JOHANNESBURG OR GROUP

News and Views

May 1969

(Your news and views will be welcomed and published)

NEXT MEETING

Chairman:	Mr. J. Joslin
Panel:	Mr. Grobbelaar Mr. Hammerstrom Mr. Sankey
Problem:	A real and continuing problem experienced by the South African Railways is being presented to the panel for solution. The problem description is included with this newsletter.
Date:	May 14th
Time:	8 p.m. - 9.30 p.m.
Venue:	Room SS4 (Social Science Building)

To get to the Social Sciences building, enter the University at the main gates on Jan Smuts Avenue. Go round the circle and north down the hill. The building is a big new yellow block on the left of this road. To get to SS4 enter at the West entrance and go up the main stairs to the second floor. SS4 is directly opposite the stairs.

Procedure:

A. The members of the panel have now received their copies of the problem description. They are not allowed to discuss the problem with each other, but are encouraged to ask questions of the South African Railways (Mr. Gert van der Veen)

B. At the meeting:

1. Mr. van der Veen will introduce the problem (20')

2. Each member of the panel will present his solution (20' each)

3. A system of lights will be used to control the speakers. For each speaker the green light will be switched on after 10', the orange light after 15', and the red light on time.

4. Discussions will be invited from the floor.

NEXT MEETING + 1

Chairman:	Mr. L. Gritzman
Speaker:	Mr. Mike Steele
Subject:	Scientific Traffic Planning Techniques
Date:	June 11th
Time:	8 p.m.

LAST MEETING

"Management Games" - Mr. Bob Tandy

This talk was valuable, in that it cleared up a number of misconceptions.

Management games are primarily for the training of junior management, sometimes for middle management, and never for directors and general managers. Because they provide a dynamic illustration of the interaction between the various functions in a compnay (advertising, costing and price decisions, etc.), they are valuable to the new manager. At the same time these games are built around mathematical models which are very simple, non-stochastic abstractions of the real situation. Because they therefore lack the complexity of the real situation they are of no value to top managers who are already aware of the general interactions within the company.

Comments from the floor included:-

Mr. Hammarstom: "Is it correct that the participants should aim at maximising profit? Should they not rather aim at understanding the interactions by boldly varying their decisions?"

Mr. Tandy: "Actually the participants with most daring did achieve the most success". He was referring to a team of school boys who are currently playing one of these games.

Mr. Zoller: "While I was with UCLA we had to play management games as a part of the MBA course. They left us with a feeling of dissatisfaction because they never involved the application of the scientific method we had learnt in the rest of the course."

The editor (in retrospect): " The purpose of scientific techniques is to cope with complexity and variety which are inherent in the real situation. No wonder the business game (as defined above) failed to satisfy".

Mr. Rozwadowski: "I take it that 'verisimulitude' means 'very similarly'; well with regard to this we did write a mine management game in which the mathematical model did represent reality. It included the complex income tax formulae, the effect of developing stopes of different gold content and so on."

SIG ACTIVITIES

The purpose of the Special Interest Groups is to help people to work together in depth, independently of our monthly meetings, on their special interests or problems. If you are interested in any of the activities outlined below, please contact the SIG leader. If you would like to lead a group in an activity not yet catered for, please inform any member of the committee.

Cybernetics:	Mr. Mike Roberts	838-3581
Dynamic Programming:	Mr. Tom Rozwadowski	48-1028
Econometric Models:	Mr. John Joslin	28-1500
Forecasting:	Dr. John Ryder	838-7545

The next meeting will be at 4 Stevens Road, Blairgowrie, Randburg from 5.30 p.m. to 7.30 p.m. on the 21st of May, 1969. Dr. Ryder will discuss some inventory control and forecasting problems. Snacks will be served. All welcome.

Simulation:	Mr. Gert van der Veer	713-4201

There will not be a talk on the 12th of May.

Statistical Quality Control:	Dr. Sichel	724-8172
Or in the Construction Industry:	Mr. V. Shaw	74-6011 (Pretoria)

CURRENT EVENTS

The 3rd Israel OR Conference will be held at Tel Aviv on the 2nd to 4th July, 1969. This will be a joint venture between the OR Society Israel and the OR Society America.

There will be an ORSA symposium on health on May 15th, 1969 at National Bureau of Standards, Gaithersburg, Maryland.

(If you would like more information about these events it can be obtained from Mr. Dave Masterson).

The IFORS Conference is taking place in June this Year in Venice, Italy. Mr. Jim Buttery, a member of the Johannesburg OR Group, will be representing South Africa.

An Operations Research Symposium is being planned for Friday and Saturday, the 21st and 22nd of November, 1969, at the University of the Witwatersrand.
The Operations Research Society of South Africa will be formed at this symposium.

National Co-ordinating Committee

Dr. Sichel	724-8172
Mr. Pirow	836-1166
Mr. Joslin	28-1500
Mr. Rozwadowski	48-1028
Professor Rudolph	Rhodes University
Professor Jacobsz	C.S.I.R.
Professor Venter	Potch. University
Mr. du Plessis	UNISA

Johannesburg Operations Research Group Committee

Mr. R.T. Rozwadowski	(Chairman)	48-1028
Dr. J.A. Ryder	(Vice Chairman)	838-3581
Mr. M.C.F. King	(Honorary Secretary)	25-2124
Mr. D. Masterson	(Honorary Treasurer)	23-6547
Mr. M.P. Roberts		838-3581
Mr. G. van der Veer		713-4201
Dr. D. Hawkins		724-1311

Address

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JOHANNESBURG

Has your address changed? If so please send us the new address in section A below.

Do you know any potential members? Get them to send us sections A and B below.

A.	Name :	
	Address (Postal) :	
	Business Telephone :	
	Home Telephone :	
B.	Occupation :	
	Position :	
	Academic and Professional Qualifications :	
	Have you worked in the field of OR?	
C.	A voluntary contribution of R2.00 per annum would be appreciated.	

Johannesburg OR Group,
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JOHANNESBURG.

The African Wire Ropes Problem - Professor G. Rudolph

The problem of how to control patented gauge wire stocks at African Wire Ropes has many aspects which make it extremely difficult to suggest a quick solution to the problem as a whole. It should therefore be realised that:

1. I am not suggesting any specific solution at this stage but am only suggesting possible ways of attacking the problem (The specific model for inventory control that will be presented is merely an illustrative example of the type of model that one could use).

2. In order to get a quick solution, based on available techniques, I propose to subdivide the problem into a number of smaller problems which can be solved in turn. Since these smaller problems are interrelated, such an approach implies that one is going to sub-optimize. Being fully aware of the dangers and disadvantages of sub-optimization, I nevertheless believe that a good practical (though perhaps not optimal) solution can be obtained in this manner.

Although there are several interrelated smaller problems (e.g. quality control, possible modification of the process, possibility of buying new equipment, etc.) the two main problems seem to be a.) an inventory problem; and
b.) an allocation problem

More precisely, these two problems can be formulated as follows.

a. Inventory Problem:

What are the optimal lot sizes and the frequencies with which stocks should be replenished? (That is, how often and how much of the various kinds of rod should be bought in order to satisfy demand in an economic manner; similarly, how often and how much of each kind of patented gauge wire should be produced and stocked; how often and in what quantities should various types of finished wire be produced; etc.)

b. Allocation Problem:

Given the available resources (i.e. various quantities of rod, patented gauge wire and operational facilities) at a specific point in time and also given the production requirements at that time, specified both with respect to quality (e.g. required carbon content, tensile and thickness) and quantity (as determined by the solution to the inventory problem), what is the optimal allocation of the resources in order to meet the requirements?

The above allocation problem can be formulated and solved as a mathematical programming problem. We shall not go into the details of this because we have been asked "how to control the patented gauge wire stocks", which means that we must concentrate on the inventory problem and in particular that we must concentrate on one particular level (patented gauge wire) of this multi-echelon inventory system.

One may of course reduce the multi-echelon inventory problem to a number of single station problems by first solving the inventory problem for wire ropes; then using the determined optimal quantity of wire ropes to determine the demand for finished wire, one can solve the inventory problem for finished wire; then, using the solution of the finished wire problem, one can solve the problem for patented gauge wire; etc.

It should, however, be noted that this again implies sub-optimization.

Although the Management of African Wire Ropes has mentioned several objectives, such as:

a. to increase wire mill efficiency
b. to improve customer service
c. to decrease rope stocks by reducing lead time
d. to decrease (primary) fall-out and scrap, all these objectives can be replaced by one single overall objective - "to maximize profits (or to minimize costs)".

By "costs" we not only mean the ordinary costs that appear in the company's books. We also mean that monetary values should be assigned to intangibles such as "customer goodwill". We realise that this is not an easy thing to do but unfortunately it is necessary in order to express the problem in quantitive terms. If one refuses to formulate a problem quantitively it is impossible to find a solution and it would have to suffice to discuss advantages and disadvantages, not knowing precisely what one is talking about. This quantification of a problem is not as bad as it would seem to non-mathematicians because what one is interested in is a realistic mathematical model and not a specific numerical answer. Once you have a suitable model for a problem, questionable numerical values can always be varied within a likely range to test the sensitivity of a solution. A very sensitive solution should not be implemented. Fortunately, it is usually found that in practice solutions to inventory problems are not very sensitive for changes in doubtful costs.

In any inventory problem the solution consists of finding a balance between three relevant costs, viz "set up cost", "shortage cost" and "holding cost". These costs represent several minor cost aspects, for example:

(i) Set up cost includes clerical and administrative costs; machine set up labor costs; cost of materials used during set up testing; cost of production time lost during set up.

(ii) Shortage cost includes loss of sales because of a shortage; loss of customers and goodwill.

(iii) Holding cost includes cost of money tied up in inventories (at least 6% of the value of average inventory;) cost of storage; insurance premiums and other risks e.g. rust, theft, deterioration and obsolescence.

In addition to the above three costs one must also take into account the cost of inventory control. However, this latter cost only affects one's choice of a model and method of control (e.g. whether by means of an electronic computer or not).

The next step in constructing a mathematical model for inventory control is to specify a suitable operating doctrine. Examples of operating doctrines are: "order a fixed quantity Q every t days" "as soon as the inventory reaches a level s, order to bring it up to S".

The disadvantages of these two operating doctrines are obvious. For example, the first one assumes the demand to be known and constant, while the second doctrine requires us to keep track of the inventory level all the time, i.e. transactions reporting. As a compromise one may use a so-called "periodic review doctrine" which means that the inventory level is reviewed at fixed time intervals and orders are placed to bring it up to R.

An example of a model that uses this doctrine is the following:

<u>Example</u>:

Let T = time between reviews
R = inventory on hand plus on order immediately after review
J = cost of making a review
A = set up cost
π = penalty cost per unit back ordered (we assume all shortages to be back ordered, i.e. there are no lost sales)
h = unit holding cost per time unit
λ = average demand rate
τ = procurement lead time (may be a random variable)
μ = expected lead time demand
$f(x;t)$ = density function for demand x in a time interval of length t.

We have to determine the optimal values of T and R so as to minimize K the total average cost per time unit.

$$\text{Now } K = K_1 + K_2 + K_3 \qquad (1)$$

where

K_1 = average cost of reviewing and set up per time unit

$$= (J+A)/T \qquad (2)$$

K_2 = average cost of holding inventory per time unit

= h ($\frac{1}{2}$ expected inventory level just before arrival of a procurement + $\frac{1}{2}$ expected inventory level just after arrival of a procurement)

$$= h\left[\tfrac{1}{2}(R-\mu-\lambda T) + \tfrac{1}{2}(R-\mu)\right] = h\left(R-\mu-\frac{\lambda T}{2}\right) \qquad (3)$$

$$K_3 = \pi\, E(R,T) \text{ where} \qquad (4)$$

$E(R,T)$ = average number of backorders per time unit as a function of R and T

$$= \frac{1}{T}\int_R^{\infty}(x-R)\, f(x;\tau+T)\, dx \qquad (4a)$$

Substituting (2), (3), (4) and (4a) into (1) and differentiating we get

$$\frac{2K}{2R} = h - \frac{\pi}{T}\int_R^{\infty} f(x;\tau+T)\, dx \qquad (5)$$

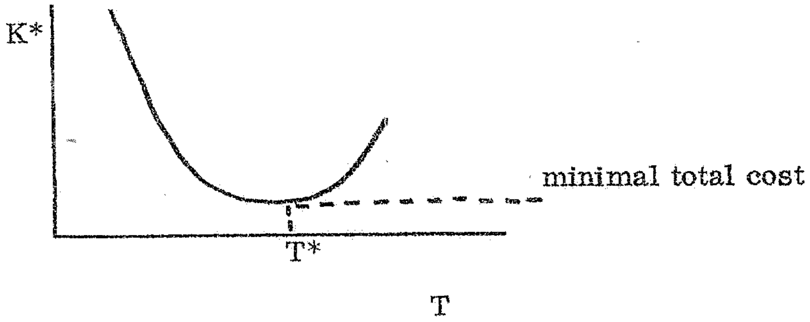
Therefore the optimal value of R for fixed T is obtained by solving

$$\frac{2K}{2R} = o, \text{ i.e.}$$

$$\int_R^{\infty} f(x;\tau+T)\, dx = \frac{hT}{\pi}$$

From the cumulative distribution function of the demand, i.e. $F(x;\tau) = \int_0^x f(y;\tau)\, dy$, one can therefore read $R^*(T)$

the optimal value of R for any given T.
To determine the optimal set of values (T^*, R^*) one can plot the function $K^*=K(T, R^*)$ against T and read of the optimal value T^* from the curve obtained, i.e.



If the lead time is a random variable with density $g(\tau)$ and range between τ_{min} and τ_{max} then (4a) must only be replaced by

$$E(R, T) = \frac{1}{T} \int_{R}^{\infty} (x-R) \quad h \quad (x;T) \, dx \text{ where}$$

$$h \ (x;T) = \int_{\tau_{min}}^{\tau_{max}} f(x; \tau + T) \ g(\tau) \, d\tau$$

As a final remark we should like to point out that all inventory models are based on the principle of balancing two or more of the three costs, "set up", "shortage" and "surplus or holding" cost. At least two of these costs must be positive otherwise the answer is DO NOT KEEP STOCKS. In the case of African Wire Ropes, however, the set up cost appears to be very small and, because there are very few competitors and wire ropes have more or less to be made to order, there also seem to be only a very small penalty cost for shortages. Intuitively one therefore arrives at the answer that hardly any stocks must be kept. I would therefore suggest to the company that solving the allocation problem indicated at the beginning of this discussion may be far more important than giving attention to the problem of stock control.