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History and Development of Operations Research : A Review

Pooja Paratane

Department of Mathematics

Modern College of Arts, Science and Commerce, (Autonomous), Shivajinagar, Pune 411 005

Abstract : Operations Research is multidisciplinary subject having applications in the field of management, Industry, Science, Civil service departments and Engineering etc. The concepts and tactics of Operational Research were used in the history and in Second World War. But it was recognized by the name 'Operations Research' as a subject after Second World War. In this paper a review of history and development of Operations Research is discussed.

Key words: operations research, Second World War

1. INTRODUCTION

Operations Research includes effective and efficient techniques helpful in decision making, allocation, scheduling, transportation, traffic control, project time duration, optimal values, inventory control and queuing theory etc. The tactics of Operations Research were used widely during the period of Second World War. It can be observed that many researchers have given their contribution in development of models and its method of solving as per requirement of the Operations Research during Second World War. Maurice W. Kirby [6] has written about the origin of Operations Research in his book 'Operational Research In War and Peace: The British Experience from 1930s to 1970'. Norman Gaither [3] has highlighted some important operations during Second World War. We can also get more information from the research papers by the scientists working at the time of Second World War viz. McNaughton [8], McCloskey [7], Air Ministry [9] and Blacklett [1]. Dantzig [2] discussed about linear programming model and it's solving method. Hitchcock [5] had given first the transportation model. Though Operations Research has got recognition in period of Second World War, the strategies in decision making, management, planning using available resources and getting desires output all had been used from ancient period. The great kings ruled their dynasty many years using concepts of Operations Research only. Every human being uses it in day to day life. Operations Research has great importance in executives, management, food industries, hospitals etc. as solution of any real life problem can be obtained using Operations Research techniques.

The paper is organized as follows: in section 2, the origin of Operations Research is discussed in brief. In section 3, the applications of Operations Research in Second World War are discussed. In section 4, the extension of Operations Research and establishment of Operations Research organizations is given. Highlights of Operations Research in India are given in brief in section 5 and in section 6, the basic introduction of Operations Research subject and models is given. In the last section 7 is of conclusion.

2. ORIGIN OF OPERATIONS RESEARCH

The historical development of Operations Research using mathematical and statistical concepts was started actually before Second World War during nineteenth century. The study of Operations Research was started from 1885 by Ferderic W. Taylor. He wanted to find the weight load of ore moved by shovel which would result in maximum of ore moved with minimum efforts. After many experiments, he got the optimal solution and productivity increased substantially.

It was found that operations research techniques had used in First World War also. An anti-aircraft research sub-committee was established by the CID of Great Britain to investigate the present position in regard to research for anti-aircraft purposes. As a result after analysis the problem a prototype acoustic device was placed to detect the air-crafts on Romney Marsh. Balcklett, a junior naval officer and a team of scientists presided by Robert Watson-Watt, Superintendent of the Radio Department at the National Physical Laboratory and team was appointed by Committee for the Scientific Survey of Air Defence (CSSAD)

had been appointed to examine the feasibility of a 'death-ray' which would either claw an aircraft out of the sky or burn up the occupants at the turn of the switch in 1935. It is evident that Operations Research is originated at Bawdsey in 1938. A. P. Rowe was appointed as Deputy Superintendent at Bawdsey in 1938. Watson-Watt's was also appointment as Director of Communications Development responsible for all radio equipment research and with overall responsibility for the activities at Bawdsey. Rowe had given instructions to take the responsibilities of activities of Air Force. An university scientist E. C. Williams was appointed for control room procedures and a telephone engineer G. A. Roberts for examining the communications system in 1938.(Book [6]). Thomas Edison made a effort to use a tactical game board for finding a solution to minimize shipping losses by enemy submarines. Some scientists started used Operations Research techniques. Henry L. Gantt used job scheduling method and successful in minimizing the delay. A. K. Erlang worked on congestion of telephone traffic, in 1917. F. W. Harris studied inventory control and published his work in 1915. An American astronomer analyzed the problems of merchandising scientifically. This first Industrial revolution leads to the development of Operations Research in many areas.

3. PERIOD OF SECOND WORLD WAR

It is agreed that Operations Research came into existence during the Second World War. in second world war it was a need to manage the limited resources and also for strategic planning. We will see some highlights of use and development of Operations Research during this war (Refer: Norman Gaither [3]) . In 1939, British operational research team was called to train military personnel in the operational use of radar. Mr. G. A. Roberts of the Bawdsey Research station was in charge of this operation. This first development became the distinguishing characteristic of Operations Research.

A small group of scientists was sent to the Royal Air Force headquarters. This group analyzed all phases of night operations and resulted the pattern on which other operational research sections based their analyses of operations under the directions of wing commander R. Hart.

A team of scientists from different disciplines containing three physiologists, two mathematical physicists, one astrophysicist, one army officer one surveyor, one general physicist and two mathematicians headed by Prof. P. M. S. Blackett of University of Manchester was formed to solve the problems with newly installed radar equipment at gun sites in British Army. This group was named 'Blackett's Circus". In March 1941, Blackett and team moved to coastal command. They involved there to detect ships and submarines by use of radar equipment in air-planes in British Navy. Thus, Blackett came across all these Admiralty's antisubmarine warfare problems and became Director of Naval Operational Research in December 1941. In 1942, Operations Research team worked on the merchant convoy problem which was effective in minimizing the losses from submarine action and of escort vessels requirement. Thus, British Military services established such operational research groups after beginning of Second World War. Civilian defence also started to apply the techniques searched by Operations Research groups. British Operations Research was originally developed to improve defensive actions in the war, but later it can be seen that Operations Research techniques are effective also in strategy planning against enemy based on information gained. This is resulted in the first 1000 plane RAF raid over Germany in 1942.

America involved in Second World War after two years of war. Two Americans Dr. James B. Conant and Dr. Vannevar Bush had observed Operations Research groups in England during 1939-1941. They also developed a National Defence Research Committee. Dr. Ellis A. Johnson, head of the counter- measures section of the Naval Ordinance Laboratory (NOL) created a group to study mine warfare- strategic, tactical and technological. This group used game theory techniques to develop strategies and applied them successfully on the Japanese controlled waters from Singapore to the home islands. This work done was the high water mark and got special attention in American Operations Research during the Second World War period. It is due to not only success in optimality with existing systems and equipments but also predicted the results by adopting proposed courses og actions. In April 1942, as per the request of Commanding officer of the Atlantic Fleet Antisubmarine, a group of scientists was formed under the leadership of Dr. Phillip M. Morse (Massachusetts Institute

of Technology- M.I.T) to analyze the sea and air attacks against German U-boats and improve the efficiency of Navy and Army forces. A group Antisubmarine Warfare Operations Research group was sent to Readiness Division of the Cominch Headquarters.

Same as the naval problems Operations Research groups solved many more problems in Army and Air Force America. A team of scientists was sent to coordinate radar equipment with other defences of the Canal Zone. Dr. Bush along with Dr. Ward S. Davidson and Major W. B. leach investigated the situation in Britan and similar activities within U.S war and submitted the report on 15 August 1942. One Operations Research team of scientists had been appointed to eighth Air Force station in England on request of General Eaker and so to all Air Force headquarters. There were around 26 such Operations Research groups appointed at Air Force headquarters including every combat air force and a number of Z1 headquarters. Similar groups are formed in Army Ground Forces also on recommendation of General George Marshall.

American commander was not getting the solution on ship under attack during the last months of the Pacific War. Based on report submitted by Operations Research team it was observed that the hit

percentage is reduced. In England, the study of three scientists Youden, Scott and and Clarkson improved the accuracy of placing bombs during 1943-1944.

It cannot be measured that how much impact was there of using Operations Research techniques in the second world war but influenced by the effective use of Operations Research, most of the countries like U.S., U.K., Canada, France etc. started paying attention to the study of Operations Research.

4.OPERATIONS RESEARCH AFTER SECOND WORLD WAR

The great success of Operations Research techniques applied by Operations Research teams working in Military, Navy, Air Force at the time of Second World War attracted the Industrialists to seek solutions for their problems. In a short period the need of applications of Operations Research in government, Industrial, social, economical planning was in demand. The Operations Research and Management Science (OMRS) were established in Britan and United States. As a part of research and development of Operations Research , many organizations, society's in different countries are formed such as Army Operational Research Group (AORG, 1945, Britan), Operational Research Sections (ORS, 1942,Britan), Weapons System Evaluation Group (WSEG, 1947, America), the group working for Navy was converted into Operations Evaluations Group (OEG, 1947, America), the group working for Air force was converted into Operations Analysis Section (OAS, 1946, America) and the centralized organization for Air Force became Operations Analysis Division (OAD, 1946, U.S.), General Research Office (GRO, 1948, U.S.) later converted to Operations Research Office (ORO, 1951, U.S.). In U.S.A the study and use of Operations Research leads to the second revolution in industry towards automation...i.e. work by machines replacing man by means of computers. Use of computers in computations in Operations Research began in the early 1960's. Thus the use of computers made easy to perform complex/infeasible computations.

The course Operations Research is included part of the curriculum by many institutes Viz. Massachusetts Institute of Technology (1952), Columbia University, Case Institute of Technology (First institution offered M.Sc. in Operations Research), University College (London), Birmingham University and Stanford University etc.

The OMRS societies initiated to publish the first journal Operational Research Quarterly so that the ideas can be exchanged. Operations Research Society of America (ORSA) was formed in 1951 with chairman as Phillip M. Morse. ORSA published 'The Journal of Operations Research' in 1952 and 'The Journal of Management Science' in 1955. OMRS organized various conferences after Second World War. The International Federation of Operational Research Societies initiated to start the journal 'International Abstracts in Operations Research' in 1961.

OMRS has a great contribution in expansion of Operations Research in Defence, Universities, Colleges, Institutes and Industries etc. References are taken from Norman Gaither [3] and the book [4].

5. HIGHLIGHTS OF OPERATIONS RESEARCH IN INDIA

The study of operations research techniques had been started in India around 1950's. (References taken from book [10]).

- The Operations Research unit was established at the regional research laboratory, Hyderabad. Prof. R.S. Verma set up the team in Defence Science Laboratory.
- In 1953, Prof. P.C. Mahalanobis established the team in the Indian Statistical Institute, Kolkata for solving problem of National planning.

In 1957, Operations Research Society of India (ORSI) was formed and its first conference was held in Delhi in 1959. One of the outcome of this conference was the publication 'Opsearch' which was published in 1963.

- ORSI became member of the International Federation of Operations Research.
- ORSI is publishing number of research journals :-

1) Industrial Engineering and Management
2) Materials Management Journal of India
3) Defence Science Journal
4) Journal of the Indian Society of Statistics and Operations Research
5) Pure and Applied Mathematika Sciences
6) SCIMA

- Operations Research in Education of India

1) In 1963, University of Delhi started a complete M.Sc in Operations Research.
2) Indian institute of management (IIM) at Calcutta and Ahmadabad started teaching Operations Research in their MBA courses.
3) Operations Research is introduced in almost all institutes and universities in various disciplines like Mathematics, Statistics, Economics, Management Science, Engineering etc.
4. Government introduced this as an examination subject for IAS, CA and ICWA examinations Applications of Operations Research used in India
5) Prof. Mahalanobis first applied Operations Research techniques in India by formulating second Five Year Plan
6) Planning commission made use of Operations Research techniques for planning the optimum size of the Caravelle fleet of Indian Air Lines
7) Industries namely Hindustan Lever Ltd., Union Carbide, TELCO, Hindustan Steel, Imperial Chemical Industry, Tata Iron and Steel Company, Sarabhai Group, FCI.
8) Kirloskar Oil Engines Company, Pune is using Assignment Problem technique of O.R. to max- imize profit.
9) Textile firms like DCM, Binni's and Caloco etc. are using linear programming techniques.

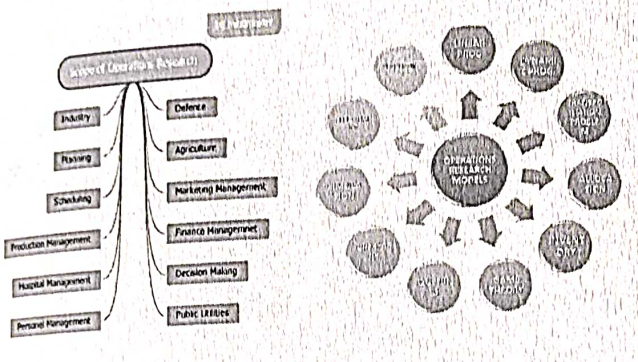
6. BASIC INTRODUCTION OF OPERATIONS RESEARCH

The successful use of Operations Research techniques in Second World War proved the wide application in defence, industry and also solving real life problems. Operations Research has got more at attention in the Industrial management. Operations Research is the systematic way of dealing with a sequence of actions through the models towards desired satisfactory optimal results with help of man, machine and organization. It helps the management and executives in proper decision making using scientific quantitative techniques. Many scientists quoted the definitions of Operations Research in various ways. Thierauf and Klekamp (1975) quotes '*Operations Research utilizes the planned approach following scientific method and an interdisciplinary team in order to represent complex functional relationship as mathematician models, for the purpose of providing a quantitative basis for decision making and uncovering new problems for quantitative analysis*'

Due to the complexity of all factors like demand in market, uncertainty in environment and economy, availability and requirement of raw material, capacity of equipments and their maintenance etc, the decision makers were in need of best solution. In the process of decision making, the objective to be achieved under some restrictions and influencing factors in the form of variables when to be put in some mathematical expression, it forms a Mathematical Model for that task. Operation Research has fulfilled this need through the different models for different situations. The linear programming model is developed by Dantzig [2] to achieve the optimum value on the basis of available resources and demand. This model was

used in Second World War to solve the Air Force and Military problems. This model can be used to solve the problems of product mix, allocation problem, least cost diet, transportation advertising media selection etc. In 1952, Bellman [11] extended this model and established new model as Dynamic Programming which was initially taken as stochastic linear programming. This has been used for cargo loading and optimal routing problems, employment smoothening and so many. Inventory control models have been used to determine economic order quantities, safety stock, minimum and maximum stock levels. Queuing models are useful in scheduling and air traffic, solving traffic congestion, number of service facilities etc. Similarly, decision theory, game theory, Network techniques CPM and PERT, Simulation, Replacement theory are helpful in solving real life and executive level problems.

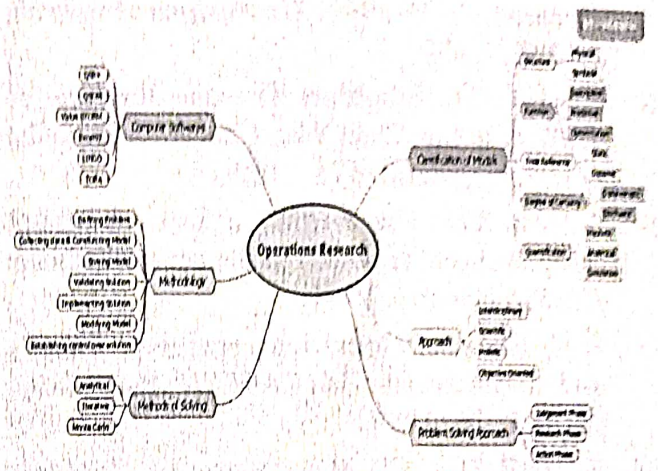
The models and applications are shown diagrammatically in the following diagram.



Thus, Operations Research is multidisciplinary subject having enormous applications in various fields. It

Manages three M's– Manpower, Machine and Money. The needs of the society can be meet using some more advanced models like Non linear programming, Integer programming, Goal programming, Quadratic programming, Stochastic Models etc. are also developed.

The process of model formulation includes first the data collection. The method of solving the model can be decided based on classification and approach of the problem. It cannot be represented every aspect of the problem due to conflicting, innumerable changing nature of real life problem. The following chart shows the steps to process the model towards feasible solution. The progress and success in research and development of each model of Operations Research was extended rapidly and also the methods/algorithms were developed subsequently. It becomes difficult in getting the solutions due to large number of decision variables and complexity of the problems. Some computer softwares have bed developed to solve the Operations Research problems.



7. CONCLUSION

Operations Research has roots before the Second World War. It widespread in the period of Second World War and post second world war. It had been recognized as 'Operations Research' in 1940 as the series of successful operations had been performed during Second World War in military, Air Force and Navy. Operations Research had been widely used in industry, management, agriculture, planning, hospitals, finance, economics etc. Many models had developed to solve the problems in defence. Operations Research is interdisciplinary subject having scientific approach.

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