


## Lecture 01: Introduction to Operations Research



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## Operations Research (OR)

- *Operations Research* deals with the general problem of allocating limited resources to competing activities.
- It is a scientific approach to decision making that seeks to best design and operate a system, usually under conditions of constraints on resources.

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## Origins of Operations Research (OR)

- The roots of OR can be traced back many decades and even centuries (Newton, Euler, Bernoulli, Bayes, Lagrange, etc).
- Beginning of the activity called Operations Research → attributed to the military services early in the World War II (1937).
  - Need to allocate scarce resources to the various military operations in an effective manner.
  - The British first and then the U.S military management called upon a large number of scientists to apply a scientific approach to dealing with several military problems.

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## Origins of Operations Research (OR)

- End of war → scientists understood that OR could be applied outside the military as well.
- The industrial boom following the war led to an increasing complexity and specialization of organizations → scientific management techniques became more and more crucial.
- By the early 1950s, OR techniques were being applied to a variety of organizations in business, industry, and government.

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## Nature of Operations Research (OR)

- As the name implies, operations research involves “**research on operations.**”
- Areas of applications:
  - manufacturing
  - transportation
  - construction
  - telecommunications
  - financial planning
  - health care
  - the military
  - public services, etc.

## Nature of Operations Research (OR)

- OR process begins by carefully observing and formulating the problem, including gathering all relevant data.
- The next step is to construct a scientific (typically mathematical) model that attempts to abstract the essence of the real problem.
- It is then hypothesized that this model is a sufficiently precise representation of the essential features of the situation that the conclusions (solutions) obtained from the model are also valid for the real problem.
- Next, suitable experiments are conducted to test this hypothesis, modify it as needed, and eventually verify some form of the hypothesis. (**This step is frequently referred to as model validation.**)

## Nature of Operations Research (OR)

- “Search for optimality” is an important theme in OR.
- When a full-fledged OR study of a new problem is undertaken, it is usually necessary to use a team approach.
- Usually this is a multidisciplinary team.

## Impact of Operations Research

Organization	Nature of Application	Year of Publication*	Annual Savings
The Netherlands Rijkswaterstaat	Develop national water management policy, including mix of new facilities, operating procedures, and pricing.	1985	\$15 million
Monsanto Corp.	Optimize production operations in chemical plants to meet production targets with minimum cost.	1985	\$2 million
United Airlines	Schedule shift work at reservation offices and airports to meet customer needs with minimum cost.	1986	\$6 million
Citgo Petroleum Corp.	Optimize refinery operations and the supply, distribution, and marketing of products.	1987	\$70 million
San Francisco Police Department	Optimally schedule and deploy police patrol officers with a computerized system.	1989	\$11 million
Texaco, Inc.	Optimally blend available ingredients into gasoline products to meet quality and sales requirements.	1989	\$30 million
IBM	Integrate a national network of spare parts inventories to improve service support.	1990	\$20 million + \$250 million less inventory

## Operations Research Techniques

•Very broad discipline covering a variety of Optimization topics such as:

- Linear Programming
- Advanced Linear Programming Models
- Network Models
- Integer Programming
- Dynamic Programming
- Heuristic techniques
  - Simulated Annealing
  - Genetic Algorithms
  - Tabu Search
  - Neural Networks
- Non-linear Programming
- Decision Making under Uncertainty
- Decision Making with Multiple Objectives
- Game Theory
- Queuing Theory
- etc.

## Content

- **Non-linear Programming**
  - Optimality conditions
  - Classical optimization techniques
  - Convexity

## Content

- **Linear Programming**
  - Introduction
  - Simplex/Revised Simplex
  - Duality and Sensitivity Analysis
  - Other LP Algorithms
- **Network Models**
  - Transportation Problems
  - Assignment Problems
- **Special Topics**
  - Integer Programming
  - Dynamic Programming
  - Queuing Theory
  - Game Theory
  - Simulation

## Key Factors for Rapid Growth of OR

- Substantial progress was made early in improving the techniques in OR
- Simplex (**developed by George Dantzig in 1947**)
- Dynamic Programming, Integer Programming, Inventory Theory, Queuing Theory, etc.
- Computer revolution - 1980s → further boosted this trend.

## Algorithms and Software



- Algorithms → systematic solution procedures (e.g., simplex).
- Software → *Microsoft Excel Solver*, LINDO, CPLEX, etc.