Lecture 1

Introduction and overview of OR

1.1 Origin of Operations Research

The term Operations Research (OR) was first coined by MC Closky and Trefthen in 1940 in a small town, Bowdsey of UK. The main origin of OR was during the second world war – The military commands of UK and USA 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 to arrive at the decision on optimal utilization of scarce military resources and also to implement the decisions effectively. In simple words, it was to uncover the methods that can yield greatest results with little efforts. Thus it had gained popularity and was called "An art of winning the war without actually fighting it"

The name Operations Research (OR) was invented because the team was dealing with research on military operations. The encouraging results obtained by British OR teams motivated US military management to start with similar activities. The work of OR team was given various names in US: Operational Analysis, Operations Evaluation, Operations Research, System Analysis, System Research, Systems Evaluation and so on.

The first method in this direction was simplex method of linear programming developed in 1947 by G.B Dantzig, USA. Since then, new techniques and applications have been developed to yield high profit from least costs.

Now OR activities has become universally applicable to any area such as transportation, hospital management, agriculture, libraries, city planning, financial institutions, construction management and so forth. In India many of the industries like Delhi cloth mills, Indian Airlines, Indian Railway, etc are making use of OR activity.

1.2 Concept and Definition of OR

Operations research signifies research on operations. It is the organized application of modern science, mathematics and computer techniques to complex military, government, business or industrial problems arising in the direction and management of large systems of men, material, money and machines. The purpose is to provide the management with explicit quantitative understanding and assessment of complex situations to have sound basics for arriving at best decisions.
Operations research seeks the optimum state in all conditions and thus provides optimum solution to organizational problems.

Definition: OR is a scientific methodology – analytical, experimental and quantitative – which by assessing the overall implications of various alternative courses of action in a management system provides an improved basis for management decisions.

1.3 Characteristics of OR (Features)

The essential characteristics of OR are

1. **Inter-disciplinary team approach** – The optimum solution is found by a team of scientists selected from various disciplines.
2. **Wholistic approach to the system** – OR takes into account all significant factors and finds the best optimum solution to the total organization.
3. **Imperfectness of solutions** – Improves the quality of solution.
4. **Use of scientific research** – Uses scientific research to reach optimum solution.
5. **To optimize the total output** – It tries to optimize by maximizing the profit and minimizing the loss.

1.4 Applications of OR

Some areas of applications are

- Finance, Budgeting and Investment
  - Cash flow analysis , investment portfolios
  - Credit polices, account procedures
- Purchasing, Procurement and Exploration
  - Rules for buying, supplies
  - Quantities and timing of purchase
  - Replacement policies
- Production management
  - Physical distribution
  - Facilities planning
  - Manufacturing
  - Maintenance and project scheduling
- Marketing
  - Product selection, timing
  - Number of salesman, advertising
- Personnel management
  - Selection of suitable personnel on minimum salary
  - Mixes of age and skills
- Research and development
  - Project selection
  - Determination of area of research and development
  - Reliability and alternative design

1.5 Phases of OR

OR study generally involves the following major phases

1. Defining the problem and gathering data
2. Formulating a mathematical model
3. Deriving solutions from the model
4. Testing the model and its solutions

5. Preparing to apply the model
6. Implementation

Defining the problem and gathering data

- The first task is to study the relevant system and develop a well-defined statement of the problem. This includes determining appropriate objectives, constraints, interrelationships and alternative course of action.
- The OR team normally works in an **advisory capacity**. The team performs a detailed technical analysis of the problem and then presents recommendations to the management.
- Ascertaining the appropriate **objectives** is very important aspect of problem definition. Some of the objectives include maintaining stable price, profits, increasing the share in market, improving work morale etc.
- OR team typically spends huge amount of time in gathering relevant data.
    - To gain accurate understanding of problem
    - To provide input for next phase.
- OR teams uses Data mining methods to search large databases for interesting patterns that may lead to useful decisions.

Formulating a mathematical model

This phase is to reformulate the problem in terms of mathematical symbols and expressions. The mathematical model of a business problem is described as the system of equations and related mathematical expressions. Thus

1. **Decision variables** (x_1, x_2 … x_n) – 'n' related quantifiable decisions to be made.
2. **Objective function** – measure of performance (profit) expressed as mathematical function of decision variables. For example $P=3x_1 +5x_2 + \ldots + 4x_n$
3. **Constraints** – any restriction on values that can be assigned to decision variables in terms of inequalities or equations. For example $x_1 +2x_2 \geq 20$
4. **Parameters** – the constant in the constraints (right hand side values)

The advantages of using mathematical models are

- Describe the problem more concisely
- Makes overall structure of problem comprehensible
- Helps to reveal important cause-and-effect relationships
- Indicates clearly what additional data are relevant for analysis
- Forms a bridge to use mathematical technique in computers to analyze

Deriving solutions from the model

This phase is to develop a procedure for deriving solutions to the problem. A common theme is to search for an optimal or best solution. The main goal of OR team is to obtain an optimal solution which minimizes the cost and time and maximizes the profit.

Herbert Simon says that “Satisficing is more prevalent than optimizing in actual practice”. Where satisficing = satisfactory + optimizing

Samuel Eilon says that “Optimizing is the science of the ultimate; Satisficing is the art of the feasible”.

To obtain the solution, the OR team uses

- **Heuristic procedure** (designed procedure that does not guarantee an optimal solution) is used to find a good suboptimal solution.
- **Metaheuristics** provides both general structure and strategy guidelines for designing a specific heuristic procedure to fit a particular kind of problem.
- **Post-Optimality analysis** is the analysis done after finding an optimal solution. It is also referred as **what-if analysis**. It involves conducting **sensitivity analysis** to determine which parameters of the model are most critical in determining the solution.

Testing the model

After deriving the solution, it is tested as a whole for errors if any. The process of testing and improving a model to increase its validity is commonly referred as **Model validation**. The OR group doing this review should preferably include at least one individual who did not participate in the formulation of model to reveal mistakes.

A systematic approach to test the model is to use **Retrospective test**. This test uses historical data to reconstruct the past and then determine the model and the resulting solution. Comparing the effectiveness of this hypothetical performance with what actually happened, indicates whether the model tends to yield a significant improvement over current practice.

Preparing to apply the model

After the completion of testing phase, the next step is to install a well-documented system for applying the model. This system will include the model, solution procedure and operating procedures for implementation.

The system usually is computer-based. **Databases** and **Management Information System** may provide up-to-date input for the model. An interactive computer based system called **Decision Support System** is installed to help the manager to use data and models to support their decision making as needed. A **managerial report** interprets output of the model and its implications for applications.

Implementation

The last phase of an OR study is to implement the system as prescribed by the management. The success of this phase depends on the support of both top management and operating management.

The implementation phase involves several steps

1. OR team provides a detailed explanation to the operating management
2. If the solution is satisfied, then operating management will provide the explanation to the personnel, the new course of action.
3. The OR team monitors the functioning of the new system
4. Feedback is obtained
5. Documentation