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THE HISTORY OF THE CASE INSTITUTE OPERATIONS RESEARCH GROUP

by

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In the early part of 1951 there occurred at Case Institute of Technology two independent events which were to lead to the establishment of the first academically seated Operations Research Group in the world. The first event consisted of an offer made to Case by John E. Kusik, Vice President of Finance of the Chesapeake and Ohio Railway Company. Mr. Kusik offered to support a Professorship in Operations Research if part of that Professor's time were available to the C.& O. for consultation. Dr. Elmer Hutchisson, then acting President of Case, discussed this possibility with several departmental chairmen and decided to locate this professorship in the newest department on campus, the Department of Engineering Administration. The chairman of this department, Clay H. Hollister, was very anxious to explore the implications of Operations Research for industrial management and education.

The second event consisted of the granting to Case of a research and development contract by the U.S. Air Force. This led, in June of 1951, to the establishment of a research unit, Project Doan Brook. Its director, Professor Stuart P. Cooke, in planning for his staff, felt the need of an Operations Research Group. While part-time aid of several members of the Case faculty who had previous experience in military operations research was obtained, Professor Cooke also sought a small full-time staff in this area.

These two events led to the appointment of Dr. C. West Churchman to the Professorship in the Engineering Administration Department, and Dr. Russell L. Ackoff as a Research Associate on Project Doan Brook.

Because of their continuous association over a ten year period before coming to Case, Churchman and Ackoff, although in different administrative units at Case, began at once to plan activities which would lead to the establishment of Case as a center of industrial operations research activities. In this they were enthusiastically supported by Professor Hollister and Acting President Hutchisson. In November of 1951, Case held a three day conference entitled "Operations Research in Business and Industry." This was the first conference in the U.S.A. to bring industrial managers and operations researchers together to explore the possibility of applying OR in this area. The conference was attended by about 150 industrial managers, who made of it a most successful meeting.

Plans were developed for a two week short-course in Operations Research to be conducted in June 1952. This course was designed to provide a short intensive training program in Operations Research with emphasis on applications to business and industry. The limit of 50 registrants was quickly reached. The teaching staff consisted of Case personnel and a number of experts from other organizations. A detailed outline of the course was developed which, over a five year period, was developed into the form in which it was eventually published: Introduction to Operations Research by C. West Churchman, Russell L. Ackoff, and E. Leonard Arnoff (John Wiley and Sons, Inc., New York, 1957).

By June of 1952, the work at the Chesapeake and Ohio Railway Company had led to the development of a full scale OR project directed toward improvement of clerical operations involved in the division of revenues of interline less-than-carload shipments. Additionally,

another Cleveland organization, The Warner and Swasey Co., one of the world's leading manufacturers of machine tools, indicated an interest in having Case perform some operations research in the area of production and inventory control. At this point, Ackoff was transferred from Project Doan Brook to the Engineering Administration Department and Dr. Walter R. Van Voorhis, Professor (now chairman of the department) of Mathematics at Fenn College in Cleveland, came to Case on a year's leave of absence. Thus, in July of 1952, the Operations Research Group consisting of three people was formed at Case under the directorship of C. West Churchman.

The expansion and development of this group has been continuous since then. In 1954, Churchman resigned his directorship to increase his teaching activities and Ackoff assumed this position. In 1954, Dr. E. Leonard Arnoff, who in 1952 had come to the group from the National Advisory Committee for Aeronautics, was named assistant director. At the time of this writing the group has a staff of thirty.

Since its inception the Group has been interdisciplinary in character. This is best illustrated by the current composition of the Group: 7 Mathematicians, 3 Statisticians, 1 Physicist, 1 Chemist, 2 Psychologists, 2 Mathematical Economists, 3 Philosophers of Science, 1 Mechanical Engineer, 4 Industrial Engineers, 4 Chemical Engineers, 1 Market Analyst, and 1 Operations Researcher (Case Graduate).

Additionally, in the past, the Group has had the following disciplines represented: Electrical Engineering, Sociology, History of Science, Law, and Engineering Administration.

The activities of the group have fallen into three major areas:

education, research, and communication: The development of each of these activities will be considered in turn:

EDUCATION

Education in operations research at Case Institute was formalized in 1952 by the creation of the Operations Research Group. Since that time, the Operations Research Group at Case has pioneered in the education of practitioners and consumers of operations research. The OR educational program has been steadily expanded to the present level which includes:

1. An undergraduate curriculum in Management Science.

2. Graduate curricula in Operations Research leading to the M.S. and Ph.D. degrees.

3. Noncurricular Short Courses in Operations Research, both general and technical.

4. A 4-month special program in Operations Research.

5. On-the-job training for both curricular students and industrial representatives by means of sponsored joint research projects.

Undergraduate Curriculum in Management Science

At the undergraduate level, the newly developed curriculum in Management Science is directed toward developing industrial managers who are equipped with the requisite degree of knowledge in the mathematical, physical, and behavioral sciences - knowledge that is, and will be, required by the increasingly complex industrial organizations of the present and future.

This curriculum includes established Case Institute courses in mathematics, statistics, probability, economics, psychology, etc., as well as courses specifically designed for this curriculum: Operations Research (2 semesters); Introduction to Management (4 semesters); History of Science and Technology; Measurements for Management; Organization Structure and Operation; Data Processing and Computers; etc.

Graduate Curricula in Operations Research

At the graduate level, programs are offered leading to the M.S. and Ph.D. degrees for work in Operations Research. The following courses are among those offered:

Methods of Operations Research
Problems in Operations Research
Sampling Theory Applied to Industrial Problems
Scientific Method
Costs, Utilities, and Values
Queuing Theory
Production and Inventory Control
Operations Research Seminar (Advanced Topics)
Theory of Games
Mathematics of Management Systems
Linear Programming

These courses, supplemented by related courses in mathematics, statistics, computing, physical science, engineering, and management, together with a required dissertation, enable the graduate student to develop a firm foundation in the methods, techniques and tools of operations research.

Special emphasis is placed on the experiential aspect of OR education by means of term projects and theses and also by providing graduate students the opportunity to work as Research Assistants with the Operations Research Group in sponsored research projects.

A number of fellowships and scholarships are also available for qualified graduate students.

As most of the courses at the graduate level have been offered in the evening to enable those employed in business, industry, and governmental agencies to attend, only a few advanced degrees have been awarded to-date. However, in addition to the many who are taking individual courses in operations research, there are approximately 75 persons now working toward the M.S. in Operations Research. Additionally, there are currently approximately 30 persons studying for the Ph.D. degree in Operations Research. Many of the latter are pursuing their studies on a part-time basis while participating in sponsored industrial research as members of the OR Group.

Short Courses in Operations Research

Each year, at least one intensive two-week introductory course in operations research is offered to those in industry, business, and government who are interested in determining the potential value of OR to their own organizations, and to those who want to obtain a foundation on which to base a program of self-education in OR. A more technical program is also offered during the year for those further interested in increasing their competence.

As an outgrowth of the lecture material used in these Short Courses, the text, Introduction to Operations Research, was prepared, and published

in January, 1957.

Special Program in Operations Research

Case Institute recognizes that since the demand for qualified practitioners in Operations Research far exceeds the supply, many companies interested in developing this research function find that they must retrain their own technical personnel to qualify them to undertake such work. Consistent with its policy of aiding industry in the development of activities in Operations Research, the Case Institute O.R. Group also offers an intensive one-semester (four month) program at the graduate level for qualified scientists and engineers with industrial experience. Specifically, all enrollees must have:

1. A degree in science or engineering.
2. Knowledge of mathematics through differential equations.
3. Knowledge of introductory statistics or probability.

The courses included in this special program are:

Methods of Operations Research

Problems of Operations Research

Operations Research in Production and Inventory Control

Linear Programming

Waiting Line (Queuing) Theory and Application

Additionally, a special seminar on "Administration, Training and Organization for Operations Research in Industry" is conducted.

Finally, special program enrollees are given the opportunity to observe and participate in the industrial Operations Research activities

at Case and are also able to discuss their own company problems with senior members of the Case O.R. Group, who serve as their advisors.

RESEARCH

Since the initial work with the Chesapeake and Ohio Railway Company, the Case O.R. Group has performed research with twenty-seven sponsors on approximately 35 projects. With three exceptions, all of the sponsors have been private industrial organizations. The three exceptions have been the National Science Foundation, the Corps of Engineers of the U.S. Army, and the Operations Research Society of America. The industrial sponsors include:

American Airlines

Chesapeake and Ohio Railway Company

Cleveland Electric Illuminating Company

Cummins Engine Company

General Electric Company

M. A. Hanna Company

Mullins Manufacturing Company

North American Aviation Corporation

Oster Manufacturing Company

Procter and Gamble Company

Railway Express Agency

Warner and Swasey Company

In each of these projects, an OR team is set up consisting of two or more of Case personnel and one or more of the sponsoring organization's personnel. There are several reasons for the insistence on company participation on the team: First, Case's objective is to establish and train within every organization with which it works a company-staffed OR team that is capable of independent research work. Case's O.R. Group provides on-the-job training to company personnel by means of the company projects and supplements this with formal training usually provided at the Short Courses. Secondly, having someone on the research team who is thoroughly familiar with the company's operations reduces the length of time necessary for Case personnel to develop an understanding of these operations.

These teams generally report to a Management Advisory Committee which consists of the managers of each department involved in the study and, where possible, all departments. Meetings with this Committee take place every 4 to 8 weeks. Progress is reported and direction from management is provided. These periodic meetings reduce the need for written reports to one - a final report - and give management an opportunity to check and absorb results gradually, as they are obtained.

Case operates on a "cost plus" basis and, hence, does not contract with industry to do research for a fixed sum in a specified time. After a month or so in the company, however, when the problem to be researched has been defined in detail, estimates of time and cost are provided to management.

Case retains the right to publish all methods and techniques developed in the course of a project. However, revelation of the sponsor, the operations involved, or specific results must be approved by the company. In more than half of the projects, almost unrestricted rights to publish have been granted. In only two cases has it not been possible to reveal enough to publish a Case study based on the project.

Three criteria are used by Case in the selection of projects on which to work. In order of importance they are as follows:

1. Projects requiring the development of new methods or techniques.

2. Projects requiring the application of available methods and techniques to operations to which they have not previously been applied.

3. Projects requiring the application of available methods and techniques to types of industries in which the Case group has not previously worked.

In keeping with its educational function, the Case Group will not do "routine" studies. Its interest is in the "high risk" areas where there is a high probability of obtaining experience, methods, or techniques which will contribute to the development of OR as a science and a profession.

The approximately 35 projects which the group has done have involved every industrial function: production, marketing, finance, research and development, personnel, and administration. It would require too much space to describe even a few of these in any detail. However, it may be helpful to indicate very briefly the nature of a few, say 12, of these projects.

1. The development of a five year plan for a large integrated industry. This involved establishing objectives for each function and product type, operating policies, plans for acquisition and development of resources, a new organizational structure, and procedures of control and communication.

2. The determination of the optimal number of accounts on which a salesman should call and the development of a procedure for determining when this number changes due to changing competitive conditions.

3. The development of an optimal competitive strategy on the commodity exchange.

4. The development of an optimal strategy for bidding on property rights.

5. The selection of optimal sites for retail operations.

6. The determination of when to add the next turbo-electric generator to a utility system and how large it should be.

7. The determination of when to order the next electronic computer for a computing center and when to add shifts on available computers.

8. The development of procedures for determining the location of ore and coal deposits and estimating their size.

9. The determination of what products to add to a line in a diversification program.

10. The scheduling of a job shop to maximize its output.

11. The development of production and inventory control systems in a variety of conditions.

12. The determination of how to modify the preparation and dissemination of recorded scientific information so as to increase scientific productivity.

Many of these cases have been published. A complete list of references is provided at the end of this article.

Since many of the sponsored research projects require the development of new research methods and techniques, the distinction between applied and basic research is difficult to maintain. About 20 per cent of the Group's research time, however, is devoted to basic research projects designated as such. These have all been sponsored by Case Institute itself. A third source of basic research is in the work of graduate students in preparation of their dissertations.

Basic research has been done in the past on Replacement Theory, Bidding Theory, Organization Theory, and Inventory Theory. Current projects fall into four areas.

1. Information Collection Processes. The problem here is to select a number of observations to make which will minimize the sum of the costs arising from sampling error and observational error where sampling error decreases with increases in sample size and observational error increases. This is a generalized problem of search theory.

2. Optimizing the Bias of Estimates. In most O.R. solutions the cost of over- and under-estimation of a parameter's value are not symmetrical. The problem is how to bias the estimate of the parameter's value so as to minimize the expected cost of estimation errors.

3. Behavioral Communication Theory. This is a generalization of Claude E. Shannon's theory to cover not only the physical aspects of communication but the psychological as well. "Meaning," which is excluded in Shannon's theory, plays a central role in this work.

4. Control of Dynamic Systems. An O.R. solution to a problem holds only as long as the parameters of the system remain fixed. This is seldom the case. This research is directed toward designing optimal procedures for detecting significant changes in a parameter's value and for adjusting the solution appropriately when such a change has been found.

An effort is made to give each member of the Group an opportunity to work on a basic as well as applied research. Nevertheless, basic problems are identified and defined much more rapidly than they are solved. Hence, the backlog of basic research continues to build up.

COMMUNICATION

The annual three-day conferences conducted at Case are conceived of as devices for communicating the results of recent applications of operations research to representatives of management. Following the initial conference, "Operations Research in Business and Industry," in November, 1951, the following conferences have been held.

1953: "Operations Research in Marketing"

1954: "Operations Research in Production and Inventory Control

1955: "What Is Operations Research Accomplishing In Industry?"

1956: "Case Studies in Operations Research"

1957: "Operations Research, Computers, and Management Decisions."

The proceedings of each of these Conferences has been published by Case and have enjoyed rather extensive distribution.

Since the number of such conferences offered annually by various institutions has increased from one to several dozen, Case no longer feels it can provide a unique service through such conferences and hence will not continue the series in 1958. Instead, emphasis will be increased in technical courses offered to those in industry.

All published articles by Group members are reprinted and made available on request. In addition, technical memoranda reporting on basic research work in process are circulated to a selected group of professionals for comments and suggestions.

One of the Group's most important functions is that of serving as a communication center for the rapidly growing profession. Numerous inquiries are received daily about research agencies, personnel, reference material, and so on. This correspondence has originated from every continent. Through this activity the Group not only manages to inform others or to put them in contact with those who can provide the requested information, but the Group itself is continually informed thereby.

The international scope of its informational service is facilitated by the inclusion in the Group at various times of professionals from

many countries other than the U.S.A. At this writing it contains subjects of Britain, Germany, Israel, India, Turkey, and the Union of South Africa. Within the last year, it has served as hosts to visitors from these countries and from Denmark, Egypt, France, Italy, Japan, Spain, and Sweden.

Members of the Group have given freely of their time to address both large and small professional meetings. More than 50 such presentations are given by Group members each year.

Keeping informed on the rapidly growing field is no easy task. It is accomplished, to a large extent, by activity of Group members on the editorial boards of Operations Research and Management Science and in the affairs of the corresponding societies, the Operations Research Society of America and The Institute of Management Sciences.

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