CHAPTER – I

INTRODUCTION AND HISTORICAL BACKGROUND

Operations Research was coined in forties of twentieth Century and obtained its formal recognition during the period of second world war in the services of military where in group of scientists with mixed disciplines were concerned with the analysis of complex type military operation in order to improve the existing efficiency to the large extent. Subject operations research brings out better awareness at the same time opens newer possibilities for the greater utility and the use of the developed powerful tools in planning, scheduling and controlling the cost etc. for the economic conduct of the economical endeavors for which the use of men, machine and material alongwith the management in escapable. The term operations research was first coined by Meelosky and Trefthen in 1940 in a small town Bowdsey of the United Kingdom.

Regarding the definition of OR, various opinions have been changed according the development of the subject to name a few Morse and Kimbad (1946), P.M.S. Blackelt (1948), churchman A,
Arnoff etc. (1957), T.L. Satty (1958), Jagjit Singh (1968), Miler and Starr C, Netzorg, Fabrycky Torgersen, Ackoff and Sasieni (1968) and many others. Solution to the problems were worked upon by Prof. P.M.S. Blackett and the group that was attached with "Radar O.R.". On account of inclusion of various types of character such as physiologist, Astrophysicist, Mathematical Physicists, army officer, surveyor and general physicist etc. Blackett's group was nicknamed as Blackett's Circus. In view of this multi-disciplinary approach OR has received wide acceptability from all quarters. The OR society of India was set up in 1957.

The methodology of operations research examines the essential features of the problem generates the data and subsequently carried out quantitative analysis using the suitable statistical and mathematical principles. One of the important feature of the linear programming problem is the presence of linearity in the problem which enables to convert the objective to the from of a linear function of the decision variables and the constraints into linear inequalities. Any single method was not available for solving all types of optimizations problem efficiently as such a number of optimization methods have been developed for solving different types of optimization problem. Men like Taylor, Eralang, Lanciaher Edison and Levinson and few others have
contributed to the early development of operations research but not under their names. The indispensability of the tools and techniques in operation research particularly with the use of computer oriented techniques in a varieties of practical problems is nowadays a well recognized and widely accepted fact.

The transport services that are accessible to each soci-economic group vary widely. The social and other roles played by transportation brings in the beneficial interaction in the society. While evaluating the current literature of science, engineering and technology it has been observed that the modern techniques of OR are exerting their profound influence on the formation of the mathematical models and on the development of the theory in many applied field and as its consequence problems posed in applied field are motivating research in OR techniques. Transportation technique is one of the sound method which would go in a long way to solve the financial impediments in the implementation of the plans. Operations Research technique are vastly developed into a well recognized and well accepted interdisciplinary scientific method which addresses itself to the problems in optimization. From the users points of view these methods are accepted as the most rational one and the best scientific one.
In the recent researchers in operation Research Transportation area provides the most fertile and off-dwelt upon the subject matter and variety of optimization method come into the grip with the problems of real life. Transportation systems of Paul Zipkin (1982), Bellman R. (1962), Rao S.B.S. and Other (1980), Williams (1963), and others are not suited to the conditions in developing countries like for India. In developing countries like India the transport facilities are not uniformly spread over the country as such boundary lines of the market area will be non-linear and Loset's formulation will give rise to set of equations of higher order and that will be difficult to get solved those. J.P. Saksene (1972) through his research paper has shown that the total time spent in the delivery and collection of dak will be considerably reduced if its proposed plan is implemented and it will result in the saving of Rs. Seven Thousand and Five Hundred per month approximately and or 32 dak manners/peons/attendants. Transportation plans by various factory managers are prepared taking into consideration the amount of supply demand patterns, volume of procurement storage facilities at the various depots both in the dispatching district as well as in the receiving district. Satya Prakesh (1981) has obtained a solution by the standard transportation method.
Hammer, Graifinked and Rao, Szwane and few others have studied the problems of minimizing the cost of transportation. Mobility, Connectivity and Accessibility are the three important requirements of a transportation system. It is a vital infrastructure facility for the economic development of a country. It also helps in social cultured and administrative development of a nation. Gupta N.D. and Jatinder (1968) have made an attempt to present the theoretical developments in solving the travelling salesman problem that stimulates the interest both at practical and academic levels. Miller, Tucker and Zemlin have shown through their research article the possibility of the formulation of the travelling salesman problem as an Integer Programming Problem.

After the introduction of the simplex method many people have contributed for the growth of Linear Programming by developing its mathematical theory, designing efficient computational methods and codes, exploring new applications and by their use of Linear Programming as aiding tool for solving more complex problems e.g. discrete programmes, non-liner programmes, combinatorial programmes, stochastic programming problems, and problems of optimal control. Leonfield's input output model Koopmans model of transportation, the Hitchcock transportation problem.
Primitive mathematical programming models were advanced by economists Frederick W. Taylor (1885) emphasized the application of scientific analysis to the methods of production. A.K. Erlang (1917) published his work on the problem of congestion of telephonic traffic. Levinson during thirties of Twentieth century applied scientific analysis to the problems of merchandising inclusive of scientific study of customers, buying habits, response to advertising and relation of environment to the types of articles sold. The military commands of UK and USA engaged several interdisciplinary teams of scientists to undertake scientific research into a strategic and tactical military operations. As such Operations Research can be associated with an art of winning the war without actually fighting it. The work of OR team was given various names in the US e.g. operational analysis, operations evaluation system Analysis, Systems Evaluation, Systems Research and Management Science.

Later on Scientists actively engaged with the military group of OR have started their efforts in applying the OR approach to the problems of civilians, particularly related to business, Industry, Research and Developments etc. George B. Dantzig was the Key person (1947). Before the end of the 1950's in addition to simplex method of Linear Programming many other tools or OR such as statistical quality control,
Dynamic Programming, Queuing Theory, Inventory models etc. also were developed.

In India OR came into existence in the year 1949 when an unit of OR was established at the Regional Research Laboratory, Hyderabad. Prof. R.S. Verma during the same period has set up an OR group at defence science laboratory to solve the problems of stores, purchase, and planning etc, Mahalanobis P.C. of Calcutta established the same in order to solve the problems related on national planning and survey.

Today the impact of OR can be felt in many areas. Many management consultancy firms are engaged in the activities of OR. It also includes libraries, hospitals, city planning, financial institutions etc. Prof. P.C. Mahalanobis firstly applied the techniques of OR in formulating the second five year plans in the order to forecast the trends of demand, availability of resources and for scheduling the complex scheme necessary for the developments of country's economy. It was estimated that India could become self-sufficient in food merely be reducing the wastage of food by 15% and get solved her foreign exchange problem.

Some of the industries namely Hindustan Lever Ltd., Union Carbide, TELCO, BHEL, Tata Iron and steel company, Sarabhai group,
FCI, etc. have engaged OR groups. In order to maximize the profit, the assignment technique or OR is being used by the Kirloskar Company.

DCM, Binnis and Calica and other textile firms are using the techniques of Linear programming. Nowadays realizing the importance of OR, the courses on OR as per their requisites have been included in almost all the faculties.

Because of the operation Research Multi-disciplinary character and applications in varied fields, it has good future provided the people devoted to OR group help in meeting the needs of society. Some of the problems in the area of hospital management, energy conservation environment pollution, etc. which have been solved by the experts of OR is an indication that OR can contribute towards the improvements in the pattern of social life and areas of global need. Thomas A. Cowan (1995) has discussed the social implications of OR.

On account of its wide scope, giving a precise definition is a difficult job. However a few definitions or OR given by different scientists are as follows.
a) OR is an art of giving bad answers to the problems to which otherwise worse answers are giving - T.L. SAATY (1988)

b) OR is a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control - P.M. Morse-Kimbal (1946)

c) OR may be described as a scientific approach to decision making that involves the operations of organizational system.


d) OR is a scientific approach to problems solving for executive management.

- H.M. Wagner.

In addition to above other definitions are also given by Churchman Ackoff and Arnof (1957), Daellenbach and George (1978), Thierauf and klekamp (1975), H.A. Taha (1976), S.L. Cook (1977), D.W. Miller and M.K. Stan, C. Kiltel, E.L. Arnof and M.J. Natzorg, Ackoff and Sasiene etc.
Essential characteristic of OR are,

a) Its system orientation.
b) Uncovering of new problems.
c) Improvement in the quality of decision.
d) Use of computer.
e) Human factor.
f) Application of scientific methods.
g) Quantitative solutions.

Scientific method or OR involves the three main phases

1) Judgment phases.
2) Research phase.
3) Action phase.

OR says something about both the approach and the area of application of the field. Its goals is to identity the best possible course of action. Search for an optimality is an important theme of OR. OR group selected also needs to have the necessary experience and variety of skills to give an appropriate consideration to the many ramification of the problem throughout the organization and to execute effectively all the diverse phases of the OR group.
Arnoff and Netzorg have pointed out through their research articles that OR techniques are particularly useful in balancing the conflicting objectives where there are many alternative courses of action.

Arnoff has indicated that OR should be used in conjunction with integrated, decision-oriented management information system. The basic problem in most of the developing countries is to remove poverty and hunger as quickly as possible, as such there will be a great scope for economist, statisticians, administrations, politicians and technicians working in the team of OR group to get these problems solved by the approach of OR.

OR is useful in various field such as In defence to the military executive and managers in selecting the best strategies to win the battle. In agriculture to formulate the best policies under the given restriction of land, water, fertilizers etc. In industry for deciding the optimum allocation of various limited resources such as men, machines, material, money time etc. to arrive at the optimum decision. In production management for finding the number and size of the items produced and in scheduling and sequencing the production run by proper allocation of machine.
In marketing distribution of the product for sale in order to have an optimum cost of transportation, price per unit (minimum), Economic lot size to cater the needs of future demands, period and investment for the purchase of raw material etc. In personnel management appointing a suitable and efficient person with the minimum salary to decide the recruitment policies etc. In finances to have the careful planning for the economic development of the country it helps in maximizing per capita. Income with minimum resources, to determine the best possible replacement policies, etc. In LIC to decide the premium rates for various modes of policies.

The capabilities, flexibilities, speed and scope of usefulness of electronic computers have aided in the growth of OR. Many large scale applications of OR techniques which require only few minutes on the computer may take weeks months and some times years even to yield the same results manually.

As such nowadays OR methodology and computer methodology are growing up simultaneously. It seems that in near future the two sciences will combine to form a more general and comprehensive science.
At the implementation stage the decision cannot be governed by quantitative considerations alone. One should take into account the delicacies of human relationships. That is one has to be tactful and learn the art of getting the decision implemented. This art can be achieved by experience as well as by getting training in social sciences, particularly psychology. OR is concerned with the optimal decision making and modeling of deterministic and probabilistic systems that originate from real life. Considerable insight can be obtained from scientific analysis such as that provided by OR. On account of the wide applicability of OR and its close concern with our day-to-day practical life problems, it has motivated me to study and to do some research in it.

Some of the applications of linear programming are to optimize the mixing of livestock feed, the transporting of goods from a number of plots to a number of warehouses, the production schedule in manufacturing industries, the flight schedule of airlines, the selection of a portfolio, the assignment of jobs to people etc. In all these problems Linear programming models involves a linear function of several variables to be optimized subject to a set of linear constraints and non-negativity restrictions on the variables.
A renounced economist Mr. W.W. Leontief firstly developed the input output analysis through Linear Programming model. Stigler's developed the diet problem in 1945 to obtain an optimal solution. Objectives that are generally used in L.P.P. are the minimization of the cost, maximization of the profit, highest turnover, maximum capacity utilization, etc.

One of the earliest applications of the L.P. technique was the formulation and the solution of the transportation problem as a L.P.P. Basic T.P. was originally developed by F.L. Hitchcock in 1941 through the article entitled "The distribution of a product from several sources to numerous locations". In 1947, T.C. Koopman published an article" Optimum Utilization of the transportation system". It deals with a special class of L.P.P., wherein the objective is to transport a single commodity from various origins to different destinations at the minimum total cost or maximum total profit. The name "Transportation model" is misleading as this model can be used for machine assignment plant location, product mix problem and many other types of problems.

Initial basic feasible solution to any of the transportation problem can be obtained by using North West Corner Rule, Matrix Minima Method, Vogel's Approximation Method etc. and then the optimality of
the I.B.F.S. can be tested by using the stepping stone method or modified distribution method.

Transportation is a basic infrastructural facility for the economic, social, cultural and administrative development of a Nation. Many mathematicians, statisticians and researchers who have contributed their works in the area of transportation have suggested various algorithms of optimization to solve variety of real life problem. Aneja Y.P. and K.P.K. Nair (1979) have developed a method to solve a bicriteria transpiration problem. H.G. Berrisford (1960) has studied the economic distribution of coal supplies in the gas industry. It has been shown that if linear programming transportation technique is applied with the help of computer programming in distribution of coal, considerable savings are obtained. Puri M.C., M.L. Bhatia and Kantiswaroop (1976) have developed an enumerative technique in order to obtained successive time cost commodity in piper line trade-off relationship in a transportation problem. Chowdhary subir Shahu K.G. and Bishwal S.K. (1971) have developed an transportation for optimal plant location. Leon Cooper (1972) has also made an attempt to solve the transportation location problem.
Flood Merril M. (1954) has suggested transportation theory to scheduling a military tanker fleet. Glover Fred, Klingman D. and Napieral (1976) have shown that any generalized network problem can be transformed into a generalized transportation problem. Mittal Madanal (1976) has suggested a method of obtaining optimal solutions to degenerated transportation problems. It is observed that the method proposed would be more effective than the modified distribution method especially when the problem is highly degenerated. Mr. M.M. Sundara (1976) has developed an algorithm to solve a bulk transportation problem. Prakash Satya (1981) has studied a transportation problem with two objectives primary and secondary. Primary objective is to minimize the total cost of transportation whereas the secondary objective is to minimize the duration of the transportation.

Arrora S.R. and Tirwani Deepa (1997) have proposed algorithm to find the most efficient time-cost-trade pairs in a fixed charge bicriterion transportation problem with mixed constraints.

Assignment problem is also a special type of L.P. Problem. This name is originated from the classical problem where the objective is to assign a number of tasks to an number of facilities at minimum cost or maximum profit. Assignment is to be made on a one-to-one basis i.e. every task is associated with one and only one facility. There are number of decision making situations where assignment technique can be successfully used.

Management generally makes assignment on a one-to-one basis in such a manner that the group maximizes the revenue from the sales the vehicles are deployed to various routes in such a way that the transportation cost is minimum and so on.

Many researches have contributed their work in the area of an assignment problem Jt. Ping Lee W.B. and L. Hongru (1977) have proposed a new algorithm for the assignment problem. This algorithm is simple as its all the operations are performed on a 2n x 2n matrix. It may be an alternative to the well-known Hugarian method. Beckmann
Martin and others (1957) have discussed the assignment problem and location of economic activities. Mr. Machol Robort (1961) has discussed various application of the assignment problem.

Mazzola Joseph B, Neebe Alan W. (1993), V.Eric. Benardo (2005), H.L., Bhatia (2007), Rita, Malhotra, A.K. Agrawal and Prakash, Satya (2008), have developed and algorithm for the bottleneck generalized assignment problem. Mc Ginnis Leon F. (1983) presented a detailed development for a computationally efficient primal - dual algorithm. Using dual ascent method Murty Ishwar in the year 1993 has suggested a procedure for solving the multi-period assignment problem having start-up cost. Mathirajan M. and B.G. Raghavendra (1989) have used the assignment technique for the optimum allocation of buses to various depots. This model has been rightly used by the Bangalore transportation services having fleet of nearly 4000 buses serviced by twenty depots. Substantial saving for the BTS has been indicated by this model and resulted in the significant reduction in the dead mileage. In the year (1979) Ross T.G. and Zoltners A.A. have described a weighted assignment models along with their applications. Further by using the functional equation technique of dynamic programming Saksena J.P. (1969) has suggested a method to get the solution to the problem of job assignment. Subramanyam Y.V. (1979) has developed
an algorithm in order to show the extension of the cost matrix. Volgement A. (1996) has used the Core approach to solve linear and Semi-assignment problems.


The technique of converting an Unbalanced transportation problem to balance form and then solving it, strikes me while I am going through the literature of OR. I felt this as an unrealistic one as in real life generally we come across with the transportation problem in it unbalanced form. This motivated me and created an interest in obtaining solution to such type of problems which are unbalance one without its conversion. By trail and error method after many days a solution is obtained to the unbalanced transportation problems without balancing it.
Charnes, Glover and klingman (1970) have studied and also obtained solution to the UBTP according to "More for the Less" principle which appears to be unrealistic. Herein a procedure is suggested which is based on real situation i.e. if the total availability is in excess than the total requirement, then the excess amount of availability remains in balance at some particular origin and in the converse case the excess amount of requirement remains in deficit at some particular destination.

In general assignment problem are solved by using the four given methods.

1) Enumeration method.
2) Simplex method.
3) Transportation method.
4) Hungarian method.

Hungarian method is used as one of the efficient method for finding an optimal solution of an assignment problem where the number of sources are less than equal to or more than the number of activities by converting to balanced one if necessary. It leads to the consideration of an assignment table of higher order and require more number of
computations and iterations. In view of this a new method has been suggested to set an optimal solution to the assignment problem with less number of computations and iterations. Solution to UBAP is obtained without converting it to balance one.

Transportation problems and assignment problems under different types of forms have been evaluated by using the method suggested through suitable examples, wherein solutions have been obtained in less number of computations and iterations.

Motivated thus in the applications of operations research technique we propose to make some further contribution in the area of operations research.

Entire thesis is comprising of totally five chapters. The first chapter is introducing in its nature. It is inclusive of some basics needed for further work in the subsequent part of the thesis along with the historical background and developments in the various operation research tools used therein in arriving at some decision under the constraints.
Chapter two deals with the transportation problem. Proofs of the new theorem suggested therein is given along with various types of examples falling under different categories and constraints. Two new methods row penalty and column penalty methods have been proposed to obtain an initial basic feasible solution of an unbalanced transportation problem without balancing it. For balanced transportation method, Row penalty or Column penalty method is suggested depending on number of rows or columns are greater than those of columns or rows. At the end, its optimality is tested by using modified distribution method. It is ended with suitable illustrative examples.

Through chapter three a new method for the solution of an assignment problems is suggested. Non-basic smallest effectiveness method suggested to obtain an optimal assignment of the problem without balancing it is also optimized by proposed non-basic smallest effectiveness method. Illustrative examples are at the closer of the chapter.

Through chapter four a global non-probabilistic human reliability method have discussed. The first part of the chapter presented human reliability and human error concepts which are defined as a degradation function depending on human behavioral degradation when performing
tasks (i.e. in terms of causes of human error) and/or on system degradation due to human actions (i.e. in terms of consequences of human error). After having debated on different methods to analyze human behaviour, the ACIH method was proposed and applied to railway system.

This ACIH method aims at analyzing consequences of human unreliability and at guiding the specification of error prevention support tools depending on the severity of these consequences. It has focused on both prospective and retrospective analyses of human behavioral degradations, which may degrade system safety. A model of unreliability was proposed to categorize human factors of unreliability. Three main factors were retained: the acquisition related degradation, the problem solving related degradation and the action related degradation. Two steps is composed by consecutive prospective analysis whereas the APOSCIH step focuses on retrospective analyses. Both steps can be realized independently or results of one step can be used by the other one. They use a simplified cognitive models that includes the three factors of human behavioral degradation. The principles of the APRECIH step were used to identify scenarios of a railway system and those of the APOSCIH step were used to analyze railway accidents.
Chapter five deals with asymptotic expansion for the posterior CDF of reliability of series system with very reliable components is obtained. This result allows us not only to calculate the cdf easily but to estimate the magnitude of error when the infinite series expansion is truncated. Numerical result show that the asymptotic expansion converges very rapidly. Consequently the computation of bayes credibility intervals based the truncated expansion in efficient & accurate.

In the last we have given the list of books and journals referred therein the form of bibliography.