1. Introduction

Welcome to the series of E-learning module on Nature, scope and models in operation research.

At the end of this session, you will be able to:

- Explain concept of operation research
- Explain scope of operation research
- Explain models in operation research

Let us start with an introduction:
With the growth in the economy, we have seen a lot of large organizations having a large number of management specialists, needing a proper coordination for balancing the conflicting objectives because of the alternative courses of action available to the decision makers.

Let us take an example of maintaining stocks of finished goods.
For a marketing manager, stocks of a large variety of products are a means of supplying the company customers with what they want and when they want it, which clearly indicates that according to a marketing manager a fully stocked warehouse is of prime importance to the company.

Take the opinion of a production manager, for him the prime importance would be to have a long production on a smaller range of products, especially when there is a consumption of time while switching of production from one variety to another.
The result would again be a tendency to increase the amount of stock carried but it is vital that the plant should be running.

In case of financial management, the focus of a finance manager would be in terms of capital tied up unproductively and argues strongly for their reduction.

In case of human resource management, the personnel manager would be looking at a steady level of production which would be advantageous for maintaining labor relationship.

Each one of them try to uphold the interest of the organization from their specialized point of view but still there could be contradictory solutions, it is in such a situation that the whole system, the decision makers , the specialists will need help and Operations research attempts to resolve the conflicts of interest among the various sections of the organizations and seeks the optimal solutions which may not be acceptable to one department but it is in the interest of the organization as a whole.

Operation research is concerned with providing the decision maker with the decision aids like a total system orientation, scientific methods of investigations and models of reality, generally based on quantitative measurement and techniques.

Operation research definitions are as follows:
We cannot get a precise definition for operation research as the scope and application of

operation research is wide.

Operations Research is concerned with scientifically deciding how to best design and operate man-machine system usually requiring the allocation of scarce resources. – Operation Research Society, America.
Operation research is the systematic application of quantitative methods, techniques and tools to the analysis of problems involving the operations of systems. – Daellenbach and George, 1978.

This new decision-making field has been characterized by the use of scientific knowledge through interdisciplinary team effort for the purpose of determining the best utilization of limited resources. – H A Taha,

As the discipline of operation research grew, many other names such as Operations Analysis, Systems Analysis, Decision Analysis and Management Science comes into picture.
The successful application of operations research techniques for solving a problem must involve:

- Constructing mathematical, economic and statistical model of the problem under study to treat situations of complexity and uncertainty. This helps to view the problem in its entirety
- Analyzing the relationships among different variables and /or parameters associated with the problem so as to determine consequences of decision alternatives
- Suggesting suitable measures of desirability (that is, effectiveness or objective function) in order to evaluate the relative merit of decision alternatives (that is, courses of action, acts or strategies)

2. Methodologies

The features of Operation Research to any decision and control problems can be considered under the following methodologies;
Interdisciplinary, methodological, Holistic and Objectivistic.

In the interdisciplinary approach, a team of individuals specializing in mathematics, statistics, economics, engineering, computer science, psychology is organized so that each aspect of the problem can be analyzed by a particular specialist in that field in order to arrive at an appropriate and desirable solution of the problem.

In the methodological approach, scientific methods, techniques and tools are involved to control operations and get optimum solutions to the problems.
The scientific method will consist of observing and defining the problem, formulating and testing the hypothesis, analyzing the results of the test and then deciding whether to accept the hypothesis or reject.
Once the hypothesis is accepted it should be implemented and if rejected an alternative hypothesis should be formulated.

In the holistic approach, an operation Research team examines the relative importance of all conflicting and multiple objectives and validity of the claims of various departments of the organizations from the perspective of the whole organization.

In the objectivistic approach, the operation research seeks to obtain an optimal solution to the problem under analysis.
For this a measure of desirability or effectiveness is defined based in the objectives of the organization.
A measure of desirability so defined is then used to compare alternative courses of action with respect to their outcomes.

The most important approach among the mentioned one is the scientific method and building the decision model.
There are three phases of the scientific method on which the Operations Research practice is based such as, Judgment phase, Research phase and Action phase.

In Judgment phase, we include the following activities in deciding the effectiveness of the measures:

- Identification of the real - life problem
- Selection of an appropriate objective and the value of various variables related to the objective
- Application of the appropriate scale of measurement
- Formulation of an appropriate model of the problem, abstracting the essential information's so that a solution at the decision maker's goals can be sought

Research phase is the largest and the longest among the other two phases.
All phases are equally important as they provide the basis for scientific method. This phase utilizes :

- Observations and data collections for a better understanding of the problem
- Formulating of hypothesis and models
- Observation and experimentation to test the hypothesis on the basis of additional data
- Analysis of the available information and verification of the hypothesis using pre-established measures of desirability
- Predictions of various results from the hypothesis
- Generalizations of the result and consideration of alternative methods

Action Phase consists of making recommendations for implementing the decision by an individual who is in the position to implement results. This person should be aware of the environment in which the problem occurred, objective, assumption and omissions of the model of the problem.

3. Application & Scope

Application and Scope of Operations research are as follows:
The scope of the discipline Operation Research is very wide and has been a popular approach used in the industrial, government and Business problems.
Let us here try to understand the scope of the Operation Research use on solving the problems in the various functional areas.

Let us take the finance and accounting function: Here the operation research is used in various areas like dividend policies, investment, portfolio management, auditing, balance sheet, cash flow analysis for making decisions.
It is also useful for analysis the capital resources of the organization with respect to break even analysis, capital budgeting, cost allocation and control, financial planning.
Creating the claim and complaints procedure and public accounting.

In the field of marketing the operation research can be applied while making decisions like selection of product-mix, marketing planning, export planning. Identifying the sales effort, allocation and assignments and also in advertising and media planning.

Operations research plays an important part in deciding the Purchasing, Procurement and exploration policies and decision making process in an organization to address a business requirement.
The key areas of application of Operations research system are Optimal buying and reordering underprice quantity discount, bidding policies, vendor analysis, transportation planning and replacement policies.

Another important application of operations research is in the area of Production management.
Production management comprises of a vast set of sub areas that determine the setup and management of an industrial house.
As a part of production management functions within an industrial house, OR plays an important factor in the Facilities planning which includes,

- Deciding on Location and Size of the warehouse
- Transportation planning
- Scheduling and optimization
- Optimal connection points between warehouse, distribution centers and retail outlet
- Deciding on the Plant layout, logistics and engineering design

OR also helps in Manufacturing process to outline the Production planning, assembly line, blending, purchasing, inventory control process, aiding in planning employment, training, layoff management and quality control activities.

OR provides information to manage and control Maintenance and project scheduling that covers regular maintenance activities, Maintenance policies, preventive maintenance, size of the resource pool for maintenance and scheduling & allocation of resources.

Another important area of any industrial or business house is Personnel Management and OR plays an important part in aiding manpower planning, wage and administration, skills management, wage balancing, training programme.

In addition, OR aids in General management covering Management Information systems, decision support systems, forecasting, organizational design & control, project management and strategic planning.

The biggest and most widely popular usage of Operations research data is in the Government bodies in the functional areas of Economic planning, natural resources, social planning and energy department.

In addition another significant area of OR applications is in Urban planning, housing planning, military, police, pollution control board, transportation planning for all means of transport in a country.

4. Models & Modeling in OR

Let us now discuss about Models and modeling in Operations Research:

A Common approach of breaking down a bigger system in to smaller systems, creating a model for the key features of a system instead of concentrating in every detail of the system. A model is an abstraction of essential elements of the system which is constructed in various forms and establishing an relationship between the variables and parameters of the systems.

A model, as the name symbolizes, captures only the key characteristics features of a system since there are constant changes that happen in a system.
For example, in a factory, the flow of material can be modeled and it is not important to mention the colour of the machines or the temperature of the building unless and until these parameters are important for the functioning of the system.

For a model to be effective the key aspects of the reality that are being investigated must have a major impact on the decision situation.
However good a model is, it cannot cover all aspects of a system and the reliability and effectiveness of a model depends on the validity of the model in representing the system.

A model examines the behavioral changes of a system without disturbing the ongoing operations.
Models can be classified based on structures, purpose, time reference, degree of certainty and method of solution.
The notable ones are presented as follows:

1. Classification based on structures

Physical models provide a physical appearance of the real object, typically in a scaled down or scaled up model.
Physical models are used in design problems because they are easy to observe, build and describe.
Take the example of aircraft and shipping industry, where a scaled down model is used to study the behavior of the aircraft in different conditions like wind, storm, rain, and lightning.

The models are tested in wind tunnels or towing tanks to study the effect of external forces on body structure, strength of materials, maneuverability, response times, stability, etc.
The beauty of the model is that it can be modified, tuned, corrected till the desired level of system perfection is achieved.

Once the model has achieved its desired end result, the final product gets into production stage thereby significantly reducing the cost of work, rework, and corrections to be applied.
Physical model can be further classified into three models, which is explained as follows

Iconic Models: These retain some physical properties and characteristics of the system that they represent. An iconic model is either an idealized form or scaled version of the system. Blue prints of home, globes, photographs, atom models are example of iconic models.

Analogue models: These represent a system by set of properties different from that of original systems and does not resemble physically. Once the problem is solved, the solution is re-interpreted in terms of the original system. The organizational chart represent the state of formal relationships existing between members of the organization.

Maps in different colours may represent water, desert and other geographical features. Time graphs, series graphs, frequency curves, trend prediction graphs may be used to quantitative relationship between any two properties. They are less specific but easier to manipulate and generalized.

Symbolic Models:
It uses letters, numbers and other symbols to represent the properties of the system. These models are also used to represent relationship which can be represented in a physical form. Symbolic models can be classified into two categories – verbal model and mathematical model.

Verbal models which describes a situation in written or spoken language for example, books, sentences.
Mathematical models which involves the use of mathematical symbols, letters, numbers, and operators to represent relationship among various variables of the system to describe its properties or behaviour. Symbolic models are precise and abstract, can be manipulated by using laws of mathematics.

2. Classifications based on Purpose: There are 2 models that come under this category.
Descriptive Models: Based on purpose of their utility, some aspects of a situation are described based on observations survey, questionnaire results or other available data of a situation and there is no need to predict or recommend.
For example the Organization chart, plan layout diagram, block diagram that represent an algorithm or a problem solving method.

Predictive models: These are based on dependent and independent variables and permit the options of trying out “what if” questions based on conditional decision making. These models are used to predict the outcome of a given set of alternatives to a problem. In these models we cannot get a best decision alternative but can have an idea of each alternative available to an individual and the predicted end result or consequences of taking each of the those alternatives.

Normative Models: These models provide the best or optimal solutions to problems subject to limitations on the use of resources. They recommend courses for actions; models are formulated for optimizing the given objective function. They are also called prescriptive models because they prescribe what the decision makers ought to do.

3. Classification based on Time reference: There are 2 models that come under this category.

Static models: Models that present a system at some specified time and does not account for changes over time are called Static models. An inventory model developed and solved to determine economic order quantity for the next period assuming that the demand in planning period would remain the same as that of today.

Dynamic models: Time is considered as one of the variables and admits the impact of changes generated by time in the selection of the optimal course of action. Thus, a sequence of inter related decisions are made to achieve the optimal course of action to optimize the given objective. Dynamic programing is an example of dynamic model.

4. Classification based on degree of Certainty: There are 2 models that come under this category.

Deterministic models: If all the parameters, constants and functional relationships are assumed to be known with certainty when the decision is made, then the model is said to be deterministic. Thus, in such a case, the outcome associated with a particular course of action is known.

For a specific set of input values there is a uniquely determined output which represents the solution of the model under conditions of certainty. The results of the models assume single value. Linear programming models are example of deterministic models

Probabilistic models or Stochastic models: Models in which at least one parameter or decision variables is a random variable are called probabilistic models. Since at least one decision variable is random, an independent variable which is the function of the dependent variable will also be random.

This means the consequences or payoff due to certain changes in the independent variable cannot be predicted with certainty. Insurance against risk like fire, accidents, sickness are examples where patterns of events is studied in the form of a probability distribution.

5. Classification based on Method of Solution: There are 2 models that come under this category.

Analytical models: These models have specific mathematical structure and thus can be solved by known analytical or mathematical techniques. Any optimization model is an analytical model

Simulation models: These models have mathematical structure but are not solved by applying mathematical techniques to get a solution.
Instead a simulation model is essentially computer assisted experimentation on a mathematical structure and typically symbolizing a real life problem in order to describe and evaluate its behaviour under certain circumstances over a period of time.

Simulation models are more flexible than mathematical models and can be used to represent a complex system which otherwise cannot be represented mathematically. These models do not provide general solutions like those of mathematical models.

5. Steps Involved in Methodology of OR

Let us now discuss about the steps involved in methodology of operation research:

For the effective use of the operation research technique, it is essential to follow steps in planning, organizing, directing and controlling Operations Research activities within an organization. The following steps represent the methodology of operation research.

Step 1: Analysis of the system and problem formulation:
The analysis begins by detailed observations of the organizational structure, climate, communication and control system, the objectives and expectations of the organization. This information will help in assessing the difficulty of the study in terms of costs, time requirement, resource requirement and probability of success.

While formulating the problem we should consider the following points:

- Problem components
- Decision environment
- Alternative courses of action
- Measure of effectiveness

Step 2: Constructing a mathematical model:
In every decision problems, certain basic components are required like the controllable variables, uncontrollable variables, the objective function, constrains or limitations on the value of the decision variable, specific functional relationships between the decision variables in the objective function & in the constrains and parameters that are deterministic or probabilistic.

Step 3: Solution of the model:
In these stage different methods like the analytical method, numerical method and monte carlo method are adopted to find the optimal value of the decision variable; such a solution is called the optimal solution to the problem.

Step 4: Validation of the Model:
The model should be tested for the error to measure its accuracy., the degree to which it actually represents the system or problem being modeled must be established as a model which must be applicable for a longer time and can be updated from time to time taking into consideration the past, present and future aspects of the problem.

A model is valid or accurate if,

- It contains all of the objective, constrains and decisions variable relevant to the problem
- Those objectives, constrains, and decisions variables included in the model are all relevant to, or actually par, of the problem
- The functional relationships among variables are valid

Step 5: Implementing the solution
The system not only helps in identifying the good decision but also to select alternatives that are capable of being implemented.
It is important to ensure that any solution implemented is continuously reviewed and updated in the light of a changing environment.

The behavioural aspects of change are exceedingly important to the successful implementation of results.
In any case the decision maker who is in the best position to implement results must be aware of the objective, assumption, omissions and limitations of the model

Step 6: Establishing Controls over the solutions:
The dynamic environment and changes within the environment can have significant implications regarding the continuing validity of models and their solutions.

Thus, a control procedure has to be established for detecting significant changes in decision variables of the problem so that suitable adjustments can be made in the solution without having to build a model every time a significant change occurs.

Here's a summary of our learning in this session, where we have understood:

- The Concept of Operation Research
- The Scope of Operation Research
- The Models in Operation Research