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MANAGEMENT SIMULATION - A METHOD OF IMPROVED MANAGEMENT DEVELOPMENT

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MANAGEMENT SIMULATION –

A METHOD FOR IMPROVED MANAGEMENT DEVELOPMENT

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ABSTRACT

The discussion begins with a general summary of management development concepts and then applies these concepts to a management development program. Next, the discussion focuses on management simulation as a tool for development. Advantages and disadvantages of simulation are discussed and potential application of management simulation is shown.

An analysis of simulation design philosophy and design objectives is presented for a simulation at the first-line supervisor level for a hypothetical engineering organization. In addition, there is a discussion on the integration of various factors into this simulation design such as project tasks, short-term engineering tasks, personnel capability, coordination, overtime, sub-contractors, and others.

Results of tests of the simulation are discussed and conclusions are drawn; first, regarding the potential achievement of a management development objective by using the simulation, and second, regarding the manner in which the simulation as designed takes advantage of the strengths of simulation while minimizing the effects of weaknesses of simulation methods. In addition, there is a discussion regarding implementation of the simulation in a development program.

The Appendix contains a guide, example of play, aids, and an example planning sheet that will provide anyone who has a copy of this paper an opportunity to play the simulation. A selected bibliography is also included for those who wish to read further on this topic of research and engineering management.

BIOGRAPHY

Jan Paul Hope is a native of Northern Virginia. He received his BS degree in Mechanical Engineering from the University of Virginia. Upon graduation in 1969, he began his career with the Department of the Navy in NAVSHIPS (PMS 382) where he was awarded an outstanding performance rating for his work on the ASR-21 Project.

In January 1971, he transferred to the Ship Arrangements Branch, NAVSEC 6131, where he has been involved in numerous ship designs and special projects. He was Task Leader for NAVSEC 6131 on the AO-177 design and was awarded another outstanding performance rating in 1974.

He was selected for the long-term training program in 1974 which included a year of full time study at George Washington University. He completed the program with the degree of Master of Engineering Administration, awarded in February 1976.

After his return to NAVSEC, he was assigned as Task Leader for NAVSEC 6131 and also Assistant Task Group Manager for Hull Division on the collocated DDG-47 preliminary design team. Upon completion of preliminary design, he was assigned to the AEGIS cruiser program and is currently Task Leader for NAVSEC 6131 and Hull Assistant Task Group Manager for CSGN, CSGN(VSTOL), and CGN 9 Conversion.

He has presented papers to the 8th, 11th and 13th ASE Technical Symposia, and his paper, Management of Research and Engineering: Selected Topics, won the coveted JOHN C. NIEDERMAIR Award for best paper presented at the 13th ASE Symposium. His memberships in professional societies include ASE, SNAME, ASNE, ASME, and the U.S. Naval Institute.

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INTRODUCTION

The purpose of this paper is to solve a management problem of engineering organizations which is: how can the development of managers from technical personnel be improved. In order to solve this problem, or more appropriately in this instance, realize an opportunity, a systematic approach is used which consists of a number of sequential steps.

The first step is diagnosis of the problem which consists of defining a comprehensive management development program and then comparing it to existing programs. This comparison reveals gaps between the comprehensive and existing programs which must be closed if the existing program is to be improved.

The next step in the problem solving process is to identify alternative means of closing this gap and thereby offer potential realization of the management development opportunity. The third step is the comparison of the various alternative solutions against a set of evaluation criteria. After comparison of the alternatives, it is necessary to select one alternative as a tentative solution for further development.

The tentative solution can be tested to determine if it does, in fact, represent a realization of the opportunity. If testing the tentative solution reveals positive results that indicate that the tentative solution will achieve the opportunity, then means to implement the solution should be identified.

This paper is organized to follow the above problem solving approach in the sequence described. Chapter I defines a comprehensive management development program, describes the existing management development programs, compares the two, and identifies the potential opportunities for improving the existing program. This analysis concludes with the identification of alternative means of achieving an improved program.

Chapter I also discusses management simulation in comparison to the other alternatives identified, and based on the criteria presented and referenced to other more in depth studies, selects a tentative solution. This alternative, management simulation, is developed further in Chapter II which describes the design of a unique management simulation applicable to medium sized engineering organizations. Testing of the tentative solution represented by the unique simulation is described in Chapter III and consisted of volunteer, play-testing with response by questionnaire and also multi-run testing to develop average scores for the different scenarios of the simulation.

In view of the results of the testing phase, conclusions are drawn in Chapter IV regarding the potential for the unique simulation to realize the management development opportunity identified in Chapter I. Chapter IV concludes with a discussion of means to implement the potential solution represented by the simulation.

The complete simulation as it would be presented to a potential player is contained in Appendix A. By playing this simulation, the student will be able to experience, in a simulated environment, the essential elements of management of the workload of a technical group.

CHAPTER 1

MANAGEMENT DEVELOPMENT OF TECHNICAL PERSONNEL

Comprehensive Program

Program Required

A comprehensive program for management development has been defined by J. P. Hope in the paper, Management of Research and Engineering: Selected Topics[7]. This program has been defined specifically for developing engineers and scientists for management of technical organizations and recognizes the requirements and needs of technical personnel in making the transition from engineering to technical management. The rationale and background research for defining the specified comprehensive program is discussed in detail in the reference and also in another paper, Management Simulation: A Way To Improve Management Development At NAVSEC[8]. This rationale and research will not be discussed here, however, the final conclusion regarding the recommended comprehensive program will be summarized.

In summarizing the comprehensive management development program, it may be said that after recognizing the need for technical personnel in technical management, a sensitive and rational approach should be taken to develop these personnel for management. Candidates for the management development program should be selected on the basis of those most suited for the managerial position, which may or may not include those who are the best technical personnel in their areas.

The development program must be designed to address the unique problems of technical personnel in relation to the demands of the managerial process. Further, the program should consist of three phases: an orientation phase, a formal course phase, and an on-the-job development phase.

The orientation phase should highlight the difficulties of the transition from technical fields to management and should prepare the potential manager for the following phases. The formal course phase should use both general and special courses, in a complementary manner, and utilize unique resources available to the organization in developing course content. The emphasis in these phases is on development prior to promotion. During the on-the-job development phase of the program, the method of personal coaching by the new manager's superior and objectives-oriented development should be used in a complementary manner.

After defining the comprehensive program, the next step in the analysis is definition of available development programs.

Programs Available

In general, there are good management development materials available within each of the program phases identified above, especially in the general course element of the formal course phase. However, there are also areas of potential improvement, particularly in the orientation phase and special course element of the formal course phase.

Orientation

Generally, there are few, if any, established developments materials that meet all of the needs of the orientation phase as defined in reference[7]. There are excellent management short courses available from universities and some professional societies that fill most of the requirements of this phase. One area that needs further strengthening is to provide a means for the person to actively participate in a management environment as opposed to only being exposed to management concepts through traditional development methods such as lectures and study of text material.

Brief case studies and especially simulation are two methods for exposing potential managers to the new and different environment of management before entering a long and expensive (in terms of actual costs and also in terms of personal time expended) management development program. If, after the orientation phase, the person desires to pursue the development program, he next enters the formal course phase.

Formal Development

Two means of formal development were identified in the comprehensive program, which are: general courses on the subject of management and specific courses devised for the organization that relate concepts of management to the environment of the organization. In the area of general courses, excellent management development programs are available, such as the Master of Engineering Administration program at George Washington University. Programs and courses of this nature provide a broad background on the subject of management, and require that the student develop a broad base of knowledge in the basic concepts of management. Extensive availability of courses in the general area permits management candidates to formulate a program that will fulfill the general course portion of the formal development phase defined for the comprehensive management development program. The extensive availability of general courses contrasts sharply with the lack of management development courses which apply basic management concepts to the specific environment of many engineering organizations, particularly at the first line manager level.

There are few courses or development methods which relate concepts of planning, organizing, leading, and controlling to the context of specific organizations. One of the primary functions of the first line manager of engineering organizations is planning and control of the workload of his group. There are few formal development methods which relate planning and control to such tasking and administrative documents as may be utilized in the organization. In addition, there are often procedures to be followed in one's organization that can affect the form of the group leader's planning and control functions, which are not treated in formal course materials.

Usually, the group leader must apply the background of information he has obtained from general courses to the existing environment through on-the-job experience without benefit of formal development methods. The comprehensive program includes development methods with a specific orientation toward planning and controlling workload which would be applied during the formal course phase. This, then, is clearly an area for improvement in the management development program.

Summary

In comparing the management development program that exists against the proposed comprehensive program, two areas of potential improvement have been identified. These areas are in the formal development phase and the orientation phase. In the formal development phase, it was found that available general courses, such as those offered by local universities, fulfilled the management development need for that category, however, it was found that there is a real need for specialized formal courses that relate the concepts of management to the working environment of specific organizations. This need is particularly acute for lower level managers, whose duties are sometimes delegated to operating level personnel as a result of personnel shortages, and for those operating level personnel who perform some management duties. The next step in the analysis is to create opportunities to eliminate these gaps in the existing management development program.

Opportunity for Improvement

Having recognized the need for improving the management development program, opportunities should be created to fulfill this need. The need for improvement falls primarily in the area of the formal course phase of the development program. Thus, it would be appropriate to develop course material that would address the stated need. The question is now, what form should this course material take? Several alternative course formats are available which include lecture and text material, case studies, and also management simulation, or some combination of all of these.

Fulfilling the need for improvement in the orientation phase of the development program could be achieved either by lecture and text materials or partially by management simulation methods. Management simulation directly involves the student in a decision making environment and if used during the orientation phase, can show him a simulated view of what management involves without requiring him to make the transition to a management position. This experience coupled with other information derived from lecture and text material and on-the-job experiences would form the basis for the candidate's decision to pursue further management development.

In view of the unique characteristics of management simulation as a development method that can be used in orientation and for formal courses, subsequent chapters will focus on the development of a management simulation adapted to the environment of a technical group leader (first line supervisor). Before discussing the design of such a simulation, the topic of management simulation in comparison to other development methods will be discussed in the following section.

Management Simulation

Experience and Alternatives

Experience can be simultaneously a benefit and a hindrance to a manager or a potential manager. Experience can be a benefit because it is through experience that one learns how things are to be done in the context of one's organization. However, this experience can also be a hindrance because standard methods are sometimes not as effective in today's dynamic management environment as more innovative methods may be. This problem can be particularly acute for the technical person who is aspiring to a management position. Often, the basis for decision making in technical positions is very different from that in management positions as wll be discussed in greater depth in Chapter II. Moreover, the technical person generally achieves his objectives through things, whereas the manager generally achieves his objectives through people. The outlook and experience gained in these two modes of achieving objectives is very different, and the exper ınce ot the technical person may need augmentation before he is able tc ssume the role of a manager. How, then, can the aspiring manager overcome the inertia of previous experience when faced with the new demands of management?

One obvious way of providing expeıience is simply to place the person in the position and allow him to learn on the job. However, as pointed out in the previous section, a formal development phase should precede the on-the-job development phase, which leads to the alternative development method identified at the end of the previous section. Of the methods identified, management simulation has the potential to cast the person being developed into a management role and give him experience in a simulated environment.

As stated by Graham and Gray, "With the increasing general recognition of the importance of the management profession has come insistence on better and shorter methods of acquiring management experience - at least vicariously". Moreover, business games (or simulations) are identified as a way to achieve this experience.[6] Before discussing various aspects of management simulation in comparison to other development methods, it would be useful to define management simulation as the term is used herein.

Definitions

The term "game" has been used to denote a ". . . form of simulation in which human beings make decisions at various stages . . ."[12]. Gaming has been defined as ". . . the use of a game model to permit players to make decisions and observe the behavior of a model as a result of their action"[12]. Gaming is distinguished from operational gaming which has been defined as the use of games ". . . to determine optimal solutions for strategies and to determine optimal structures for systems"[12].

However, the term "game" has the connotation of a development method constructed in a multi-player interactive format. As will be seen in subsequent chapters, a solitaire simulation has been developed to be used in a program of management development, and the solitaire nature of the simulation that has been developed is at variance with the connotation usually associated with the term "game". Therefore, the term "management simulation" will be used herein to denote a form of simulation which is defined as a game by Meier, Newell, and Payer, but has nothing to do with the concept of operational gaming defined above. The term "game" is avoided, in denoting the simulation that is presented in this paper because of the multi-player connotation of that term.

In referring to the Carnegie Institute of Technology business game, Richard M. Cyert states, "Essentially, the Game is a living case. The student is put in a situation with a variety of problems to be identified and solved. More important, the student must be prepared to live with his decisions. In this respect, the Game is unique. No other educational tool presents this opportunity and challenge"[3]. Thus, it is seen that while simulation is a unique method of management development, it also has an overlap with case studies which is one of the alternative methods of management development identified in the previous section. In comparing simulation against the other methods of development, strengths of simulation will be focused upon first which will then be followed by a discussion of the limitations of simulation methods.

Design Considerations

An extensive comparison among management development methods has been made by J. P. Hope in the paper, Management Simulation: A Way To Improve Management Development At NAVSEC. That discussion will only be summarized here in the context of design considerations that would be applicable to the design of a simulation to be used for management development[8]. The basic problem of the simulation designer is to develop a design that takes advantage of the strengths of simulation while minimizing the effects of weaknesses as these strengths and weaknesses compare to other management development methods such as lectures and case studies.

In order to achieve a simulation that will realize the strengths of simulation methods, it is necessary to develop the simulation design with careful consideration of several factors. Student involvement is a primary strength of simulations, and the designer must ensure that the simulation will present a situation that will induce student involvement. As stated by McKenney, ". . . involvement is largely dependent on the prompt feedback on the student's decision making. To make this involvement a continuous challenge, the student manager and his competitors should strongly influence the environment"[11]. McKenney also recommends that games ". . . include uncertain events, elements of risk, and a complex payoff problem"[11]. Clark Abt feels that games should ". . . encourage imaginative freedom to experiment with alternative solutions, while at the same time offering a realistic set of constraints on less practical responses to problems"[1]. Another factor that can be important in the design of a management simulation is to use terminology and situations in the simulation from the prospective environment of the students who will be playing it[6].

The designer should try to create a design that will inform the student about the environment for which the student is being developed. For example, if it is the purpose of the simulation to help achieve a management development objective at the first line supervisor level of an engineering organization, then the design should focus on recreating the environment of that position.

The designer should then focus on developing a model of the first line supervisor's decision making process. The simulation design should focus on the decision making process, because it is through making simulated decisions and receiving prompt feedback that the player's involvement will be enhanced. Also, in accordance with the guides presented above, elements of risk and uncertainty should be built into the model which will be the key to developing technical personnel for management. Technical decisions are often made with a basis on certainty afforded by the application of natural physical laws, whereas in management, there is a greater proportion of decision making under conditions of risk and uncertainty. The issues involved in certainty, risk, and uncertainty in decision making is discussed in greater depth in Chapter II.

In order for the simulation to be an interesting challenge, the player should be able to try alternative strategies. If one strategy fails, he should be able to formulate a new strategy and experiment with it. If the simulation is properly designed, alternative strategies will be available for the player to experiment with in making his simulated decisions.

If the designer carefully considers these design factors in relation to the strengths and weaknesses of simulation, he should be able to develop a simulation that can achieve a specified management development objective.

Summary

In summary, it may be stated that simulation has unique characteristics that make it attractive for management development, however it is to be emphasized that any one method of management development should not be utilized to the exclusion of other methods. Graham and Gray point out that games should be used for teaching things that can be handled by simulation methods while other methods should be used where simulation is not as appropriate[6]. In discussing the Carnegie Institute of Technology business game, it is stated, "It seems that in choosing the proper mix of cases, lectures, and games, the main overlap resides in cases and games, for the kinds substantive knowledge brought out in lectures is not developed in cases and games, even though such knowledge may be applied here"[3].

In view of the unique strengths of management simulation as a development method in comparison to other methods, simulation is tentatively selected as the potential solution for closing the gap in the management development program identified in the previous section of this chapter. The simulation would be used as a special course in the formal development phase and would be part of a larger program of general courses including case studies, lecture, and text materials. The larger program would include a variety of development methods and sources, including university courses as well as courses offered in-house within the engineering organization.

The problem now becomes one of taking the tentative solution represented by management simulation and developing a simulation that has the potential to achieve a management development objective. This topic is the subject of Chapter II.

CHAPTER II

SIMULATION DESIGN

Objectives

There are two basic management development objectives that this simulation is to achieve. First, by playing the simulation, the individual will be able to increase his knowledge of the interrelationships between objectives and resources of a technical group as work is performed within it to achieve organizational goals. Second, by playing the simulation, the individual will become more familiar with the management environment as it relates to such things as objectives, planning, control, terminology, potential resources, and other factors which are included in the simulation.

In addition, two design objectives are of central importance to the form of the final simulation. First, the simulation is to be completely manual, i.e., no computer assistance is required, and second, an individual is to be able to play the simulation by himself during free time and without the services of a game administrator.

The concept of a manual simulation is considered essential as a cost reducing factor. Computer simulations allow a more complex model to be used, but significant costs are incurred through use of computer time and auxiliary personnel required to administer the simulation-computer interface. If a method of management development is too expensive, it will not be used regardless of its merits. Under current budgetary constraints, it is considered essential that this simulation be in a manual format to minimize cost and thereby ensure maximum utilization. A second drawback to the use of computer simulation is that the potential exists for interrupting the development effort through mechanical breakdown, delay by priority programs, and other similar occurrences. Therefore, a manual simulation is considered more appropriate for the intended purpose, assuming that an appropriate manual model can be developed.

In keeping with the philosophy of self-development referenced in Chapter 1 above, a design objective has been established that requires the simulation to be in a format that permits an individual to use it without outside assistance. This concept has two important implications for the model design. First, the play sequence and decision actions must be within the capability of the player to comprehend and second, the simulation must present an interesting challenge that will provide the opportunity for the individual to exercise self-motivation in playing the game on his own initative.

The reason for this self-play design objective is, like the manual simulation objective, primarily one of cost reduction. If the individual is motivated to study the simulation during his free time away from work, then this part of the development program will not interfere with the student's normal productivity at his assigned job. By reducing costs in this way, the attractiveness of the tool for full utilization is enhanced. Furthermore, by emphasizing self-development and providing the student with a specific means to use his free time for development, it will be possible to identify those potential management candidates who are truly interested in increasing their knowledge of the management field.

After establishing these multiple objectives, it is now necessary to formulate a general concept of a simulation model that will achieve these objectives.

General Concept

The primary purpose envisioned for this simulation is to expose, in a new way, students of management to the issues involved in managing the workload of a technical group. The perspective of an operating level, technical person is very different from that of the technical group leader (first line supervisor). By playing this simulation, the operating level person can be given an insight into the perspective of a group leader without the problems of placing the inexperienced or unqualified in a real-life position as a manager of other personnel.

The simulation emphasizes planning and control functions, not necessarily because these are considered to be more important than other functions of management, such as organizing or leading, but because planning and control can be effectively modeled by simulation methods while other functions are considered to be more readily studied by other methods.

When one is playing the simulation, he is taking the position of a technical group leader and he seeks to assign tasks to his subordinates in such a way as to maximize the performance of the group. The emphasis is placed on the management of Short Term Engineering Tasks because in the hypothetical organization, the group leader is assumed to have more direct management responsibility for Short Term Engineering Tasks than for other types of work such as major projects which are assumed to be planned, organized, directed, and controlled from higher levels in the organization. While group input into these processes is important, the group leader is assumed to have more of a total and independent responsibility in managing workload in the Short Term Engineering Task system.

The simulation model that is to be developed is an abstraction of real life as it necessarily must be. If the simulation model is too complex in an attempt to duplicate reality, it will lose its effectiveness as a development tool because players may become overwhelmed by the complexity of the model. In addition, the cost in terms of manhours required to perform and administer the simulation could well exceed the cost of on-the-job training in which a measure of productivity would be achieved that cannot be attained when playing the simulation. Furthermore, to achieve the design objective of individual play, the model must be of sufficiently low complexity and formulated in such a way that the individual player will be self-motivated to play it.

On the other hand, if the model is too abstract and oversimplified, it will not contain the essence of reality that is necessary for the simulation to be used to achieve a management development objective. Therefore, the simulation model must be developed to achieve a balance between duplicating reality in its total complexity and capturing the essential elements of reality for development purposes.

In addition, the simulation model is to be developed specifically as a management development tool and not as a simulation for investigating and optimizing the process of workload management. If the purpose of the model were to optimize workload management through the use of quantitative simulation techniques, then a more complex model would be essential. The more abstract model to be utilized for this simulation will illustrate important elements and interrelationships in the management of technical group workload without being too complex for the student to study it through individual playing. It is, however, essential that the key elements of managerial work that the group leader performs in managing workload be included in the simulation.

In managing the workload of a group, the group leader is faced with making decisions concerning the allocation of his resources, i.e., people and time, to the work involved in achieving objectives, i.e., due dates for Short Term Engineering Task and work contributed to large projects. His primary considerations are decisions about the work to be done, decisions about getting the work started and keeping it going, and decisions regarding keeping the work on course. These categories of decisions might be conveniently labelled planning, directing, and controlling, respectively (adapted from an unpublished illustration by Professor J. B. Smith, Jr., George Washington University, 1975).

This simulation will focus on the factors involved in decision making and the planning and controlling processes, because these processes are more readily modeled by simulation methods than is directing. Furthermore, this simulation is modeled to take an eight week slice of the total environment of the group leader to specifically illustrate the short term planning process which is of great importance in the group leader position in the postulated engineering organization.

As discussed by Newman, Summer, and Warren, "Leading [or directing as identified above] is impossible without communication between persons"[13]. As one of the design objectives discussed above, the intent of the simulation is to provide a development tool that can be studied by the individual through solitary play, thus this simulation is incompatible with a necessary condition of the leading process. Moreover, the principal issues and concepts of leading are not easily modeled in simulation format and are considered to be more effectively studied by means other than simulation playing. Also, a large part of effective leadership behavior can only be developed by being in a leadership position in which the manager can exercise the concepts of leadership, such as those identified by Newman, Summer, and Warren of "....personally and actively working with his subordinates in order; (1) to guide and motivate their behavior to fit plans and jobs that have been established, and (2) understand the feelings of his subordinates and the problems they face as they translate plans into completed action"[13]. Personally and actively working with subordinates in leading can only be performed in an organizational situation or an elaborate multi-person artifical setting which is not within the scope of the objectives established for this simulation.

Furthermore, even in the organizational situation, time is required to develop an effective supervisor-subordinate relationship which tends to reduce the usefulness of simulation for developing this aspect of managerial skill[13]. Therefore, the process of leadership will not be explicitly built into this simulation model although results of leader behavior such as subordinate personnel capability are implicitly considered.

In addition, the process of organizing will not be explicity considered in this simulation. The group leader often has little input into organizational considerations as related to managing group workload.

Organizational changes may be infrequent and involve many people in higher line management and staff positions. Therefore, considerations concerning the process of organizing are not included in the simulation model.

Having narrowed the focus of the simulation model to planning and controlling, it is now necessary to discuss the nature of decisions in relation to organizational objectives to be achieved.

Decision Making in Planning

In planning and controlling group workload, the group leader must make decisions on allocating his resources, i.e., personnel and time, to achieve established objectives. The objectives of the group leader are of two general types. First, there are objectives related to large projects such as new system engineering designs, and second, there are objectives related to short term engineering tasks. These short term tasks are small in both time allowed for completion and scope of work. Short term engineering tasks might include things such as, routine engineering support for system life cycle maintenance and clarification of design specifications during system construction.

The group leader attempts to make decisions that will result in achievement of objectives, however he does not know prior to making the decison precisely how well a given person will perform a given task. It could be assumed that he is making a decision under conditions of uncertainty, because he does not know how well the person assigned will perform, and he also does not know the future state of his workload particularly with regard to short term engineering tasks.

For simulation purposes, modeling uncertainty can be difficult because creation of events must be abstracted into the model. One way to create the occurrence of events is through probability methods in which generation of a random number falling within a range of possible numbers triggers the event. However, if the player knows the range that will trigger the event and all the possible numbers, he will be able to determine the probability of occurrence of an event which will change the decision situation from one under uncertainty to one under risk. If the simulation is to achieve the self-play design objective discussed above, these ranges of trigger points must be known to the player. Furthermore, the self-play design objective will permit the player to know in advance the total workload that he may be required to perform over the duration of the simulation although he may not know the sequence in which tasks will arrive.

By using a game administrator, the method of triggering events can be concealed from the player, thus the player will be making decisions under conditions of uncertainty. However, using a game administrator defeats the self-play design objective. In addition, if the decision environment of the group leader can be modeled under conditions of risk, convenient methods for triggering events through generating random numbers will be available for design of the simulation model.

The immediate task is, then, to examine the decision environment of the group leader to identify situations as having either uncertainty, risk, or certainty conditions. If this examination reveals that assuming risk conditions does not distort reality sufficiently to preclude achieving an effective management development tool, then a simulation can be developed that will achieve the self-play design objective.

With regard to workload, the group leader will know with a high degree of reliability the amount of effort his group must perform to meet organization objectives associated with large projects. Projects are planned throughout the managerial hierarchy well in advance of the actual work. Generally, there is little deviation from the overall plan once work has started and, in fact, in terms of the simulation being developed, project workload could be reasonably modeled under conditions of certainty. As an example, each ship design at the Naval Ship Engineering Center uses the same set of standard tasks for each section (technical group), and the process of developing the project budget usually results in a comprehensive statement of the scope of work required to complete the tasks for a particular ship design. Schedules are also developed along with the budget and as a result of this project planning process, the section head (technical group leader) will have a reliable indication of the effort required to support the project for up to a year in advance. With this information, the section head can often assign personnel to the project under conditions that approach certainty.

Evaluating personnel capability and incorporating this consideration into the technical group leader's planning process also approaches a decision condition of certainty because of the long term nature of the project. While it is exceedingly difficult to forecast an individual's performance on one specific day in the future, technical group leaders should be able to assess, in a general way, the performance of a person over a period of months. A background of knowledge of past performance provides the group leader with data for forecasting future long term performance. Such forecasts are certainly of a very crude and general nature, but can be accurate for assignment of personnel to project work. Thus, it is considered a reasonable assumption to model personnel capability on project work under conditions of certainty, i.e., the group leader knows the capability of each individual for long term performance on the project.

On the other hand, work performed on Short Term Engineering Tasks does not lend itself to modeling under conditions of certainty. The time of arrival, urgency, and magnitude of a particular task may be unknown to the group leader prior to its appearance on his desk. However, over a period of time, a background of workload data can be accumulated that can be used to forecast the total amount of workload that a group may be required to perform to support their customers. While this forecast may be of a rough nature, it could be assumed to be reliable for developing workload and manning estimates for up to a year in the future. Therefore, it is reasonable to assume that a group leader will know his approximate total workload for a given segment of time which will be represented by the total period of play of the simulation.

The group leader generally has no way of determining in advance the priority, timing, or magnitude of specific tasks. This aspect of the group leader's environment can be readily modeled to simulate these uncertain conditions. First, individual tasks can be prescribed which provides the urgency and magnitude of the task. A set of tasks can be developed with a distribution of priorities typical of that to be found by the group leader in his daily environment. The total manhours for all of these tasks represents the total amount of work that must be performed by the group to support Short Term Engineering Tasks during the period of play of the simulation. To simulate the random arrival of tasks, all task statements (in the form of a Short Term Engineering Task card) are placed face down, mixed by the player, and then consolidated into one stack of tasks. As play progressess, the player draws tasks from the stack which will provide him with the latest state of his workload. Thus, the total manhours may be known for the simulation period which is a reasonable assumption based on the fact that a group leader can roughly estimate potential workload over extended periods of time. The random drawing of specific tasks from the pool simulates the arrival of tasks in a sequence that is unknown in advance and simulates the uncertainty of this aspect of group workload.

Once the task arrives, the group leader is faced with a significant planning decision and that is, to whom should the task be assigned? In making this decision, the group leader is guided by the requirements of the task, existing workload, and the ability of his subordinates to complete the task. The requirements of the task and existing workload are known factors while personnel capability is a subjective judgement made by the superviser.

This judgement is complicated by the short term nature of the tasks. While it was shown that performance over the long term could be reasonably simulated under conditions of certainty, predicting performance over a period of several days is much more uncertain because of the many intervening factors that can affect short term performance. For example, a person may become slightly ill and be unable to work at peak effectiveness for several days which could drastically reduce performance over a short period of a week. In the long term, minor illnesses will probably average out and become a relatively constant percentage of the total period of time. In addition, a person may have an "off" day occasionally during which he functions at reduced effectiveness. Precise prediction of "off" days or illnesses cannot be reliably made by the group leader, therefore, planning short term workload might be characterized as decision making under conditions of uncertainty.

However, the simulation design objective of achieving a manual, solitaire game requires that the player be aware of individual capabilities of his subordinates in a quantitative manner. Generation of random numbers is a technique that can be used to trigger events. The player will be required to compare the random number against a range of numbers that indicate a specific outcome. If the player knows the range of numbers associated with the capability of each subordinate as well as the total range of possible numbers, he will know the probability of generating a number that falls within the capability range. This knowledge will change the planning decision from one under uncertainty to one under risk.

This information could be concealed from the player either through the use of a computer or by having an active game administrator. However, both of these options defeat the simulation design objectives of a manual, solitaire simulation, the advantages of which are discussed above. The problem now is to review the decision environment of the group leader with respect to short term personnel capability to establish if decision under risk is a reasonable approximation for management development purposes.

Usually, a group leader can state the capabilities of each of his subordinates in relation to each other. Annual performance ratings of each subordinate often require him to rank subordinate performance in relation to that of other subordinates. Within the ranking system, it is usually possible to establish, by experience in the group environment, a basis for distinguishing between marginal performers and those who are average or better. Thus, the group leader has information to help in his planning decision which reduces the uncertainty that would exist if he were not able to assess subordinate capability subjectively.

The next step is to assign quantitative values to categories of personnel capability. Few group leaders make quantitative assessments of personnel capability, however, it is not impossible to make such an assessment. For example, if a group leader felt that his outstanding subordinate had a 90 percent chance of completing a Short Term Engineering Task by a certain date, he might assign correspondingly lower percentages to less capable subordinates such as 80 percent to a good performer and 70 percent to a marginal one. By utilizing such a method of assigning probabilities in his real environment, the group leader has altered his planning decision from one under uncertainty to one under risk. Therefore, it is considered reasonable to model the group workload decision environment under conditions of risk for management development simulation purposes. This distortion of reality still captures the essential element of the decision environment, i.e., performance cannot be predicted with certainty in the short term, but it can be forecast by the group leader who knows the capabilities of his subordinates. One of the most important ideas that must be conveyed to technical, operating level personnel who are studying management is that there is a dramatic contrast between the decision environment in technical positions as opposed to managerial positions. Many technical decisions are based on equations that will convert an input to an output with complete certainty. However, few management decisions are made under similar conditions of complete certainty and are more likely to be characterized by conditions of risk and uncertainty. The important concept that must be shown is that the management decision environment includes certainty, risk and uncertainty which may be a new and dramatically different environment from that experienced by the technical person. Given the advantages of a manual, solitaire simulation, it is considered that modeling personnel capability under conditions of risk is an acceptable compromise. Having established the basis for modeling the decision environment, it is now appropriate to summarize the characteristics of the model in relation to the workload environment of the group leader.

Essential Elements

As discussed above, there are two distinct sources of workload for the group. Project work is long term in nature and workload decisions regarding it will be modeled under conditions of certainty. Support work is tasked by Short Term Engineering Tasks, is short term in nature, and workload decisions regarding these tasks will be modeled under conditions of risk.

In responding to these inputs, the group leader has resources that can be applied within the constraints established by the task. He has subordinates who vary in capability to perform certain work and he is assumed to have the option to obtain assistance from sub-contractors.

Overtime can also be used if authorized. If the group leader feels that the task cannot be completed within the established due date, he can request an extension which may or may not be granted. Furthermore, many tasks require coordination with other groups which can affect the ability of the group to complete the task within a specified due date and limited number of manhours.

Finally, there is a penalty on the group leader for not meeting due dates. While this penalty is not usually quantitatively defined in real organizations, it does exist because the managerial ability of the group leader is reflected by the achievement of objectives assigned to his group. If objectives are not achieved, the group leader's reputation suffers, particularly if delinquency lists are distributed throughout the organization's chain of command.

How these essential elements are interwoven into a simulation design is discussed in detail in the following section.

Design Considerations

Course of Play

The full course of play would include all of the essential elements discussed above and would start by drawing all of the project cards and one Short Term Engineering Task card. Project card instructions are recorded on the planning sheets, one project card for each week. The player then reviews the task card and his project workload. He establishes the completion date objectives that he wishes to achieve (which may be different from the task due date, hopefully earlier) and plans the allocation of his personnel resources to achieve the objective. If circumstances turn out differently from the player's plan (and they will through drawing new task cards and other factors), then he must decide on corrective action or replanning to meet these new conditions.

After these phases of planning and control, the player executes the administrative functions of the simulation of attempting completions, recording penalties, and finally recording all events of the day on the master sheet. These actions complete one day of work for the player, and he now proceeds to the next day until forty days are completed.

The player's primary objective is to avoid accumulating penalty points for overdue Short Term Engineering Tasks. He is constrained in this task by the number and capability of his personnel and the number of mandatory hours devoted to project work. He is given flexibility in this task through due date extension, use of sub-contractors, and overtime.

All project cards are drawn at the beginning of the game and are recorded on the planning sheet. The player is required to allocate the number of hours specified each week although he has the freedom to decide on which days work will be performed and who will do the work, within the limits identified on the card.

At the start of the simulation, all Short Term Engineering Task cards are shuffled and placed face down, in order that the player not know which tasks will be arriving on which days. At the beginning of each day a new task card is drawn simulating the arrival of a task from a customer (blank cards are included to simulate the fact that tasks do not always arrive every day). The task card has an identification number, a due date in number of days from the day currently being played, priority, coordination level, number of personnel who may simultaneously work on the task, and the number of hours required to be applied to the task before a completion attempt can be made.

The coordination level indicates how many different groups are required to provide input and is used to simulate the increased difficulty in completing a task when several different groups are involved.

The number of personnel that can work on the task is specified to simulate the nature of various types of work received by Short Term Engineering Task. Some tasks can be divided into discrete segments thus allowing more people to work on them. However, other tasks require the concentrated efforts of one person and cannot be done by several people as efficiently as by one person alone.

As a result of simulation prototype testing, which is discussed in detail in Chapter III, it was decided that a sequential approach was required to lead the player into the full course of play described above. It was found that the complete simulation, even though comparatively simple, was too comprehensive to be absorbed by the player in one initial play. Therefore, the course of play is arranged in stages which begin with the basic simulation and additional elements are gradually introduced in subsequent stages. A detailed narrative of the elements included in each stage of the simulation is included as part of the simulation guide contained in Appendix A.

Each of the essential elements is included in the narrative and the description of each element shows how the concept of the element is transformed into the simulation model.

Design Conclusions

Stage IV of GROUP WORKLOAD MANAGEMENT in Appendix A represents the simulation that has been designed to achieve the management development and design objectives established at the beginning of this chapter while considering the strengths and weaknesses of simulation referenced in Chapter I. The simulation is designed to illustrate the interrelationship between objectives and resources of a group leader (first-line supervisor) and is presented in a format that uses factors from the assumed management environment. Achievement of these management development objectives by the simulation results in a fully developed but still tentative realization of the management development opportunity described in Chapter I. The simulation must be tested to determine if the simulation does, in fact, represent a potential solution for closing the gap in the development program. Before results of the test program are discussed in the following chapter, it is appropriate to review the manner in which the simulation is designed to emphasize the strengths of simulation methods while minimizing the effects of weaknesses of simulation methods.

As pointed out in Chapter I, the primary strength of simulation is that the student can become involved in the simulation. Guides discussed in Chapter I for inducing involvement included prompt feedback to and strong influence by the player. In the simulation, the player's performance depends directly on the decisions that he makes. There are factors beyond his control, but his decisions in allocating resources can influence these factors. Feedback will be very prompt because the entire simulation, representing forty days real time, can be played in less than an hour. Feedback on decisions made for Short Term Engineering Tasks due in several simulated days may be known in a matter of minutes.

Another guide was that uncertain events and elements of risk be incorporated into the design. Uncertain events occur in the simulation through drawing of a new task card each simulated day. The player does not know the sequence of the cards in the deck which makes the new draws uncertain events. Elements of risk are introduced in completion capability of personnel, due date extensions, and farm-out procedures.

A third guide for design was that the player be able to experiment with alternative strategies. The simulation as designed permits the player to develop and then test alternative strategies. For example, the player may assign the outstanding person to Short Term Engineering Tasks exclusively and assign the marginal person to project work. He could then try the reverse strategy with the outstanding person on project work and the marginal person on Short Term Engineering Tasks. By experimenting with different strategies and comparing results of each strategy, the player has a means to help him gain an insight into the interrelationship between objectives and resources of the technical group leader.

Weaknesses pointed out in Chapter I included the problem of balancing time and complexity, the problem of unreasonable game defeating strategies, and the problem of expense in terms of time, space, and money required to play simulations.

With regard to time and complexity, the simulation as designed has sufficient complexity to introduce the major elements of workload planning, but some simplifications have been made. The simulation is primarily intended for use by technical personnel who aspire to management and too much complexity might deter some individuals from attempting the simulation. The simulation, as designed, is felt to have the proper balance of complexity and playability which results in a playing time of approximately one hour per run of the simulation.

Extensive design effort, prototype testing, and final model testing has not resulted in the development of any game defeating strategy. In fact, the strategy that usually gave best results was one of assigning the marginal person exclusively to project work and assigning outstanding and good personnel to both projects and Short Term Engineering Tasks. This strategy reduces high risk associated with the marginal person in completing Short Term Engineering Tasks. By using sub-contractors working through higher capability personnel, it was possible to have these people complete Short Term Engineering Tasks at less risk and also to simultaneously contribute to project work. This strategy has been observed in real situations in planning actual workload. Higher capability personnel are often assigned a variety of work including projects, Short Term Engineering Tasks, and monitoring of sub-contractor efforts, while less capable people are often assigned to long term projects in which there is less risk associated with their contribution to the total effort.

With regard to expense involved in playing simulations, the simulation as designed minimizes this weakness of simulation methods. The simulation presented in Appendix A can be played on the player's own time, at home, and using only a normal desk surface. Time required for the simulation can be less than one hour per run, thereby reducing the expense associated with time. The design objectives of a manual solitaire simulation were achieved, thereby eliminating the need for computers, computer personnel, and the game administrator. The final result is a simulation that is very inexpensive in terms of time, space, and money required for playing the simulation.

The next step in the systematic design development process is to test the simulation which now represents a fully developed, tentative realization of the management opportunity identified in Chapter I. The testing process used for the purpose of ascertaining if the simulation represents a potential realization of the management opportunity is described in the following chapter.

CHAPTER III

SIMULATION TESTING

Test Method

Testing of the simulation was divided into two distinct phases. The first phase consisted of play testing by various people who had been requested to play the simulation and respond to a questionnaire. The second phase consisted of playing through five runs of each stage of the simulation.

The purpose of the first phase of testing was to assess the reaction to the simulation by people at the Naval Ship Engineering Center and to establish the appropriate context of its use. In addition, the questionnaire requested information from the play testers regarding modification of design features of the simulation. The purpose of the second test phase was to develop average scores for each stage of the simulation. These averages would show the relative impact of changing workload and adding means to increase resource availability which are introduced in the various stages.

In order to receive a wide variety of feedback, the simulation and questionnaire were given to both management and operating level personnel. Management personnel included section and branch heads as well as higher level managers. Specific operating level personnel were chosen as play testers by the author's assessment of their potential to become managers, which are those people to whom the simulation is primarily directed. Feedback from management personnel, who have a degree of influence over the selection of management development methods, would indicate receptiveness to simulation as a development method as well as the context of simulation, e.g., if simulation should be used with lectures and other materials. Feedback from operating level personnel would indicate the acceptance of simulation methods as a development tool. Both groups would indicate, through questionnaire feedback, improvements or modifications to the simulation to maximize its usefulness to the individual. Thus, the questionnaire was developed to seek responses in these three areas; simulation as a development method, context of the simulation, and potential improvements and modification to the simulation.

Questionnaire

The questionnaire used to probe response to the simulation is shown in Appendix B. Six of the questions concern the individual's reaction to the simulation and the part that the simulation could play in a management development program. The remaining five questions concern design of the simulation and suggested improvements by the play testers.

Eighteen copies of the simulation and questionnaire were distributed to personnel at the Naval Ship Engineering Center. Nine of these people were in management positions (first line supervisor and higher) while the remaining nine were in operating level positions.

Prior to completing the questionnaire, informal feedback from play testers indicated that there was a threshold of understanding that had to be overcome by those not familiar with simulation methods[4]. Basically, those who had had little or no previous experience with simulation found it difficult to grasp the concept and flow of the simulation. The complete simulation is relatively simple compared to many simulations currently on the market, and the extensive play aids provided, further simplify the player's task. However, there was still the threshold of understanding that had to be overcome. While explanation of the simulation concept was sufficient for the play testers, the design objective of achieving a solitaire simulation led to use of this preliminary feedback to modify the design of the simulation to its final form as described in Chapter II and Appendix A.

This modification resulted in a design that introduces the player to simulation methods in gradual stages. The initial stages teach the player how to play simulations by starting with the most elementary concepts and gradually builds upon this base until finally, in Stage IV, one is playing the complete simulation. Thus, the player is able to overcome the threshold of understanding which was identified in the testing process.

Of the eighteen questionnaires distributed, five were completed and returned which included three from working level personnel and two from management level personnel. The five returned questionnaires represent 27.8 percent of the total distributed, and considering the magnitude of volunteer effort required to play the simulation and complete the questionnaire, this return is considered reasonable. In addition, informal feedback was obtained from three other people who had read the material and started playing the simulation. These people were not able to complete the simulation nor the questionnaire because of other commitments, but all three were generally favorable to the management development concept of the simulation.

Of the five formal questionnaire respondents, four thought that the simulation would be an effective management development tool in responding to question three. The other questionnaire response, which was from a section head, indicated that the simulation could be conditionally effective in that it might be a useful tool in some branches, but not for developing managers in his own branch. This person also stated, in response to question ten, that no formal management development should be used and that all management development should occur through on-the-job training.

In responding to question four, four people (including the one who did not advocate any formal training) thought that no other development method would be a more effective tool than the simulation. Regarding the context of the simulation in a program of management development, probed by question five, four people thought that the simulation would be a valuable addition to a program including other development methods, such as lectures. The person who advocated on-the-job development, to the exclusion of any formal development, also responded negatively to this question.

In response to the question on complexity, three respondents gave a complexity rating of seven on the scale of one to nine given in question six; one person gave a rating of four. The person who advocated only on-the-job development rated simulation complexity as "one" in relation to the real life situation in his branch with the comment that the simulation was "...relatively complex in absolute terms". All responses to question nine indicated that making the simulation more complex would not make it more effective.

Playing time for the four responses (question seven) averaged approximately three hours. However, subsequent discussion with the players indicated that responses were somewhat low in comparison to actual time spent playing the simulation. The number of times played averaged slightly less than two per respondent and ranged from one to "many" which, through subsequent discussion, was found to be approximately four plays.

Four of the respondents advocated a short program for prospective managers using a variety of development methods and, as mentioned previously, one person advocated only on-the-job development. All of the working level respondents indicated that prospective managers should have a management development program, including the simulation, and it should be recalled that working level personnel were selected for play testers based on the author's assessment of their management potential. A comment by one of the management personnel, who is a branch head, is particularly relevent and is quoted as follows: "I feel the simulation is an excellent adjunct to any management training program, and that it has great potential for expansion into a management workload planning tool".

The person quoted also indicated, in response to question twelve, that he would continue to use the management simulation by modifying it into an actual workload planning tool, not just as a development tool. The other four respondents indicated that they would not continue to use the simulation to study management of group workload. However, all of the working level personnel indicated that the simulation, which is primarily intended for use by working level personnel aspiring to management, revealed information to them about how to manage group workload more effectively. One management level respondent indicated that the simulation did not reveal any new information to him regarding how to manage group workload more effectively.

In general, the feedback obtained from volunteer play testers, both through formal questionnaire and informal discussion, indicates that the simulation is potentially useful in developing working level personnel for management and may have a "spinoff" benefit in being adapted for actual workload management. The results obtained also emphasize again that the simulation will be most effective if it is included as part of a program of development that would include other development methods such as lectures and case studies. While it is unfortunate that a larger return of questionnaires could not be obtained, it is felt that the formal and informal feedback received demonstrates that the simulation has the potential for improving management development programs. Moreover, the response indicates that a wider test of the simulation is warranted which is one of the purposes of this paper.

In addition to volunteer play testing, there was also a test phase that used a series of trial runs to develop average scores for each stage of the simulation. This topic is discussed in the following section.

Trial Runs

Trial runs of each stage were performed to establish average scores for the mix of resources and objectives represented by each stage. These average values are scores that the player could expect to achieve, however, the random events built into the simulation, such as arrival of tasks and completion capability of personnel, will result in variation of scores achieved, as is shown by the trial run results. Results of the five trial runs for each stage are shown in Appendix C.

In the initial stage, the player has three people "working" for him and his objectives include only completion of Short Term Engineering Tasks. This stage is well balanced and the player will be able to complete this stage with few penalty points. In the second stage, workload is added that is equivalent to the outstanding person working full time on project work without addition of other personnel resources. As would be expected, the penalty points incurred increases dramatically. This increase will graphically show the player the implications of adding workload without adding resources or flexibility in meeting objectives.

In the third stage, the player is allowed to use overtime and extend due dates of Short Term Engineering Tasks. As can be seen from the trial run scores for the third stage, it is possible to achieve very low scores (all results were "zero" or "one"). These low scores show that this stage is well balanced between workload and resources. Depending upon the random arrival of tasks, the player will be able to achieve comparatively low scores. After playing Stage III, the player will see the importance of extending due dates and using overtime to achieve flexibility in applying his personnel resources. In Stage II, the player does not have this flexibility and as a result his penalty score will be much greater. In real life, the technical group leader avoids incurring overdue tasks by extending due dates and by using overtime. The third stage of the simulation dramatically points out the advantages of using these means to achieve flexibility.

In the fourth stage, sub-contractor assistance is available. The addition of these outside personnel resources allows the player to score zero penalty points with relative ease. Sub-contractor assistance is useful in two ways. First, it permits sending large tasks to a sub-contractor who can apply the maximum number of people to the task and thereby complete it sooner. Secondly, it permits more tasks to be performed through the outstanding person in the group. By farming out tasks through the outstanding person, advantage can be taken of the outstanding person's greater ability to complete tasks after the required number of hours have been applied to the task. If the outstanding person must work on tasks himself, the number of tasks that he can perform is very limited. However, by farming the tasks out, he will be able to complete more tasks which reduces the player's risk involved in task completion.

As a result of the two phase test program, several conclusions can be added to the general conclusions regarding the design and development of the simulation described in Chapter II. These conclusions are discussed in Chapter IV.

CHAPTER IV

CONCLUSION

Simulation Design

There are a number of conclusions that may be drawn from the design, development, and testing of the simulation contained in Appendix A. The most important is that the simulation has the potential to be used in realizing the management opportunity described in Chapter 1.

The simulation, as designed, could be used in improving the management development program in engineering organizations similar to the organization postulated in Chapter 1. The simulation would fill the gap in the lack of development materials during the formal development phase relating concepts of management to the environment of specific engineering organizations, particularly at the first line supervisor position. The simulation casts the player into the role of the first line supervisor, and by playing the simulation, he must make planning decisions in the allocation of group workload under conditions of risk, uncertainty, and certainty.

A second potential application of the simulation is in the orientation phase of the management development program. By playing the simulation, potential managers would be given a simulated introduction to one aspect of the technical group leader's management responsibilities.

Although the simulation has the potential to be utilized in closing the gaps identified in a management development program, it must be recognized that a balanced program including a variety of teaching methods is necessary to achieve management development objectives. Simulation can be an effective method, but it must be balanced by lecture and text materials, case studies, and other teaching methods. Thus, this simulation is envisioned as but one part of a complete and balanced management development program consisting of other courses on general subjects and those specific courses that are available in existing programs.

With regard to the design of the simulation itself, several conclusions may be drawn. The simulation has been designed to involve the player in making decisions in the simulated environment that abstracts a true life environment. Involvement is one of the principal advantages of simulation methods. Through the design objectives of manual and solitaire play, which were achieved in the simulation, the player must become involved in the simulation in order to complete the sequence of steps outlined in the simulation guide. A second advantage of simulations, in general, is that simulations permit the player to experiment with alternative strategies. This flexibility is built into the simulation design by allowing the player free choice in the assignment of workload which he may vary to test alternative assignment strategies. Moreover, the individual stage test results of the simulation show the impact of adding flexibility in strategies by the addition of overtime, task extension, and use of sub-contractors.

One of the primary disadvantages of simulation is the expense in terms of employee time lost during play and the expense of development and administration of the simulation. The simulation presented in this paper minimizes these negative factors through the manual and solitaire design features which have been incorporated into the design. Manual play, as opposed to computer assisted play, eliminates costly computer time as well as administration of the player-computer interface. The solitaire design eliminates the need for a game administrator, thereby reducing costs, but more importantly permitting the player to study the simulation during leisure hours away from his place of employment. The simulation can be used by those persons interested in studying management without interfering with their job responsibilities.

The simulation presented here emphasizes the strength of simulation methods while minimizing the effects of weaknesses of simulation. In addition, it has been tested by people who represent potential users and has been favorably received by them. In view of the foregoing, it is considered that the simulation included in Appendix A has the potential to be used in realizing the management opportunity of improving management development programs.

Implementation

It must be remembered that the simulation presented in Appendix A is based on an assumed, hypothetical organization which may or may not be a true representation of the individual user's organization. Thus, the user may wish to adapt the simulation to his particular organization before implementing its use as a management development tool within that organization. In view of the potential need for this adaptability requirement, the simulation model has been designed with variable parameters that can be modified to suit the environment of specific organizations.

These variable parameters include primary variables which are number and quality of personnel in the technical group and workload characteristics such as typical due dates, manhours per task, coordination level, number of people per task, and rate of arrival of tasks. Secondary variables are overtime policy; farm-out process, if permitted at all; and due date extension process, if permitted. The most dramatic alterations can be achieved by modifying primary variables while modifying secondary variables will have less overall impact on the structure and playability of the simulation.

When one is seeking to modify the simulation to suit his own organization he should first establish the number and type of personnel available in the group within the organization that is to be modeled. These personnel factors then become the basis for the simulation scenario. For example, if it is desired to model a technical group of five good performers because that is typical of the organization, then those factors should be established in the scenario.

The next step is to establish typical workload parameters and then change the Short Term Engineering Task (STET) cards to suit this typical workload. For example, if the type of work simulated by STET cards was found to arrive at the rate of three per day and all tasks had a coordination level of zero because of the type of work performed in the organization, then the scenario would be changed to require three STET card draws per day and all STET cards would be changed to reflect zero coordination level. The other parameters (number of people per task, due date, effort required per task) could be similarly modified. The key to this step is to perform a realistic management survey of the characteristics of the work performed in the group and then modify the simulation model to suit.

The final step in developing the simulation model is to establish the secondary parameters that reflect organizational policies regarding the use of overtime, sub-contractors, and extension of due dates. Once the new model has been developed, there is one last step that must be taken before general use of the simulation.

This step is testing the model. Testing the model may be done by the person who developed the new model or by other people in management positions in the organization. The purpose of this test is to ensure that combined effects of variation of the parameters do not distort the results one obtains when playing the simulation. If reasonable results are obtained during the test phase, the revised simulation is then ready for general use in the specific organization.

Author's Closure

The simulation GROUP WORKLOAD MANAGEMENT, in the Appendix immediately following this section, is based on a hypothetical organization and has been developed to establish a basic design concept for simulating workload management of a technical group. Testing has been performed as discussed in Chapter III.

One of the primary objectives of this paper is to obtain broader exposure of the design concept in the hopes that the reader will be encouraged to play the simulation and then complete the questionnaire contained in Appendix B. The results of this valuable feedback from potential users can then be utilized in further development of the simulation model used in GROUP WORKLOAD MANAGEMENT.

GROUP WORKLOAD MANAGEMENT
SIMULATION GUIDE

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APPENDIX A

TABLE OF CONTENTS

INTRODUCTION

The purpose of this simulation (GROUP WORKLOAD MANAGEMENT) is to expose students of management to the issues involved in managing the workload of a technical group of an engineering organization. GROUP WORKLOAD MANAGEMENT emphasizes planning and control functions, not necessarily because these are considered to be more important than other functions, such as organizing or leading, but because planning and control can be handled well by simulation methods while other functions are considered to be more readily studied by other means. Thus, GROUP WORKLOAD MANAGEMENT is envisioned as part of a total management development program that could be used in a complementary way with other methods in the program to achieve a management development objective.

When one is playing GROUP WORKLOAD MANAGEMENT, he is taking the position of a technical group leader (first-line supervisor) and he seeks to assign work to his subordinates in such a way as to maximize the performance of the group. The emphasis is placed on management of Short Term Engineering Tasks (STET) because the technical group leader has more direct management responsibility for STETs than for other types of work such as major projects which are often planned, organized, directed, and controlled from many higher levels in the postulated organization. While group input into these processes is important, the technical group leader has more of a total and independent responsibility in managing workload of STETs.

It will be noticed when playing GROUP WORKLOAD MANAGEMENT that some elements have been simplified over the environment that exists in real life. This simplification has been done in such a way to achieve a balance between duplicating reality in its total complexity and achieving a simulation that captures the essential elements of reality for training purposes while being comprehensible to the person using it. If a simulation is too complex, it is not as effective for training purposes as a more abstract version that captures the essence of reality. It should be remembered that the simulation is envisioned as part of a program of management development.

At first glance, it may appear that GROUP WORKLOAD MANAGEMENT is more complex than it will be in actual play. There are play aids that appear to add complexity, but these aids present the simulation in an orderly format that can be placed in front of the player. Through use of these aids, the player will not be required to memorize any rules or other data.

GROUP WORKLOAD MANAGEMENT is designed for the player to study it without assistance from other sources. The player, in performing the role of a technical group leader as it relates to managing workload, is faced with decisions to be made under conditions of certainty, risk, and uncertainty just as he would be faced with decisions under these conditions in a real life situation. Elements of the workload management task, such as project and STET work, use of overtime and sub-contractors, extension of due dates, and personnel capability are included in the simulation.

The basic scenario is structured to provide an interesting and challenging task to the player and is a synthesis of various conditions that exist in group workload. The model used in the simulation is very flexible and could be modified by the player to place more or less emphasis on STET work and to change the number and capability of personnel if he so desires.

Actual play of GROUP WORKLOAD MANAGEMENT (GWM) follows a sequence of steps in planning, control, and administration which is outlined on the MASTER SEQUENCE. This chart provides the player with all of the steps required to execute the simulation and refers to subsequences that may be required during the course of play. Sample planning sheets are included from a trial run of GWM and illustrate a convenient notation that may assist the player.

GROUP WORKLOAD MANAGEMENT is presented in stages to gradually introduce the player to simulation methods. The complete simulation is not complex, but could overwhelm the player not familiar with simulations if he attempts the complete GWM on the initial play. By gradually adding additional factors at each stage, the player will be able to learn how to play GWM without becoming overwhelmed. The player should begin with Stage I and progress through the stages one at a time to Stage IV. The appropriate playing aids and guide text are provided at each stage. In addition to the new items introduced at each stage, all of the materials from the previous stages are required for subsequent stages, except for the MASTER SEQUENCE which is replaced as noted.

STAGE I

Preliminary Preparations

1. Clear an area about the size of a desk top or a card table.

2. Obtain two dice.

3. Make 16 copies of sample planning sheet.

4. Cut out and shuffle the STET cards. Place stack face down.

5. Place the MASTER SEQUENCE STAGE I close at hand and other charts within convenient reach.

6. Turn over the top STET card to begin play for first day.

Scenario

1. Group personnel consists of one outstanding, one good, and one marginal.

2. Play lasts for 40 simulated days although the player may abbreviate this period if he feels that he has grasped the basic concept.

Guide Comments

Personnel Capability

Different people have different capabilities which are simulated by the ability to complete a STET task.

The ability to complete a task in finished form is one of the distinctions among personnel capabilities and these distinctions are shown on the COMPLETION CAPABILITY CHART. In general, all people in the group can put in time required to bring a task near completion, but the higher capability person can finish it more reliably than the lesser capable. This design feature is not to imply a demeaning viewpoint of the less capable, for this condition may be found in a person of high potential who may be new to a job and lacks experience or has not yet been trained to perform the job as others may have been. This simulation takes an eight week slice of the total job of the technical group leader to illustrate planning and control functions in workload management, and personnel capability is assumed to be constant for those eight weeks. The longer term situation of the technical group leader in real life involves identifying those marginal performers and raising their capabilities through training, experience, or other means. Methods for achieving these goals are not within the scope of this simulation and would be addressed in other parts of the management development program of which this simulation would be but one part.

Completion of STETs

Each STET has a specified number of hours to be performed on that task before completion can be attempted. There is an element of risk involved in finally completing a task even when sufficient time has been put in to bring it to completion. Editorial changes may be required, an important factor may have been overlooked, modification and review may be required, among other delays.

Higher capability people are more likely to submit an acceptable product than are the less capable. This effect is simulated through the generation of random numbers to indicate completion of a STET after the required number of hours has been applied to the task. If the random number falls within the range specified on the COMPLETION CAPABILITY CHART, the STET is completed. If the number is not within the range, the STET is not completed and additional work is required. The amount of additional work is determined by generating a random number which gives the number of additional hours required and simulates the range of additional work from minor editorial changes to revision of concept. Random numbers are generated by the simple method of rolling a pair of dice.

A COMPLETION SUBSEQUENCE is included in the play aids which gives the player a step-by-step guide for completing STETs.

It should be recognized that several attempts may be required to complete a task with additional hours added each time. While the probability of incompletions is increasingly smaller for larger numbers of attempts, it does effectively simulate the potential for the occasional "snafu" that inevitably occurs in real life when a task, like the plague, seems impossible to eliminate.

Coordination Level

It can be seen on the COMPLETION CAPABILITY CHART that the ability to complete a task is reduced by the coordination level of the STET. This effect is provided in the design to simulate the increased difficulty of completing a task when more than one activity must provide input and review the final reply. As more groups become involved, delay and difficulty is inevitably increased over that experienced when one group is solely responsible for the final reply.

Overdue Penalties

Penalty points are arbitrarily established as a reference point for the player to assess his performance over several runs of the simulation and are set at one point per day overdue for routine STETs and three points per day overdue for urgent STETs. The primary objective is to achieve a score of zero.

MASTER SEQUENCE STAGE I

1. Draw STET card (if due date exceeds end of simulation discard it and draw again until one is drawn that is within the time remaining).

2. Plan STET workload on planning sheets.

3. Control phase, note deviations from plan.

   a. Change objectives; replan--shift personnel.

   b. Keep objectives; corrective action--shift personnel.

4. Administrative Phase

   a. Attempt completion. **(COMPLETION SUBSEQUENCE).

   b. Record overdue penalty.

      1 point per day - Routine STET.

      3 points per day - Urgent STET.

   c. Record events of the day on master sheets.

   d. Move to next day until 40 days are complete. (Return to step 1).

** Indicates subsequences and/or charts are available to assist in performing these steps.

COMPLETION SUBSEQUENCE

1. Hours performed on task are equal to the hours required on the STET card.

2. Locate the appropriate column on the COMPLETION CAPABILITY CHART for:

a. Personnel capability (of least capable person working on the task if more than one worked on it) considering the effects of overtime of previous week (see GUIDE, Stage III; overtime not permitted Stages I and II).

b. Coordination level specified on STET card.

3. Roll two dice and index the number thrown with the appropriate column, then read the result indicated.

4. a. If result is completion, proceed to step 5.

b. If result is not a completion, proceed to step 4c.

c. Roll two dice, the number thrown is the number of hours of additional work that must performed before completion may again be attempted.

d. Note additional hours on planning sheet.

5. If have attempted completion for all eligible tasks, proceed to next step of MASTER SEQUENCE.

COMPLETION CAPABILITY CHART

Number Thrown	Personnel Capability/Coordination Level								
	0/0	0/1	0/2	G/0	G/1	G/2	M/0	M/1	M/2
2	C	C	C	C	C	C	C	C	C
3	C	C	C	C	C	C	C	C	C
4	C	C	C	C	C	C	C	C	C
5	C	C	C	C	C	C	C	C	C
6	C	C	C	C	C	C	C	C	-
7	C	C	C	C	C	C	C	-	-
8	C	C	C	C	C	-	-	-	-
9	C	C	-	C	-	-	-	-	-
10	C	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-

NOTES:

C = STET is completed
- = STET is not completed

STET No. 1 Due +15 Routine Coordination Level 0 One person only 16 hours	STET No. 2 Due +5 Urgent Coordination Level 1 One person only 24 hours	STET No. 3 Due +20 Routine Coordination Level 1 One person only 32 hours
STET No. 4 Due +3 Urgent Coordination Level 0 One person only 16 hours	STET No. 5 Due +10 Routine Coordination Level 1 One person only 24 hours	STET No. 6 Due +8 Routine Coordination Level 0 One person only 8 hours
STET No. 7 Due +9 Routine Coordination Level 2 One person only 8 hours	STET No. 8 Due +15 Routine Coordination Level 2 One person only 40 hours	STET No. 9 Due +20 Routine Coordination Level 2 Two people only 64 hours
STET No. 10 Due +10 Routine Coordination Level 2 One person only 40 hours	STET No. 11 Due +20 Routine Coordination Level 2 One person only 24 hours	STET No. 12 Due +10 Routine Coordination Level 1 One person only 24 hours

STET No. 13 Due +10 Routine Coordination Level 2 Two people maximum 40 hours	STET No. 14 Due +15 Routine Coordination Level 1 One person only 32 hours	STET No. 15 Due +5 Urgent Coordination Level 2 One person only 40 hours
STET No. 16 Due +10 Routine Coordination Level 2 One person only 32 hours	STET No. 17 Due +5 Urgent Coordination Level 2 Two people maximum 40 hours	STET No. 18 Due +3 Urgent Coordination Level 0 One person only 16 hours
STET No. 19 Due +4 Urgent Coordination Level 1 One person only 24 hours	STET No. 20 Due +10 Routine Coordination Level 1 One person only 32 hours	STET No. 21 Due +15 Routine Coordination Level 1 One person only 48 hours
STET No. 22 Due +12 Routine Coordination Level 2 One person only 24 hours	STET No. 23 Due +5 Routine Coordination Level 0 One person only 8 hours	STET No. 24 Due +6 Routine Coordination Level 0 One person only 16 hours

STET No. 25 Due +15 Routine Coordination Level 2 Three people maximum 64 hours	STET No. 26 Due +20 Routine Coordination Level 2 Four people maximum 80 hours	STET No. 27 Due +20 Routine Coordination Level 2 Four people maximum 120 hours
STET No. 28 Due +15 Routine Coordination Level 0 One person only 24 hours	STET No. 29 Due +15 Routine Coordination Level 2 Two people maximum 64 hours	STET No. 30 Due +10 Routine Coordination Level 0 One person only 24 hours
STET No. 31 Due +5 Routine Coordination Level 0 One person only 16 hours	STET No. 32 Due +8 Routine Coordination Level 1 One person only 32 hours	STET Blank
STET Blank	STET Blank	STET Blank

STET Blank	STET Blank	STET Blank
STET Blank	Project 40 hours (16 hrs 0 or G 24 hrs any type)	Project 40 hours (8 hrs 0 or G 32 hrs any type)
Project 40 hours (8 hrs 0 or G) 32 hrs any type)	Project 40 hours (any type)	Project 40 hours (any type)
Project 40 hours (any type)	Project 40 hours (any type)	Project 40 hours (any type)

Retain project cards for Stage II

	Mon.					Tues.					Wed.					Thurs.					Fri.					Sat.				
	A	B	C	D	T	A	B	C	D	T	A	B	C	D	T	A	B	C	D	T	A	B	C	D	T	A	B	C	D	T
Week __																														
Project																														
STET																														
Week __																														
Project																														

STAGE II

Preliminary Preparations

1. Assemble all materials from Stage I.

2. Replace MASTER SEQUENCE STAGE I with MASTER SEQUENCE STAGE II.

3. Make 16 copies of sample planning sheet.

4. Cut out and shuffle project cards. Place in stack, face down.

5. Turn up first project card and record on first week planning sheet. Repeat until all project cards are recorded.

6. Shuffle STET cards, place face down.

7. Turn over the top STET card to begin play for first day.

Scenario

1. Group personnel consists of one outstanding, one good, and one marginal.

2. Play lasts for 40 simulated days although the player may abbreviate this period if he feels that he has grasped the basic concept.

Guide Comments

Project Work

The hours specified on the project cards are the number of hours of actual work that must be contributed to the project during that week. In view of the differences in capabilities among personnel, hours worked will not always be the same as actual work contributed to the project. For example, if a marginal person works on a project for eight hours, his contribution in actual work to the project is only four hours. It is the total of actual hours that must meet the weekly total required. The PROJECT WORK CHART is provided to convert hours worked to actual hours contributed.

MASTER SEQUENCE STAGE II

1. Draw STET card (if due date exceeds end of simulation discard it and draw again until one is drawn that is within the time remaining).

2. Plan workload on planning sheets.

   a. Project. **(PROJECT WORK CHART).

   b. STET.

3. Control phase, note deviations from plan.

   a. Change objectives; replan--shift personnel.

   b. Keep objectives; corrective action--shift personnel.

4. Administrative Phase.

   a. Attempt completion. **(COMPLETION SUBSEQUENCE).

   b. Record overdue penalty.

      1 point per day - Routine STET.

      3 points per day - Urgent STET.

   c. Record events of the day on Master Sheet.

   d. Move to next day until 40 days are complete. (Return to step 1).

** Indicates subsequences and/or charts are available to assist in performing these steps.

PROJECT WORK CHART

Personnel Capability	Hours Worked										
	1	2	3	4	5	6	7	8	9	10	11
Outstanding	1	2	3	4	5	6	7	8	8-1/2	9	9-1/2
Good	1	2	3	4	4-1/2	5	5-1/2	6	6-1/2	7	7-1/2
Marginal	1/2	1	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2	5	5-1/2

Number in box is the number of hours contributed to the project for the amount of hours worked.

STAGE III

Preliminary Preparations

1. Assemble all materials from Stages I and II.
2. Substitute MASTER SEQUENCE STAGE III for previous ones.
3. Make 16 copies of sample planning sheet.
4. Record project work as in Stage II.
5. Prepare STET cards as in Stages I and II.

Scenario

1. Group personnel consists of one outstanding, one good, and one marginal.

2. Play lasts for 40 simulated days although the player may abbreviate this period if he feels that he has grasped the basic concept.

Guide Comments

Overtime

Overtime is provided to give the player flexibility in meeting commitments. While overtime can be used, there is a diminishing return to its effectiveness. Too much overtime can reduce a person's effectiveness in performing his work and continual resort to overtime may well lead to a reduction of a person's performance per unit time in order for him to stay on the job for extended periods.

Overtime may be used, but the effects of the diminishing return are simulated as found on the PROJECT WORK CHART and also by lowering the completion capability of personnel under certain conditions.

If a person works more than ten hours of overtime in one week or any hours on Saturday, his completion capability for the following week is reduced to the next lower capability for both STET work and for project work. Total time worked per day may not exceed eleven hours (three hours overtime, eight hours regular). An outstanding person would be rated good for the following week, good would be rated marginal, and marginal would have his range of completion lowered by one number in STET work, e.g., a marginal person working on a task with a coordination level of 2 would require a dice roll of 2 through 4 instead of the normal 2 through 5 to complete the task. Successive weeks of more than ten hours overtime per week does not lower capability below the original reduction. Assuming a constant ten hour per week overtime threshhold is a necessary simplification to enhance playability. As is well known, people have different capacities for overtime work. Some may function at normal capacity on a 60 hour week while others may suffer degradation on only a 45 hour week. Assuming the ten hour overtime threshhold is considered an acceptable compromise between complexity and playability.

Extension of Due Dates

Flexibility in meeting the basic of objective of avoiding overdue STETs is also achieved by negotiation of due date extensions with the customer. The greater the urgency of a task, the greater will be the difficulty in obtaining an extension. Also, the greater the length of extension, the greater will be the difficulty in negotiation. If the technical group leader is unsuccessful in negotiating a date that he can meet, he may appeal to the customer representative (CR) who will advise the technical group leader if his extension request will be granted or if he must meet the original due date.

The sequence of steps that the player follows to simulate this procedure is shown on the EXTENSION SEQUENCE and the negotiation phase is simulated on the EXTENSION REQUEST CHART. While the EXTENSION REQUEST CHART does not give the essential flavor of negotiation, it represents a necessary compromise to achieve a simulation that can be used in solitaire play. More than one person is required to learn and practice negotiation while this simulation is designed to provide a person with a vehicle that may be used in individual study to expand his knowledge of the processess involved in managing group workload. Thus, it is felt that this simplification is justified to achieve the design objectives of this simulation.

MASTER SEQUENCE STAGE III

1. Draw STET card (if due date exceeds end of simulation discard it and draw again until one is drawn that is within the time remaining).

2. Plan workload on planning sheets.

   a. Project. **(PROJECT WORK CHART).

   b. STET.

      (1) Inhouse.
      (2) Overtime (3 hours per day, each persom maximum).

3. Control phase, note deviations from plan.

   a. Change objectives; replan--

      (1) Secure extension. **(EXTENSION SUBSEQUENCE).
      (2) Overtime (3 hours per day, each person maximum).
      (3) Shift personnel.

   b. Keep objectives; corrective action--

      (1) Overtime (3 hours per day, each person maximum).
      (2) Shift personnel.

4. Administrative Phase.

   a. Attempt completion. **(COMPLETION SUBSEQUENCE).

   b. Record overdue penalty.

      1 point per day - Routine STET.

      3 points per day - Urgent STET.

   c. Record events of the day on Master Sheet.

   d. Move to next day until 40 days are complete. (Return to step 1).

** Indicates subsequences and/or charts are available to assist in performing these steps.

EXTENSION SUBSEQUENCE

1. Initial planning or replanning indicates that an extension in due date is desirable.

2. Task to be extended was received today (no extensions permitted unless requested on the day that the STET to be extended was received).

3. Locate task priority as specified on STET card in column for desired number of days of extension (5, 10, 15, or 20) on the EXTENSION REQUEST CHART.

4. Roll two dice and cross index the number thrown with the appropriate column.

5. a. If extension is granted, modify due date on planning sheet, proceed to step 6.

   b. If extension is not granted, appeal to the Customer Representative (CR), proceed to step 5c.

   c. Roll two dice and cross-index the number thrown with CR column on EXTENSION REQUEST CHART.

   d. If extension is granted, modify due date on planning sheet. If extension is not granted, the original due date is not changed.

6. If all extensions have been requested, proceed to next step of MASTER SEQUENCE.

EXTENSION REQUEST CHART

NUMBER ROLLED	TIME REQUESTED (DAYS) 5		10		15		20		
	PRIORITY								
	R	U	R	U	R	U	R	U	CR
2	G	G	G	G	G	G	G	-	G
3	G	G	G	G	G	G	G	-	G
4	G	G	G	G	G	G	G	-	G
5	G	G	G	G	G	G	G	-	G
6	G	G	G	G	G	G	G	-	-
7	G	G	G	G	G	-	-	-	-
8	G	G	G	-	-	-	-	-	-
9	G	G	G	-	-	-	-	-	-
10	G	-	-	-	-	-	-	-	-
11	G	-	-	-	-	-	-	-	-
12	G	-	-	-	-	-	-	-	-

NOTES:

G = Extension is granted.
- = Extension is not granted.

STAGE IV

Preliminary Preparations

1. Assemble all materials from Stages I, II, and III.

2. Substitute MASTER SEQUENCE STAGE IV for previous ones.

3. Make 16 copies of the sample planning sheet.

4. Record project work as in Stages II and III.

5. Prepare STET cards as in Stages I, II, and III.

Scenario

1. Group personnel consists of one outstanding, one good and one marginal.

2. Play lasts 40 simulated days.

Guide Comments

Sub-Contractors

Another factor which gives the technical group leader flexibility in meeting commitments is the use of sub-contractors. Tasks can be sent to sub-contractors thus tapping a valuable manpower resource, but it must be recognized that additional complication can result from the coordination required, obtaining necessary data for the sub-contractor, and reformulating the sub-contractor's response into a format that can be provided to the customer. The farm-out procedure is outlined, step-by-step, on the FARM-OUT SUBSEQUENCE. The procedure may be somewhat complex, as it can be in real life, but the complexity should not deter the player from using this valuable source of manpower when conditions require it.

In order to farm-out a task, the player assigns one of the group personnel to monitor the task and prepare the documentation required to send the task to the sub-contractor. A period of time intervenes, simulating the time required for in-house approval of the farm-out documentation and receipt of the task by the sub-contractor. The player then rolls the dice to obtain a number which indicates the number of hours that the assigned person must spend before the contractor may start work and simulates the need for the person in the group to provide technical information or guidance before the sub-contractor can proceed. The sub-contractor then works on the task until the number of hours specified on the STET card has been performed by the sub-contractor. The player rolls the dice to obtain another number to simulate the time required to convert the sub-contractor's output into a format that can be provided to the customer. After these hours have been performed, the task is eligible for a completion attempt as described on the COMPLETION SUBSEQUENCE where further delay may be incurred.

The rolling of dice to generate numbers for the amount of work required is used to simulate the variable and uncertain nature of initial effort required to start the sub-contractor and final effort required to convert sub-contractor output into a reply. This effort can range from a simple amplification of the task statement to a large effort to gather information such as drawings, specifications and other technical data before the sub-contractor can effectively perform the assigned task. Similarly, converting the sub-contractor's output can range from simple review and editorial modifications to such things as clarification of assumptions, identification of constraints on the solution presented, and other similar time consuming issues. Which of these considerations will occur for any given task are not generally known in advance and rolling dice to generate numbers simulates the risk and uncertainty involved.

After the time has been spent bringing the task near completion, there is still the internal review before the task is finally completed as with all STETs. Therefore, the STET goes through the normal completion process as required for those STETs performed completely in-house.

MASTER SEQUENCE STAGE IV

1. Draw STET card (if due date exceeds end of simulation discard it and draw again until one is drawn that is within the time remaining).

2. Plan workload on planning sheets.

   a. Project. **(PROJECT WORK CHART).

   b. STET.

      (1) Inhouse.
      (2) Overtime (3 hours per day, each person maximum).
      (3) Farm-out. **(FARM-OUT SUBSEQUENCE).

3. Control phase, note deviations from plan.

   a. Change objectives; replan--

      (1) Secure extension. **(EXTENSION SUBSEQUENCE).
      (2) Farm-out. **(FARM-OUT SUBSEQUENCE).
      (3) Overtime (3 hours per day, each person maximum).
      (4) Shift personnel.

   b. Keep objectives; corrective action--

      (1) Overtime (3 hours per day, each person maximum).
      (2) Farm-out. **(FARM-OUT SUBSEQUENCE).
      (3) Shift personnel.

4. Administrative Phase

   a. Attempt completions. **(COMPLETION SUBSEQUENCE).

   b. Record overdue penalty.

      1 point per day - Routine STET.

      3 points per day - Urgent STET.

   c. Record events of the day on Master Sheet.

   d. Move to next day until 40 days are complete. (Return to step 1).

** Indicates subsequences and/or charts are available to assist in performing these steps.

FARM-OUT SUBSEQUENCE

1. Assign task to one of group personnel.

2. Person spends 2 hours (planned in normal way) preparing farm-out documentation.

3. Two days elapse (task in transit to sub-contractor).

4. Roll two dice, this number is the number of hours that must be spent by the person assigned to the task before the sub-contractor can start work (these hours are planned in the normal way).

5. Sub-contractor starts work on the day following completion of the hours in step 4 above. The sub-contractor works at the rate of 8 hours per day per man allowed on the STET card until sub-contractor hours equal the number of hours specified on the STET card.

6. On the day that the sub-contractor completes his work, roll two dice; this number is the number of hours that must be spent by the person assigned to the task before completion may be attempted (these hours are planned in the normal way).

7. After these hours have been completed, the task completion may be attempted as for any STET according to the COMPLETION SUBSEQUENCE.

EXAMPLE OF PLAY

A stage IV simulation is picked up on Monday of the third week for this example. STET #26, #1, #17, and #27 are carried over from the previous week and STET #22 is drawn from the stack. The player decides to put "A", "B", and "C" on the project to complete the hours required. Hours worked and hours contributed per day (with running totals of hours contributed) are planned as shown for Monday through Friday (see PROJECT WORK CHART). "A" needs 2 more hours against #17 (which is due today) to attempt a completion, and the player plans these two hours. Although #26 has been in hand since last week nothing has been done on it to date, and it is decided to farm it out through "A". "A" puts in the 2 hours required to send it to the sub-contractor where it will arrive on Thursday (when a number of additional hours must be determined for "A"; see FARM-OUT SUBSEQUENCE). "A" also has #1 which he previously worked on for 8 hours and it is planned that the remainder of the 8 hour day will be applied to #1 bringing the running total to 12 hours on #1. It is further planned that 4 hours will be spent on Tuesday to put "A" in position to attempt a completion which is indicated on the sheet as shown.

STET #27 has been previously farmed out through "B" and the sub-contractor has four people (as allowed on STET card #27) working full time through Thursday when #27 will come back to "B". This planning is indicated through Thursday. In that "B" has no other work, the newly drawn #22 is assigned to him and 8 hours on this task are planned each day through Wednesday when "B" will attempt a completion.

At the end of the planning phase on Monday, the planning sheet will appear as shown on the example sheet. After reviewing plans and confirming that he desires to implement the plan shown, the player proceeds through the master sequence and attempts a completion for STET #17. The player locates the outstanding capability of "A" with coordination level of 2 for STET #17 in the appropriate column of the COMPLETION CAPABILITY CHART. He then throws two dice obtaining a number "6". Cross-indexing "6" with the column he finds that the STET is completed, and the small "c" on the planning sheet is circled to indicate this occurrence. If a 9, 10, 11 or 12 had been thrown, the task would not have been completed, and the dice would have been thrown again (suppose the new number was a 4, this throw would require that "A" spend 4 more hours on #17 before another completion attempt could be made, and in view of the fact that urgent STET #17 is due today, it would go overdue at a cost of 3 penalty points per day overdue until finally completed).

The player now records the plan as implemented for Monday on the master sheet (the master sheet is the same as the planning sheet but records only final decisions day-by-day and is not used to plan in advance as was done in this example on the planning sheet).

The player proceeds to Tuesday, draws a STET card, and plans, replans, or takes corrective action as necessary to meet the current circumstances.

	Mon.					Tues.					Wed.					Thurs.					Fri.					Sat.				
	A O	B G	C M	D	T	A O	B G	C M	D	T	A O	B G	C M	D	T	A O	B G	C M	D	T	A O	B G	C M	D	T	A O	B G	C M	D	T
Week 3																														
Project 40, (8,0 G, 32 any			8/ 4		4			8/ 4		4/ 8	8/ 8		8/ 4		12/ 20	6/ 6	8/ 6	8/ 4		16/ 36			8/ 4		4/ 40					
STEI 17	2/ 40c																													
1	4/ 12					4/ 16c																								
26	2 FO															FO Roll														
27		FO 32/ 32					FO 32/ 64					FO 32/ 96					FO 24/ 120		Roll											
22		8/ 8					8/ 16					8/ 24c																		

APPENDIX B

QUESTIONNAIRE

1. Name and organization (optional)

2. Level in the organization (check one)

___ Higher level manager
___ Second level manager (supervisor of first level managers)
___ First level manager (supervisor of working level)
___ Working level

3. Do you think that this simulation would be an effective tool in developing working level personnel for management of the workload of a technical group?

___ Yes ___ No

4. Do you think that other training methods such as lectures, case studies, role playing, etc. would convey workload management concepts more effectively than this simulation? If so, what other methods would you suggest (use back of sheet).

___ Yes ___ No

5. Do you think that this simulation would be a valuable tool for management development if included in a program including this simulation with lectures and other methods?

___ Yes ___ No

6. How would you rate this simulation as to complexity? (1 = too simple, 5 = about right, 9 = too complex, other numbers can be used to express an opinion between these).

___ 1 ___ 2 ___ 3 ___ 4 ___ 5 ___ 6 ___ 7 ___ 8 ___ 9

7. How much time did it take you to play this simulation?

___ Hour(s)

8. How many times did you play the simulation?

___

9. Do you think the simulation would be better if it were more complex and took more factors into consideration at a greater level of detail?

___ Yes ___ No

10. Would you advocate having prospective managers take a short development program including lectures, this simulation, case studies, etc., or would you advocate on-thejob training without a prior short program?

___ Advocate short program prior to on-the-job training
___ Advocate onthe-job training only

11. How would you modify the simulation to be more effective for your own use and for use in a management development program? (See back of sheet).

12. Will you continue to use this stimulation to study management of group workload?

___ Yes ___ No

13. Did this simulation reveal anything to you about how to more effectively manage group workload?

___ Yes ___ No

14. If you have any additional comments, feel free to include them on the back of these sheets or attach additional sheets.

Please return to: J. P. Hope
Naval Ship Engineering Center
SEC 6131
NC #3 3S12
Washington, D.C. 20362

Thank you.

APPENDIX C

TRIAL RUN SCORES

Play	Stage I	Stage II	Stage III	Stage IV
1	1	125	1	0
2	8	82	0	0
3	5	79	0	0
4	3	59	1	0
5	15	103	0	0
Mean	6.4	89.6	0.4	0

APPENDIX D

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