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# An Analysis upon the Concept and Applications of Operation Research: Tools and Techniques

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***Abstract – This study will provide an overview of Operations Research (O.R.) from the perspective of an industrial engineer. The focus of the study is on the basic philosophy behind O.R. and the so-called "O.R. approach" to solving design and operational problems that industrial engineers commonly encounter. In its most basic form, O.R. may be viewed as a scientific approach to solving problems; it abstracts the essential elements of the problem into a model, which is then analyzed to yield an optimal solution for implementation.***

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## INTRODUCTION

Operations Research (OR) is a science which deals with problem, formulation, solutions and finally appropriate decision making. This subject is new and started after World War II, when the failures of missions were very high. Scientists and technocrats formed team to study the problem arising out of difficult situations and at the later stage solutions to these problems. It is research designed to determine most efficient way to do something new. OR is the use of mathematical models, statistics and algorithm to aid in decision-making. It is most often used to analyze complex real life problems typically with the goal of improving or optimizing performance. Decision making is the main activity of an engineer/manager.

Some decisions can be taken by common sense, sound judgement and experience without using mathematics, and some cases this may not be possible and use of other techniques is inevitable. With the growth of technology, the World has seen a remarkable changes in the size and complexity of organisations. An integral part of this had been the division of labour and segmentation of management responsibilities in these organisations. The results have been remarkable but with this, increasing specialization has created a new problem to meet out organizational challenges. The allocation of limited resources to various activities has gained significant importance in the competitive market. These types of problems need immediate attention which is made possible by the application of OR techniques. The tools of operations research are not from any one discipline, rather Mathematics, Statistics, Economics, Engineering, Psychology, etc. have contributed to this newer discipline of knowledge.

Today, it has become a professional discipline that deals with the application of scientific methods for decision-making, and especially to the allocation of scare resources. In India first unit of OR started in the year 1957 with its base at RRL Hyderabad. The other group was set up in Defence Science Laboratory which was followed by similar units at different parts of the country. The popular journal of OPSEARCH was established in 1963, to promote research in this field. Keeping in view the critical economic situation which required drastic increase in production efficiency, OR activities were directed, in all areas of business activities. In the late 50's OR was introduced at university level. With the development of PC's the use of OR techniques became prominent and effective tool as large amount of computation is required to handle complex problems. In recent years application of OR techniques have achieved significance in all walk of life, may it be industry or office work for making strategical decisions more scientifically.

Operation Research is a relatively new discipline. The contents and the boundaries of the OR are not yet fixed. Therefore, to give a formal definition of the term Operations Research is a difficult task. The OR starts when mathematical and quantitative techniques are used to substantiate the decision being taken. The main activity of a manager is the decision making. In our daily life we make the decisions even without noticing them. The decisions are taken simply by common sense, judgment and expertise without using any mathematical or any other model in simple situations. But the decision we are concerned here with are complex and heavily responsible. Examples are public transportation network planning in a city having its own layout of factories, residential blocks or finding the appropriate product mix when there

exists a large number of products with different profit contributions and production requirement etc.

Operations Research tools are not from any one discipline. Operations Research takes tools from different discipline such as mathematics, statistics, economics, psychology, engineering etc. and combines these tools to make a new set of knowledge for decision making. Today, O.R. became a professional discipline which deals with the application of scientific methods for making decision, and especially to the allocation of scarce resources. The main purpose of O.R. is to provide a rational basis for decisions making in the absence of complete information, because the systems composed of human, machine, and procedures may do not have complete information.

Operations Research can also be treated as science in the sense it describing, understanding and predicting the systems behaviour, especially man-machine system. Thus O.R. specialists are involved in three classical aspect of science, they are as follows:

i) Determining the systems behaviour

ii) Analyzing the systems behaviour by developing appropriate models

iii) Predict the future behaviour using these models

The emphasis on analysis of operations as a whole distinguishes the O.R. from other research and engineering. O.R. is an interdisciplinary discipline which provided solutions to problems of military operations during World War II, and also successful in other operations. Today business applications are primarily concerned with O.R. analysis for the possible alternative actions. The business and industry befitted from O.R. in the areas of inventory, reorder policies, optimum location and size of warehouses, advertising policies, etc.

Although it is a distinct discipline in its own right, Operations Research (O.R.) has also become an integral part of the Industrial Engineering (I.E.) profession. This is hardly a matter of surprise when one considers that they both share many of the same objectives, techniques and application areas. O.R. as a formal subject is about fifty years old and its origins may be traced to the latter half of World War II. Most of the O.R. techniques that are commonly used today were developed over (approximately) the first twenty years following its inception. During the next thirty or so years the pace of development of fundamentally new O.R. methodologies has slowed somewhat. However, there has been a rapid expansion in (1) the breadth of problem areas to which O.R. has been applied, and (2) in the magnitudes of the problems that can be addressed using O.R. methodologies. Today, operations research is a mature, well-developed field with a sophisticated array of techniques that are used routinely to solve problems in a wide range of application areas.

## THE OPERATIONS RESEARCH APPROACH

Given that O.R. represents an integrated framework to help make decisions, it is important to have a clear understanding of this framework so that it can be applied to a generic problem. To achieve this, the so-called *O.R. approach* is now detailed. This approach comprises the following seven sequential steps: (1) Orientation, (2) Problem Definition, (3) Data Collection, (4) Model Formulation, (5) Solution, (6) Model Validation and Output Analysis, and (7) Implementation and Monitoring. Tying each of these steps together is a mechanism for continuous feedback; Figure 1 shows this schematically.

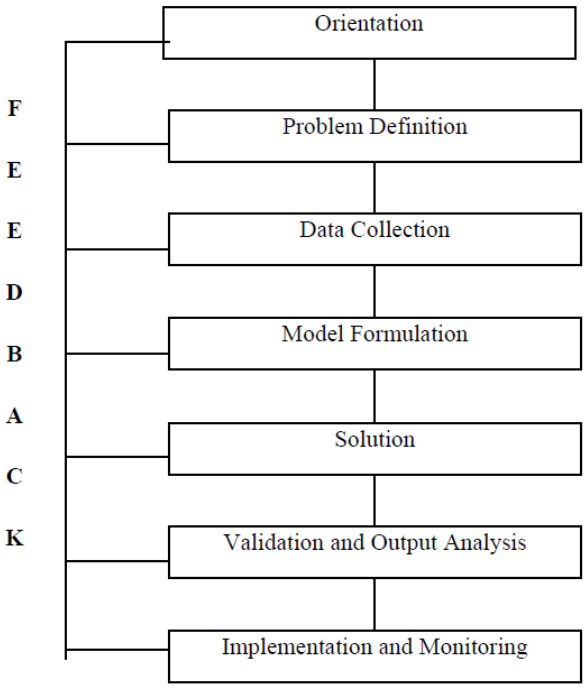


**Figure 1: The Operations Research Approach**

While most of the academic emphasis has been on Steps 4, 5 and 6, the reader should bear in mind the fact that the other steps are equally important from a practical perspective. Indeed, insufficient attention to these steps has been the reason why O.R. has sometimes been mistakenly looked upon as impractical or ineffective in the real world.

Each of these steps is now discussed in further detail. To illustrate how the steps might be applied, consider a typical scenario where a manufacturing company is planning production for the upcoming month. The company makes use of numerous resources (such as labor, production machinery, raw materials, capital, data processing, storage space, and material handling equipment) to make a number of different products which compete for these resources. The products have differing profit margins and require different amounts of each resource. Many of the

resources are limited in their availability. Additionally, there are other complicating factors such as uncertainty in the demand for the products, random machine breakdowns, and union agreements that restrict how the labor force can be used. Given this complex operating environment, the overall objective is to plan next month's production so that the company can realize the maximum profit possible while simultaneously ending up in a good position for the following month(s).

As an illustration of how one might conduct an operations research study to address this situation, consider a highly simplified instance of a production planning problem where there are two main product lines (widgets and gizmos, say) and three major limiting resources (A, B and C, say) for which each of the products compete. Each product requires varying amounts of each of the resources and the company incurs different costs (labor, raw materials etc.) in making the products and realizes different revenues when they are sold. The objective of the O.R. project is to allocate the resources to the two products in an optimal fashion.

***Orientation*:** The first step in the O.R. approach is referred to as problem orientation. The primary objective of this step is to constitute the team that will address the problem at hand and ensure that all its members have a clear picture of the relevant issues. It is worth noting that a distinguishing characteristic of any O.R. study is that it is done by a multifunctional team. To digress slightly, it is also interesting that in recent years a great deal has been written and said about the benefits of project teams and that almost any industrial project today is conducted by multi-functional teams. Even in engineering education, teamwork has become an essential ingredient of the material that is taught to students and almost all academic engineering programs require team projects of their students. The team approach of O.R. is thus a very natural and desirable phenomenon.

***Problem Definition*:** This is the second, and in a significant number of cases, the most difficult step of the O.R. process. The objective here is to further refine the deliberations from the orientation phase to the point where there is a clear definition of the problem in terms of its scope and the results desired. This phase should not be confused with the previous one since it is much more focused and goal oriented; however, a clear orientation aids immeasurably in obtaining this focus. Most practicing industrial engineers can relate to this distinction and the difficulty in moving from general goals such “increasing productivity” or “reducing quality problems” to more specific, well-defined objectives that will aid in meeting these goals.

***Data Collection*:** In the third phase of the O.R. process data is collected with the objective of translating the problem defined in the second phase into a model that can then be objectively analyzed. Data typically comes from two sources – observation and standards. The first corresponds to the case where data is actually collected by observing the system in operation and typically, this data tends to derive from the technology of the system. For instance, operation times might be obtained by time studies or work methods analysis, resource usage or scrap rates might be obtained by making sample measurements over some suitable interval of time, and data on demands and availability might come from sales records, purchase orders and inventory databases. Other data are obtained by using standards; a lot of cost related information tends to fall into this category. For instance, most companies have standard values for cost items such as hourly wage rates, inventory holding charges, selling prices, etc.; these standards must then be consolidated appropriately to compute costs of various activities. On occasion, data may also be solicited expressly for the problem at hand through the use of surveys, questionnaires or other psychometric instruments.

***Model Formulation*:** This is the fourth phase of the O.R. process. It is also a phase that deserves a lot of attention since modeling is a defining characteristic of all operations research projects. The term “model” is misunderstood by many, and is therefore explained in some detail here.

***Solution*:** The fifth phase of the O.R. process is the solution of the problem represented by the model. This is the area on which a huge amount of research and development in O.R. has been focused, and there is a plethora of methods for analyzing a wide range of models.

## OPERATION RESEARCH TOOLS AND TECHNIQUES

Operations Research uses any suitable tools or techniques available. The common frequently used tools/techniques are mathematical procedures, cost analysis, electronic computation. However, operations researchers given special importance to the development and the use of techniques like linear programming, game theory, decision theory, queuing theory, inventory models and simulation. In addition to the above techniques, some other common tools are non-linear programming, integer programming, dynamic programming, sequencing theory, Markov process, network scheduling (PERT/CPM), symbolic Model, information theory, and value theory. There is many other Operations Research tools/techniques also exists. The brief explanations of some of the above techniques/tools are as follows:

**Linear Programming:** This is a constrained optimization technique, which optimize some criterion

within some constraints. In Linear programming the objective function (profit, loss or return on investment) and constraints are linear. There are different methods available to solve linear programming.

**Game Theory:** This is used for making decisions under conflicting situations where there are one or more players/opponents. In this the motive of the players are dichotomized. The success of one player tends to be at the cost of other players and hence they are in conflict.

**Decision Theory:** Decision theory is concerned with making decisions under conditions of complete certainty about the future outcomes and under conditions such that we can make some probability about what will happen in future.

**Queuing Theory:** This is used in situations where the queue is formed (for example customers waiting for service, aircrafts waiting for landing, jobs waiting for processing in the computer system, etc). The objective here is minimizing the cost of waiting without increasing the cost of servicing.

**Inventory Models:** Inventory model make a decisions that minimize total inventory cost. This model successfully reduces the total cost of purchasing, carrying, and out of stock inventory.

**Simulation:** Simulation is a procedure that studies a problem by creating a model of the process involved in the problem and then through a series of organized trials and error solutions attempt to determine the best solution. Some times this is a difficult/time consuming procedure. Simulation is used when actual experimentation is not feasible or solution of model is not possible.

**Non-linear Programming:** This is used when the objective function and the constraints are not linear in nature. Linear relationships may be applied to approximate non-linear constraints but limited to some range, because approximation becomes poorer as the range is extended. Thus, the non-linear programming is used to determine the approximation in which a solution lies and then the solution is obtained using linear methods.

**Dynamic Programming:** Dynamic programming is a method of analyzing multistage decision processes. In this each elementary decision depends on those preceding decisions and as well as external factors.

**Integer Programming:** If one or more variables of the problem take integral values only then dynamic programming method is used. For example number or motor in an organization, number of passenger in an aircraft, number of generators in a power generating plant, etc.

**Markov Process**: Markov process permits to predict changes over time information about the behavior of a system is known. This is used in decision making in situations where the various states are defined. The probability from one state to another state is known and depends on the current state and is independent of how we have arrived at that particular state.

**Information Theory:** This analytical process is transferred from the electrical communication field to O.R. field. The objective of this theory is to evaluate the effectiveness of flow of information with a given system. This is used mainly in communication networks but also has indirect influence in simulating the examination of business organizational structure with a view of enhancing flow of information.

## APPLICATIONS OF OPERATIONS RESEARCH

Today, almost all fields of business and government utilizing the benefits of Operations Research. There are voluminous of applications of Operations Research. Although it is not feasible to cover all applications of O.R. in brief. The following are the abbreviated set of typical operations research applications to show how widely these techniques are used today:

**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

**Organizational Behavior / Human Resources:**

Personnel planning

Recruitment of employees

Skill balancing

Training program scheduling

Designing organizational structure more effectively

**Purchasing:**

Optimal buying

Optimal reordering

Materials transfer

**Research and Development:**

R & D Projects control

R & D Budget allocation

Planning of Product introduction

## PHASES OF OPERATION RESEARCH

OR is a logical and systematic approach to provide a rational basis for decision-making. The phases of OR must be logical and systematic. The various steps required for the analysis of a problem under OR are as follows:

**Step I. Observe the Problem Environment**

The first step of OR study is the observation of the environment in which the problem exists. The activities that constitute this step are visits, conferences, observations, research etc. with the help of such activities, the OR analyst gets sufficient information and support to proceed and is better prepared to formulate the problem.

**Step II. Analyze and Define the Problem**

In this step not only the problem is defined but also uses objectives and limitations of the study that are stressed in the light of the problem. The end results of this step are clear grasp of need for a solution and understanding of its nature.

**Step III. Develop a Model**

The next step is to develop model, which is representation of same real or abstract situation. OR models are basically mathematical models representing systems, process or environment in form of equations, relationships or formulae. The activities in this step is to defining interrelationships among variables, formulating equations, using known OR models or searching suitable alternate models. The proposed model may be field tested and modified in order to work under stated environmental constraints. A model may also be modified if the management is not satisfied with the answer that it gives.

**Step IV. Selection of Data Input**

It is an established fact that without authentic and appropriate data the results of the OR models cannot be trusted. Hence, taping right kind of data is a vital step in OR process. Important activities in this step are analyzing internal-external data and facts, collecting opinions and using computer data banks. The purpose of this step is to have sufficient input to operate and test the model.

**Step V. Solution and Testing**

In this step the solution of the problems is obtained with the help of model and data input. Such a solution is not implemented immediately and this solution is used to test the model and to find its limitations if any. If the solution is not reasonable or if the model is not behaving properly, updating and modification of the model is considered at this stage. The end result of this step is solution that is desirable and supports current organizational objectives.

**Step VI. Implementation of the Solution**

This is the last phase of the OR study. In OR the decision-making is scientific but implementation of decision involves many behavioral issues. Therefore, implementation authority has to resolve the behavioral issues, involving the workers and supervisors to avoid further conflicts. The gap between management and OR scientist may offer some resistance but must be eliminated before solution is accepted in totality. Both the parties should play positive role, since the implementation will help the organisation as a whole. A properly implemented solution obtained through OR techniques results in improved working conditions and wins management support.

## CONCLUSION

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.

Proposing a definition to the operations research is a difficult one, because its boundary and content are not fixed. The tools for operations search is provided from the subject's viz. economics, engineering, mathematics, statistics, psychology, etc., which helps to choose possible alternative courses of action. The operations research tool/techniques include linear programming, non-linear programming, dynamic programming, integer programming, Markov process, queuing theory, etc.

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