

## **1.3 OPERATIONS RESEARCH - HISTORICAL BACKGROUND AND DEVELOPMENT**

### **LEARNING OBJECTIVES:**

- To know the history of OR
- To understand the development of OR
- To understand various definitions of OR
- To know the steps in OR methodology
- To understand the limitations of OR

### **ORIGIN, HISTORY**

Operations Research as a new field started in the late 1930's and has grown and expanded tremendously in the last 30 years. The British army was conducting exercises on the radar system for detecting the aircrafts. In July 1938, the Superintendent of Bawdsey Research Station, announced that although the exercise had demonstrated the technical feasibility of the radar system for detecting aircraft, its operational achievements were not up to what was required.) He therefore proposed that a crash program of research into the operational - as opposed to the technical - aspects of the system should begin. The term "Operational Research" was coined as a suitable description of this new branch of applied science.

On 15th May 1940, with German forces advancing rapidly in France, Stanmore Research Section was asked to analyze a French request for ten additional fighter squadrons. They prepared graphs for Winston Churchill (British Prime Minister), based upon a study of current daily losses and replacement rates, indicating how rapidly such a move would deplete fighter strength. No aircrafts were sent and most of those currently in France were recalled. This is held by some to be the most strategic contribution to the course of the war made by Operations Research (as the aircraft and pilots saved were consequently available for the successful air defense of Britain, the Battle of Britain). In 1941 Operational Research Section (ORS) was established in Coastal Command which was to carry out some of the most well-known OR work in World War II. Thus OR as a separate field of specialization was born!

In order to make the effective and efficient decisions, managers must have fundamental understanding of the decision science tools utilized in developing set of recommendations to choose from. The Operations research is usually the mathematical treatment, analysis of a process, problem, or operation to determine its purpose and effectiveness and to gain maximum efficiency. The operation technique is utilized by functional groups such as Industrial Engineering in effort to support Operations Managers to make economically feasible decisions on a range of systematic challenges. The main responsibilities of operations management are to manage and operate as efficiently and effectively as possible with the given resources. Quantitative methods which comprises of Simulation, Linear and nonlinear programming, Queueing Theory and Stochastic Modeling, are well-accepted techniques by both research and practice communities.

Functional entities such as Industrial or Systems Engineering use methodologies to provide feasible alternatives for operations managers to decide on. An important component of decision-making process is verifying and validating alternatives, which typically involve decision makers, engineers or analysts. Growth of Operations Research is to a large extent, the result of the widespread availability of computers. Most Operations Research involves carrying out a large number of numeric calculations and without computers this would simply not be possible.

In India, Operation Research came into existence in 1949 when an Operation Research unit was established at Regional Research Laboratory, Hyderabad. Also Prof. R.S.Verma set up an Operation Research team at Defence Science Laboratory to solve problems of store, purchase and planning. During the 1950"s there was substantial progress in the application of Operation Research techniques for civilian activities along with a great interest in the professional development and education in Operation Research. Many colleges and universities introduced Operation Research in their curricula. They were generally schools of engineering, public administration, business management, applied mathematics, economics, computer science etc.

In 1953, Prof. P.C. Mahalanobis established an Operation Research team in the Indian Statistical Institute, Calcutta to solve problems related to national planning and survey. In 1958, project scheduling techniques: PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) were developed as efficient tools for scheduling and monitoring lengthy, complex and expensive projects of that time. The real development of Operation Research in the national field was carried out by Prof. Mohalanobis in India when he used it in national planning. Operation Research is also being used in Railway, waiting or queueing problems of passengers for tickets at booking windows or trains queueing up in marshalling yard, waiting to be sorted out are tackled by various Operation Research techniques.

## **DEVELOPMENT OF OPERATIONAL RESEARCH**

Operations Research is relatively a new discipline, which originated in World War II, and became very popular throughout the world. India is one of the few first countries in the world who started using operations research. Operations Research is used successfully not only in military/army operations but also in business, government and industry. Now a day's operations research is almost used in all the fields.

Operational Research is defined as the systematic study of how best to solve problems in business and industry. Sometimes referred to as Management Science or in the US operations research looks at an organisation's operations and uses mathematical models and other analytical approaches, to find better ways of doing them. Once improvements are implemented benefits include greater efficiency, higher quality or lower costs.

Operational Research has been utilised for many years but the real birth of Operational Research came in response to the Britain's defence needs against Nazi Germany. A team of scientist's lead by a man named Blackett made a number of analyses, which were crucial to the war effort. The late 1930s to 1970 coincide with 'golden age' of Operational Research.

Britain employed a convoy system to reduce shipping losses, the principle of using warships to accompany merchant ships was generally accepted, but research was needed as to whether it was better for convoys to be small or large.

Small convoys can travel faster since large convoys can only travel at the speed of the slowest member. It was argued that small convoys would be harder for German U-boats to detect. Once detected large convoys are better because they could deploy more warships against an attacker, also the proportion of merchant ships sunk by a U-boat would be lower.

Blackett's and his staff clearly proved that; Large convoys were more efficient; The probability of detection by U-boat was statistically unrelated to the size of the convoy; slow convoys were at greater risk. From his findings he showed that larger fleets are preferable because they are more efficient.

There were also significant achievements in Britains air defence against the Luftwaffe. Blackett's team analysed a report of a survey carried out by RAF Bomber Command. The RAF Bomber Command surveyed all aircraft returning from bombing raids and battles over Germany. After the inspection any damage inflicted by German air defenses was noted. After a short period a recommendation was given by Blackett to place extra armour on the areas that were not heavily damaged. This seems like a strange recommendation but they

reasoned that the undamaged areas were vital and if hit would result in the loss of the aircraft. Whereas the areas that were heavily damaged clearly were not so critical as they returned from combat.

After the war (1945), a large range of industries and services adopted the discipline of Operational Research. By the 1960s, Operational Research was being incorporated in to university curricula and civil government departments. It played a major part in the Iron and Steel industry growth and also in Coal mining. Nowadays Operational Research plays a large role in modern warfare as well as in industry and business

A few examples of applications in which operations research is currently used include the following:

- Designing the layout of a factory floor for efficient flow components.
- Making telecommunications infrastructure at low cost while guaranteeing quality service even if a particular line becomes very busy or gets damaged.
- Determining the routes of public transport so that as few buses are needed to satisfy all demand.
- Designing the layout of microchips to reduce manufacturing times and therefore make them cheaper.
- Designing supply chains to manage the flow of raw materials and products based on uncertain demand.
- Minimising costs by solving transportation problems, staff rotas etc
- Maximise profits by meeting demand and making the most profitable selection of products.

Some of the primary tools used by operations researchers are statistics, optimization, stochastics, queueing theory, game theory, graph theory, and simulation. Many of these theories are based on repetition, computers play an important role in operational research today.

## **THE ROLE OF THE PROFESSIONAL ENGINEER IN INDUSTRY AND SOCIETY**

An engineer is a professional concerned with applying scientific knowledge to practical problems. There are many types of engineer that specialize in fields such as;

**Civil**-branch of engineering concerned with the design and construction of such public works as dams or bridges

**Mechanical**-branch of engineering that deals with the design and construction and operation of machinery

**Chemical**-branch of engineering that is concerned with the design and construction and operation of the plants and machinery used in industrial chemical processes

**Electronic, electrical**- branch of engineering science that studies the uses of electricity and the equipment for power generation and distribution and the control of machines and communication

**Aeronautical** - branch of engineering science concerned with the design and construction of aircraft

**Industrial engineering**.-branch of engineering that deals with the creation and management of systems that integrate people and materials and energy in productive ways.

An engineer of some sort designs almost everything, whether it's the engine in your car or the plastic coating on your shoelace. Essentially engineering is design with science and an engineer is someone who applies knowledge of math and natural science to practical design and manufacture.

Engineers are not trained for specific tasks or problems they 'engineer' their own solutions sometimes in a team. In today's society they are respected for their problem solving skills and logical thinking. However there remains a common misconception that people who fix washing machines or drive trains are engineers but they are trained to fix common problems not find their own solutions.

Engineers play an important role in industry. They analyse a problem and find a better solution, generally an engineer will be employed to design a new product or modify an existing product, service or procedure. They often work under tight financial, logistical or other constraints. The aims of an engineer are usually to maximise profit or efficiency or to minimise overheads or costs.

Examples of an engineer's task in industry include;

1. Designing a product from scratch-
2. Improving or testing an existing product
3. Improving efficiency and therefore cost of manufacture, distribution or transportation

Society has become dependant on technology, every day they use roads, buildings, planes, electricity and more. Therefore society is dependant on engineers of all kinds.

## **EVOLUTION OF OPERATION RESEARCH AS AN ACADEMIC DISCIPLINE**

Because of this historical legacy, operational research was accepted as a legitimate management tool in defense research establishments and subsequently for efficient resource planning and allocation by Government departments. Business supported the accelerated growth of this discipline by funding real and potential applications. Over period of time, a symbiotic relationship between government, business and academia ensured the growth and expansion of the discipline for their mutual benefit. During the last 50 years, operational research has evolved as a multidisciplinary function involving economics, mathematics, statistics, industrial engineering and management.

Broadly, operational research as a discipline can be classified into three distinct set of categories. They correspond to tools, models and methodology. Tools include ABC analysis, 80:20 rule, and Break Even Analysis. Blending models, optimized distribution system, portfolio optimization of assets would broadly represent examples under the category of models. Operational research methodology would include project management systems, multi criteria optimization, game theory, simulation methodology, data envelopment analysis, enterprise resource planning systems and conflict resolution methods . The tools, models and methodology of operational research have found a variety of applications in different contexts. Also, several outstanding academicians have contributed to the development of this discipline.

Most commonly used techniques and methods of Operation Research, which can be freely applied by a progressive management in decision-making processes are: Linear Programming, Decision Models, Network Theory, Inventory Control Models, Queuing Theory, Sequencing, Game Theory, Simulation, Replacement theory, Reliability, Markovian Models.

## DEFINITIONS OF OR

The definitions stressed by various experts and Societies on the subject together enable us to know what O.R. is, and what it does. Some of them are as follows:

1. Winston: “a scientific approach to decision making, which seeks to determine how best to design and operate a system, usually under conditions requiring the allocation of scarce resources.”
2. Morse and Kimball have stressed O.R. is a quantitative approach and described it as “a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control”.
3. Saaty considers O.R. as tool of improving quality of answers. He says, “O.R. is the art of giving bad answers to problems which otherwise have worse answers”.
4. Miller and Starr state, “O.R. is applied decision theory, which uses any scientific, mathematical or logical means to attempt to cope with the problems that confront the executive, when he tries to achieve a thorough-going rationality in dealing with his decision problem”.
5. Pocock stresses that O.R. is an applied Science. He states “O.R. is scientific methodology (analytical, mathematical, and quantitative) which by assessing the overall implication of various alternative courses of action in a management system provides an improved basis for management decisions”.
6. Churchman : “Operations Research is the application of scientific methods, techniques and tools to problems involving the operations of systems so as to provide those in control of operations with optimum solution to problems”.
7. OR Society of America: “It is an experimental and applied science devoted to observing, understanding and predicting the behavior of purposeful man-machine systems: and OR workers are actively engaged in applying this knowledge to practical problems in business, Govt and society”.
8. OR is a scientific method of providing executive with an analytical and objective basis for decisions – PMS Blackett (1948).
9. Term ‘OR’ has here – to fore been used to connote various attempts to study operations of war by scientific methods. From a more general point of view, OR can be considered to be an attempt to study those operations of modern society which involve organizations of men or of men and machines – PM Morse.
10. OR is the application of scientific methods, techniques & tools to problems involving the operations of systems so as to provide those in control of the operations with optimum solutions to the problem – church man, Ackoff, Arnoff.
11. OR is a management activity pursued in two complementary ways – one half by the free and bold exercise of common sense untrammelled by any routine, Another half by the application of a repertoire of well established pre created methods and techniques – Jagit singh

## **STAGES OF DEVELOPMENT OF OPERATIONS RESEARCH**

The stages of development of O.R. are also known as phases and process of O.R, which has six important steps. These six steps are arranged in the following order:

Step I: Observe the problem environment

Step II: Analyze and define the problem

Step III: Develop a model

Step IV: Select appropriate data input

Step V: Provide a solution and test its reasonableness

Step VI: Implement the solution

### **Step I: Observe the problem environment**

The first step in the process of O.R. development is the problem environment observation. This step includes different activities; they are conferences, site visit, research, observations etc. These activities provide sufficient information to the O.R. specialists to formulate the problem.

### **Step II: Analyze and define the problem**

This step is analyzing and defining the problem. In this step in addition to the problem definition the objectives, uses and limitations of O.R. study of the problem also defined. The outputs of this step are clear grasp of need for a solution and its nature understanding.

### **Step III: Develop a model**

This step develops a model; a model is a representation of some abstract or real situation. The models are basically mathematical models, which describes systems, processes in the form of equations, formula/relationships. The different activities in this step are variables definition, formulating equations etc. The model is tested in the field under different environmental constraints and modified in order to work. Some times the model is modified to satisfy the management with the results.

### **Step IV: Select appropriate data input**

A model works appropriately when there is appropriate data input. Hence, selecting appropriate input data is important step in the O.R. development stage or process. The activities in this step include internal/external data analysis, fact analysis, and collection of opinions and use of computer data banks. The objective of this step is to provide sufficient data input to operate and test the model developed in Step III.

### **Step V: Provide a solution and test its reasonableness**

This step is to get a solution with the help of model and input data. This solution is not implemented immediately, instead the solution is used to test the model and to find there is any limitations. Suppose if the solution is not reasonable or the behaviour of the model is not proper, the model is updated and modified at this



stage. The output of this stage is the solution(s) that supports the current organizational objectives.

### Step VI: Implement the solution

At this step the solution obtained from the previous step is implemented. The implementation of the solution involves many behavioural issues. Therefore, before implementation the implementation authority has to resolve the issues. A properly implemented solution results in quality of work and gains the support from the management.

The process, process activities, and process output are summarized in the following Table

Process Activities	Process	Process Output
Site visits, Conferences, Observations, Research	Step 1: Observe the problem environment	Sufficient information and support to proceed
Define: Use, Objectives, limitations	Step 2: Analyze and define the problem	Clear grasp of need for and nature of solution requested
Define interrelationships, Formulate equations, Use known O.R. Model , Search alternate Model	Step 3: Develop a Model	Models that works under stated environmental constraints
Analyze: internal-external data, facts Collect options, Use computer data banks	Step 4: Select appropriate data input	Sufficient inputs to operate and test model
Test the model find limitations update the model	Step 5: Provide a solution and test its reasonableness	Solution(s) that support current organizational goals
	Step 6: Implement the solution	

## CONCLUSION

OR started just before World War II in Britain with the establishment of teams of scientists to study the strategic and tactical problems involved in military operations. The objective was to find the most effective utilisation of limited military resources by the use of quantitative techniques.

Following the end of the war OR spread, although it spread in different ways in the UK and USA.

It should be clear that the growth of OR since it began (and especially in the last 35 years) is, to a large extent, the result of the increasing power and widespread availability of computers. Most (though not all) OR involves carrying out a large number of numeric calculations. Without computers this would simply not be possible.

## REFERENCES:

1. Hillier, F., and G. Lieberman, Introduction to Operations Research, Eighth Edition, McGraw-Hill, New York, 2005
2. Taha, H.A., Natarajan, A.M., Balasubramanie, P., Tamilarasi A., Operation Research: An Introduction, Pearson Education, Eighth Edition, 2008.
3. N.D.Vohra – Quantitative Techniques in Management – Tata McGraw Hill – 2<sup>nd</sup> Edition – 2001.
4. J.K.Sharma – Operations Research, Theory and applications, Macmillan India Ltd.2001
5. Pannerselvem.R., “Operations Research”, Prentice Hall, New Delhi, 2002
6. U K Srivastava; G V Shenoy; S C Sharma – Quantitative Techniques for Managerial Decisions – New age international P Ltd – 2<sup>nd</sup> Edition – 2002
7. S.D.Sharma – Operations Research – Kedar nath Ramnath & Co. – 12<sup>th</sup> Edition – 2001.
8. Hamdy A Taha,. Introduction to Operations Research, PHI Limited, New Delhi - 1999
9. Wagner, Harvery M., 1975. Principles of Operations Research, PHI, Egnlewood Cliffs, N.J.