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Details and Description of Operations Research

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DETAILS AND DESCRIPTION OF INDUSTRIAL ENGINEERING

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Note: this is not original work. Much of this material is a conglomeration of descriptions and examples obtained from the internet or from testbooks

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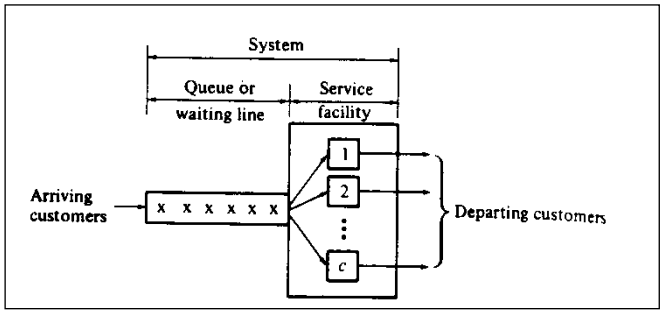
The ambiguous term *operations research* was coined during World War II. A frequent substitute is *management science*. Operations research is a scientific approach to analyzing problems and making decisions. It uses mathematics and mathematical modeling on computers to forecast the implications of various choices and zero in on the best alternatives.

Developed during World War II, operations research was used to take the guesswork out of deploying radar, searching for enemy submarines, and getting supplies where they were most needed. Following the war, numerous peacetime applications emerged. Manufacturers used operations research to make products more efficiently, schedule equipment maintenance, and control inventory and distribution. Success in these areas have expanded operations research's use into strategic and financial planning and into such diverse areas as criminal justice, education, meteorology, and communications.

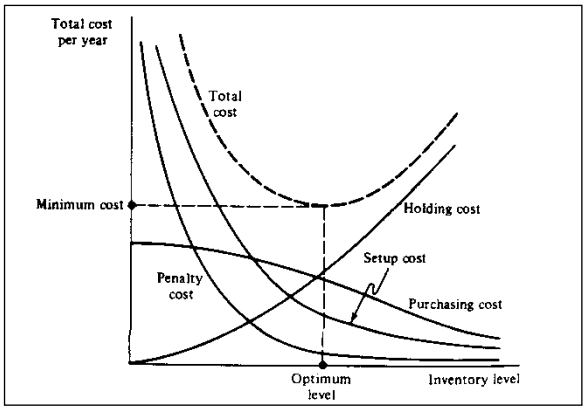
Operations Research Problems

Every day, operations researchers help make critically important decisions that affect the success of major corporations and the policies of local, state, and national governments around the globe. The problems they tackle usually involve designing systems to operate in the most effective way or deciding how to allocate scarce human resources, money, equipment, or facilities.



Example of a Queuing Model: A parallel queueing system in with *c* servers for processing customers.

Consider a production schedule for a factory. It must take into account customer demand, requirement for raw materials, levels of intermediate inventories, the capacities of the equipment, the possible of equipment failure, and manufacturing process restrictions (*e.g.*, a part must be drilled before is painted). It is not easy to make up a schedule that is both realistic and economical. Operations research allows you to develop the best or optimal schedule.



Example of an Inventory Model: Variation of the cost components of the general inventory model as a function of the inventory level.

Suppose, for example, you run a manufacturing firm and you have developed a remarkable new coffee maker. When and where should the firm market it to make coffee drinkers everywhere sit

up and take notice? Operations research will aid you in deciding the best markets for concentrating sales and distributions.

Suppose you are a fire chief in a medium-sized city. Will relocating some of your present fire stations reduce your response time? And how much will that save in terms of lives and property? Operations research will evaluate the alternatives and help in deciding what is their best placement.

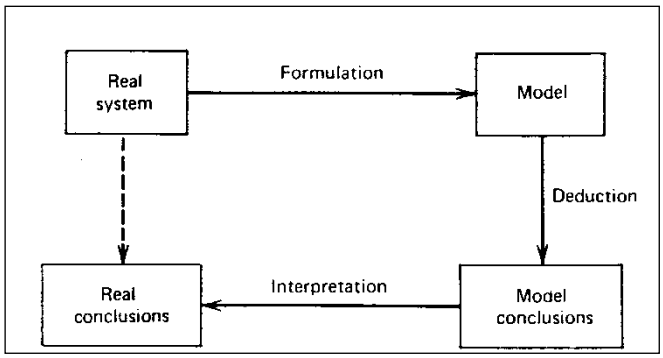
An operations researcher's job is to determine the various alternatives that are available and then carry out an analysis that would enable an objective assessment and recommendation to be made.

Operations research is used daily to help answer the following complex questions:

- How many elevators should be installed in a new office building to cut waiting time?
- What is the most effective way to route trucks through a city to pick up debris from all the neighborhoods?
- What will be the power demand for the month of January in Omaha ?
- How can a dress manufacturer lay out its patterns to minimize wasted material?
- What's the most efficient method for routing a long-distance telephone call?
- How often should the sales force of a frozen yogurt company call on its customers?
- What are the most cost-effective precautions to reduce the occurrence and environmental impact of oil spills?
- How often should check-ups be scheduled for members of a group health plan and what should be included?
- Or how long should the warranty on an automobile or appliance run, what should it cover, and what will it cost the manufacturer?

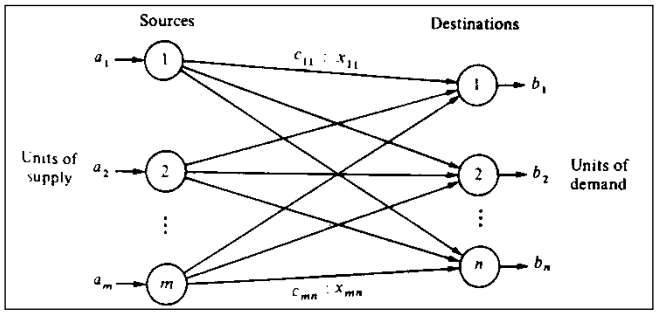
Methods for Solving Problems

Operations researchers begin to solve problems by immersing themselves in the details of the problem they're studying. They talk with people involved in all aspects of it, soliciting their varying perspectives, needs, and input into the solution. They examine available data, separating that which is truly relevant from that which is not. And they focus on practical, workable results - making sure what they propose is not just a theoretically appealing model, but one that will function effectively in the real world.



General solving approach of operations research: Different models are fit to different real system depending upon what needs to be analyzed.

A practitioner of operations research provides rational bases for decision making by seeking to understand and structure complex situations and to use this understanding to predict system behavior and improve system performance. Much of this work is done using analytical and numerical techniques to develop and manipulate mathematical and computer models of organizational systems composed of people, machines, and procedures. In undergraduate and graduate courses, operations research students learn to analyze problems and break them down into components, and determine which modeling approach to use for the analysis.



Example of Transshipment Model: Material must be send from the supply centers to the demand centers subject to shipment constraints and costs.

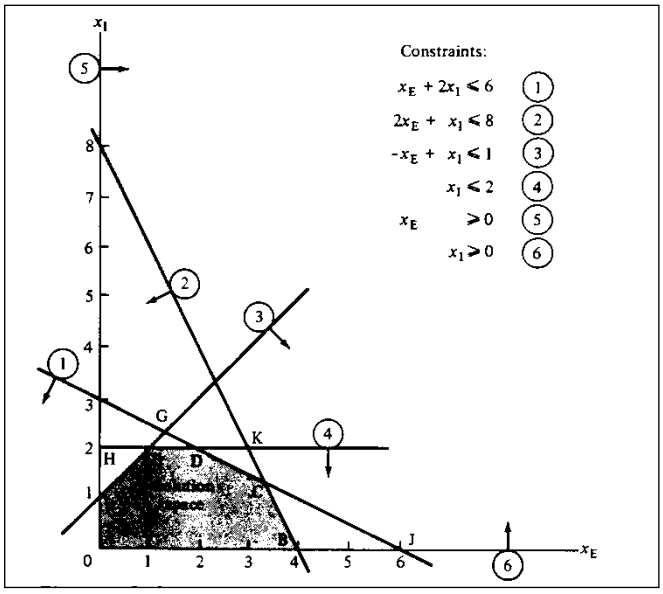
Operations research draws upon ideas from engineering, management, mathematics, and psychology to contribute to a wide variety of application domains; the field is closely related to several other fields in the "decision sciences" - applied mathematics, computer science, economics, industrial engineering, and systems engineering. You need not be a math major to become proficient in operations research. But

since it is mathematically based, you will need a solid grounding in statistics, probability, calculus, linear algebra, and economics. In addition, because the field relies so heavily on computers, an understanding of how they work is essential.

It is important to realize that operations research is interdisciplinary - often drawing solutions from engineering, logic, psychology, and other social and political sciences. For this reason, a well-rounded scientific background can also prove very useful. Operations research isn't all science, however. Since a great deal of our work involves the gathering of information, the presentation of results, and assistance in implementing solutions, strong interpersonal and communications skills are vital.

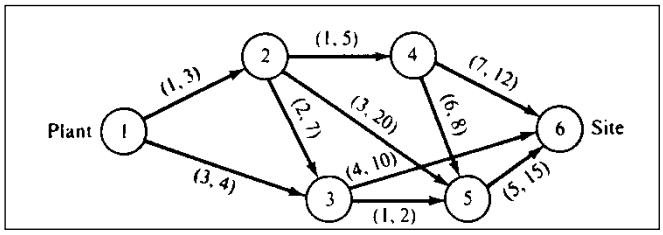
Different Areas of Operations Research

Within operations research there are several different types of modeling techniques. *Linear programming* seeks to find an optimal solution for a problem. For example, what's the best stock portfolio for a conservative investor or how should timber of varying diameter be cut to minimize waste and maximize profits?



Example of Linear Programming Model: The constraints of the problem form a solution space of feasible solutions from which the best solution must be determined.

Queuing theory studies waiting lines and makes sure they operate in the most efficient manner given limited resources. It's what Walt Disney World uses to keep the lines moving at Space Mountain and Mr. Toad's Wild Ride and how TV newsrooms decide how many editors they'll need to meet a deadline.



Example of Shortest Route Model: What is the best route from the plant to the site subject to *d* (the length of the route) and *t* (the time to cross the road segment).

An operations researcher might also use *forecasting* to estimated personnel requirements over a five-year period. *Network analysis* can be used to schedule routes for airline fleets or police patrol cars. *Computer simulations* allows an operations researcher to create a model of a situation and then experiment with it on a computer.

Most solutions involve a combination of methods. And it's the operations researcher's job to figure out how they all fit together.

Example Problems

Consider the following ***linear programming*** example:

Problem: A bakery makes two types of cakes (chocolate and vanilla). Each chocolate cake can be sold for $1, and each vanilla cake can be sold for $0.50. Each chocolate cake requires 20 minutes of baking time and uses 4 eggs. Each vanilla cake requires 40 minutes of baking time and uses 1 egg. Eight hours of baking time and 30 eggs are available. How many of each type of cake should the bakery make to maximize it profit?

Solution: If the bakery makes 5.14 chocolate cakes and 9.43 vanilla cakes it will make a maximum profit of $9.86. If fractional cakes cannot be made, an *integer programming model* would have to be used for modeling this situation.

Consider the following ***queuing analysis*** example:

Problem: An average of 10 cars per hour arrive to a drive-in teller. Assume the average service time for each customer is 4 minutes and that both arrival times and service times follow an exponential probability distribution. What is the probability that the teller is idle? What is the average number of cars waiting in line for the teller? What is the average amount of time a drive-in customer spends in the bank parking lot? On the average, how many customers per hour will be served by the teller?

Solution: Using queueing theory formulas and analysis, the teller will be idle 1/3 of the time, on average there will be 1-1/3 vehicles waiting for the teller, a customer will spend an average of 12 minutes in the teller system, and the teller will serve an average of 10 customers per hour.

Consider the following ***transportation*** example:

Problem: The demand for a perishable item over the next 4 months is 500, 630, 200, and 230 tons, respectively. The supply capacities for the successive months of the planning period are 400, 300, 420, and 380 tons and the corresponding prices per ton are $100, $140, $120, and $150, respectively. Because the item is perishable, the current month's purchase must be totally consumed within 3 months. It is estimated that storage cost per ton per month is about $3. What is the minimum cost production schedule?

Solution: To meet the 1st months demand of 500 tons, purchase 400 the 1st month and 100 the 4th month. To meet the 2nd months demand of 630, purchase 300 the 2nd month, 220 the 3rd month, and 50 the 4th month. To meet month 3's demand of 200, purchase 200 in month 3. To meet month 4's demand of 230, purchase 230 during the 4th month. Note that month 2 will be 60 units short of satisfying demand. Total cost (which is the minimum) is $49,900.

More Information

There are several sources for finding out more information about operations research.

The first source is our department web site:

http://imse.unl.edu/

The professional society of operations research, the Institute for Operations Research and Management Science (INFORMS), has an extensive web site. The web address is:

www.informs.org/