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Eighth National Meeting of the Society—Ottawa, Canada, January 9—10, 1956

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Eighth National Meeting of the Society

OTTAWA, CANADA, JANUARY 9–10, 1956

THE Eighth National Meeting of the Operations Research Society of America was held at the Chateau Laurier Hotel, Ottawa, Canada, on January 9 and 10, 1956. This was the first meeting of the SOCIETY to be held in Canada. There were 186 paid registrations, of which 105 were by members and 81 by non-members. Including registrants, wives, and guests, approximately 210 were in attendance.

DR. O. M. SOLANDT, Chairman, Canadian Defence Research Board, who was to give the invited address, was not able to attend the meeting, and in his place an address on the subject of "Control in War and Peace" was given by DR. GEORGE S. FIELD, Chief Scientist, Canadian Defence Research Board. MR. E. C. WILLIAMS of the Ministry of Defence, United Kingdom, was the principal speaker at the banquet held on the evening of January 9. Mr. Williams gave a humorous thought-provoking talk on some possible future problems for Operational Research. DR. LEROY A. BROTHERS, President of the SOCIETY, addressed the banquet briefly and reported on the progress and plans of the SOCIETY.

Five sessions of papers were held on various aspects of operations research:

A. Historical Development of Operations Research	Chairman, LINCOLN R. T. THIESMEYER Pulp & Paper Research Institute
B. Techniques and Tools in Operations Research	Chairman, GEORGE E. KIMBALL Columbia University
C. Military Operations Research	Chairman, LARRY J. HENDERSON The Rand Corporation
D. Industrial Operations Research	Chairman, M. E. BELL Sylvania Electric Products
E. Training and Organization in Operations Research	Chairman, LEROY A. BROTHERS U. S. Air Force

The last session took the form of a symposium with a round-table discussion by the speakers, followed by an open discussion.

The Program Committee consisted of:

JOHN W. ABRAMS, *Chairman*	Department of National Defence, Canada
JOHN H. MORGAN, *Program Director*	Department of National Defence, Canada
W. PETRIE	Department of National Defence, Canada
N. W. MORTON	Department of National Defence, Canada
GEORGE GLINSKI	Data Processing Associates Ltd., Ottawa
CHARLES M. MOTTLEY	U. S. Department of Defense

Thanks and appreciation are due to the following who assisted in arranging the meeting: MR. J. L. DEVONPORT, MRS. J. DAVIES, MISS FRANCES SHAW, MRS. W. PETRIE, MRS. N. W. MORTON, and MISS CAROL M. BYCROFT. Also to MISS

ORMOND of the Ottawa Tourist and Convention Bureau, who assisted in arranging sightseeing and shopping tours for wives and guests. Public relations were handled by MR. DAVID KATCHER, Public Relations Chairman of the SOCIETY, and MR. CHARLES POPE, Public Relations Officer, Canadian Defence Research Board. MESSRS. BROTHERS, WILLIAMS, ABRAMS, and other members of the SOCIETY were present for informal discussions with the press on Operations Research, its methods and its progress.

ABSTRACTS

A1. History and Development of OR in the United Kingdom, E. C. WILLIAMS, *U. K. Ministry of Defence*; HAROLD LARNDER, *Department of National Defence, Canada*, AND I. H. COLE, *Department of National Defence, Canada.*

A2. History and Development of OR in the U. S. A., RUSSELL L. ACKOFF, *Case Institute of Technology, Cleveland, Ohio.*

A3. History and Development of OR in Canada, N. W. MORTON, *Department of National Defence, Ottawa, Canada.*

B1. Decision Making in a Complex Organization, CHARLES M. MOTTLEY, *Department of Defense, Washington, D. C.* The purpose of the presentation is to focus attention on a critical problem which confronts the top management of defense organizations. In the United States the Department of Defense runs the largest business in the nation; its activities encompass a wider range than those of any other enterprise; it includes three separate operating departments, the Army, Navy and Air Force, with diverse organizations, missions and requirements; and it is administered by three sets of executives: the politically-appointed administrators, the career civilians and the professional military officers. The crucial issues facing this "team" arise from the varied and complex problems of maintaining combat ready forces under conditions of great uncertainty and at the same time creating, producing and readying the highly complex weapons systems needed to keep these forces modern and effective. The formidable "competitor" which threatens Free-World security is also modernizing his forces under the impetus of active research programs and a rapidly advancing technology. Recent appraisals of this situation have revealed that one of the greatest problems in administering the U. S. Department of Defense comes from the difficulty of obtaining complete, reliable and understandable information on which to base management decisions. It is evident that a two-fold challenge is presented, one to those skilled in the application of operations research to apply them to the problems of top management, the other to top management itself to appreciate and use these skills to a greater extent, especially for decisions involving technical matters. In order to open up this problem for study, the paper describes the relationships between the various top-management functions, discusses the principal issues involved, outlines the decision-making process and suggests a possible working model.

B2. The Application of Operations Research and Digitalized Computational Methods to Forecasting in Baseball, LAWRENCE ROSENFELD, *Melpar, Inc., Falls Church, Virginia.* During a major league season 1232 games are played involving 16 teams. Insofar as forecasting is concerned there is associated with each game g_j a gain $R_{ij} > 0$ if team t_i wins and a loss $r_{ij} < 0$ if team t_i loses. The probabilities associated with team t_i winning or losing cannot be qualitatively defined with any degree of accuracy. Therefore the question arises whether one can develop a strategy and play, i.e. forecast, in such a way as to exploit the inherent weakness that exists because there is no qualitative relationship between the return R_{ij} and the probability that the team t_i wins the j^{th} game.

An operations research method is discussed which introduces a number of parameters $\mu_1, \mu_2, \cdots, \mu_n$ which can be associated with every game. A computing code is written for the IBM 650 digital computer which examines 5 years history of games (i.e. over 6000 games) with respect to these parameters. The regression and correlation in the n variables are determined and statistical inferences are drawn, confidence limits established, and a highly successful strategy developed. Analogies to business and industrial situations are made.

B3. Electronic Data Processing Equipment for Managerial Decisions, George Glinski, *Data Processing Associates Ltd., 1313 Wellington St., Ottawa, Canada.* The paper will discuss the problems arising from the managerial decisions to acquire the electronic data processing equipment. These include: 1. the study of current methods and procedures and their adaptation to EDPE, 2. solution of suitable EDPE, 3. training of personnel for EDPE, 4. organization of EDPE facility and its integration with overall activities.

B4. An Application of Mathematical Models to Entomology, R. A. Langevin and N. J. Hopkins, *Technical Operations Incorporated, 777 14th St., Washington, D. C.* Entomological literature is replete with experimental data of the most varied kind. It is, however, surprising to find that mathematical models have seldom been used to provide a theoretical framework around which the experimental data can be organized. In the present paper a modified, one-dimensional diffusion theory is used to study the migration of insects. Expressions are derived for the dependence of the migration velocity on the initial distribution of insects and food supply for a number of cases of interest. Some consideration is given to the extension of the model to include the effects of insect reproduction. Suggestions are made for the practical application of the results in the control of economically-important insect pests.

B5. The Solution of the Single-Step Queuing Equation for a General Class of Time-Dependant Coefficients, George Luchak, *Department of National Defence, Defence Research Board, Suffield Experimental Station, Ralston, Alberta, Canada.* The single-step queuing equation considered in this paper is characterized by an exponential-time service facility of mean service rate $\mu(t)$ and by a Poisson distributed arrival rate $\lambda(t)$. The solution of the equation is obtained for the case in which the utilization factor $\rho(t) = \lambda(t)/\mu(t)$ is a continuous function of time and possesses continuous derivatives of all orders. The method of solution is applied to several examples including the problem for which ρ is a constant in which case the method produces, in closed form, the solution which has recently appeared in the literature.

C1. The Measurement of Leadtimes, Richard B. Foster, *Stanford Research Institute, Economics Division, Menlo Park, California.* The prediction of the future availability of complex weapons systems is an increasingly critical problem. The long leadtimes from R&D to operational status; the relatively high cost of the systems; the rapid changes in technology and in the threat imposed by a growing enemy capability have made it both necessary and desirable to replace intuitive guesses with more exact measures of availability.

Previous papers* have discussed the nature of strategic decisions viewed as a dy-

* Richard B. Foster and Francis P. Hoeber, "Cost-Effectiveness Analysis for Strategic Decisions," an invited paper for the Symposium on Problems and Methods in Military Operations Research, Seventh National Meeting of ORSA, Los Angeles,

namic series over time. Before a measurement of leadtimes is possible, a framework for availability solutions must be laid out, and a systematic set of assumptions must be arrived at. The sequence for solution implies at least the following considerations:

1. A defined time-frame with future limits must be laid out;
2. The level of sub-optimization must be exactly defined;
3. The national state(s) of urgency must be explored;
4. A "boundary solution" of effectiveness yielding quantities of alternate weapons systems required for various levels of defense must be made;
5. A key strategic decision date must be postulated;
6. Time phases of the weapons schedule must be defined;
7. Finally, a cost chart of accounts correlated with the time phases must be arrived at.

Within the above framework, a selection of those "schedule-limiting" components of the system can be made; the critical problem areas can be delineated (e.g., reliability); and the expansibility of sources of production and personnel training establishments can be determined. The leadtimes are then measured from a series of assumed dates: the decision date; or a following military "obligation date." The leadtimes can be classified according to the phases of development of a weapons system. The entire process of time phasing must be examined. A summary classification of this process is as follows:

1. Development
   a. Technical Feasibility study
   b. Component development and test
   c. System design
   d. System prototype construction
   e. System demonstration
   f. System evaluation
2. Production
   a. Pre-production engineering specifications
   b. Pre-production engineering design
   c. Pre-production tooling
   d. Production work in process (flowtime) to first unit
   e. Time to rate of production
3. Deployment
   a. Site preparation and construction (if necessary)
   b. Tech manuals and training aids
   c. Training establishment construction and activation
   d. Unit activation and training
   e. Shipment and installation of the defined "force unit" equipment
   f. Operational status of the first force unit
   g. Time to rate of deployment of operational units

These phases are correlated with program cost chart of accounts, and a total program cost is arrived at from the decision date forward. These costs are then distributed on an annual basis as rates of expenditure. A test for feasibility of the schedule is the realism of the early rates of expenditure; i.e., can the rates of expenditure for a particular phase of the schedule, such as production engineering, be achieved? Finally, the annual rates of expenditure are plotted cumulatively over time, and the leadtimes between the required rate of expenditure; the rate of obligation; and the rate of funding are derived from historical analysis as a further test of feasibility. The leadtimes for any given fiscal year funding requirements necessary to support the annual expenditure rate, which latter in turn is keyed to an output of a given quantity of the weapons system at a predetermined rate of production and deployment is considered.

Thus leadtimes are of various kinds—schedule phases, annual funding, annual

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California, August 15, 1955; and Francis P. Hoeber and Alvin Karchere, *J. Opns. Res. Soc. Am.* 2, 306–315 (1954).

expenditures, and the phasing of available production units with operational force unit deployment. Each must be determined in accordance with its own requirements; and each must be defined within a framework of carefully delineated assumptions and ground rules.

C2. Optimum Ammunition Properties for Salvos, DR. JOHN E. WALSH, *Lockheed Aircraft Corporation, California Division, Burbank, California.* Let us consider a salvo of ammunition rounds with common aiming point which are fired at a specified target. These rounds have the same arbitrary but fixed hit location probability density function and, for given aiming error, are statistically independent. The aiming error has a specified probability density function which can be of any type. The given round lethality and target properties can be of any nature such that cumulative damage can be neglected. An easily applied method of determining the largest salvo kill probability attainable by optimum choice of the round hit location probability distribution is presented. This method furnishes a basis for determining the optimum form of the round hit location probability distribution. This ideal form provides a guide for use in development of optimum ammunition properties for the situation considered. The results derived also can be used to examine the effects on salvo kill probability of: changes in target vulnerability and shape, variation in salvo size, the form of the fire control error probability distribution, various types of target manoeuvre, etc.

C3. Reliability Concepts in Guided Missiles Performance, STEPHEN WALDRON, *Operations Evaluation Group, OCNR(OPO3EG), Navy Department, Washington 25, D. C.* Much thought and effort is being applied to increase the reliability of permanent electronic equipment such as communications sets and radar. This paper considers those aspects of the reliability program which are applicable to *expendable* electronic apparatus such as guided missiles. An example is given in which the reliability of a given missile in simulated combat trials was consciously reduced in order to increase future reliability. The implications of this "trade" are drawn for actual combat use of guided missiles.

C4. A Rationale for Operational Gaming, NICHOLAS M. SMITH, JR., *Operations Research Office, JHU, 7100 Connecticut Ave., Chevy Chase 15, Md.* There are so many and so divergent opinions as to the efficacy of operational gaming as a rational tool for arriving at decisions that it is felt that a clear statement of a rationale for such gaming is needed. This paper attempts to do so.

A game, military or otherwise, consists of a "model" composed of (sometimes "aggregated") constructs together with the rules for the interactions of these constructs. Operational games should be designed for a specific purpose—that is, to solve a specific decision problem which is narrowed as much as possible in scope. *This particular decision problem then serves as the fundamental criterion for the adequacy of the game model, the aggregations and the rules for interaction.* This viewpoint is the core of the rationale presented here and is supported by an analysis of the model, the aggregations, the interaction and the relationship between games at various levels of synthesis. Too often such a specific decision problem is unstated, hence every critic judges the game by problems he, personally, has in mind. In this situation the very same game may appear as good and adequate to some critics, and as completely valueless to others—i.e., its results may apply to some decisions and not to others. An analytical procedure exists for determination of "adequacy" with respect to the particular decision problem.

The game payoff is given separate consideration. Five basic postulates lead to a definite rationale for the determination of game payoffs through the design of separate games for this purpose. Here, again, the particular decision problem faced serves as a fundamental criterion for adequacy.

C5. A Pattern Bombing Problem, George Shapiro, *Westinghouse Electric Corp., Baltimore, Maryland.* A salvo of N/n bomb groups is considered. Each group consists of n bombs independently and randomly distributed on a circle of fixed radius. The centers of the circles are determined by independent, through identical normal distributions about one point, the aim point. This point, while fixed for any one salvo is normally distributed about the target center when many engagements are considered. The bomb-target vulnerability is such that a bomb exploding at a distance R from the center of the target has a probability exp $(-R_2/R_T^2)$ of killing the target. (R_T is a parameter related to target "size".) Assuming that damage is non-cumulative and that the average kill probability of a bomb group is small, the expected number of lethal hits resulting from a salvo of given aiming error is determined in closed form. The result indicates that the number of lethal hits does not depend on the number of bomb groups and the number of bombs per group, but only on N, the total number of bombs. Using the Poisson relation the overall salvo kill probability may be obtained by a numerical integration. Under certain conditions the numerical integration may be avoided and the result obtained in closed form.

D1. A Graphical Solution of the Transportation Problem, Marcello L. Vidale, *Arthur D. Little, Inc., 30 Memorial Drive, Cambridge 42, Mass.* This paper will describe a simple graphical technique applicable to a variety of transportation problems involving a large number of production centers and market areas. The assumption is made that transportation costs are monotonically increasing as one moves out from a given production center but the rate of increase need not be constant or uniform in all directions. Some applications of this technique to specific operations research problems will be discussed.

D2. An Imperial Oil Research Service Station for Marketing Experimentation, R. A. McDougall, *Imperial Oil Ltd., 56 Church St., Toronto, Ontario, Canada.* Operations Research in Marketing is most often characterized by the multiplicity of interactions involved in the required models. Marketing Research studies have concentrated on describing marketing situations as they exist. Imperial visualizes the Research Station as a manipulative tool through which deeper insight into the human and operative factors involved will permit a determination of the fundamental variables of marketing systems. Actual operation of a limited facility began a few months ago. This paper describes the planning of the project, some of the experiments carried out to date, and the relationship of other studies to the Research Station project.

D3. Three Applications of Operations Research in a Large Electric Utility, Peter J. Sandiford, *The Hydro-Electric Power Commission of Ontario, 620 University Ave., Toronto 2, Ontario, Canada.* The studies described are (1) the development of a system for forecasting daily peak loads up to 24 hours in advance, based on a new model of load behaviour, whose input is a normal weather forecast and whose output has a median error of one per cent; (2) the development of a "self-correcting" system for estimating up to 12 months in advance the future monthly mean levels of Lake Erie which control the flow available for power generation at Niagara Falls; (3) the development of a method for determining the optimum replacement point for trucks in a large fleet under changing economic conditions.

D4. Statistical Methods in Activity Areas of Production and Costs as They Relate to Forward Planning and Follow-Up Control, Mr. E. E. Sorensen, *British American Oil Co. Ltd., Toronto, Ontario, Canada.* The speaker will show the applicability of various statistical techniques such as multi-dimensional correlation to attainment of control on forward optimized plans regarding activities within a system such as a plant. Optimization to be achieved with linear programming and the execution of plan to be measured and controlled with the help of control chart techniques in areas such as cost and production. It will then be shown that these charts will feed back information to mathematical planning functions to correct for changes in plant equipment, changes in methods, etc. which will modify the functional correlations developed initially. The whole procedure is what is referred to within modern thinking as the management information servo loop. These principles are present in various stages of development within the Manufacturing Department of our Company.

D5. A Short Survey of Non-Linear Pricing Forms, John Alden Bliss, *Transportation Economist, East Greenbush, New York.* Since the principal developers and users of non-linear pricing forms have been electric power companies most of the illustrations and the comparisons of one device with another are from this field. The scattered uses in other areas are less systematic and less easily identified, but numerous important examples exist.

Non-linear pricing developments in electricity supply have been closely associated with cost-determination and cost-optimization. It may be that the greatest immediate field for extending non-linear pricing techniques will be in intra-company "pricing" for control purposes because of their power in reconciling sub-optimizations.

Use of the systematic electric terminology is hardly necessary for such a development, which will be inspired from several directions if it is indeed sound, but may facilitate progress.

E1. On-the-Job Training for Operations Research, Joseph F. McCloskey, *Operations Research Office, The Johns Hopkins University, Chevy Chase, Maryland.*

E2. University Training for Operations Research, E. Leonard Arnoff, *Case Institute of Technology, Cleveland, Ohio.*

E3. Organization for Industrial Operations Research, Glen D. Camp, *Melpar Inc., Alexandria, Virginia.*

E4. Organization for Military Operational Research, W. Petrie, *Department of National Defence, Ottawa, Canada.*

AUTHOR INDEX BY ABSTRACT NUMBER

Note: Copies of the above papers are not available either through the Society or the Journal. Persons interested in obtaining copies of the papers presented should contact the authors directly.