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OPERATIONS RESEARCH SOCIETY OF SOUTH AFRICA
OPERASIONELE NAVORSINGSVERENIGING VAN SUID-AFRIKA

P.O. Box: / Posbus: 3982,

JOHANNESBURG.

BULLETIN

Applications for membership are coming in steadily. However, there are still a large number of persons who have not submitted their forms and these people are requested to send the completed forms to the Secretary as soon as possible.

New application forms will be available at the May chapter meetings for those who have not received or have mislaid the old forms.

The Pretoria Chapter will circulate a notice of their May meeting shortly. Unfortunately it was not available for this Bulletin. If you have any articles you wish to publish, please submit them to the Editor at the above address. A paper by Mr. R. Hills on a "New Approval to Simulation" is included in this Bulletin.

Is Simulation the last Resort?
What is Simulation?
In what cases should it be used?
What is your experience with it?
What are its strengths & shortcomings?
in the light of this experience

Bring cassette

48-4726

John Miller: MITAC re report back August 19 & let Mike know.

NEWS FROM THE JOHANNESBURG CHAPTER

LAST MEETING

Mr. Trevor Winer delivered a fascinating talk on the subject of an incentive scheme for Rave's salesmen. Most OR effort seems to concentrate on optimizing the performance of physical systems - e.g. production, distribution, etc. But here, for a refreshing change, was a study of human reaction to changes in the parameters of a model controlling the incentives of salesmen. This glimpse into the performance of a model based more on behavioural science than on the physical sciences was made all the more enjoyable by Mr. Winer's liberal sprinkling of comments on human motivation, as well as some interesting observations about the operation of Rave Stores - one of the most amazing stories of present day South African business.

It was a pity that, probably due to the inclement weather, the attendance at the last meeting was rather lower than usual. Mr. Winer's talk was very well done and certainly of interest to anyone working in Operations Research.

NEXT MEETING

Date	:	Wednesday, 20th May, 1970
Venue	:	University of the Witwatersrand, Geology Building, Room G 201
Time	:	8.00 p.m.
Speaker	:	Mr. C.F. Fiore
Topic	:	Transportation Models

The problems of optimizing transportation within a firm are legion, and will be of interest to any organisation which has to move supplies or products from place to place. Also, this is an area with which most practicing OR analysts have had at least some contact. This meeting should therefore generate a considerable amount of interest.

Mr. Fiore, who for the past 10 years has been the Chief Industrial Engineer for Anglo-Alpha Cement, has extensive experience in the field of transportation models. He will discuss the basic process of modelling transportation problems, the use of these models as marketing tools (with examples from the cement industry), and the role of models in long-range corporate planning (with a factory location problem as an example).

Frank Fiore is known for his very practical, "down-to-earth" attitude to problem-solving and he is also a fine speaker. This promises to be one of our best meetings so far.

NEXT MEETING + 1

Date	:	Wednesday, 17th June, 1970
Venue	:	University of the Witwatersrand, Geology Building, Room G 201
Time	:	8.00 p.m.
Topic	:	"Is simulation the last resort ?"

This will be our first inter-active meeting of 1970. A panel of four OR professionals with experience in simulation - and a wide range of opinions on its relative pros and cons as an OR tool - will discuss its benefits and pitfalls. A limited number of questions from the floor will be welcomed and we hope for both a lively and informative discussion.

A NEW APPROACH TO SIMULATION

AUTHOR: P.R. HILLS, P-E CONSULTING GROUP LTD.,

ABSTRACT

A major problem in extending the use of discrete event simulation has been the degree of specialist programming ability required by the model builder. The HOCUS system overcomes this by enabling a flow chart logic description to be tested by hand simulation and then used as data for a standard computer simulation program. By this approach the system provides both a framework for teaching the principles of simulation and a practical working system while avoiding the need to write and de-bug computer programs. HOCUS has been successfully used in university teaching and by industrial organisations and consultants for problem solving for two years. During this period a cross-section of some hundreds of managers, management scientists and university students have been taught to use the system by participating in either a public or in-plant, three-day course in the UK or Europe. Most of them had no previous programming or simulation experience but during the course all constructed working simulation models. The paper introduces the system and describes these courses. Many participants have returned to complete successful simulation studies in their own organisation and three of these are described in the areas of plant design, production planning and surface mining.

INTRODUCTION

Over the last few years the usual method of carrying out simulation studies has been to write special one-off computer programs. This procedure has several drawbacks, mainly stemming from the fact that it is a computer programming activity. To write a good program required a rather special sort of ability which is not as common as many would have us believe and which may well not go with the many other attributes required of a successful analyst. Inevitably the de-bugging of the program is time-consuming (usually far beyond the estimate of the programmer) and often delays the completion of the project, while programs when finally de-bugged tend to become sacrosanct, so that an attitude of mind - 'well it may not do quite what we want but at least it works now' - may hold. Again, since a programmer needs to be used, even if a team of personnel are engaged in the project, all communication with the model is via the programmer with consequent opportunities for misunderstandings. Finally a computer program is hardly the best means of presenting the actions of the model it controls to a non-specialist audience, the language is strange, the sequential nature of the instructions which are often describing parallel activities is false, and this is a considerable drawback when selling the results obtained to management or clients.

There have been various attempts to ease these problems in the form of special computer languages e.g. SIMSCRIPT, GPSS, GSP, CSL, BASIC, MONTECODE, etc., However, most of these languages require their own compiler and are therefore not available on all machines. Since most machines have either FORTRAN or ALGOL compilers, a language which used a set of FORTRAN or ALGOL subroutines should be universally available. I developed such a language, SIMON, which meets the basic requirements of a simulation language in that it has:-

1) a listing facility

2) a method of sampling from distributions. SIMON has reduced if not eliminated, the learning time required each time the simulation expert meets a new machine.

While this has eased the programmer's task considerably it has not touched on what, in our minds, is the central problem. This is not the gap between the programmer and the computer but rather the gap between the problem and the programmer. Indeed to some extent they make this worse, for the manager with the problem having just stumbled through his FORTRAN appreciation course or with a hazy recollection of this from his college days is presented with a program in yet another language, whose general form may well be easy to follow but whose exact meaning often is not.

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THE HOCUS TECHNIQUE

We have produced a technique which avoids the need for computer programming of the conventional sort. It provides a simple logic language to enable the problem to be described as a model, the description taking the form of a flow diagram which is easily understood, since it demonstrates quite clearly the interrelationship between the processes taking place in much the same way as a network analysis chart. It also provides a consistent terminology by making use of pre-printed diagram formats, thus providing a discipline in setting up models which considerably reduces the likelihood of errors. Once set up the simulation may be run by hand, moving counters around on the actual diagram to represent the changing state of the model; this way the formulation may be checked, its exact consequences understood and all the team carrying out the analysis may take part in this exercise and agree the formulation. All this, it should be noted, is done before the computer is even approached. At this stage the entries on the diagram may be copied on to punched cards and then fed to one of the many computers having the HOCUS program. The computer then reproduces and continues the hand simulation giving output of various sorts as directed by the analysts.

The system known as HOCUS (Hand Or Computer Universal Simulator) has as its central concept one of 'entities' which engage together in 'activities'. An entity is the thing whose behaviour is being simulated, such as a man, a crane or a carton. An entity can be engaged in a state of doing something - the activity - or doing nothing when it is idle and considered to be in a queue. A model postulates a set of entities, each of which may exist in several active or idle states, and by declaring the particular state of each entity at any time the state of the entire model is completely and unambiguously declared.

Since the entity states are discrete, changes of state of the model are instantaneous and at discrete times. Moreover, in observing the passing of time in a simulation it is necessary only to consider the discrete change times, so time may advance by jumps from one change to the next.

In carrying out such a simulation the operations can be divided into two parts. At any observation time the appropriate change of state at the time must be determined. Then it is necessary to determine the time until the next change in order to jump simulation time forward by the right amount. These calculations are eased by making use of the concept of the activity. An activity is a time consuming co-operation of entities in performing some task, and as a result it is the activities that control the advance of the model.

The way in which entities engage in activities and then relapse to idle states is described by means of an activity cycle chart. In this the life cycle of each entity is represented as a series of alternate activity and idle states. Figure 1 shows the chart for a simple machine-minding situation where one mechanic tends three machines which queue for his attention if necessary. There are two entity types, the man and the machines, and their life cycles come into contact in the repair activity.

At any time several activities may be in progress and each of the entities must be in a particular state. To find out when the state of the model will change it is necessary only to look at the activities in progress and find the one whose life will end first; the time when this happens must be the time of the next event. Providing a structure is adhered to, as in the simple example, of all entity cycles comprising alternately an active state, idle state and then active state, the rules for changing the model state are simple. First the entities engaged in the particular activity just ended are moved to their next idle states. Then a test is made to see if, as a result, any activity not in progress may start; this is done by determining whether the entities needed for the particular activities are in the right idle states. Any entities which can start an activity are moved on to their appropriate active states, and the life of the activity is predicted.

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The activity cycle chart naturally forms the basis for the hand simulation exercise and standard activity and queue formats are used for the formulation of the model as shown in Figure 2.

Idle states or queues are represented by circle diagrams. This allows addition and removal of counters without requiring the movement of all counters already in position to take up empty places. If the queue has a limited size this may be entered. Activities are represented by square diagrams and allow specification of the conditions for starting and for duration time. The activity starting conditions are the presence of one or more entities in specified queues. The method used is as follows. In the activity diagram a series of entity names may be listed. To the left the queue numbers in which they must be found are written. The entity may be required to be at the head of the queue, as its tail or merely present in it. Several entities may be given the same source queue or the same entity may be looked for in different queues, and conditions may be specified to be alternatives.

The time that an activity is to take, once it starts may be specified as a constant, or looked up as the next value in a timetable, or it may be a sample from a statistical distribution or co-related with some time in the previous life of one of the entities engaged in the activity. When an activity comes to an end the entities involved in it are released to the queues and positions specified to the immediate right of the entity name. If a queue specified has reached its maximum size then the entity is released to an alternative queue which may be specified in the next right hand position.

During hand simulation, when an activity is started, the counters representing the entities required are moved from their queues

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to the activity diagram. After the activity is ended they are moved to their destination queues. On starting, all the entities must be allocated to queues and the clock time set to zero. Operation then proceeds through two phases. During the first phase a check is made of the conditions for starting each activity in turn. If a check is successful then the activity is started and the time of ending, made up of the sum of its duration and clock time, is entered into the cell thus labelled at the head of the activity diagram. In the second phase the activity time cells are compared with the clock time and the earliest time which is greater than or equal to clock time is chosen. The activities whose time cells hold this value are ended, and the clock time is advanced to this time. Then the first phase is started again.

This 'playing board' enables testing to be started by hand simulation but, when the user is satisfied that it is correctly set up, the entries on the board may be punched on to computer cards exactly as they appear. These are then taken to a computer with the HOCUS program, where they are read and checked for inconsistencies. For example, if the user specifies that the mechanic has four machines but allocates only three on his board at the start of the simulation the program stops and announces the fact. As an alternative to using punched cards a terminal typewriter is used by some HOCUS users, to input the board entries.

Once the data is accepted, the computer enters into a conversational mode of operation, asking questions via a typewriter and expecting replies. By giving appropriate answers the user can run the simulation at various degrees of monitoring. At the highest level he can have an output of a complete description of all that is going on at every time change: what is in each queue, which activities are in operation, which entities are bound to them and so on. At the lowest level, statistics may be collected for printing out at the end of a run. He can then re-run the simulation or make changes via the console typewriter, thus adopting a mode of operation similar to that employed when using an analogue computer for design problems. Where an interactive mode is not appropriate operating instructions may be pre-determined and fed as control cards.

THE USE OF HOCUS

Since HOCUS is written in basic FORTRAN it is available on a wide range of machines e.g. IBM 360-30,-40,-50,-65; IBM 1130's; ICL 1903, 1905; Burroughs 3500; and CDC 6600.

A number of major organisations have adopted HOCUS as a standard procedure and have both line managers and management service staff undertaking simulation studies. To illustrate the sort of problems that are being tackled three examples are given below.

EXAMPLE 1 - PLANT DESIGN

Parts of a design for a major semi-automatic warehouse handling approximately 40,000 stock lines were simulated using HOCUS. The model enabled the designer to test the sensitivity of the system to changes in input and output level and working procedures. This study facilitated the selection of the appropriate number of computer directed stacker cranes and their operating procedures. Also such parameters the number of idle bin positions necessary to sufficiently decouple the cranes from the manual input and output operations, patrolling regimes and the consequences of breakdowns were studied all at the design stage.

EXAMPLE 2 - PRODUCTION PLANNING

A major manufacturer of copper tubes has constructed simulation models of its different production units. This has been achieved by setting up a project team at each factory. The teams typically consist of a work study or industrial engineer familiar with the process together with a member of central management services and a management trainee. Each team constructed a HOCUS model of each part of the production process which they verified as individual modules before joining them into a composite model of the production unit which will be used for experimental and control purposes. The individual modules having been established by hand simulation are finally tested on a small IBM 1130 to allow the models to be refined to their essential components. The composite model is being run on the organisation's large ICL 1900 series machine.

EXAMPLE 3 - SURFACE MINING

The work study engineers of a civil engineering group constructed a HOCUS model of a large excavation project. A number of faces were being worked concurrently by a variety of excavators supported by a fleet of earth moving vehicles. The working face configuration could affect the choice of excavator used, the freedom of movement of support vehicles in the excavated channel and the manner in which excavators retreat to allow for shaling and consolidation should be organised. A HOCUS model was constructed of each type of working face configuration, the road network and the dump area site. These were tested separately and then linked into a composite model which included a mix of working faces linked by the transport system to the dump area. Working faces could be added or withdrawn from the model as the project progressed and travelled distances increased as working faces migrated from the dump area.

These examples give some idea of the range of practical simulation models which have been built by line managers, work study and industrial engineers and OR specialists in the last two years.

Other examples include work in shipyard design, distribution systems, flow line production systems, manufacture of prefabricated building components, food process plant, mechanical handling systems, port organisation and textile production.

CONCLUSION

It is the author's belief that in order to carry out successful simulation projects those persons familiar with the problem and responsible for implementation of any solutions should be involved in the study and be fully conversant with every part of

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it. In this way a realistic model will be created and any consequent recommendations will be understood and trusted by management. Therefore, any system used to construct simulation models should be capable of being understood by the persons with no previous simulation experience or computer background. Also it is essential to reduce the all too familiar de-bugging time of simulation models.

P-E's experience using HOCUS is that there has been a significant improvement in the case of involving line management in simulation studies and in communicating results of these studies to management. Furthermore the model building phase - that is the time required to get a valid simulation model operating on the computer - is of the order of 20% of that required previously using simulation languages.

These improvements can be attributed to:

The simplicity and discipline of model representation.

The ease of training personnel with no previous simulation or computer experience.

The validation of the model by hand simulation prior to use of the computer.

The ability to rapidly refine models during hand operation stage.

The comprehensive error diagnostic and monitoring service provided by the HOCUS program.

The ease of linking together HOCUS models.

ACKNOWLEDGEMENT

The authors with to express their gratitude to the P-E Consulting Group, who sponsored this development, for permission to publish this paper.

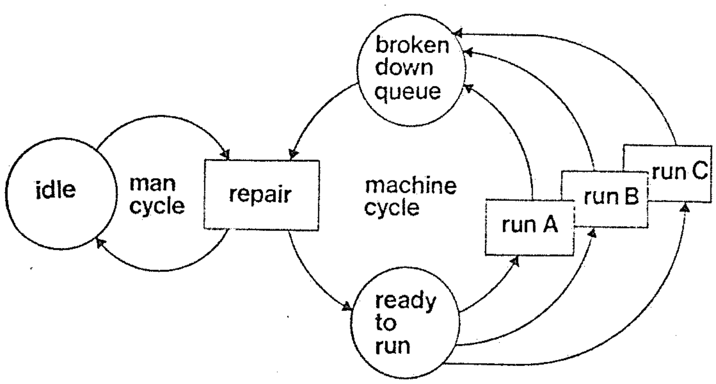

Figure 1. An activity cycle diagram

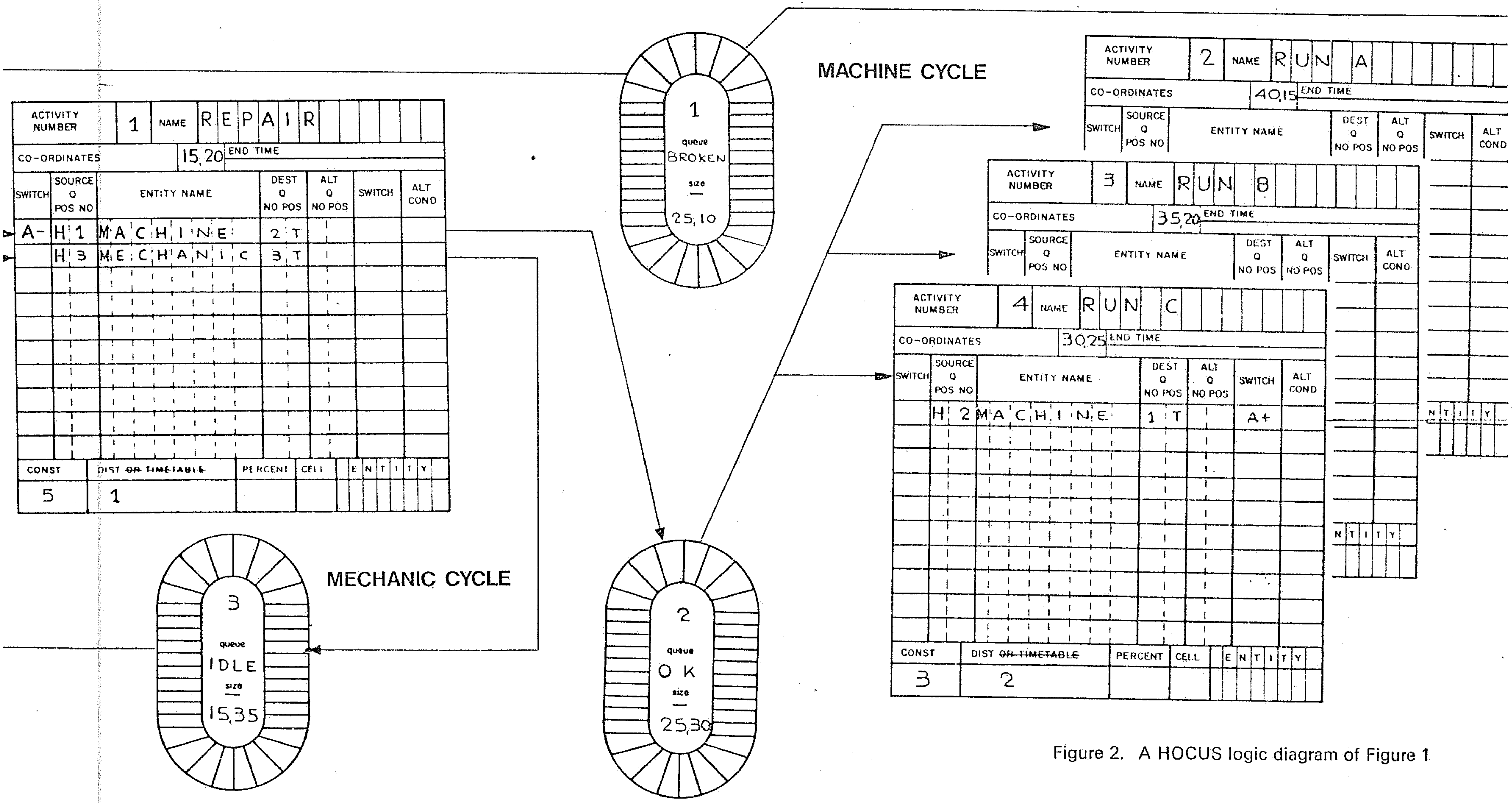

Figure 2. A HOCUS logic diagram of Figure 1