
<td>71</td>
<td>87</td>
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<td>DUE OUT IN WEEK 14</td>
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<td>1671</td>
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<td>0</td>
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<td>DUE OUT IN WEEK 16</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>BACKLOG</td>
<td>980</td>
<td>1570</td>
<td>1540</td>
<td>2230</td>
<td>640</td>
<td>6960</td>
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</table>

**Delinquent:**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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**Non-Delinquent:**

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<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>980</td>
<td>1570</td>
<td>1540</td>
<td>2230</td>
<td>640</td>
<td>6960</td>
</tr>
</tbody>
</table>

**Due in Week:**

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<tr>
<th>Week</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>210</td>
<td>380</td>
<td>350</td>
<td>540</td>
<td>190</td>
<td>1670</td>
</tr>
<tr>
<td>10</td>
<td>240</td>
<td>330</td>
<td>380</td>
<td>530</td>
<td>100</td>
<td>1580</td>
</tr>
<tr>
<td>11</td>
<td>250</td>
<td>390</td>
<td>480</td>
<td>510</td>
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<td>12</td>
<td>280</td>
<td>470</td>
<td>330</td>
<td>650</td>
<td>190</td>
<td>1920</td>
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</table>

**Forecasted Demand:**

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<tr>
<th>Week</th>
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<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>TOTAL</th>
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<tr>
<td>13</td>
<td>199</td>
<td>425</td>
<td>456</td>
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<td>14</td>
<td>198</td>
<td>426</td>
<td>460</td>
<td>617</td>
<td>246</td>
<td>1947</td>
</tr>
<tr>
<td>15</td>
<td>197</td>
<td>426</td>
<td>464</td>
<td>629</td>
<td>258</td>
<td>1973</td>
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<tr>
<td>16</td>
<td>196</td>
<td>427</td>
<td>467</td>
<td>640</td>
<td>269</td>
<td>1999</td>
</tr>
</tbody>
</table>
**NOTE**

DECLINING DEMAND AND/OR CONTINUED OVER PRODUCTION HAS CREATED EXCESS INVENTORIES IN SOME OF YOUR PRODUCT AREAS.

YOU MUST NOW WRITE OFF AT LEAST THE FOLLOWING QUANTITIES:

(PRODUCT A ... E) = 179 0 0 0 425

SPECIFY YOUR WRITE-OFF (PRODUCT A ... E)

179,0,0,0,425

PLEASE VERIFY YOUR INPUTS

INV WRITE-OFF (PRODUCT A ... E) : 179 0 0 0 425

IS THIS DATA CORRECT?

YES

**NOTE**

YOU ARE CURRENTLY CARRYING INVENTORIES ABOVE AVERAGE MONTHLY DEMAND.

THESE EXTRA INVENTORIES ARE AS FOLLOWS (PRODUCT A ... E):

820 246 0 116 606

YOU WILL INCUR A WAREHOUSE 'HOLDING' COST FOR CARRYING THESE EXTRA INVENTORIES.
Based on the above information and your keen knowledge of operations, input the following information:

Enter your material 'starts' for month 3.

Specify weekly quantities (units); separate your inputs with commas.

Material type 1? 3652,1302,2775,2722
Material type 2? 0,0,0,0
Material type 3? 64,2031,260,1107

Verify your inputs.

Material type 1 3652 1302 2775 2722
Material type 2 0 0 0 0
Material type 3 64 2031 260 1107

Is this data correct?

Yes

Performance for month 3:

<table>
<thead>
<tr>
<th>Product</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net units shipped</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Deling to cust. req.</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Per customer request</td>
<td>980</td>
<td>1710</td>
<td>1670</td>
<td>2330</td>
<td>760</td>
<td></td>
</tr>
<tr>
<td></td>
<td>980</td>
<td>1710</td>
<td>1670</td>
<td>2330</td>
<td>760</td>
<td>9520</td>
</tr>
</tbody>
</table>

| Net sales ($) |
| Deling to cust. req. |
| Per customer request | 9555 | 14535 | 13025 | 23532 | 8511 |
| | 9555 | 14535 | 13025 | 23532 | 8511 | 69158 |

| Cost ($) |
| Mat'l-Manuf. cost | 6870 | 10272 | 10012 | 14166 | 3569 |
| Inv. write-off cost | 1297 | 0 | 0 | 0 | 3506 |
| Warehouse holding cost | 594 | 164 | 0 | 91 | 499 |
| | 8761 | 10436 | 10012 | 14257 | 7874 | 51340 |

| Gross profit margin | 794 | 4097 | 3013 | 9275 | 637 | 17816 |

| Operating efficiency (%) | 83 | 28.2 | 23.1 | 39.4 | 7.5 | 25.8 |
BIBLIOGRAPHY

Books


**Articles**


Barish, Norman N. and Frederick H. Siff, "Operational Gaming Simulation With Application to a Stock Market," Management Science, XV (June, 1969), B530-B541.


Eilon, Samuel, "Management Games," Operational Research Quarterly, XIV (June, 1963), 137-149.


"In Business Education, the Game's the Thing," *Business Week*, (July, 1959), 56.


Kornbluh, Marvin, "Who's the Master of Your System?"
*Proceedings of AFIPS*, Bethesda, Maryland, (May, 1970), 2-17.


Reports and Proceedings


Proceedings of the National Symposium on Management Games, Lawrence, Kansas, Center for Research in Business, The University of Kansas, 1959.


Unpublished Material


Newsletters


Significant Interviews

Catter, Malcolm G., Product Engineering Manager, Silicon Department, Texas Instruments Incorporated, Dallas, Texas, Interview, December 11, 1970.


Eichman, P. F., Computer Systems Manager, Customer Center Systems Department, Texas Instruments Incorporated, Dallas, Texas, Interview, October 21, 1970.


Hopper, C. D., Manager of Systems Department, Customer Center Systems Department, Texas Instruments Incorporated, Dallas, Texas, Interview, February 5, 1971.

Houchin, William E., Production Systems Manager, Electron Device Division, Texas Instruments Incorporated, Dallas, Texas, Interview, March 2, 1971.

Lineback, James T., Engineering Manager, Germanium Power Department, Texas Instruments Incorporated, Dallas, Texas, Interview, February 19, 1971.


Rosson, N. S., Production Planning Analyst, Electron Device Division, Texas Instruments Incorporated, Dallas, Texas, Interview, November 2, 1970.