PRIMER

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OPERATIONS RESEARCH (OR)

General

1. OR is the application of modern science on complex problems arising in the direction and management of large systems of men, machines, materials and money in industry, business, government and defense. Its distinctive approach is to develop a scientific model of the system, incorporating measurements of factors such as change and risk, with which to predict and compare the outcomes of alternative decisions, strategies or controls. The purpose is to help management determine its policy and actions scientifically. OR applies scientific methods to improve the effectiveness of operations, decisions and management.

Definition

2. An apt definition of OR in the domain of Armed Forces is:-

> ***"Employment of scientific methods of analysis to provide commanders with quantitative basis for making decisions regarding operations under their control"***.

Historical Perspective

3. During the Second World War, the British and American forces realised that military knowledge by itself was not adequate to analyse military systems for finding the best or optimum solutions to their tactical problems. Therefore, the British and then the U.S. military management called upon a large number of scientists to apply a scientific approach to dealing with this and other strategic and tactical problems. In effect, they were asked to do **Research on (Military) Operations**. By developing effective methods of using the new tool of radar, these teams were instrumental in winning the Air Battle of Britain. Through their research on how to better manage convoy and antisubmarine operations, they also played a major role in winning the Battle of the North Atlantic. Similar efforts assisted the Island Campaign in the Pacific. When the war ended, the success of OR in the war effort spurred interest in applying OR outside the military as well. By the early 1950s, these individuals had introduced the use of OR to a variety of organizations in business, industry, and government. Additional reading material on the history of OR can be accessed at https://www.informs.org/ORMS-Today/Public-Articles/June-Volume-42-Number-3/History-of-OR-Useful-history-of-operations-research.

OR Methodology

4. OR methodology consists of seven steps as follows:

(a) Identification of the Problem / Symptoms by the Commander or the Organisation.

(b) Formulation of the Problem.

(c) Data Collection.

(d) Model Building (Mathematical Model).

(e) Deriving Solutions from the Model.

(f) Validation and Implementation.

(g) Monitoring.

Techniques of OR

5. Some of the more commonly used models and their uses are as follows:

(a) **Linear Programming (LP)**. This is the most commonly used technique and it deals with the allocation of scarce resources in an optimal manner so as to maximise effectiveness or minimise cost e.g. best mix of weapons, units, obstacles etc., to achieve a specified objective. Special models, as variations of LP are: -

(i) **Transportation Model.** Matching of sources of supply to destinations on basis of cost, distance or time. e.g. movement of stores from depots to forward areas.

(ii) **Assignment Model.** To assign a number of 'origins' to the same number of 'destinations' at a minimum total cost e.g. assigning men/machines/units to the same number of jobs/tasks.

(b) **Queuing Models**. To determine the amount of servicing facilities to be provided to reduce delays to acceptable levels, considering random pattern of arrivals and servicing time; and optimal utilisation of resources, e.g. number of doctors/beds to be provided in a hospital.

(c) **Simulation Models**. Quantifying risk/probability of occurrence of the phenomenon based on probabilistic estimates. Simulation of behaviour pattern of queues, weapons/weapon systems, the outcome of engagements in battle, the breakdown of equipment, repair facilities etc.

(d) **Decision Matrix (Expected Value Models)**. Simultaneously assessment of feasible and alternative courses of action in the face of a number of different environments (states of nature) with assessed probabilities of occurrence e.g. selection of own best course of action from various alternatives considering different courses of action open to the enemy.

(e) **Decision Tree**. Basic approach is similar to the decision matrix. Whereas, decision matrix deals with single point decision problems, the decision tree analyses sequential problems e.g. multiphase attack/advance operation.

(j) **Analytic Hierarchy Process (AHP)**. To carry out a fair and objective selection of personnel or equipment/weapons against laid down criteria / desired attributes even if choices are not closely competing.

(k) **Decision Rules**. These deal with the risk-taking profile of a commander, based on which he takes a decision under situations of uncertainty.

(l) **Game Theory**. This technique can be used effectively to analyse conflict situations (like war), under conditions of uncertainty.

OR Software

6. Various software are available for solving the problems of OR like MS Excel, POM/QM etc. MS Excel is extensively used at CDM for solving the OR problems. Officers are advised to learn basic functions of MS Excel prior to the commencement of the course. Brief on the basic functionality of Excel required for OR along the important formulas are annexed for reference. Additional material on the usage of MS Excel may be accessed at https://support.office.com/en-us/article/excel-for-windows-training-9bc05390-e94c-46af-a5b3-d7c22f6990bb. Basic tutorial on excel may be viewed at https://www.youtube.com/watch?v=rwbho0CgEAE.

Web Reference

http://www.me.utexas.edu/~jensen/ORMM/

http://ifors.org/web/

https://www.informs.org/

http://www.apors.asia/

http://www.orsi.in/

SYSTEMS ANALYSIS (SA)

Historical Background

7. Right from the evolution stage, human beings have been facing problems arising from operations of systems. At the initial stage, involvement of human beings was limited to their own social systems. With the growth of human civilisation, the types and size of systems has increased and so have the related problems. This brought about the need to systematically scrutinise the systems using scientific tools. Till 1930s there wasn't any known approach to solving complex systemic problems. During World War II some successful systems studies were carried out which had a telling effect on the outcome of war.

8. By mid 1950s, the problems related to very large operating systems were investigated. The systems being complex in nature and scope being quite large, specialists from many disciplines were involved in solving these systemic problems and this problem solving approach was called '**Systems Analysis**'. The name emphasizes the fact that there existed an operating system associated with each problem that was being investigated. The latter half of the last century has seen tremendous growth in both the scope and diversity of 'Systems Analysis' and the growth and scope is getting enlarged in the twenty first century. New tools are being developed by modern systems analysts to address the complex systems problems. Since 1980s the traditional System Analysis is being progressively called '**Systems Thinking**'.

Purpose of Systems Analysis

9. The central purpose of Systems Thinking is to help decision makers to ameliorate the problems and manage the policy issues faced by them. They do it by improving the basis for their judgment by generating information and marshaling evidence bearing on their problems and on possible actions that may be suggested to alleviate the problem. *Thus, a* ***Systems Approach commonly focuses on a problem arising from interactions among elements in society, enterprises, and the environment; considers various responses to this problem; and supplies evidence about the consequences – good, bad, and indifferent – of these responses.***

Definition

10. There is no standard and universal definition of Systems Analysis. For our purpose, the following definition will meet the objective of studying the discipline:-

A systematic approach for helping a decision maker choose a course of action by investigating his full problem, searching out objectives and alternatives, and comparing them in the light of their consequences, using an

appropriate framework or yardstick – in so far as possible analytic – to bring expert judgment and intuition to bear on the problem.

Systems Thinking Methodology

11. Three major methodologies of Systems Thinking **as relevant to Armed Forces** can be broadly classified as:-

(a) Hard Systems Thinking (HST).

(b) Systems Dynamics.

(c) Soft Systems Methodology (SSM).

Hard Systems Thinking (HST)

12. A hard systems approach to problem solving requires the analyst to check that there is a large measurement of agreement among the system owners as to what the perceived problem or opportunity is. There will also have to be a large measure of agreement about the overall goal. Such cases therefore, lend themselves to quantification of various aspects related to the problem.

Systems Dynamics

13. Systems dynamics relates to the problems where the participants are unitary and the complexity of the problem is high. System dynamics thus extends to application of systems thinking to more strategic problems. System dynamics employs the science of feedback, harnessed to the power of the modern digital computer, to unlock the secrets of complex, multiple-loop non-linear systems.

Soft Systems Methodology (SSM)

14. Soft Systems are perceived as those concerned with human activity of some kind. In soft systems a situation is perceived to exhibit crisis, conflict, uncertainty or unease in relationships among the human ‘actors’.

Reading Material

Dennis Sherwood: Seeing the forest for the trees.

Peter Senge: The fifth discipline.

Alan Waring: Practical Systems Thinking.

Michael C Jackson: Systems Thinking Creative Holism for Managers.

www.systemsthinking.org