



Operations Research

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Operations-Research Services

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With 12,500 members from nearly 90 countries, INFORMS is the largest international association of operations research (O.R.) and analytics professionals and students. INFORMS provides unique networking and learning opportunities for individual professionals, and organizations of all types and sizes, to better understand and use O.R. and analytics tools and methods to transform strategic visions and achieve better outcomes. For more information on INFORMS, its publications, membership, or meetings visit <http://www.informs.org>

$$P_i = \frac{1}{8} [K (SMAU_i) + LFWU_i + PFWU_i - ASP_i - EIP_i], \quad (11)$$

and K is given by (12), where TP is the total production on a weekly basis

$$K = [8 TP - \sum LFWU_i - \sum PFWU_i + \sum ASP_i + \sum EIP_i] / \sum SMAU_i, \quad (12)$$

The calculation is performed by adding the terms of equation (12) to find K , then calculating the individual productions from (11). This calculation is made weekly. The procedure requires perhaps a day's work by a clerk.

Recently a policy change was made that in effect implied that the total stock must be constant. This restriction can be introduced easily. The total stock in the future is the total stock now plus the future production less the future use

$$TSF = TSN + FP - FU = C, \quad (13)$$

so that the future production is no longer arbitrary, but

$$FP = C - TSN + FU \quad (14)$$

The equation (10) for K then becomes

$$K = [2(C - TSN + FU) - \sum FO_i - \sum MEU_i + \sum ASP_i + \sum EIP_i] / \sum VU_i$$

The individual production equations are unchanged

OPERATIONS-RESEARCH SERVICES

ON MARCH 15, 1956, the following letter was sent to some fifteen organizations believed to be offering industrial operations-research services and not a part of educational institutions

'Management's Corner' in OPERATIONS RESEARCH *The Journal of the Operations Research Society of America* is going to run a series of brief accounts of agencies providing operations-research services. These accounts are to be factual rather than propagandistic. They are intended to provide management with information rather than stimulation. I would like to obtain from you or someone in your group a write-up, not to exceed four double-spaced typewritten pages, in which the following questions are answered (in any order you desire)

1. When did you start to offer operations-research services?
2. What type of services do you offer?
3. What facilities do you have?
4. How many and what kind of people?
5. Names of your principal personnel
6. Types of problems you have worked on, together with names of sponsors or customers when possible
7. Geographical area of operations (restrictions, if any)
8. Publications
9. How to get further information

To date, six replies have been received, these replies are published below. Replies from other organizations will be printed in later issues of Management's Corner. If any organizations have been overlooked in sending out these letters, similar information from such organizations will be welcomed.

The operations-research services offered by groups in educational institutions will be described in a later series of articles that will also include information on educational opportunities.

R L A

ALDERSON AND SESSIONS

Philadelphia, Pennsylvania

ALDERSON AND SESSIONS was among the first private consulting firms to manifest an interest in operations research. Its interest in the area extends back to about 1950. Explicit public announcement of the availability of such services occurred in the middle of 1952. Since then the techniques have been employed wherever they offered promise of advancing the investigation of client problems.

Alderson and Sessions describes itself as a firm offering marketing and management counsel. It is prepared to investigate any problems in this broad area except those which are purely engineering matters. Rather than investigating isolated segments, the firm prefers to conduct an over-all examination of a client's problem area. This includes examination and where necessary collection of data, thorough analysis of the problem, and the formulation of appropriate policy recommendations. In many cases Alderson and Sessions has subsequently collaborated with the client in putting its recommendations into action.

Among the services offered are the formulation of mathematical analysis of operational problems wherever these methods are appropriate and the training of client personnel in the use of mathematical techniques. Other services include the collection of marketing information by consumer surveys, further investigation by means of the more intensive depth interview and consumer experimental clinics, forecasting, evaluation of client organizational structures, etc. In addition, as part of its basic research program the firm has conducted pioneering research in several OR areas as part of its continuing effort to be, and remain, a leader in the field.

A fundamental point in the firm's philosophy and practice is that operations research is not an isolated and esoteric body of method to be employed only by itself and only on problems which clearly bear the OR label. Rather the analysis of almost any problem can profit from the application of systematic techniques which may easily be classified as OR methods. Moreover these methods can be used most effectively not by themselves but in conjunction with the other tools of market analysis.

The Philadelphia offices of Alderson and Sessions contain a growing OR library.

There are specially designed facilities for the conduct of consumer experimental clinics, in which are gathered many of the data employed in the OR analyses. There are also well-established contacts with leading computational services who can conduct whatever computational work is required by client problems.

The staff of Alderson and Sessions contains a group of trained investigators. WROE ALDERSON, one of the firm's senior partners, was one of the earliest marketing men to become aware of the importance of and to keep himself abreast of the new OR techniques. Our leading analysts in the field include MICHAEL HALBERT (now on leave with the Operations Research Group at the Case Institute of Technology), EDWARD IDE, the firm's director of planning, KENNETH MIDDLETON, its principal statistician, JACK MURRAY, chief of industrial analysis, and WILLIAM BAUMOL, who also teaches mathematical economics at Princeton University. In addition we have a number of top analysts in closely related fields and a statistical computing staff. To assure further the quality of its services, Alderson and Sessions retains leading authorities in the field on a consulting basis.

Types of problems worked on have included, among many others, inventory control, market forecasting, new-product testing, location problems, pricing, advertising and promotional budget allocation, and line simplification.

Alderson and Sessions regularly conducts operations in any area within the continental limits of the United States. Large- and small-scale investigations have also been conducted in Central and South America and in Canada, and the firm maintains a branch office in Mexico City.

Cost and Profit Outlook is a monthly publication of Alderson and Sessions which is available on request. Past articles of particular relevance to operations research include Operations Research in Marketing, Operations Research and Management Problems, The Motivation of Consumer Buying, Buying Motives and Consumer Shopping, Experimental Methods in Motivation Research, Systems and Models in Operations Research, Development and Use of Models in Operations Research, Selecting an Appropriate Model for an Operations-Research Problem, and Statistical Forecasting and Operations Research. Many of these articles describe the results of the Alderson and Sessions Basic Research Program in which the firm has sought to make its contribution to the advancement of research techniques. The others are expository articles designed to explain the methods of operations research, the types of problems to which they have been applied, and the ways in which the businessman can use and benefit from OR. More articles in this series are in preparation. There have also been many relevant articles in other publications, including leading technical journals, by individual members of the firm.

Further information can be obtained by writing to Alderson and Sessions, 3 Penn Center Plaza, Philadelphia, Pennsylvania.

DUNLAP AND ASSOCIATES, INCORPORATED

Stamford, Connecticut

DUNLAP AND ASSOCIATES, INC is a contract research organization furnishing its services to government and industry. The company was

founded in 1948 and shortly thereafter began providing Operations Research services. In addition, the company also provides services in Systems Analysis, Human Engineering, Economic Analysis, Production Engineering, Personnel Management, and Motivation Research.

At present, the staff consists of 57 persons of whom 42 are employed in research capacities. Their training includes advanced degrees in the following studies: Industrial Psychology, Experimental Psychology, Social Psychology, Clinical Psychology, Chemical Engineering, Industrial Engineering, Mechanical Engineering, Electrical Engineering, Economics, Mathematical Statistics, Psychological Statistics, Mathematics, Meteorology, Biology, and Agronomy.

The organization is located at Stamford, Connecticut, 45 minutes from New York City. Its physical facilities include conference rooms, private offices, an extensive technical library, and computational equipment.

Dunlap and Associates, Inc., has employed operations-research methods and procedures for the evaluation of alternatives and for operations design in the following areas of business and industry: Accident Prevention (Industrial, Highway), High-Speed Data Processing Systems, Strip Mining, Acquisition of Ore Reserves, Supermarket Operation, Truck Loading and Scheduling, Inventory Control, Production Balancing, and Moving-Stairway Operations.

The highway accident prevention study was formulated as a problem on providing information for highway administrators. One of the administrators' problems is the isolation of those highway sections which are more dangerous than others. A method for assessing the risk on each section was developed from accident and traffic data. The method provides for drawing conclusions with known degrees of confidence and has been applied for three successive years on a major highway system. It has shown almost perfect reliability.

The primary purpose of one industrial accident study was to find means of evaluating the effectiveness of the various parts of safety campaigns. The procedure consisted of developing information about alternative measures of effectiveness, developing new measures and techniques, implementing them, and training management personnel to use them. These procedures are now being installed in five plants for the purpose of developing a catalogue of effective accident prevention measures.

In military areas, we have studied Environmental Analysis of Equipment, Logistics, Anti-Submarine Warfare (Airships, Aircraft, Ships, Submarines), Ground Observer Systems, Minesweeping, Anti-Aircraft Fire Control Systems, Missile Systems, and Communication Systems.

The environmental study had the purpose of aiding Army planners in determining the feasibility of various campaigns, the needs for research and development, and the desirability of new test programs, in connection with the effects of environment on military equipment of all kinds. Military equipment is complex, and covers a very wide gamut of mechanical, optical, explosive, and electronic devices. These are affected by environment in complex and variable ways. A need exists for collecting and storing information on environmental effects, in a form capable of giving planners rapid access to data in the detail they need for various purposes.

The first task was to determine exactly what information was needed by various agencies for various purposes. The second was to develop means of quantifying those aspects of environment which affect military equipment. The third was to obtain information on the reactions of items of equipment to the environmental factors, and the final task to incorporate both into a system with the required rapid access and other characteristics. A prototype system has now been built, and was tested on Army maneuvers in Louisiana in the fall, and Alaska during the winter with a considerable measure of success.

Some of the company's clients prefer that work performed for them be held as private information. Consequently, only a partial list of clients can be given as follows: U S Navy (many bureaus and branches), U S Air Force, U S Army, International Minerals and Chemicals, Inc., Radio Corporation of America, and Raytheon Manufacturing Company.

Articles published in recent months about the company's work include the following:

JACK W DUNLAP AND HERBERT H JACOBS, "Strip Mining Phosphate Rock with Large Walking Draglines—A Problem in Operations Research," *Operations Research*, vol 3, February 1955

THOMAS M WARE, "Operations Research and the Mine of Tomorrow," *Engineering and Mining Journal*, August 1955

JACK W DUNLAP AND HERBERT H JACOBS, "How Operations Research Solved the Dragline Problem," *Engineering and Mining Journal*, August 1955

HERBERT H JACOBS, ROBERT J SCHREIBER, AND SEBASTIAN B LITTAUER, "Mathematical, Psychological, and Engineering Aspects of Accident Phenomena," *Transactions of the New York Academy of Sciences*, vol 18, January 1956

HERBERT SOLOW, "Operations Research Is in Business," *Fortune*, February 1956

HERBERT H JACOBS, "Principles of Operations Research and Applications to Mining," *Seventeenth Annual Mining Symposium*, University of Minnesota, January 1956

HERBERT H JACOBS, "Principles of Operations Research," *Eleventh Annual S A M -A S M E Management Engineering Conference*, April 1956

Reprints of these and other articles are available upon request.

Almost all staff members have been associated with one or more of the operations-research studies. Those most active in this work include JACK W DUNLAP, KENNETH W YARNOLD, HERBERT H JACOBS, GERSHON COOPER, FRANK M CULPEPPER, and ROBERT J SCHREIBER. Other staff members support them in specific areas of research.

All of the company's studies are performed cooperatively with the sponsoring organization. Problem definition, formulation, data collection, and analysis all draw on the intensive experience of operating personnel. None of the company's work is done in isolation from the sponsors. There are no geographical restrictions on the company's operations.

For further information, contact Dunlap and Associates, Inc., at 429 Atlantic Street, Stamford, Connecticut.

MIDWEST RESEARCH INSTITUTE

Kansas City, Missouri •

MIDWEST RESEARCH INSTITUTE offers complete research and development service in some twenty major fields of science. Its staff of 250 people, of whom 195 are technically trained, conducts work in the following major divisions: Applied Physics, Engineering, Chemistry, Chemical Engineering, and Industrial Economics.

The Institute began operating in the field of Operations Research as early as July of 1952. At that time this work was carried on where needed within the five major divisions. In August of 1955 an Operations Research Section was formally organized as part of the Applied Physics Division. Whenever the requirements of a project warrant, personnel from any of the other divisions may be employed on an operations-research project. Those groups that are most frequently consulted in this connection are the Mathematical Analysis Section, the Computing Services Section, and the Industrial Economics Division.

The Mathematical Analysis Section provides desk-calculator service for cases in which machine calculations are not practical. For larger jobs, the Institute has an IBM Card Programmed Calculator, and several analog computers, including a McIlroy Network Analyser and a GEDA Computer.

General direction of the Institute's work in operations research is by Dr. SHELDON L. LEVY, Manager of the Applied Physics Division. Specific supervision of this work is by TAGE A. MORTENSEN, Head of the Operations Research Section. Other staff members who are directly involved in this activity are L. D. FINDLEY, Head of the Computing Center, YUDELL L. LUKE, Head of the Mathematical Analysis Section, A. D. ST. JOHN, S. M. ZIVI, W. T. KOPP, BERNDT KOLKER, R. A. BEEBEE, JR., W. L. RUTHERFORD, and P. C. CONSTANT, JR.

Following are brief descriptions of typical projects in the operations-research field on which the Institute has worked:

SCHEDULING of batched operations in a pipe-line network so as to deliver about eight grades at each of some twelve terminals in accordance with given demands.

SIMPLIFICATION AND MECHANIZATION of data handling in connection with service-order procedures. This involved analysis of present service-order procedures, analysis of causes for errors occurring in the present system, considerations of modifications to the manual system, and consideration of an automatic data-processing system.

FORMULATION of optimum inventory policies for a mail-order house, including analysis of samples of past sales data to determine patterns, formulation of a mathematical order policy based on these data, and application of this policy to other data to test the proposed policy.

AN EXPLORATORY STUDY to determine whether operations-research techniques are applicable for a given chemical company, particularly with regard to inventory and production scheduling.

OPTIMUM DESIGN of traffic counts in rural areas adjacent to a city A tentative model of traffic patterns has been formulated and will be used to predict traffic densities from limited sample counts at roads and streets. The ultimate purpose of the project is to establish the need for, and layout of, additional road construction

A STUDY to develop means of automating truck loading and predicting the adequacy of terminal facilities

A STUDY of the application of electronic data-processing equipment to reservation and ticketing operations

A STUDY of queuing at pipe-line terminals offering additive service

Since all research at Midwest is done on a confidential basis, no identification of sponsors can be made in connection with these projects. However, the Institute has conducted research projects for over 750 sponsors in this country and abroad.

Articles concerning work in this field which are available are "Operations Research Scientific Approach to Management," by MARTIN GOLAND AND ERNEST KOENIGSBERG, *Chemical Week*, May 21, 1955, and "Queuing with Special Service," by ERNEST KOENIGSBERG, *Operations Research*, April 1956.

For further information contact DR. SHELDON L. LEVY, Manager, Applied Physics Division, Midwest Research Institute, 425 Volker Boulevard, Kansas City 10, Missouri.

OPSEARCH ASSOCIATES

Cuyahoga Falls, Ohio

OPSEARCH ASSOCIATES is a new organization, founded in 1955, and the first such organization located in Akron. It is prepared to undertake the full range of operations-research work, and will contract to do research with its own personnel, to conduct research with a mixed group of its own personnel and company personnel, or to provide consultants to work with company personnel. It will conduct surveys and undertake computational problems in connection with operations-research undertakings, and insofar as this service does not conflict with its primary purpose, it will perform these services on direct contract.

During the early days of its existence, the organization feels it desirable to restrict its geographical area to Ohio and adjacent states, except as special circumstances may justify a relaxation of this restriction.

Opsearch Associates has three Senior Associates, a large staff of Consultants, and junior personnel. The Senior Associates are DR. LAURENCE J. LAFLEUR, *Director*, Head of the Department of Philosophy, University of Akron, DR. SAMUEL SELBY, Head of the Department of Mathematics and Chairman of the Natural Sciences Division of the University of Akron, and DR. LOUIS ROSS, Associate Professor of Mathematics at the University of Akron.

Further information can be obtained from Opsearch Associates, 2995 Overlook Road, S. L. V., Cuyahoga Falls, Ohio.

THE RAMO-WOOLDRIDGE CORPORATION*Los Angeles, California •*

THE RAMO-WOOLDRIDGE CORPORATION has been in business now for about two years and we offer management consulting services in quantitative types of business problems. We have a strong interest in the application of electronic computers to business and therefore we place particular emphasis on this field. However, we do not limit our services to the application of electronic computers to business and industry. We are also emphasizing the use of operations-research techniques in the solution of managerial problems.

Some of the most important areas in which we have been doing work are as follows: Production Control, Inventory Control, Cost Accounting, Banking, Public Utilities, Transportation Industry.

Our clients are in many fields of business and industry, and include such firms as Thompson Products in Cleveland and Bankers Trust Company in New York City. In addition, we do work for our own company.

As far as the geographical location of our services is concerned, we have no particular restriction here, though so far most of our clients are in the eastern part of the United States. At the present time we have no clients outside of the United States.

Our staff has published some 10 papers in the fields of management sciences.

For further information, contact ANDREW VAZSONYI, Head of the Management Sciences Department, Computer Systems Division, The Ramo-Wooldrige Corporation, 8820 Bellanca Avenue, Los Angeles 45, California.

STANFORD RESEARCH INSTITUTE*Menlo Park, California*

STANFORD RESEARCH INSTITUTE has been engaged in operations research for over eight years, but until 1954 this activity was confined to military problems. In that year, the Institute established a program of operations research for industry and since then a number of projects have been undertaken. The usual mode of operation is a cooperative one in which representatives of the client company join members of the operations-research staff of the Institute for the duration of the project. This plan of joint participation has greatly facilitated the collection of data and communication of results within the company concerned and has helped in implementation of research results, it has also led to the formation of permanent operations-research groups in some of the companies concerned, with the company representatives on the original research team forming the nucleus of the permanent group.

The following operations-research projects are among those undertaken by the Institute:

1. A warehouse distribution problem involving central-plus-branch warehouse operations for W. P. Fuller and Company.

2. Effective layout and utilization of office space for the Southern Pacific Company
3. Inventory control in material supply operations for the Southern Pacific Company
4. Distribution of empty freight cars for the Southern Pacific Company
5. Optimum relationship of supply, sales, and storage of natural gas for the Southern California Gas Company and the Southern Counties Gas Company
6. Inventory control and production scheduling of certain materials for the General Petroleum Corporation
7. An inventory control, production scheduling, and data-processing study for the Crown Zellerbach Corporation
8. A warehouse and inventory-control problem for the Hawaiian Pineapple Company, Limited
9. A study of optimum location of egg-processing plants for the Poultry Producers of Central California
10. Inventory control and production scheduling for the Dinnerware Division of Gladding McBean Company
11. Forecast of catch and determination of optimum scheduling of fishing fleet operations for Star-Kist Foods, Incorporated

In addition to these industrial projects the Institute has continued working on military and other operations-research problems for the government. Such problems have included economic model building for war gaming, economic-vulnerability studies relating to industrial and civil defense, weapons-evaluation and cost-effectiveness studies, analysis of feasibility, availability, and phasing in research and development programs, studies of logistics support and mobility. Agencies or departments for which such work has been performed include the Air Force, the Army, the Navy, the Office of the Secretary of Defense, Office of Defense Mobilization, Federal Civil Defense Administration, Atomic Energy Commission, The Rand Corporation, and the Operations Research Office of The Johns Hopkins University.

Operations-research projects are conducted in the Institute offices at Menlo Park, California (headquarters), and in permanent branch offices in Los Angeles, Washington, D. C., Honolulu, Phoenix, and Portland, Oregon.

While a majority of clients are located in the western states, the Institute also serves clients throughout the United States and in several foreign countries.

The Institute shares an IBM 650 Computer with Stanford University at favorable academic rates. Use of this facility for simulation or other numerical investigations has been supplemented when necessary by recourse to larger computers available in Los Angeles, San Francisco, and New York service bureaus. The Stanford University library is also available to the Institute, and members of the University faculty are available for consultation.

The staff engaged in military and industrial operations research numbers from 40 to 60 professional personnel, with about one-third working on industrial problems. This staff includes operations-research and data-processing specialists, as well as mathematicians, statisticians, industrial engineers, psychologists, and

economists The Economics Research Division, to which the operations-research groups are attached, has a total of 270 persons including 186 professional personnel all engaged in applied economic research on problems such as marketing research, plant location, area development, product diversification, product application and feasibility, data processing, and research in the behavioral sciences The Engineering Division of the Institute undertakes systems analyses of communication and detection equipment, as well as other aspects of military electronics, and collaborates with the Economics Division in operations-research work relating to such electronic systems

Publications by members of the staff on operations-research problems include

Analogue Computations of Business Decisions, by WILLIAM R FAIR, *Operations Research*, vol 1, August 1953

A Note on Amusement Park Economics, by WILLIAM J PLATT, *Operations Research*, vol 3, February 1955

A BASIS for Strategic Decisions in Inventory Control Operations, by GEORGE J FEENEY, *Management Science*, vol 2, October 1955

Cost-Effectiveness Analysis for Strategic Decisions, by RICHARD B FOSTER AND FRANCIS P HOEBER (of the Operations Research Office of The Johns Hopkins University), *Operations Research*, vol 3, November 1955

A Review of Ronald W Shephard's Cost and Production Functions, by FRANCIS W DRESCH, *Operations Research*, vol 1, November 1953

Inventory Fluctuations in Flaxseed and Linseed Oil, 1926-1939, by STEPHEN G ALLEN, *Econometrica*, vol 22, July 1956

Waiting Lines in Office Operations, by GEORGE J FEENEY, *Systems and Procedures Quarterly*, vol 7, February 1956

Professional personnel engaged in operations research include the following

S G ALLEN	D M FINNIGAN	W J PLATT
M S BLUMBERG	E C FOLLETT	D R SCHEUCH
H M BRIDGEMAN	R B FOSTER	R O SHREVE
BONNAR BROWN	R A HARKER	F L STAFFANSON
P H BUTTERFIELD	C D HENDERSON	P D TILTON
R S CANNELL	GEORGE HOPKINS	R E UTMAN
F W DRESCH	E J ISAAC	W L WHITE
A R EAGLE	L J LOW	G S WILEY
W R FAIR	E J MOORE	W L WITTIG
G J FEENEY	H C NIELSON	

Further information may be obtained from WILLIAM J PLATT, Assistant Director of Economics Research, or from GEORGE FEENEY, Manager of Industrial Operations Research