So what exactly is the MS/OR approach? Philip McCord Morse, who established the pioneer operations research group within the Navy during World War II, and George Kimball, who was head of the Washington research section of this group, defined it in the first book ever published in the field in 1951 as: “A scientific method of providing executive departments with a quantitative basis for decisions regarding operations under their control.” They note that, from the beginning, the field supported the executive function but was distinct from it.

Gene Woolsey, a leader in MS/OR consulting, defines MS/OR as: “The use of logic and mathematics in such a way as to not interfere with common sense.” In his definition, Woolsey introduces two important concepts: logic and common sense. Both play a key role in any MS/OR analysis. As we discuss in Sections 1.3 and 1.4 much of management science deals with mathematical modeling and developing or applying quantitative solution techniques. Some of the models can be quite complex, and some of the solution techniques can be quite sophisticated. But when management science is actually used, it should, as Woolsey bluntly puts it, “look, feel, and taste like common sense.”

Since MS/OR had its roots in military applications during World War II, it might be useful to examine the military’s official definition of MS/OR. According to U.S. Army Pamphlet 600-3, MS/OR involves:

> The use of techniques such as statistical inference and decision theory, mathematical programming, probabilistic models, network and computer science [to solve complex operational and strategic issues].

Although this definition is more specific about the approaches used in MS/OR, it again emphasizes the decision-making purpose of the field.

**MANAGEMENT SCIENCE APPLICATIONS**

Management science analyses, which have been applied to a wide variety of situations, have had a dramatic impact on the effectiveness of many organizations. A small sampling of the many successful applications of the MS/OR approach include the following.

**Producing Hamburgers at Burger King** Burger King, a division of Grand Metropolitan Corporation, uses linear programming (see Chapters 2 and 3) to determine how different cuts of meat should be blended together to produce hamburger patties for its restaurants. The objective of this analysis is to produce the patties at minimum cost while still meeting certain specifications such as fat content, texture, freshness, and shrinkage. As the cost of different cuts of meat changes, the company reevaluates its model to determine whether its recipe should be modified.

**Scheduling Crews at American Airlines** Scheduling aircraft crews is a complex problem involving such factors as the type of aircraft to be flown, the cities of origination and termination for the flight, the intermediary cities visited by the aircraft, and the length of the flight. Federal and union rules govern the placement of personnel on the aircraft. To address these issues, American Airlines has developed an integer linear programming (see Chapters 2 and 3) model that allows the company to quickly determine an optimal flight schedule for its personnel.

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Planning the Sony Advanced Traveler Information System  The marriage of the microprocessor with the Global Positioning Satellite System has enabled Sony Corporation to develop an onboard navigation system capable of giving directions to a car’s driver. This information is especially valuable during traffic conditions such as rush hour congestion. The software is based on a management science model known as a shortest path network. (See Chapter 4.)

Rebuilding the Interstate 10 Freeway  Following the disastrous California earthquake in January 1994, Interstate 10, a main freeway serving the Los Angeles area, needed to be rebuilt quickly. The project’s prime contractor was given a fairly short five-month deadline to reopen the roadway. To encourage the work to be done as quickly as possible, the contractor was offered a bonus of $500,000 for each day by which it was able to beat the deadline. Using a project scheduling technique known as the critical path method (see Chapter 5), the contractor was able to schedule work crews so as to be able to complete the repair work a month earlier than the project deadline. As a result, the contractor collected a $15 million bonus.

Planning Environmental Policy in Finland  Political decisions about environmental issues are often complex. To assist in the development of a comprehensive framework for future water policy issues in Finland, that country’s National Board of Waters and the Environment used a decision analysis (see Chapter 6) approach to analyze a wide range of issues. Among the items studied were standards for allowable water level changes in lakes resulting from energy production and measures to fight acid rain.

Cooking at Mrs. Fields  Mrs. Fields operates a nationwide chain of cookie shops specializing in fresh-baked chocolate chip cookies. The chain has equipped each shop with a PC-based information system to aid personnel in deciding when additional cookies should be baked and the amounts that should be produced. This system relies on management science techniques such as demand forecasting (see Chapter 7) and inventory modeling (see Chapter 8).

Designing Attractions at Disneyland and Disneyworld  Disneyland and Disneyworld are two of the most visited family resort destinations in the world. The attractions at these theme parks draw a large number of people daily. Lines form as visitors await their turn to ride or view the most popular attractions. Today, “imaginiers” at these parks incorporate waiting line or queueing models (see Chapter 9) into their overall design plans for the park. These models mirror customer behavior and tolerance for waiting in line. As a result of these models, Disney park planners developed an entirely new “industry” of waiting line entertainment to maintain customer satisfaction levels and enhance the value and excitement of the ride or attraction.

Transporting Trash in New York City  The New York City Department of Sanitation handles over 20,000 tons of garbage per day. To dispose of this trash, the department operates three incinerators. Refuse is also sent by barge from marine transfer stations to the Fresh Kills Landfill. To determine future operational plans for this landfill, the Department of Sanitation undertook a management science analysis. The result of this analysis was the development of the BOSS (barge operation systems simulation) model. This simulation model (see Chapter 10) enabled the Department of Sanitation to determine the number of additional barges that should be purchased to handle future demands. It also helped plan the dispatching of these barges.
Linear and Integer Programming Models

Chapter 2

With assets totaling over $4.4 billion, San Miguel Corporation (http://www.sanmiguel.com.ph), the most diversified company in the Philippines, generates over 4% of that country's gross national product. Beverage production and distribution is a major component of the company's operations. San Miguel produces six brands of beer and bottles three wine and spirit brands at three different sites. It also bottles five brands of soft drinks for Coca-Cola Bottlers Philippines at 18 bottling plants.

Among its other endeavors are the manufacturing of packaging materials, such as glass containers, plastic crates, polybags, and cardboard boxes, and the development and manufacturing of animal feeds for its chicken, hog, and cattle interests. Other sources of profit are the manufacture and distribution of ice cream, butter, cheese, and other dairy and nondairy products, the raising of prawns for export, and the processing and trading of coconut oil.

Since 1971, management science, in general, and linear models, in particular, have had a significant impact on the company's bottom line. Projects in which linear models have played a major role include blending problems for determining animal feed mixes and ice cream base composition, distribution problems for determining allocations among its 68 production facilities and 230 sales offices, and marketing problems, such as minimizing the cost of television advertising.

Over the course of several years, use of these models has saved the company millions of dollars, allowing it to expand at a vigorous rate. By 1995, San Miguel had become the first non-Japanese and non-Australian firm to rank in the top 20 Asian food and beverage companies. As it looks to the future, San Miguel will continue to refine and develop integrative linear models in order to enhance its growth and financial strength.
Applications of Linear and Integer Programming Models

With approximately $20 billion in revenues, FedEx Corporation (http://www.fedex.com) has become a world leader in providing integrated transportation, information, and logistics solutions. As the company has expanded, it has created a high-level management science group to provide senior management with recommendations on a wide variety of issues. This group uses state-of-the-art computer-based mathematical models to analyze a broad range of complex corporate problems with an overall goal of maintaining and increasing company profits while continuing to provide a consistently high level of service to its customers.

One of the models developed by this group is its Global Supply Chain Model, built to redesign its supply chain for revenue packaging. The model has helped management answer the following questions:

- Should FedEx pursue offshore production of packaging? If so, which items and where?
- Should FedEx consolidate nearby warehouses and pick centers into a new form of distribution center?
- Should FedEx pursue expansion of distribution center locations?
- What transportation modes on each link would most reliably get packaging from suppliers to stations while reducing costs?
- What should the service area boundaries be for each distribution center?

The Global Supply Chain Model uses, among other techniques, a large-scale mixed integer programming approach. This model has already resulted in a cost savings to FedEx of over $10 million.
Network Models

NATURE'S BEST, http://www.naturesbest.net, is the leading full-line distributor of health and natural food products in the western United States, supplying over 18,000 products. Many manufacturers deliver their products directly to Nature's Best's warehouse, but for some products, Nature's Best must make the pickup itself. One of its weekly challenges is to schedule its big rig trucks for pickups from various manufacturers around the state. The locations of the pickups vary from week to week, but each truck must begin at the warehouse location in southern California, stop at several destinations to fill its trailer with products, and return.

Another situation the company faces involves the transportation of goods to its customers. In most instances, after Nature's Best receives a purchase order, the goods are taken from the company's inventory, loaded on small pickup trucks, and transported to the customer. In other cases, the company delivers the product directly from the manufacturer to the customer, leaving only a paper trail indicating that the item was in its inventory.

To determine how much product to order from manufacturers, Nature's Best employs several buyers, who review customer orders and the inventory position of the products within the company's warehouse. The buyers possess different skills and expertise, and Nature's Best must decide which buyers to assign to which group of manufacturers.

Each of these situations is typical of a problem that can be described using a network model. One network consists of the highways and cities the trucks must visit before returning to the warehouse. The company would like the trucks to make these trips at minimum cost. Another network is comprised of local streets that must be traversed in order to reach an ultimate destination in minimal time. Finally, there is a network of buyers and manufacturers that should be paired to maximize the efficiency of the purchasing operations.

The use of network models provides both a convenient way of expressing the situation pictorially and an efficient mechanism for finding optimal solutions with minimal input.
DURING THE LAST week of April 1992, the worst riots in recent U.S. history occurred in south central Los Angeles. Within a three-day period, hundreds of businesses were damaged or destroyed. Among them was a local Taco Bell restaurant.

To demonstrate its commitment to the people of the community, Taco Bell (http://www.tacobell.com) pledged to rebuild and reopen the restaurant in record time. On Tuesday, June 9, 1992, Taco Bell began a crash project to construct a new restaurant on the same site as the one devastated by the riots. At 10:00 A.M. on Thursday, June 11, just 48 hours later, construction of the restaurant was completed, and the first taco was sold.

Less than two years later, in January 1994, another disaster struck the Los Angeles area. An earthquake measuring 6.7 on the Richter scale devastated homes, businesses, and property. Several freeways, including the Santa Monica Freeway, the most heavily traveled in the world, were severely damaged, as concrete cracked and bridges tumbled.

Roadways had to be repaired, and bridges and overpasses retrofitted to meet earthquake standards. In only three months, more than two months ahead of what many had considered to be an overly optimistic schedule, the repair work was completed and the freeway was reopened. Because the project was completed well ahead of schedule, the federal government covered all costs, and contractors were awarded $15 million in bonuses for their efforts.

The positive outcomes in both of these cases were accomplished with considerable coordination and management of the numerous individual tasks that had to be performed. Response to a disaster, of course, is only one area in which project planning plays a crucial role. New product development, manufacture of existing products, conference planning, audit design, and development of marketing campaigns are just some of the many areas in which careful project planning is essential.