INTRODUCTION TO OPERATIONS RESEARCH

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INTRODUCTION TO OPERATIONAL RESEARCH

- Operational Research is a systematic and analytical approach to decision making and problem solving.
- O.R. as termed in USA, Canada, Africa, Australia and Operational Research as termed in Europe, is an Branch of applied mathematics that uses techniques and statistics to arrive at Optimal solutions to solve complex problems.

INTRODUCTION TO OPERATIONAL RESEARCH

It is typically concerned with determining the **maximum** profit, sale, output, crops yield and efficiency and **minimum** losses, risks, cost, and time of some objective function. It have also become an important part of **INDUSTRIAL ENGINEERING PROFESSION**.

Some of the **PRIMARY TOOLS** used by operation researchers are-

- **STATISTICS**
- **GAME THEORY**
- **PROBABILITY THEORY, etc.**

HISTORY OF OPERATIONAL RESEARCH

- There is no clear history that marks the Birth if O.R., it is generally accepted that the field originated in England during the World War II. Some of them says that Charles Babbage (1791-1871) is the Father of O.R because his research into the cost of transportation and sorting of mail led to England's University Penny Post in 1840.

HISTORY OF OPERATIONAL RESEARCH

- **Modern Operations Research originated at the Bowdsey Research Station in U.K in 1937 to analyse and improve the working of the UK's Early Warning Rador System.**
- **During the Second World War about 1000 Men and Women were engaged to work for British Army.**
- **After World War II, Military Operational Research in U.K. became Operational Analysis (OA) within the U.K. Ministry of Defence with expanded techniques and graving awareness.**

OPERATIONAL RESEARCH IN INDIA

The Operational Research Society of India was founded in 1957 to provide a forum for the Operational Research Scientists as well as an avenue to widen their horizon by exchange of knowledge and application of techniques from outside the country. The Society is affiliated to the International Federation of Operational Research Societies (IFORS).

OPERATIONAL RESEARCH IN INDIA

The Headquarters of the Society is located in Kolkata at 39, Mahanirvan Road, Kolkata 700029, India. At present the Society has 12 Operating Chapters located in Agra, Ahmedabad, Ajmer, Bangalore, Chennai, Delhi, Durgapur, Jamshedpur, Kolkata, Madurai, Mumbai and Tirupati.

OPERATIONAL RESEARCH IN INDIA

The Objectives of the Society comprise advancement of, conducting of research in, study of, promotion and propagation of knowledge in Operational Research and Allied Techniques through exchange of information, as well as establishment, improvement and maintenance of professional and academic standards of work known as Operational Research.

OPERATIONAL RESEARCH IN INDIA

Contribution to the Society towards attainment of these objectives is eligible for exemption of income tax under Section 80(G)(5)(vi) of the Income Tax Act 1961.

The Society Publishes a quarterly journal OPSEARCH, which brings out high quality and state of the art papers in Operational Research.

OPERATIONAL RESEARCH IN INDIA

In order to provide opportunity to professionals and students to equip themselves with the knowledge and usage of the science of Operational Research, the Society is conducting an examination on Graduate Diploma in Operational Research since 1973.

DEFINITION OF OPERATIONAL RESEARCH

- It is an **Act** of winning wars without actually fighting.

  -Aurther Clark

- It is a **Scientific Approach** to problem solving for executive management.

  -H.M. Wagner

- It is **Art** of giving bad answers to problem which otherwise have worse answers.

  -T.L. Saaty

FEATURES OF OPERATIONAL RESEARCH

- Decision-Making
- Scientific Approach
- Inter-Disciplinary Team Approach
- System Approach
- Use of Computers
- Objectives
- Human Factors

DECISION MAKING

Every industrial organisation faces multifacet problems to identify best possible solution to their problems.

OR aims to help the executives to obtain optimal solution with the use of OR techniques.

It also helps the decision maker to improve his creative and judicious capabilities, analyse and understand the problem situation leading to better control, better co-ordination, better systems and finally better decisions.

SCIENTIFIC APPROACH

OR applies scientific methods, techniques and tools for the purpose of analysis and solution of the complex problems.

In this approach there is no place for guesswork and the person bias of the decision maker.

INTER-DISCIPLINARY TEAM APPROACH

- Basically the industrial problems are of complex nature and therefore require a team effort to handle it.
- This team comprises of scientist, mathematician and technocrats. Who jointly use the OR tools to obtain a optimal solution of the problem. They tries to analyse the cause and effect relationship between various parameters of the problem and evaluates the outcome of various alternative strategies.

SYSTEM APPROACH

The main aim of the system approach is to trace out all significant and indirect effects for each proposal on all sub-system on a system and to evaluate each action in terms of effects for the system as a whole.

The inter-relationship and interaction of each sub-system can be handled with the help of mathematical/analytical models of OR to obtain acceptable solution.

USE OF COMPUTERS

- The models of OR need lot of computation and therefore, the use of computers becomes necessary.
- With the use of computers it is possible to handle complex problems requiring large amount of calculations.
- The objective of the operations research models is to attempt and to locate Best or Optimal Solution.

OBJECTIVES

Operational Research always try to find the best and optimal solution to the problem.

For this purpose objectives of the organisation are defined and analysed. These objectives are then used as the basis to compare the alternative courses of action.

HUMAN FACTORS

In deriving, Quantitative Solutions we do not consider human factors, which doubtlessly play a great role in the problems.

So, study of O.R. is incomplete without study of human factors.

SCOPE OF OPERATIONAL RESEARCH

The scope of OR is not only confined to any specific agency like defence services but today it is widely used in all industrial organisations.

It can be used to find the best solution to any problem be it simple or complex. It is useful in every field of human activities. Thus, it attempts to resolve the conflicts of interest among the components of organization in a way that is best for the organisation as a whole.

The main fields where OR is extensively used are

- National Planning and Budgeting
- Defence Services
- Industrial Establishment and Private Sector Units
- R & D and Engineering

NATIONAL PLANNING AND BUDGETING

OR is used for the Preparation of-

- **Five Year Plans**
- **Annual Budgets**
- **Forecasting of Income and Expenditure**
- **Scheduling of Major Projects of National Importance**
- **Estimation of GNP**
- **GDP**
- **Population**
- **Employment and Generation of Agriculture Yields, etc.**

DEFENCE SERVICES

Basically formulation of OR started from USA Army, so it has wide application in the areas such as:

- Development of New Technology
- Optimization of Cost and Time
- Tender Evaluation
- Setting and Layouts of Defence Projects
- Assessment of "Threat Analysis"
- Strategy of Battle
- Effective Maintenance and Replacement of Equipment
- Inventory Control,
- Transportation
- Supply Depots, etc.

INDUSTRIAL ESTABLISHMENTS AND PRIVATE SECTOR UNITS

OR can be effectively used in-

- **Plant Location and Setting Finance Planning**
- **Product and Process Planning**
- **Facility Planning and Construction**
- **Production Planning and Control**
- **Purchasing**
- **Maintenance Management**
- **Personnel Management, etc.**

R&D AND ENGINEERING

Research and development being the heart of technological growth, OR has wide scope and can be applied in-

- Technology Forecasting and Evaluation,
- Technology and Project Management,
- Preparation of Tender and Negotiation,
- Value Engineering,
- Work/Method Study and so on.

METHODOLOGIES/APPROACHES OF OPERATIONAL RESEARCH

1. FORMULATE THE PROBLEM
2. OBSERVE THE SYSTEM/COLLECTION OF DATA
3. FORMULATE A MATHEMATICAL MODEL OF THE PROBELM
4. VERIFY THE MODEL
5. SOLUTION
6. ANALYSES AND PRESENT THE RESULT
7. IMPLEMENTATION AND EVALUTE RECOMMENDATIONS

TECHNIQUES/TOOLS OF OPERATIONAL RESEARCH

- Linear Programming
- Queuing Theory
- Transportation Problems
- Integer Problems
- Assignment Problems
- Decision Theory and Games Theory
- Replacement Problems
- Symbolic Logic

LINEAR PROGRAMMING

- This technique is used to find a solution for optimising a given objective. Objective may be maximizing profits or minimizing costs.
- Objective function and Boundary conditions are linear in nature.
- LPP techniques solve Product-Mix and Distribution problems of enterprise.
- Its also used to allocate Scarce Resources in optimum manner in problems of scheduling, product mix, etc.

QUEUING THEORY

- This theory deals with the situations in which queue is formed, e.g. customers waiting for services, machines waiting for repairmen, and aircrafts waiting for landing strips, etc.
- If the Queue will be long the cost will be high due to long waiting hour.
- This technique is used to analyse the feasibility of adding facilities and to access the amount and cost of waiting time.
- This calculations can then be used to determine the desirable number of service facilities.

TRANSPORTATION PROBLEMS

Transportation problems deals with transportation of a product

- From a number of sources
- With limited supplies
- To number of destinations
- With specified demands
- At the total transportation cost.

The main objective of transportation is to Schedule Shipment from sources to destinations in such a way so as to Minimize the Total Transportation Cost.

INTEGER PROGRAMMING

Integer means complete or whole number. By using the Integer Programming Algorithm a series of continuous linear programming problem are solved in such a way that the solution containing un-acceptable non-integer value are ruled out and the best higher programming solution is obtained.

ASSIGNMENT PROBLEMS

It is a special type of linear programming problem. It deals in allocating the various resources or items to various activities in a one to one basis in such a way that the time or cost involved in minimised and the sale or profit is maximized.

E.g. Manager may like to know which job should be assigned to which person so that all jobs can be completed in the shortest possible time.

DECISION THEORY AND GAME THEORY

Decision Theory is primarily considered with decision making under the conditions of:

- Risk
- Uncertainity

Game Theory is concerned with:

- Decision Making under Conflict

Hence, both Decision Theory and Game Theory **assist** the **Decision-Maker** in Analysing Problems with numerous alternative course of action and consequences.

REPLACEMENT PROBLEMS

This Theory is concerned with situations that arise when some items such as machines, men, etc. require replacement due to their decreasing efficiency, failure or break-down.

Sooner or later all the equipments are required to be replaced because of:

- Obsolescence
- Discovery of New Technology
- Better Design of Equipment

In Replacement Decisions we consider:

- Cost of Equipment to be Installed
- Cost of Equipment Replaced, etc.

Hence, this theory helps to solve all Replacement Problems.

SYMBOLIC LOGIC

Symbols are more meaningful and accurate. Everything is Symbolic in this world.

Words, classes of things, functional systems and rules are substituted with symbols.

The whole problem is converted into algebraic equations and propositions. Business Problems are not commonly converted into symbols but calculations are done on computers, that is why symbols have extensive applications.

OPERATIONAL RESEARCH AND MANAGEMENT DECISION-MAKING

- Operation Research increases the creative capabilities of a decision maker.
- It increases the effectiveness of mgt. decisions. Management is most of the time making decisions. It is thus a decision science which helps mgt. to take better decisions.
- Nowadays, business problems have become so complex that it is almost impossible for a human being to comprehend all important factors, OR Techniques can be helpful in such situations.
- It also helps in ascertaining best locations for factories and warehouses, project scheduling as well as most economic means of transportation.
- OR study approach in business decisions leads to better control, better co-ordination, better system and at the end better decision.

MODELS & MODELING

- A model in OR is a simplified representation of an operation, or is a process in which only the basic aspects or the most important features of a typical problem under investigation are considered. The objective of a model is to identify significant factors and interrelationships. The reliability of the solution obtained from a model depends on the validity of the model representing the real system.

A good model must possess the following characteristics:

- It should be capable of taking into account, new formulation without having any changes in its frame.
- Assumptions made in the model should be as small as possible.
- Variables used in the model must be less in number ensuring that it is simple and coherent.
- It should be open to parametric type of treatment.
- It should not take much time in its construction for any problem.

Classification of Models

- Based on structure:

A. Iconic or physical models: They are pictorial representations of real systems and have the appearance of the real thing.

An iconic model is said to be scaled down or scaled up according to the dimensions of the model which may be smaller or greater than that of the real item,

e.g., city maps, houses blueprints, globe, and so on. These models are easy to observe and describe, but are difficult to manipulate and are not very useful for the purpose of prediction

. B. Analog models: These are more abstract than the iconic ones for there is no look alike correspondence between these models and real life items. The models in which one set of properties is used to represent another set of properties are called analog models.

C. Mathematic / Symbolic models: They are most abstract in nature. They employ a set of mathematical symbols to represent the components of the real system. These variables are related together by means of mathematical equations to describe the behavior of the system. The solution of the problem is then obtained by applying well developed mathematical techniques to the model.

- Based on function or purpose

A. Descriptive models: A descriptive model simply describes 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.

B. 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.

C. 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.

- Based on certainty

A. Deterministic models: They are those in which all parameters and functional relationships are assumed to be known with certainty when the decision is to be made. Linear programming and break-even models are the examples of deterministic models.

B. Probabilistic / Stochastic models: These models are those in which at least one parameter or decision variable is a random variable. These models reflect to some extent the complexity of the real world and the uncertainty surrounding it.

- Based on time reference

A. Static models: These models do not consider the impact of changes that takes place during the planning horizon, i.e. they are independent of time. Also, in a static model only one decision is needed for the duration of a given time period.

B. Dynamic models: In these models, time is considered as one of the important variables and admits the impact of changes generated by time. Also, in dynamic models, not only one but a series of interdependent' decisions is required during the planning horizon.

- Based on method of solution

A. Analytical models: These models have a specific mathematical structure-and thus can be solved by known analytical or mathematical techniques. For example, a general linear programing model as well as the specially structured transportation and assignment models are analytical models. .

B. Simulation models: A simulation model is essentially computer-assisted experimentation on a mathematical structure of a real time structure in order to study the system under a variety of assumptions.

APPLICATIONS OF OPERATIONS RESEARCH IN BUSINESS

Accounting:

-Assigning audit teams effectively

- Credit policy analysis

-Cash flow planning

- Developing standard costs

- Establishing costs for byproducts

- Planning of delinquent account strategy

Construction:

-Project scheduling, monitoring and control

- Determination of proper work force

- Deployment of work force

- Allocation of resources to projects

Facilities Planning:

- Factory location and size decision
-Estimation of number of facilities required
-Hospital planning
- International logistic system design
- Transportation loading and unloading
-Warehouse location decision

Finance:

-Building cash management models
- Allocating capital among various alternatives
- Building financial planning models
- Investment analysis
-Portfolio analysis
-Dividend policy making

Manufacturing:

-Inventory control

-Marketing balance projection

- Production scheduling

- Production smoothing

Marketing:

-Advertising budget allocation

-Product introduction timing

-Selection of Product mix

-Deciding most effective packaging alternative

Purchasing:

-Optimal buying

-Optimal reordering

-Materials transfer

Organizational Behavior / Human Resources:

-Personnel planning

-Recruitment of employees

-Skill balancing

-Training program scheduling

-Designing organizational structure more effectively

Research and Development:

- R & D Projects control

- R & D Budget allocation

-Planning of Product introduction

LIMITATIONS OF OPERATIONAL RESEARCH

- Magnitude of Computation
- Non-Quantifiable Factors
- Distance between User and Analyst
- Time and Money Costs
- Implementation

MAGNITUDE OF COMPUTATION

Operations research models try to find out optimal solution taking into account all the factors. But, these factors are enormous

and,

expressing them in quantity,

and,

establishing relationships among these, Require voluminous calculations which can be handled only by computers.

NON-QUANTIFIABLE FACTORS

OR provides solution only when all elements related to a problem can be quantified.

All relevant variables do not lend themselves to quantification. Factors which cannot be quantified, find no place in OR study. Models in OR do not take into account qualititative factors or emotional factors which may be quite important.

DISTANCE BETWEEN USER AND ANALYST

OR being specialist's job requires a mathematician or statistician, who might not be aware of the business problems.

Similarly, a manager fails to understand the complex working of OR. Thus there is a gap between the two. Management itself may offer a lot of resistance due to conventional thinking.

TIME AND MONEY COST

When basic data are subjected to frequent changes, incorporating them into the OR models is a costly proposition.

Moreover, a fairly good solution at present may be,

More desirable than a perfect OR solution available after sometime. The computational time increases depending upon the size of the problem and accuracy of results desired.

IMPLEMENTATION

Implementation of any decision is a delicate task. It must take into account the complexities of human relations and behaviour. Sometimes, resistance is offered due to psychological factors which may not have any bearing on the problem as well as its solution.