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OPERATIONAL RESEARCH

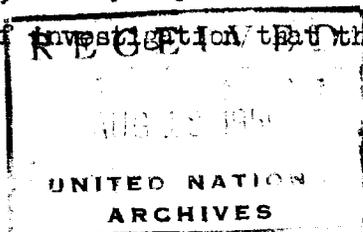
Paper prepared by Mr. F. Yates in connexion with
item 5 of the provisional agenda

What is "Operational Research"?

There appear to be two separate schools of thought on what is (or should be) meant by "operational research". These are:

- (a) That operational research has as its object the provision of administrators or executives with information on which they may base decisions.
- (b) That the term covers the study of operations by human beings and groups of human beings such as the use of machines and technical processes, organizational problems such as traffic flow, the flow of work through a factory etc., together with analogous military problems such as the use of weapons, tactics etc.

Both schools agree that operational research is essentially scientific and quantitative, and that it should be undertaken with practical ends in view, i.e., that better decisions should be reached, or that operations should be more effectively conducted. These two classes of definition cover a good deal of common ground. Many decisions of administrators and executives are concerned with operations of the type included under (b) and equally the improvement of such operations frequently requires administrative or executive action. They are, however, not synonymous and taken together can be stretched to embrace so many types of investigation that the term loses much of its value.



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E/CN.3/Sub.1/25

The first number, March, 1950, of the Operational Research Quarterly (Journal of the Operational Research Club, London) which is mainly an abstracting journal, indicates how wide the field can be. The general scope of this Quarterly is dependent on the definition given to operational research. Without being committed to a particular definition, it is felt that the Quarterly may usefully regard as within its field the application of the scientific method to the provision of bases for executive action, in particular when the behaviour of people, either by themselves or in relation to their environment and equipment is involved.

Within the broad subject thus outlined there would appear to be four main headings under which operational research work might be conveniently grouped.

The first heading would cover studies of human behaviour by itself. For example, Henry Durrant's paper on "Polls and Prophecies" describes the application of the scientific method to social problems; "social science" in the strictest sense. Operational research applied in the field of economics is conveniently included in this group, which possibly offers the most important scope for future development.

"Man and his Machines" might be the heading for the second group. A good example is L.H.C. Tippett's "Study of Industrial Efficiency with special regard to the Cotton Industry" where it is made possible for executive decisions on this subject to be rationally based on statistical analysis of the behaviour of the men, machines and environment concerned. This large group covers the majority of the application of operational research in industry, and much of the military field.

Many operational research studies are conveniently grouped under the heading "Traffic and Flow". W.F. Adams' paper is an early example, and E.L. Diamond and A.M. Frankau on "Present Methods of Open Hearth Furnace Charging" is a more recent one.

The fourth group covers, besides "general" papers that do not conveniently fall into any of the other sections, those concerned with the organization and purposes of operational research itself. W.J. Horvath's paper "Operations Research" is an example. In this connexion Professor P.M.S. Blackett's observations in an article of the same number of the above journal are of interest (loc.cit. p.4):

"If, therefore, operational research is merely the scientific method applied to the complex data of human society, then, however useful it might be, it certainly is not new."

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I believe this conclusion to be over-simplified and that operational research, as developed during the war, and subsequently, has an appreciable degree of novelty. In my view, the element of relative novelty lies not so much in the material to which the scientific method is applied as in the level at which the work is done, in the comparative freedom of the investigators to seek out their own problems, and in the direct relation of the work to the possibilities of executive action. Dr. Kittell's well-known definition of operational research as "a scientific method for providing executives with a quantitative basis for decisions", expressed this clearly, or, as another writer has put it, operational research is social science done in collaboration with and on behalf of executives.

In this sense Sir John Boyd Orr's brilliant study, "Food, Health and Income", was not operational research, as it was not done on behalf of any executive. However, like many other social studies, it was intended to lead to political action, and certainly did so, by its effect on the policy of the Ministry of Food during the war.

These observations, however, do not really dispose of the matter. I would not, myself, limit the term to work done on behalf of an executive, since there appears to be no fundamental difference between work so done and similar work done independently with the intention of bringing it to the notice of an executive. Thus the Rothamsted work on Fertilizer Policy, a description of which was given in a paper read to the International Statistical Institute in 1949, appears to me to be an excellent example of operational research which did in fact serve its purpose of providing executives with a quantitative basis for decisions. But in its initial stages it was an independent venture of type (a) above, and was actually opposed by the administrative authorities. Equally, the implication of the last sentence of the second paragraph that social science is necessarily involved can scarcely be intended.

The Sub-Commission may therefore wish to consider whether some sharper definition of Operational Research should be attempted, or whether indeed a new term or terms should be sought.

My own view is that the term is not a particularly happy one if a definition of type (a) is adopted. The word "operational" is presumably derived from military operations, and the extension of the term to other fields is, I think, a consequence of the high repute gained by military operational research in the last war.

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I should like to see the term "operational research" confined to the study of actual operations such as are included under heading (b) - the tactics, as it were, of human activity - and a further term introduced for research into the broader aspects of human activity which is required in administration and planning; though I must confess I have not thought of a suitable term. It is this latter type of activity that I attempted to define in the paper I gave to the International Statistical Institute. I there suggested the following definition:

"Operational research consists of the application of the methods of scientific research to problems arising in administration and planning", with the explanatory remarks:

"By 'methods of scientific research' I mean that combination of observation, experiment and reasoning (both deductive and inductive) which scientists are in the habit of using in their scientific investigations. Observation includes all those organized observations on large masses of material which partake of the nature of censuses and surveys, and which are frequently most easily conducted by sampling methods, and reasoning that large body of numerical deduction and induction which is covered by the term statistical analysis."

"The essence of an experiment is the imposition of a deliberate change with the intention of studying its effects. The critical, controlled experiments of scientific research must be suitably designed statistically to give estimates of the effects of certain factors freed from the disturbing effects of other factors, together with measures of the experimental errors to which these estimates are subject. Experiments form an integral part of operational research, since there are many points on which surveys are capable of giving only uncertain and tentative information, and others on which they cannot give any information at all. Many of the conclusions reached as a result of the analysis of survey data and other observational material must be subjected to critical experimental tests before any certainty can be claimed for them."

In any case too much must not be included under the term. I think the purpose of the research, namely the immediate improvement in the efficiency of the activities or operations under examination, is important. Thus many fields

of research in economics or the social sciences should not come under the heading of operational research, although their ultimate object, through a better understanding of the processes involved, is undoubtedly the improvement of human organization and relations. Equally investigations into the responses of agricultural crops to fertilizers, whether they be new experiments, or statistical summaries of previous experiments, would not in themselves constitute operational research, though they might form part of an operational research investigation into the use of fertilizers.

Qualities required in an operational research worker

If what has been said above is accepted it follows that an operational research worker must be capable of

- (a) making use as far as possible of existing data, even when such data have not been collected by rigorous sampling methods,
- (b) designing and carrying out sampling surveys, and making a critical analysis of the results of such surveys so as to draw the correct conclusions,
- (c) designing and initiating experimental investigations and appraising their results, and the results of previous experiments,
- (d) integrating the evidence from all these sources into a co-ordinated whole, and presenting the relevant portions to the administrators (with whom there should be close and continuous collaboration).

(Paper to I.S.I., 1949)

Although a large part of this work is necessarily statistical in nature an operational research worker must be much more than a statistical analyst. He must, amongst other things, have an aggressive attitude towards his task, and be prepared to take steps to fill in the gaps in information from existing sources, rather than merely accept what is readily available.

How far should operational research be the concern of the Economic and Social Council of the United Nations?

I think it is clear that the Economic and Social Council can legitimately concern itself with the type of operational research that is concerned with problems arising in public administration and planning. It is quite clear that it should not be concerned with the uses of operational research in military operations. It can scarcely properly concern itself with operational research

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which is concerned with detailed industrial processes, nor, I should think, with specialized technical problems such as traffic flow. The Food and Agriculture Organization, on the other hand, may be concerned with operational research into the technical practices of agriculture. The technical problems of agriculture in fact present a special case, since from its nature the agricultural industry is almost inevitably carried on by a large number of separate small-scale undertakings.

If therefore the Economic and Social Council feels that the methods of operational research as now developed are capable of making useful contributions to the welfare of the peoples of the world through the more effective solution of the problems arising in administration and planning, and if at the same time they feel that the methods are as yet insufficiently understood, and that they can themselves usefully assist in their dissemination, it would seem quite appropriate that they should so assist. At least, the case is just as strong as for the dissemination of methods of statistical sampling which is the primary task assigned to the Sub-Commission on Statistical Sampling.

Personally, I have no doubt that the development of the methods of operational research as defined above will make a valuable contribution to better administration and planning. Our own experience in agricultural fertilizer policy in the United Kingdom, to take a specific example with which I am familiar, has indicated that even in countries where scientific and technical knowledge is well advanced the deliberate use of operational research methods to solve the problems arising in administration and planning results in very marked gains in efficiency.

The use of operational research methods is likely to be of particular value in the development of countries which are at present undeveloped and technically backward. The uncritical adoption of technical processes which have been found to be satisfactory in more fully developed countries is always dangerous, and particularly so if the rate of development is rapid, since with rapid development there is little time to remedy defects which only become apparent after the processes have been in use for a number of years. Moreover, even if the processes are in themselves satisfactory their use frequently generates economic and social problems which cannot be properly solved without scientific investigation of the operational research type. In this field, therefore, the

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development of operational research methods appears to be of particular interest to the United Nations.

On the other hand I wish to stress the danger of a top-facile recommendation and use of operational research methods. At the end of the war there was a tendency to assume that the striking success of operational research in military operations could easily be repeated in peacetime occupations. In particular there was a tendency to under-rate the need for specialized technical knowledge of the subject matter being dealt with. Thus Blackett in the article already quoted stated:

"Specialized knowledge (technical, industrial or social) appropriate to the field of application is desirable, but is usually acquired on the job." This I think is a mistake; the reason why scientists without previous military background or training were successful in wartime operational research was because there was in fact practically no relevant previous experience. The situation is very different with peacetime activities. In all types of industry, for example, there is a very large body of technical knowledge and skill possessed by those who work continuously in the industry. The man who is in possession of the appropriate technical knowledge is in a much stronger position to carry out effective operational research than one who does not possess this knowledge. He must of course possess an independent mind which is capable of making critical judgments on already accepted practices, but such independence should not, I think, have to be based on ignorance.

Within the framework of the United Nations is the Sub-Commission on Statistical Sampling the appropriate body for dealing with the matter?

As has been pointed out, the statistical method is an essential part of operational research, and in many cases sample surveys of one type or another are required. The Sub-Commission already covers this latter field of statistical methodology. It does not, however, cover the methodology involved in the statistical analysis of accumulated bodies of material, nor the field of experimental design. I think, however, its activities might well be extended so as to embrace such fields of methodology as are required by operational research. The Sub-Commission should not be expected to undertake any actual operational research any more than it undertakes actual sampling surveys, but only to advise generally on methods and to review from time to time the progress made in the subject.