1

WHAT IS OPERATIONS RESEARCH ?

1.1 INTRODUCTION : THE HISTORICAL DEVELOPMENT

In order to understand 'what Operations Research (OR)* is today,' we must know something of its history and evolution. The main origin of Operations Research was during the Second World–War. At that time, the military management in England called upon a team of scientists to study the strategic and tactical problems related to air and land defence of the country. Since they were having very limited military resources, it was necessary to decide upon the most effective utilization of them, *e.g.* the efficient ocean transport, effective bombing, etc.

During World-War II, the Military Commands of U.K. and U.S.A. engaged several inter-disciplinary teams of scientists to undertake scientific research into strategic and tactical military operations. Their mission was to formulate specific proposals and plans for aiding the Military Commands to arrive at the decisions on optimal utilization of scarce military resources and efforts, and also to implement the decisions effectively. The OR teams were not actually engaged in military operations and in fighting the war. But, they were only advisors and significantly instrumental in winning the war to the extent that the scientific and systematic approaches involved in OR provided a good intellectual support to the strategic initiatives of the military commands. Hence OR can be associated with ***"an art of winning the war without actually fighting it"***.

As the name implies, 'Operations Research' (sometimes abbreviated OR) was apparently invented because the team was dealing with *research* on (military) *operations*. The work of this team of scientists was named as *Operational Research* in England.

The encouraging results obtained by the British OR teams quickly motivated the United States military management to start with similar activities. Successful applications of the U.S. teams included the invention of new fight patterns, planning sea mining and effective utilization of electronic equipment. The work of OR team was given various names in the United States : ***Operational Analysis, Operations Evaluation, Operations Research, Systems Analysis, Systems Evaluation, Systems Research and Management Science.*** The name Operations Research was and is the most widely used so we shall also use it here.

Following the end of war, the success of military teams attracted the attention of *Industrial* managers who were seeking solutions to their complex executive-type problems. The most common problem was : what methods should be adopted so that the total cost is minimum or total profits maximum ? The first mathematical technique in this field (called the *Simplex Method* of linear programming) was developed in 1947 by American mathematician, **George B. Dantzig**. Since then, new techniques and applications have been developed through the efforts and cooperation of interested individuals in academic institutions and industry both.

Today, the impact of OR can be felt in many areas. A large number of management consultimg firms are currently engaged in OR activities. Apart from military and business applications, the OR activities include transportation system, libraries, hospitals, city planning, financial institutions, etc. Many of the Indian industries making use of OR activity are : ***Delhi Cloth Mills, Indian Railways, Indian Airlines, Defence Organizations, Hindustan Lever, Tata Iron & Steel Co., Fertilizer Corporation of India***, etc.

In business and other organizations, OR scientists and specialists always remain enagaged in the background. But, they help the top management officials and other line managers in doing their 'fighting' job better.

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* The short word **'OR'** for **'Operations Research'** should not be confused with the word **'or'** throughout the book.

While making use of the techniques of OR, a mathematical model of the problem is formulated. This model is actually a simplified representation of the problems in which only the most important features are considered for reasons of simplicity. Then, an *optimal* or *most favourable* solution is found. Since the model is an idealized form of exact representation of real problem, the optimal solution thus obtained may not prove to be the best solution to the actual problem. Although, extremely accurate but highly complex mathematical models can be developed, but they may not be easily solvable. So from both the cost-minimising and mathematical simplicity point of view, it seems beneficial to develop a less accurate but simpler model, and to find a sequence of solutions consisting of a series of increasingly better approximations to the actual course of action. Thus, the apparent weaknesses in the initial solution are used to suggest improvements in the model, its input-data, and the solution procedure. A new solution is thus obtained and the process is repeated until the further improvements in the succeeding solutions become so small that it does not seem economical to make further improvements.

If the model is carefully formulated and tested, the resulting solution should reach to be good approximation to the ideal course of action for the real problem. Although, we may not get the best answers, but definitely we are able to find *the bad answers where worse exist.* Thus operations research techniques are always able to save us from worse situations of practical life.

Q. 1. Comment the following statements : **[Rewa (Maths.) 93]**

(i) O.R. is the art of winning war without actually fighting it.

(ii) O.R. is the art of finding bad answers where worse exist.

2. What is O.R. ? **[Garhwal 97, 96; Meerut (IPM) 90]**

3. Enumerate six applications of Operations Research (O.R.) and describe one briefly. **[IGNOU 2001 (June)]**

1.2 THE NATURE AND MEANING OF 'OR'

[IPM (PGDBA)* 82, 81; Meerut (Math.) 82]

'OR' has been defined so far in various ways and it is perhaps still too young to be defined in some authoritative way. So it is important and interesting to give below a few opinions about the definition of OR which have been changed according to the development of the subject.

1. OR is a scientific method of providing executive departments with a *quantitative basis* for *decision* regarding the operations under their control. ***—Morse and Kimbal (1946)***
2. OR is a scientific method of providing executive with an *analytical* and *objective* basis for decisions. ***—P.M.S. Blackett (1948)***
3. The term 'OR' has hitherto-fore been used to connate 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 involved organizations of men or of men and machines.* ***—P.M. Morse (1948)***
4. OR is the application of *scientific methods, techniques* and *tools* to problems involving the *operations of systems* so as to provide these in control of the operations with *optimum solutions* to the problem. ***—Churchman, Acoff, Arnoff (1957)***
5. OR is the art of giving *bad answers* to problems to which otherwise *worse answers* are given. ***—T. L. Saaty (1958)***
6. OR is a management *activity* pursued in two complementary ways—one half by the free and bold *exercise of commonsense* untrammelled by any routine, and other half by the application of a repertoire of *well established precreated methods* and techniques. ***—Jagjit Singh* (1968)**
7. OR is the *attack* of modern methods on *complex problems* arising in the *direction and management* to large systems of men, machines, materials, and money in industry, business and defence. The distinctive approach is to developed a *scientific model* of the system, incorporating measurements of factors such as

is not mentioned in the University Examination references, it should

chance and risk with which to predict and *compare* the outcomes of alternative *decisions, strategies* or *controls*. The purpose is to help management to determine its policy and actions scientifically.

***—Operations Research Quarterly* (1971)**

8. Operations Research is the art of winning war without actually fighting it.
9. OR is an applied decision theory. It uses any *scientific mathematical or logical means* to attempt to cope with the problems that confront the executive when he tries to achieve a through going rationality in dealing with his decision problems. ***—Miller and Starr.***
10. OR is a scientific approach to problem solving for executive management. ***—H.M. Wagner***
11. OR is an aid for the executive in making his decisions by providing him with the needed quantitative information based on the scientific method of analysis. ***—C. Kittel***
12. OR is the systematic method oriented study of the basic structure, characteristics, functions and relationships of an organization to provide the executive with a sound, scientific and quantitative basis for decision making. ***—E.L. Arnoff & M.J. Netzorg***
13. OR is the application of *scientific methods* to problems arising from operations involving *integrated* systems of *men, machines and materials.* It normally utilizes the knowledge and skill of an inter-disciplinary research team to provide the managers of such systems with optimum operating solutions. ***—Fabrycky and Torgersen***
14. OR is an experimental and applied science devoted to observing, understanding and predicting the behaviour of purposeful man–machine systems and OR workers are actively engaged in applying this knowledge to practical problems in business, government, and society. ***—OR Society of America***
15. OR is the application of scientific method by inter-disciplinary teams to problems involving the controls of organized (man-machine) systems so as to provide solutions which *best serve the purpose of the organization as a whole.* ***—Ackoff & Sasieni, (1968)***
16. OR utilizes the planned approach (*updated scientific method)* and an *inter-disciplinary* team in order to represent complex functional relationships as mathematical models for purpose of providing a *quantitative basis* for decision making and *uncovering new problems* for quantitative analysis.

***—Thieanf and Klekamp* (1975)**

Comments on Definitions of OR :

From all above opinions, we arrive at the conclusion that whatever else 'OR' may be, it is certainly concerned with optimization problems. ***A decision, which taking into account all the present circumstances can be considered the best one, is called an optimal decision.*** **(Note)**

There are three main reasons for why most of the definitions of Operations Research are not satisfactory.

(i) First of all, Operations Research is not a science like any well-defined physical, biological, social phenomena. While chemists know about atoms and molecules and have theories about their interactions; and biologists know about living organisms and have theories about vital processes, *operations researchers* do not claim to know or have theories about operations. Operations Research is not a scientific research into the control of operations. It is essentially a collection of mathematical techniques and tools which in conjunction with a system approach are applied to solve practical decision problems of an *economic* or *engineering* nature. Thus it is very difficult to define Operations Research precisely.

(ii) Operations Research is inherently inter-disciplinary in nature with applications not only in military and business but also in medicine, engineering, physics and so on. Operations Research makes use of experience and expertise of people from different disciplines for developing new methods and procedures. Thus, inter-disciplinary approach is an important characteristic of Operations Research which is not included in most of its definitions. Hence most of the definitions are not satisfactory.

(iii) Most of the definitions of Operations Research have been offered at different times of development of 'OR' and hence are bound to emphasise its only one or the other aspect.
For example, 8th of the above definitions is only concerned with war alone. First definition confines 'OR' to be a scientific methodology applied for making operational decisions. It has no concern about the characteristics of different operational decisions and has not described how the scientific methods are applied in complicated situations. Many more definitions have been given by various authors but

most of them fail to consider all basic characteristics of 'OR'. However, with further development of 'OR' perhaps more precise definitions should be forthcoming.

Q. 1. (a) Give any three definitions of Operations Research and explain them. [J.N.T.U. (B. Tech.) 2003; Meerut (IPM) 91; Meerut (O.R.) 90]

(b) Give reasons for : why most of the definitions of Operations Research are not satisfactory.

2. Discuss the three approaches of MIS development. [CA (May) 2000]

3. What are the pre-requisites of a computer based MIS ? [MCI 2000]

1.3 MANAGEMENT APPLICATIONS OF OPERATIONS RESEARCH

Some of the areas of management decision making, where the 'tools' and 'techniques' of O R are applied, can be outlined as follows :

1. **Finance–Budgeting and Investments**
   - (i) Cash-flow analysis, long range capital requirements, dividend policies, investment portfolios.
   - (ii) Credit policies, credit risks and delinquent account procedures.
   - (iii) Claim and complaint procedures.
2. **Purchasing, Procurement and Exploration**
   - (i) Rules for buying, supplies and stable or varying prices.
   - (ii) Determination of quantities and timing of purchases.
   - (iii) Bidding policies.
   - (iv) Strategies for exploration and exploitation of raw material sources.
   - (v) Replacement policies.
3. **Production Management**
   - (i) ***Physical Distribution***
     - (a) Location and size of warehouses, distribution centres and retail outlets.
     - (b) Distribution policy.
   - (ii) ***Facilities Planning***
     - (a) Numbers and location of factories, warehouses, hospitals etc.
     - (b) Loading and unloading facilities for railroads and trucks determining the transport schedule.
   - (iii) ***Manufacturing***
     - (a) Production scheduling and sequencing.
     - (b) Stabilization of production and employment training, layoffs and optimum product mix.
   - (iv) ***Maintenance and Project Scheduling***
     - (a) Maintenance policies and preventive maintenance.
     - (b) Maintenance crew sizes.
     - (c) Project scheduling and allocation of resources.
4. **Marketing**
   - (i) Product selection, timing, competitive actions.
   - (ii) Number of salesman, frequency of calling on accounts per cent of time spent on prospects.
   - (iii) Advertising media with respect to cost and time.
5. **Personnel Management**
   - (i) Selection of suitable personnel on minimum salary.
   - (ii) Mixes of age and skills.
   - (iii) Recruitment policies and assignment of jobs.
6. **Research and Development**
   - (i) Determination of the areas of concentration of research and development.
   - (ii) Project selection.
   - (iii) Determination of time, cost trade-off and control of development projects.
   - (iv) Reliability and alternative design.

From all above areas of applications, we may conclude that OR can be widely used in taking timely management decisions and also used as a corrective measure. The application of this tool involves certain data and not merely a personality of decision maker, and hence we can say : ***OR has replaced management by personality.***

Q. 1. "Operations Research replaces Management by personality." Discuss.
2. Explain applications of O.R. in Industry. **[Garhwal 97; Karnataka 95]**
3. Describe the various approaches used for development of MIS. **[MCI 2000]**

1.4 MODELLING IN OPERATIONS RESEARCH

Definition. *A model in the sense used in O R is defined as a representation of an actual object or situation. It shows the relationships (direct or indirect) and inter-relationships of action and reaction in terms of cause and effect.*

Since a model is an abstraction of reality, it thus appears to be less complete than reality itself. For a model to be complete, it must be a representative of those aspects of reality that are being investigated.

The main objective of a model is to provide means for analysing the behaviour of the system for the purpose of improving its performance. Or, if a system is not in existence, then a model defines the ideal structure of this future system indicating the functional relationships among its elements. The reliability of the solution obtained from a model depends on the validity of the model in representing the real systems. A model permits to 'examine the behaviour of a system without interfering with ongoing operations.

Models can be classified according to following characteristics :

1. Classification by Structure

(i) ***Iconic models.*** *Iconic models* represent the system as it is by scaling it up or down (*i.e.*, by enlarging or reducing the size). In other words, it is an image.

For example, a toy airplane is an iconic model of a real one. Other common examples of it are : photographs, drawings, maps etc. A model of an atom is scaled up so as to make it visible to the naked eye. In a globe, the diameter of the earth is scaled down, but the globe has approximately the same shape as the earth, and the relative sizes of continents, seas, etc., are approximately correct.

The iconic model is usually the simplest to conceive and the most specific and concrete. Its function is generally descriptive rather than explanatory. Accordingly, it cannot be easily used to determine or predict what effects many important changes on the actual system.

(ii) ***Analogue models.*** The models, in which one set of properties is used to represent another set of properties, are called *analogue models.* After the problem is solved, the solution is reinterpreted in terms of the original system.

For example, graphs are very simple analogues because distance is used to represent the properties such as : *time, number, per cent, age, weight,* and many other properties. Contour-lines on a map represent the rise and fall of the heights. In general, analogues are less specific, less concrete but easier to manipulate than are iconic models.

(iii) ***Symbolic (Mathematical) models.*** The *symbolic or mathematical model* is one which employs a set of mathematical symbols (*i.e., letters, numbers,* etc.) to represent the decision variables of the system. These variables are related together by means of a mathematical equation or a set of equations to describe the behaviour (or properties) of the system. The solution of the problem is then obtained by applying well-developed mathematical techniques to the model.

The symbolic model is usually the easiest to manipulate experimentally and it is most general and abstract. Its function is more often explanatory rather than descriptive.

2. Classification by Purpose

Models can also be classified by purpose of its utility. *The purpose of a model may be* descriptive, predictive or prescriptive.

(i) ***Descriptive models.*** A descriptive model simply describe some aspects of a situation based on observations, survey, questionnaire results or other available data. The result of an opinion poll represents a descriptive model.

(ii) ***Predictive models.*** Such models can answer 'what if' type of questions, *i.e.* they can make predictions regarding certain events. For example, based on the survey results, television networks such models attempt to explain and predict the election results before all the votes are actually counted.

(iii) ***Prescriptive models.*** Finally, when a predictive model has been repeatedly successful, it can be used to prescribe a source of action. For example, linear programming is a prescriptive (or normative) model because it prescribes what the managers ought to do.

Trial 3, four hits	x	y	*Result*
1	− 2·015	− 0·594	Miss
2	− 0·623	− 1·047	Miss
3	− 0·699	− 1·347	Miss
4	0·481	0·996	Miss
5	0·586	− 1·023	Miss
6	0·579	0·551	**Hit***
7	0·120	0·418	**HIt***
8	0·191	0·074	**Hit***
9	0·071	0·524	**Hit***
10	− 3·001	0·479	Miss

These three trials give 3·33 as the average number of hits per mission. Many more trials should be conducted before we can have any real confidence in the result. One way of estimating : how many trials are necessary, is to list the cumulated mean at the end of each trial, and to stop the trials when the mean seems to have settled down to stable value. In this example, we have

after trial number : 1 2 3
cummulated mean : 4 3 3·33,

so that more trials are necessary.

The mean number of hits in a mission dropping 10 bombs is 3·69.

To compare the result with the exact value.

In this problem, unlike most Monte-Carlo problems, an exact calculation of the answer is much easier than the Monte Carlo calculation.

The probability of a hit with a single bomb is

$$\left[\int_{-1.250}^{1.250} f(x)\,dx\right] \times \left[\int_{-0.625}^{0.625} f(x)\,dx\right] = 2.789 \times 0.468 \text{ (from the table of the normal integers)}$$

$$= 0.369.$$

Thus the previous value 3·69 is ten times of this value.

Advantages :

1. These methods avoid unnecessary expenses and difficulties that arise during the trial and error experimentation.
2. By this technique, we find the solution of much complicated mathematical expression which is not possible by any other method.

Disadvantages :

1. This technique does not give optimal answers to the problems. The good results are obtained only when the sample size is quite large.
2. The computations are much complicated even in simple cases.
3. It is a costly procedure for obtaining a solution of any related problem.

Q. 1. Write a short note on Monte-Carlo Technique and their usefulness in real life situations. **[Meerut (Stat.) 98]**

2. Describe the use of Monte-Carlo methods in sampling experiments. Illustrate with possible examples.

1.8 MAIN CHARACTERISTICS (FEATURES) OF OPERATIONS RESEARCH

The main characteristics of OR are as follows :

1. Inter-disciplinary team approach. In **OR**, the optimum solution is found by a team of scientists selected from various disciplines such as mathematics, statistics, economics, engineering, physics, etc.

For example, while investigating the inventory management in a factory, perhaps we may require an engineer who knows the functions of various items of stores. We also require a cost accountant and a mathematician-cum-statistician. Each member of such OR team is benefitted by the view points of others, so that the workable solution obtained through such collaborative study has a greater chance of acceptance by management.

Furthemore, an OR team required for a big organization may include a statistician, an economist, a mathematician, one or more engineers, a psychologist, and some supporting staff like computer programmers,

etc. A mathematician or a probabilist can apply his tools in a plant problem only if he gets to understand some of the physical implications of the plant from an engineer. Otherwise, he may give such a solution which may not be possible to apply.

2. Wholistic approach to the system. The most of the problems tackled by OR have the characteristic that OR tries to find the *best* (*optimum*) decisions relative to largest possible portion of the total organization. The nature of organization is essentially immaterial.

For example, in attempting to solve a maintenance problem in a factory, OR tries to consider how this affects the production department as a whole. If possible, it also tries to consider how this effect on the production department in turn affects other department and the business as a whole. It may even try to go further and investigate how the effect on this particular business organization in turn affects the industry as a whole, etc. Thus OR attempts to consider inter-actions or chain of effects as far out as these effects are significant.

3. Imperfectness of solutions. By OR techniques, we cannot obtain perfect answers to our problems but, only the quality of the solution is improved from worse to bad answers.

4. Use of scientific research. OR uses techniques of scientific research to reach the optimum solution.

5. To optimize the total output. OR tries to optimize total return by maximizing the profit and minimizing the cost or loss.

Q. 1. Give the main characteristics of Operations Research. **[J.N.T.U. (B. Tech.) 2004, 03; C.A. (May) 92]**

2. Define OR and discuss its characteristics and limitations.

1.9 MAIN PHASES OF OPERATIONS RESEARCH STUDY

About fourty years ago, it would have been difficult to get a single operations-researcher to describe a procedure for conducting OR project. The procedure for an OR study generally involves the following major phases :

Phase I : Formulating the problem. Before proceeding to find the solution of a problem, first of all one must be able to formulate the problem in the form of an appropriate model. To do so, the following information will be required.

(i) Who has to take the *decision* ?
(ii) What are the *objectives* ?
(iii) What are the ranges of *controlled variables* ?
(iv) What are the uncontrolled variables that may affect the possible solutions ?
(v) What are the restrictions or constraints on the variables ?

Since wrong formulation cannot yield a right decision (solution), one must be considerably careful while execution this phase.

Phase II : Constructing a mathematical model. The second phase of the investigations is concerned with the reformulation of the problem in an appropriate form which is convenient for analysis. The most suitable form for this purpose is to construct a mathematical model representing the system under study. It requires the identification of both *static* and *dynamic* structural elements. A mathematical model should

three important basic factors : (iii) *Objective function.*

1.11 SCOPE OF OPERATIONS RESEARCH

In its recent years of organized development, OR has entered successfully many different areas of research for military, government and industry. The basic problem in most of the developing countries in Asia and Africa is to remove *poverty* and *hunger* as quickly as possible. So there is a great scope for economists, statisticians, administrators, politicians and the technicians working in a team to solve this problem by an OR approach. Besides this, OR is useful in the following various important fields.

1. **In Agriculture.** With the explosion of population and consequent shortage of food, every country is facing the problem of—
   (i) optimum allocation of land to various crops in accordance with the climatic conditions; and
   (ii) optimum distribution of water from various resources like canal for irrigation purposes.

   Thus there is a need of determining best policies under the prescribed restrictions. Hence a good amount of work can be done in this direction.
2. **In Finance.** In these modern times of economic crisis, it has become very necessary for every government to have a careful planning for the economic development of her country. OR-techniques can be fruitfully applied :
   (i) to maximize the per capita income with minimum resources;
   (ii) to find out the profit plan for the company;
   (iii) to determine the best replacement policies, etc.
3. **In Industry.** If the industry manager decides his policies (not necessarily optimum) only on the basis of his past experience (without using OR techniques) and a day comes when he gets retirement, then a heavy loss is encountered before the Industry. This heavy loss can immediately be compensated by newly appointing a young specialist of OR techniques in *business management*. Thus OR is useful to the *Industry Director* in deciding optimum allocation of various limited resources such as men, machines, material, money, time, etc., to arrive at the optimum decision.
4. **In Marketing.** With the help of OR techniques a *Marketing Administrator* (Manager) can decide :
   (i) where to distribute the products for sale so that the total cost of transportation etc. is minimum,
   (ii) the minimum per unit sale price,
   (iii) the size of the stock to meet the future demand,
   (iv) how to select the best advertizing media with respect to time, cost, etc.
   (v) how, when, and what to purchase at the minimum possible cost ?
5. **In Personnel Management.** A personnel manager can use OR techniques :
   (i) to appoint the most suitable persons on minimum salary,
   (ii) to determine the best age of retirement for the employees,
   (iii) to find out the number of persons to be appointed on full time basis when the workload is seasonal (not continuous).
6. **In Production Management.** A production manager can use OR techniques :
   (i) to find out the number and size of the items to be produced;
   (ii) in scheduling and sequencing the production run by proper allocation of machines;
   (iii) in calculating the optimum product mix; and
   (iv) to select, locate, and design the sites for the production plants.
7. **In L.I.C.** OR approach is also applicable to enable the L.I.C. offices to decide :
   (i) what should be the premium rates for various modes of policies,
   (ii) how best the profits could be distributed in the cases of with profit policies ? etc.

Finally, we can say : wherever there is a problem, there is OR. The applications of OR cover the whole extent of any thing. A recent publication of the OR society contains a summary of the applications of OR. The reader wishing more details on applications may consult the publication : ***'Progress in OR'* Vol. 2 by *Hertz., D.B.* and *R.T. Eddison.***

Q. 1. Define O.R. and discuss its scope. **[Meerut (Stat.) 98; Garhwal 96; Kanpur 96; Rewa (Maths.) 93; Rohil. 93, 92]**

2. What are the areas of applications of O.R., **[Meerut (Maths) 91]**

3. (a) Explain the meaning, scope and methodology of O.R. **[VTU (BE Mech.) 2002]**
   (b) Discuss the significance and scope of Operations Research in modern management. **[Delhi Univ. (MBA) HCA 2001]**

4. Write a critical essay on the definition and scope of Operations Research. **[JNTU (B. Tech) 2003, 02; Virbhadrah 2000]**

1.12 ROLE OF OPERATIONS RESEARCH IN DECISION-MAKING

The Operations Research may be regardeed as a tool which is utilized to increase the effectiveness of management decisions. In fact, OR is the objective suppliment to the subjective feeling of the administrator (decision-maker). Scientific method of OR is used to understand and describe the phenomena of operating system. OR models explain these phenomena as to what changes take place under altered conditions, and control these predictions against new observations. For example, OR may suggest the best locations for factories, warehouses as well as the most economical means of transportation. In marketing, OR may help in indicating the most profitable type, use and size of advertising compaigns subject to the financial limitations.

The advantages of OR study approach in business and management decision making may be classified as follows :

1. **Better Control.** The management of big concerns finds it much costly to provide continuous executive supervisions over routine decisions. An OR approach directs the executives to devote their attention to more pressing matters. For example, OR approach deals with production scheduling and inventory control.
2. **Better Co-ordination.** Sometimes OR has been very useful in maintaining the law and order situation out of chaos. For example, an OR based planning model becomes a vehicle for coordinating marketing decisions with the limitations imposed on manufacturing capabilities.
3. **Better System.** OR study is also initiated to analyse a particular problem of decision making such as establishing a new warehouse. Later, OR approach can be further developed into a system to be employed repeatedly. Consequently, the cost of undertaking the first application may improve the profits.
4. **Better Decisions.** OR models frequently yield actions that do improve an intuitive decision making. Sometimes, a situation may be so complicated that the human mind can never hope to assimilate all the important factors without the help of OR and computer analysis.

In the present text, we restrict ourselves to discuss the problems on : ***Inventory control, Replacement, Queues, Linear programming, Goal Programming, Transportation, Assignment, Games theory, Sequencing, Dynamic programming, Information theory, PERT/CPM, Simulation, and Decision theory*** etc.

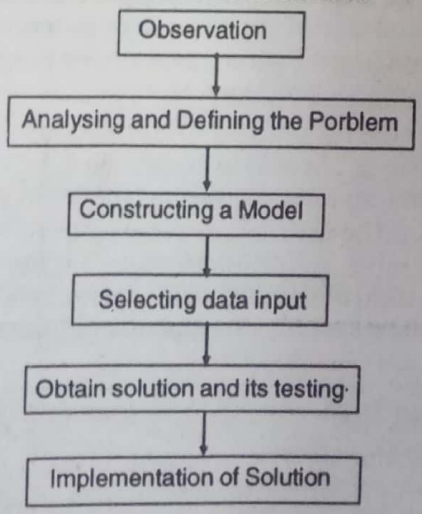
O.R. provides a logical and systematic approach for decision-making. The phases and process study must also be quite logical and systematic. There are six important steps in O.R. study, but in all each and every step does not necessarily follow logical order as below :

***Step I* : Observing the Problem Environment**

The activities in this step are visits, conferences, observations, research etc. With such activities analyst gets sufficient information and support to define the problem .

***Step II* : Analysing and Defining the Problem**

In this step the problem is defined, and objectives and limitations of the study are stated in its context. One thus gets clear grasp of need for a solution and indication of its nature.



***Step III* : Developing a Model**

Step III is to contruct a model. A model is representation of some real or abstract situations. O.R. models are basically mathematical models representing systems, processes or environment in the form of equations,

relationships or formulae. The activities in this step are defining interrelationships among variables, formulating equations, using known O.R. models or searching suitable alternate models. The proposed model may be practically tested and modified in order to work under given environmental constraints. A model may also be managerial if not satisfied with the solution it offers.

***Step IV* : Selecting Appropriate Data Input**

No model will work appropriately if data input is not appropriate. Hence using right kind of data is vital in O.R. process, Important activities in this step are analysing internal-external data and facts, collecting openions and using computer data banks. The purpose of the step is to have sufficient input to operate and test the models.

***Step V* : Providing a Solution and Testing its Reasonableness**

Step V is performed to obtain a solution with the help of model and data input. Such a solution is not implemented immediately. First it is tested not behaving properly, updating and modification of the model is considered at this stage. The end result is solution that supports current organization objective.

***Step VI* : Implementing the Solution**

Implementation of the solution is the last step of O.R. process. In O.R., the decision-making is scientific, but implementation of decision involves many behavioural issues. Therefore, the implementing authority has to resolve the behavioural issues. He has to convince not only the workers but also the superiors. The gap between one who provides a solution and the other who wishes to use it has to be eliminated. To achieve this, O.R. analyst as well as management should play a positive role. Needless to say a properly implemented solution obtained through O.R. techniques results an improved working and gets active management support.

Q. 1. What is the importance (role) of Operations Research in decision making. **[Kanpur 96]**

2. Describe in brief the role of quantitative techniques in bussiness management. **[JNTU (B. Tech.) 2003]**

3. What are the various phases through which an O.R. team normally has to proceed ?

1.13 BRIEF OUTLINES OF OR-MODELS : QUANTITATIVE TECHNIQUES OF OR

In fact, computers have played a vital role in the development of OR. But OR would not have achieved its present position for the use of computers. The reason is that—in most of the OR techniques computations are so complex and involved that these techniques would be of no practical use without computers. Many large scale applications of OR techniques which require only few minutes on the computer may take weeks, months and sometimes years even to yield the same results manually. So the computer has become as essential and integral part of OR. Now-a-days, OR methodology and computer methodology are growing up simultaneously. It seems that in the near future the line dividing the two methodologies will disappear and the two sciences will combine to form a more general and comprehensive science. It should also be noted that FORTRAN and C-programs are functionally equivalent.

The computor software packages are useful for rapid and effective calculatipns which is a necessary part of O.R. approach to solve the problems. These are :

(i) QSB+ (Quantitative System for Business Plus), Version 3.0, by Yih-long Chang and Robert S. Sullivan, is a software package that contains problem solving algorithms for OR/MS, as well as modules on basic statistics, non-linear programming and financial analysis.

(ii) QSOM (Quantitative Systems for Operations Management), by Yih-long, is an interactive user-friendly system. It contains problem-solving algorithms for operations management problems and associated information system.

(iii) Value STORM : MS quantitative Modelling for Decision Support, by Hamilton Emmons, A.D. Flowers, Chander Shekhar, M.Khot and Kamlesh Mathur, is a special version of Personal STORM version 3.0 developed for use in OR/MS.

(iv) Excel 97 by Gene Weiss Kopf and distributed by BPB publications, New Delhi, is an easy-to-use task-oriented guide to Excel Spread sheet applications.

(v) LINDO (Linear Interactive Discrete Optimization), developed by Linus Schrage Lindo in his book "An Optimization Modeling System, 4th ed. (Palo Alto, CA : Scientific Press 1991)

SELF-EXAMINATION QUESTIONS

1. (a) What is Operations Research ? A certain wine importer noticed that his sales of wine were not what they should be in comparison to other types of liquor. He hired you as a consultant to look into this problem, with the intention of improving the wine business. What would you do ?

   (b) How does one go about organising for effective Operations Research ? Explain.
2. Give a brief account of the methods used in model formulation.
3. Explain, how and why OR methods have been valuable in aiding executive decision. **[Meerut (Stat.) 90]**
4. Explain the concept, scope and tools of OR as applicable to business and industry.
5. Discuss the advantages and limitations of using results from a mathematical model to make decisions about operations.