OPERATIONS RESEARCH - CONTEMPORARY ROLE IN MANAGERIAL DECISION MAKING

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ABSTRACT

As the global environment becomes fiercely competitive, Operations Research has gained significance in applications like world-class Manufacturing systems(WCM), Lean production, Six-sigma quality management, Benchmarking, Just-in-time (JIT) inventory techniques. The growth of global markets and the resulting increase in competition have highlighted the need for Operation Research. To survive and lead the today's highly competitive and demand driven market, pressure is on management to make economical decisions. One of the essential managerial skills is ability to allocate and utilize resources appropriately in the efforts of achieving the optimal performance efficiently. In some cases such as small-scale low complexity environment, decision based on intuition with minimal quantitative basis may be reasonably acceptable and practical in achieving the goal of the organization. However, for a large-scale system, both quantitative and qualitative (i.e. intuition, experience, common sense) analyses are required to make the most economical decisions. Using Operations Research techniques including Linear Programming, Discrete Event Simulation and Queueing Theory, organization leaders can make high quality decisions. Operations managers are not expected to be experts in any decision science tools; however, he or she must have fundamental knowledge of such tools to acquire right resources and to make the most economically sounding decisions for the company as a whole. Present paper is an attempt to study the importance of Operation research and various techniques used to improve the operational efficiency of the organization.

1. INTRODUCTION:

Operations Research (OR) is one of the popular managerial decision science tools used by profit and nonprofit organizations. As the global environment becomes fiercely competitive, Operations Research has gained significance in applications like world-class Manufacturing systems(WCM), Lean production, Six-sigma quality management, Benchmarking, Just-in-time (JIT) inventory techniques. The growth of global markets and the resulting increase in competition have highlighted the need for Operation Research. In order to be competitive, businesses must meet the challenges present in a global market by offering products and services that offer good value to their customers. Good value is a combination of low cost, high quality, rapid availability and real time information on these.

In order to enhance the role of operational research and speed up the process and methodologies of different stakeholders, they should work closely and complement each other's effort. In this process, the academicians should take the lead in the design, development and demonstration of sustainable operational research models. Industry should support this initiative and accelerate the

transmission of this methodology. This would ensure wealth creation in the short term, and sustainable development in the long term. The government should encourage this initiative by adopting optimized responses. Consequently, optimized policy responses and its implementation would bring about positive changes in the socio political and economic environment. As a result, sustained use of operational research would be a regular feature in the decision making process of the government, industry and the society. Such a wide usage of operational research models by the government, industry and academicians would not only contribute to the discipline but also would contribute to the enhanced quality of life in India. The present paper is an attempt to highlight the significance of operation research, different techniques used and its application in business and industry.

2. ORIGIN, HISTORY & DEVELOPMENTS

Operations Research as a new field started in the late 1930's and has grown and expanded tremendously in the last 30 years. The British army was conducting exercises on the radar system for detecting the aircrafts. In July 1938, the Superintendent of Bawdsey Research Station, announced that although the exercise had demonstrated the technical feasibility of the radar system for detecting aircraft, its operational achievements were not up to what was required.

He therefore proposed that a crash program of research into the operational - as opposed to the technical - aspects of the system should begin. The term "Operational Research" was coined as a suitable description of this new branch of applied science.

On 15th May 1940, with German forces advancing rapidly in France, Stanmore Research Section was asked to analyze a French request for ten additional fighter squadrons. They prepared graphs for Winston Churchill (British Prime Minister), based upon a study of current daily losses and replacement rates, indicating how rapidly such a move would deplete fighter strength. No aircrafts were sent and most of those currently in France were recalled. This is held by some to be the most strategic contribution to the course of the war made by Operations Research (as the aircraft and pilots saved were consequently available for the successful air defense of Britain, the Battle of Britain). In 1941 Operational Research Section (ORS) was established in Coastal Command which was to carry out some of the most well-known OR work in World War II. Thus OR as a separate field of specialization was born!

In order to make the effective and efficient decisions, managers must have fundamental understanding of the decision science tools utilized in developing set of recommendations to choose from. The Operations research is usually the mathematical treatment, analysis of a process, problem, or operation to determine its purpose and effectiveness and to gain maximum efficiency. The operation technique is utilized by functional groups such as Industrial Engineering in effort to support Operations Managers to make economically feasible decisions on a range of systematic challenges. The main responsibilities of operations management are to manage and operate as efficiently and effectively as possible with the given resources. Quantitative methods which comprises of Simulation, Linear and nonlinear programming, Queueing Theory and Stochastic Modeling, are well-accepted techniques by both research and practice communities.

Functional entities such as Industrial or Systems Engineering use methodologies to provide feasible alternatives for operations mangers to decide on. An important component of decision-making process is verifying and validating alternatives, which typically involve decision makers, engineers or analysts. Growth of Operations Research is to a large extent, the result of the widespread availability of computers. Most Operations Research involves carrying out a large number of numeric calculations and without computers this would simply not be possible.

In India, Operation Research came into existence in 1949 when an Operation Research unit was established at Regional Research Laboratory, Hyderabad. Also Prof. R.S.Verma set up an Operation Research team at Defence Science Laboratory to solve problems of store, purchase and planning. During the 1950's there was substantial progress in the application of Operation Research techniques for civilian activities along with a great interest in the professional development and education in Operation Research. Many colleges and universities introduced Operation Research in their curricula. They were generally schools of engineering, public administration, business management, applied mathematics, economics, computer science etc.

In 1953, Prof. P.C. Mahalanobis [8] established an Operation Research team in the Indian Statistical Institute, Calcutta to solve problems related to national planning and survey. In 1958, project scheduling techniques: PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) were developed as efficient tools for scheduling and monitoring lengthy, complex and expensive projects of that time. The real development of Operation Research in the national field was carried out by Prof. Mohalanobis in India when he used it in national planning. Operation Research is also being used in Railway, waiting or queueing problems of passengers for tickets at booking windows or trains queueing up in marshalling yard, waiting to be sorted out are tackled by various Operation Research techniques.

3. EVOLUTION OF OPERATION RESEARCH AS AN ACADEMIC DISCIPLINE

Because of this historical legacy, operational research was accepted as a legitimate management tool in defense research establishments and subsequently for efficient resource planning and allocation by Government departments. Business supported the accelerated growth of this discipline by funding real and potential applications. Over period of time, a symbiotic relationship between government, business and academia ensured the growth and expansion of the discipline for their mutual benefit. During the last 50 years, operational research has evolved as a multidisciplinary function involving economics, mathematics, statistics, industrial engineering and management.

Broadly, operational research as a discipline can be classified into three distinct set of categories. They correspond to tools, models and methodology. Tools include ABC analysis, 80:20 rule, and Break Even Analysis. Blending models, optimized distribution system, portfolio optimization of assets would broadly represent examples under the category of models. Operational research methodology would include project management systems, multi criteria optimization, game theory, simulation methodology, data envelopment analysis, enterprise resource planning systems and conflict resolution methods [13]. The tools, models and methodology of operational research have found a variety of applications in different contexts. Also, several outstanding academicians have contributed to the development of this discipline.

Most commonly used techniques and methods [3] of Operation Research, which can be freely applied by a progressive management in decision-making processes are: Linear Programming, Decision Models, Network Theory, Inventory Control Models, Queuing Theory, Sequencing, Game Theory, Simulation, Replacement theory, Reliability, Markovian Models.

4. SIGNIFICANCE OF OPERATIONS RESEARCH

Because of Operation Research's multidisciplinary character and application in varied fields, it has a bright future, provided people devoted to Operation Research study can help meet the needs of society. Some of the problems in the area of hospital management, energy conservation, environmental pollution, etc. have been solved by Operation Research specialists and this is an indication that Operation Research can also contribute towards the improvement in the social life and areas of global need.

The Operation Research approach is particularly useful in balancing conflicting objectives (goals or interests) where there are many alternative courses of action available to the decision-makers. In a theoretical sense, the optimum decision must be one that is best for the organization as a whole it is often called the global optimum. A decision that is best for one or more sections of the organization is usually called suboptimum decision. Operation Research attempts to resolve the conflicts of interest among various sections of the organization and seeks the optimal solution which may not be acceptable to one department but is in the interest of the organization as a whole. Operation Research is concerned with providing the decision-maker with decision aids (or rules) derived from:

i) A total system orientation,

ii) Scientific methods of investigation, and

iii) Models of reality, generally based on quantitative measurement and techniques.

Besides its use in industry, this new technique was also utilized in a number of socio-economic problems which came up after the war. Operation Research has come to be used in a very large number of areas such as problems of traffic, question of deciding a suitable fare structure for public transport, or industrial process like ore-handling. Its use has now extended to academic spheres, such as the problems of communication of information, socio-economic fields and national planning.

5. 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,

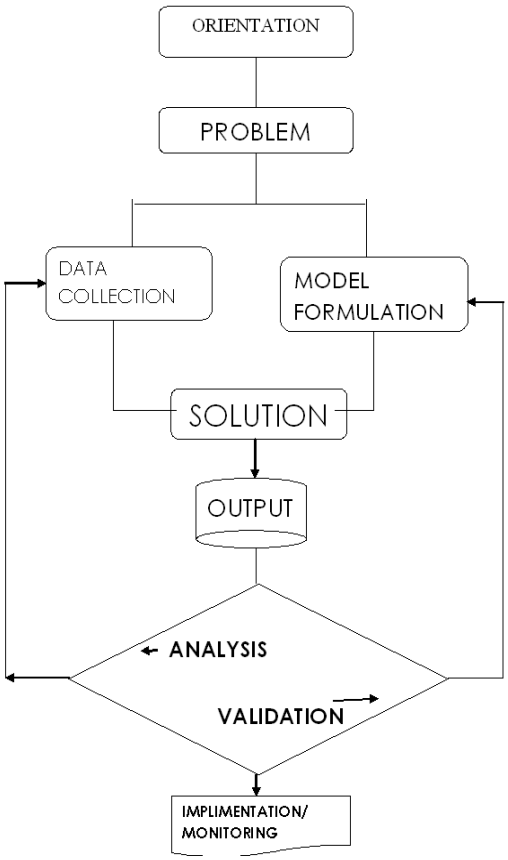
(4) Model Formulation,

(5) Solution,

(6) Model Validation and Output Analysis, and

(7) Implementation and Monitoring.

This is illustrated in the Flow Diagram:



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.

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.

6. TECHNIQUES USED IN OPERATION RESEARCH

Decision Analysis: Decision analysis refers to a set of quantitative methods for analyzing decisions that use expected utility as the criterion for identifying the preferred alternative.

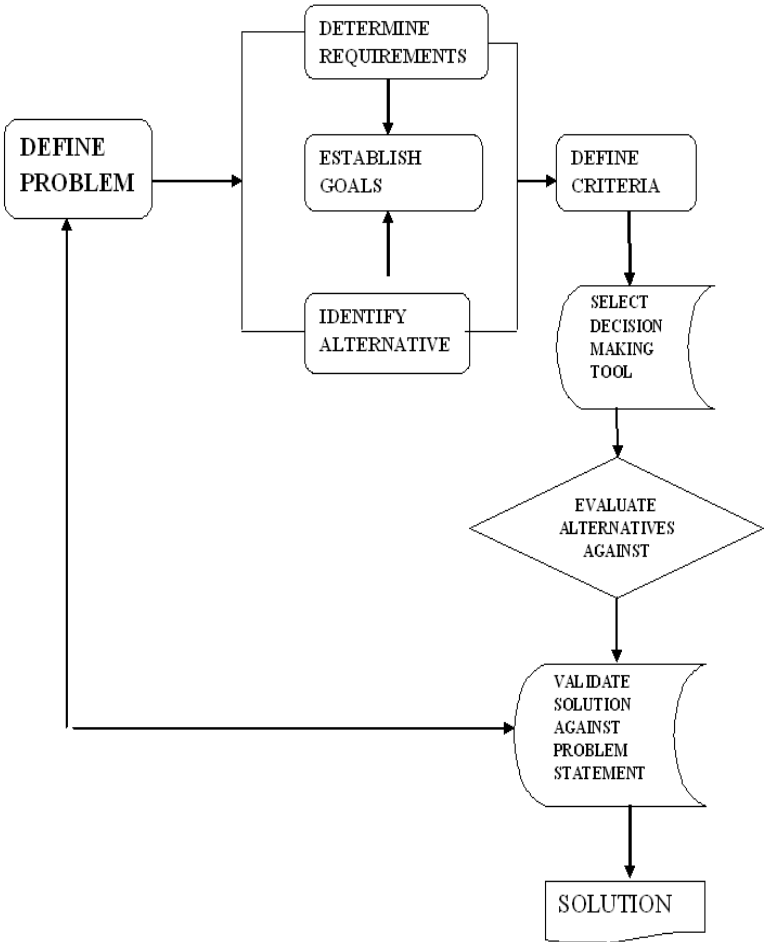
Decision analysis provides tools for quantitatively analyzing decisions with uncertainty and/or multiple conflicting objectives, and these tools can be especially useful when there is limited directly relevant data so that expert judgment plays a significant role in the decision making process. It provides a systematic quantitative approach to making better decisions, rather than a description of how unaided decisions are made.

A general decision making process can be divided into the following steps:

1. Define the problem
2. Determine the requirements
3. Establish Goals
4. Identify alternatives
5. Define criteria

6. Select a decision making tool
7. Evaluate alternatives against criteria
8. Validate solutions against problem statement

The above steps are illustrated through a Flow Diagram as given below:



Linear programming arose as a mathematical model developed during Second World War to plan expenditures and returns in order to reduce costs to the army and increase losses to the enemy. In Operation Research optimization means to find out the maximum profit and minimum loss[11] in any deal which we can done in Quantitative Techniques, in this we can narrowing our choices to the very best when there are virtually immeasurable feasible options. 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.

Standard form of describing a linear programming problem consists of the following three parts:

- A **linear function to be maximized**
  e.g. maximize $c_1x_1 + c_2x_2$
- **Problem constraints** of the following form
  e.g. $a_{11}x_1 + a_{12}x_2 \leq b_1$
  $a_{21}x_1 + a_{22}x_2 \leq b_2$

$$a_{31}x_1 + a_{32}x_2 \leq b_3$$

- **Non-negative variables**

e.g. $x_1 \geq 0$
$x_2 \geq 0$

7. SIMULATION

In this technique of Operations Research we can make the model of a real situation and then perform the various experiments on this rough sculpt. Generally it is used in uncertain conditions where we want to conduct a real experiment through this model to know more about different situations which we use in this artificial model. The actual exercise of building a simulation model reveals previously unapparent relationships and provides a systematic way to analyzing the situation. Marine fisheries are highly complex and stochastic. A simulation model, therefore, is required. Simulation-based optimization utilizes the simulation model in obtaining the objective function values of a particular fishing schedule. The decision support system for fishery management will assist the government agencies and the fishing industry to use sound data and management science techniques in making policy decisions for fishing activities. Transferable rights to fish have proved a reliable and effective means of creating incentives to conserve marine resources. By strengthening individual fishing rights under flexible quota management systems make a significant contribution to conserving fish stocks, to reducing excess capacity and to raising the profitability of the fisheries industry.

8. QUEUING THEORY

Some real time examples for this case can be customers waiting in the queue in banks or to buy groceries in departmental stores. The contribution of the computer here is to maintain the queue according to the arrival time of the event, in this case the customers, and process each event one after the other according to their arrival time. Simulation [11] represents the full extent of the models covering all perceivable systems which incorporate characteristics of a queue. We identify the unit demanding service, whether it is human or otherwise, as customer. The unit providing service is known as the server. This terminology of customers and servers is used in a generic sense regardless of the nature of the physical context. Some examples are given below.

- In communication systems, voice or data traffic queue up for lines for transmission. A simple example is the telephone exchange.
- In a manufacturing system with several work stations, units completing work in one station wait for access to the next.
- Vehicles requiring service wait for their turn in a garage.
- Patients arrive and wait at a doctor's clinic for treatment.

Queuing System 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. The term "classical" queuing theory refer to descriptive models of queuing systems, usually based on Markovian assumptions, in which the goal is to derive an explicit expression for the queue-length or waiting-time distribution (or its transform), usually in steady state.

9. TRANSPORTATION TECHNIQUE

The origin of transportation was first presented by F.L. Hitchcock in 1941 also presented a study entitled "The Distribution of a Product from Several sources to numerous Localities". This presentation is considered to be the first important contribution to the solution of transportation problems. In 1947 T.C. Koopmans presented an independent study, not related to Hitchcock's, and called "Optimum Utilization of the Transportation System". These two contributions helped in the development of transportation methods which involve a number of shipping sources and a number of destinations. The transportation problem, received this name because many of its applications involve determining how to optimally transport goods.
A special class of linear programming problem is **Transportation Problem**, where the objective is to minimize the cost of distributing a product from a number of **sources** (e.g. factories) to a number of **destinations** (e.g. warehouses) while satisfying both the supply limits and the demand requirement. Because of the special structure of the Transportation Problem the Simplex Method of solving is unsuitable for the Transportation Problem. The model

assumes that the distributing cost on a given route is directly proportional to the number of units distributed on that route. Generally, the transportation model can be extended to areas other than the direct transportation of a commodity, including among others, inventory control, employment scheduling, and personnel assignment. The objective of the transportation problem is to satisfy the required quantity of goods or services at each demand destination, within the limited quantity of goods or services available at each supply origin, at the minimum transportation cost or time.

Project Management with PERT (Project Evaluation and Review Techniques) and CPM (Critical Path method)

CPM/PERT is based on the basis that a small set of activities, which make up the longest path through the activity network control the entire project. If these "critical" activities could be identified and assigned to responsible persons, management resources could be optimally used by concentrating on the few activities which determine the fate of the entire project.

Non-critical activities can be rescheduled and resources for them can be reallocated flexibly, without affecting the whole project. Both are project management techniques, which have been created out of the need of Western industrial and military establishments to plan, schedule and control complex projects.

10. USEFULNESS

CPM/PERT have been useful in planning costs, scheduling manpower and machine time. CPM/PERT can answer the following important questions:

- What will be the project duration? What are the risks/ dependencies/ assumptions involved?
- What are the critical activities which could delay the entire project if they were not completed on time?
- What is the current status of the project i.e., Is the project on schedule, behind schedule or ahead of schedule?
- If the project has to be finished earlier than planned, what is the best way to do this at the least cost?

The procedure of drawing a network is:

1. Specify the Individual Activities: From the work breakdown structure, a listing can be made of all the activities in the project. This listing can be used as the basis for adding sequence and duration information in later steps

2. Determine the Sequence of the Activities: Some activities are dependent on the completion of others. A listing of the immediate predecessors of each activity is useful for constructing the CPM network diagram.

3. Draw the Network Diagram: Once the activities and their sequencing have been defined, the CPM diagram can be drawn. CPM originally was developed as an activity on node (AON) network, but some project planners prefer to specify the activities on the arcs.

4. Estimate Activity Completion Time: The time required to complete each activity can be estimated using past experience or the estimates of knowledgeable persons. CPM is a deterministic model that does not take into account variation in the completion time, so only one number is used for an activity's time estimate

5. Identify the Critical Path: The critical path is the longest-duration path through the network. The significance of the critical path is that the activities that lie on it cannot be delayed without delaying the project. Because of its impact on the entire project, critical path analysis is an important aspect of project planning

The critical path can be identified by determining the four parameters for each activity. The four parameters are Earliest Start, Earliest Finish, Latest Finish and Latest Start.

Models and Modeling In Operations Research

A model is defined as the approximation or abstraction, maintaining only the essential elements of the system, which may be constructed in various forms by establishing relationships among specified variables and parameters of the system. A model does not, and cannot, represent every aspect of reality because of the innumerable and changing characteristics of the real life problems to be represented. Modeling is the essence of an Operation Research approach. By building model, the complexities and uncertainties of a decision-making problem can be changed to logical structure that is amendable to formal analysis. In short a model provides a clear structural frame-work to the problem for purposes of understanding and dealing with reality.

Role of Computers in Solving Operation Research Problems

The Operation Research problems are time consuming and involve tedious computations. Even a simple problem with few variables take a long time to solve manually and even by a hand calculator. The advent of computers accelerated the wide use of Operation Research techniques for solving complex business problems faced by managers and administrators in business and government. The automation of computational algorithm allows

decision-makers to concentrate on problem's formulation and the interpretation of the solutions. Major computer manufacturers and vendor have developed software packages for the various computer systems providing computational support for problems to be solved by the application of Operation Research techniques [9]. Some academic departments in different universities have also produced software packages for solving various Operation Research problems. Computer manufacturers like IBM, CDC, Honeywell, UNIVAC, ICL, etc. have invested substantial amount in developing software programs for solving the optimizing, scheduling, inventory, simulation and other Operation Research problems. Also large scale simulations are possible only through computers by using GPSS software packages.

Growth of Operation Research in Different Sectors

The response of Indian industries by and large was poor in terms of accepting O.R. methods till early sixties. After that Operation Research activities started rapidly in this sector. Considerable effort in this direction has been made by National Productivity Council, National Industrial Development Corporation, Administrative Staff College, Hyderabad and Indian Institutes of Management, etc. Initially the industries like Hindustan Lever Ltd., the Metal Box Company Ltd., Union Carbide (India) Ltd., Larson and Toubro Ltd., Indian Chemical Industries Ltd., DCM Ltd., set up Operation Research groups to work on problems of optimization and forecasting of market requirements relevant to their companies [7].

The type of industries in which these techniques were applied includes Steel, Heavy Engineering, Chemical and Fertilizers, Textiles, Transportation & Distribution, and Electronics.

The terminology "Operations Research" is somewhat misleading, since it is not only concerned with operations, but has applications involving research in different areas and fields. 'Operations Research is the discipline of applying advanced analytical methods to help make better decisions. By using techniques such as mathematical modeling to analyze complex situations, operations research gives executives the power to make more effective decisions and build more productive systems'.The role of operational research in the Indian context is clear. It is not only important, it is even critical, given the size and magnitude of the tasks ahead to transform India as a developed nation. In order to achieve this goals, we need a responsive and accountable government to promote a positive environment of OR applications. It is hoped that the Indian democracy would lead to this. It is believed that the globalization would further accelerate this transition.

Typical Applications of Operations Research

- Capital budgeting.
- Asset allocation.
- Portfolio selection.
- Fraud prevention, Anti-Money Laundering.
- Benchmarking.
- Marketing channel optimization, Customer segmentation.
- Direct marketing campaigns, Predicting customer response, and Campaign optimization.
- Supply Chain Planning.
- Distribution, Routing, Scheduling, Traffic flow optimization.
- Resource allocation, Staff allocation.
- Inventory planning.
- Retail planning, Merchandize optimization.
- Product mix and blending, Industrial waste reduction.

Challenges in Operations Research

Due to vast quantities of data and calculation, solving optimization problems is challenging and time consuming. Thus, such approach towards performance improvement may or may not be economically feasible for some organizations. Numerous studies are conducted on development of more effective and efficient heuristic and exact algorithms that can solve large scale optimization problems [11].

OR is quantitative problem solving technique; hence, data plays important, if not the most important, role in producing high quality and executable solutions. With an organization that has data readily available using information system such as MRP and ERP should be able to use the required data with certain level of integrity. However, for a system that is highly manual, data driven decision science techniques presented her may or may not be the appropriate approach. With companies moving towards managing business with some form of company-wide information system; Linear Programming, Discrete Event Simulation and Queueing Theory will be most suitable and appropriate decision tools.

Integrity of data depends on many factors. Information system that requires manual input of data, unstable network systems, unstable programs and defective hardware are some of the factors. The most important factor that determines high data integrity is human error when inputting data. Human errors can be minimized through education combined with hands-on training such as on-the-job training. Unfortunately, many organizations tend to focus heavily on physical system implementation and give little or no attention on education and training. Regardless, employees are often reprimanded for not entering the data correctly and the quality of hardware and/or software is questioned for poor data integrity. Sustainment is as important implementation. An organization can implement the world's greatest database, but if the personnel responsible for operating and sustaining the system lacks knowledge of performing his or her job, attaining and implementing the world's greatest system is meaningless.

CONCLUSION:

Another name for managers is decision makers. To survive and lead the today's highly competitive and demand driven market, pressure is on management to make economical decisions. One of the essential managerial skills is ability to allocate and utilize resources appropriately in the efforts of achieving the optimal performance efficiently. In some cases such as small-scale low complexity environment, decision based on intuition with minimal quantitative basis may be reasonably acceptable and practical in achieving the goal of the organization. However, for a large-scale system, both quantitative and qualitative (i.e. intuition, experience, common sense) analyses are required to make the most economical decisions. Using Operations Research techniques including Linear Programming, Discrete Event Simulation and Queueing Theory, organization leaders can make high quality decisions. Operations managers are not expected to be experts in any decision science tools; however, he or she must have fundamental knowledge of such tools to acquire right resources and to make the most economically sounding decisions for the company as a whole.

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