

To assist the engineer for a productive life and position of leadership, this chapter begins with a discussion of the origins of engineering practice and education, the nature of the engineering profession, and the types of engineers, their work, and their employers. Next, management is defined and managerial jobs and functions are characterized. Finally, these topics are synthesized by defining engineering management and a discussion of the expectation of managerial responsibilities in the typical engineering career.

The words *engineer* and *ingenious* both stem from the Latin *ingenium*, which means a talent, natural capacity, or clever invention. Early applications of *clever inventions* often were military ones, and *ingeniarius* became one of several words applied to builders of such *ingenious* military machines.

Heritage of the Engineer. By whatever name, the roots of engineering lie much earlier than the time of the Romans, and the engineer today stands on the shoulders of giants. William Wickenden said this well in 1947:

Beginnings of Engineering Education. Florman contrasts the French and British traditions of engineering education in his *Engineering and the Concept of the Elite*, and the following stems both from that and from Daniel Babcock's writings. In 1716 the French government, under Louis XV, formed a civilian engineering corps, the *Corps des Ponts et Chaussées*, to oversee the design and construction of roads and bridges, and in 1747 founded the *Ecole des Ponts et Chaussées* to train members of the corps. This was the first engineering school in which the study of mathematics and physics was applied not only to roads and bridges, but also to canals, water supply, mines, fortifications, and manufacturing. The French followed by opening other technical schools, most notably the renowned *Ecole Polytechnique* under the revolutionary government in 1794. In England, on the other hand, gentlemen studied the classics, and it was not until 1890 that Cambridge added a program in *mechanical science*, and 1909 when Oxford established a chair in *engineering science*. True, the Industrial Revolution began in England, but *[k]nowledge was gained pragmatically, in the workshop and on construction sites, and engineers learned their craft—and such science as seemed useful, by apprenticeship.*

America is heir to both traditions. Harvard and other early colleges followed the British classical tradition, and during the Revolutionary War, we borrowed engineers from France and elsewhere to help build (and destroy) military roads, bridges, and fortifications. "In the early days of the United States, there were so few engineers—less than 30 in the entire nation when the Erie Canal was begun in 1817—that America had no choice but to adopt the British apprenticeship model. The canals and shops—and later the railroads and factories—were the 'schools' where surveyors and mechanics were developed into engineers. As late as the time of World War I, half of America's engineers were receiving their training 'on the job.'"

The U.S. Military Academy was established in 1802, at the urging of Thomas Jefferson and others, as a school for engineer officers, but they did not distinguish themselves in the War of 1812. Sylvanus Thayer, who taught mathematics at the Academy, was sent to Europe to study at the *Ecole Polytechnique* and other European schools: on his return in 1817 as superintendent of the Academy, he introduced a four-year course in civil engineering, and hired the best instructors he could find. As other engineering schools opened, they followed this curriculum and employed Academy graduates to teach from textbooks authored by Academy faculty. Florman continues:

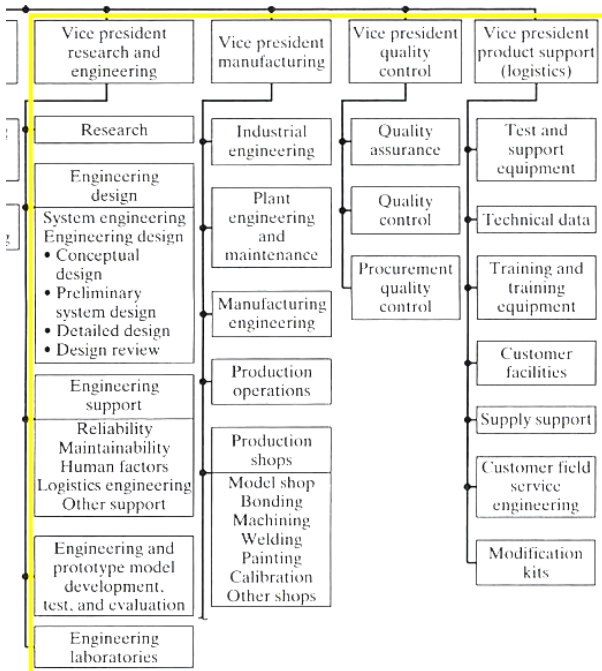
Perhaps the most crucial event in the social history of American engineering was the passage by Congress of the Morrill Act—the so-called "land grants" act—in 1862. This law authorized federal aid to the states for establishing colleges of agriculture and the so-called "mechanic arts." The founding legislation mentioned "education of the industrial classes in their several pursuits and professions in life." With engineering linked to the "mechanic arts," and with engineers expected to come from the "industrial classes," the die was cast. American engineers would not be elite polytechnicians. They would not be gentlemen attending professional school after graduation from college [as law and medicine became]. . . . Engineering was to be studied in a four-year undergraduate curriculum.



Certainly, engineering meets all the criteria of a proud profession. Engineering undergraduates recognize the need for "intensive preparation" to master the specialized knowledge of their chosen

profession, and practicing engineers understand the need for lifelong learning to keep up with the march of technology. In Part V of this book, we look at engineering societies and their ethical responsibilities in maintaining standards of conduct. Finally, engineers provide a public service not only in the goods and services they create for the betterment of society, but also by placing the safety of the public high on their list of design criteria. Each generation of engineers has the opportunity and obligation to preserve and enhance by its actions the reputation established for this profession by its earlier members.

En-gi-neer-ing *n* 1: the art of managing engines 2: the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to man in structures, machines, products, systems, and processes.



"[m]anagement" has been one of the most ubiquitous and misused words in the 20th century English language. It has been a "fad" word as well. Civil engineers discuss river basin management and coastal management, doctors discuss disease management and AIDS management, and garbage collectors are now waste management experts.

McFarland traces the meaning of the words *manage* and *management* as follows:

The word *manage* seems to have come into English usage directly from the Italian *maneggiare*, meaning "to handle," especially to handle or train horses. It traces back to the Latin word *manus*, "hand." In the early sixteenth century *manage* was gradually extended to the operations of war and used in the general sense of taking control, taking charge, or directing.... *Management* was originally a noun used to indicate the process for managing, training, or directing. It was first applied to sports, then to housekeeping, and only later to government and business.

McFarland continues by identifying "four important uses of the word *management*, as (1) an organizational or administrative process; (2) a science, discipline, or art; (3) the group of people running an organization; and (4) an occupational career." Sentences illustrating each of these in turn might be (1) "He practices good management"; (2) "She is a management student"; (3) "Management *doesn't really believe* in quality"; and (4) (heard from innumerable college freshmen) "I want to get into management." Of these four, most authors of management textbooks are

Managerial Roles—What Managers Do

Henry Mintzberg gives us another way to view the manager's job by examining the varied *roles* a manager plays in the enterprise. He divides them into three types: interpersonal, informational, and decisional roles.

Interpersonal roles are further divided into three types, depending on the direction of the relationship:

- The figurehead role involves the ceremonial or legal actions of the symbolic head of an organization in welcoming dignitaries and signing official documents; largely *outward* relationships. Many such events lose significance if they are delegated.
- The leader role is the widely recognized *downward* relationship of selecting, guiding, and motivating subordinates. This role is considered in detail in Chapter 3.
- The liaison role consists primarily of the *horizontal* relationships with peers and people in other organizations that are built and nurtured for mutual assistance. The modern term *networking* is much the same.

Informational roles are also of three types, depending on the direction of information flow:

- The monitor role involves *collecting* information about both internal operations and external events. This is done by reviewing activities and reading reports internally, attending professional meetings or trade shows, and reading the professional and trade literature to monitor the external environment and understand the trends that will affect the future of the enterprise. The researcher (often a supervisor) who performs this function is known as a *gatekeeper*.
- The disseminator role involves the *transmission* of information internally to subordinates, superiors, and peers so that everyone has the information necessary to do their job. The manager here acts as a telephone switchboard in transmitting information. This role as the source of information, if carefully handled, can strengthen a manager's formal authority.
- The spokesman [or *spokesperson*] role, normally carried out by higher management, involves speaking for the organization to the press, the public, and other *external* groups. In an *internal* version of this role, which might be called *advocate*, successful supervisors *carry the ball* for their subordinates to get the resources they need or the rewards they have earned.

Decisional roles are of four kinds in this typology:

- The entrepreneurial role of initiating change, assuming risk, and transforming ideas into useful products.
- The disturbance handler role of dealing with unforeseen problems or crises and resolving them. The use of penalties is only one—and often the least effective—mechanism for handling disturbances.
- The resource allocator role of distributing the (normally scarce) resources of money, labor, materials, and equipment where they will provide the greatest benefit to the organization
- The negotiator role of bargaining with suppliers or customers, subordinates, peers, or superiors to obtain agreements favorable to the enterprise (or at least the portion of it for which the manager is responsible).

Functions of Managers

Henri Fayol, the famous French mining engineer and executive, divided managerial activities into five elements: planning, organizing, command, coordination, and control. These elements, now called **functions of managers**, have proven remarkably useful and durable over the decades. Although each management author has his or her favored set of functions, almost all include planning, organizing, and controlling on their list. Command has become too authoritative a word in today's participative society and has been replaced by leading, motivating, or actuating. Few authors treat coordinating as a separate function. Nonetheless, as the late management author Harold Koontz concluded, "There have been no new ideas, research findings, or techniques that cannot readily

- **Planning** involves selecting missions and objectives and the actions to achieve them: it requires decision making—choosing future courses of action from among alternatives.
- **Organizing** is that part of managing that involves establishing an intentional structure of roles for people to fill in an enterprise.
- **Staffing** [included with *organizing* by most authors] involves filling, and keeping filled, the positions in the organizational structure.
- **Leading** is influencing people to strive willingly and enthusiastically toward the achievement of organization and group goals. It has to do predominantly with the interpersonal aspect of managing.
- **Controlling** is the measuring and correcting of activities of subordinates to ensure that events conform to plans.

Earlier in this chapter the characteristics of a profession were discussed, and engineering was shown to meet all the criteria of a profession. Management also has a body of *specialized knowledge*, which is introduced in Part II. Many managers will have first completed bachelor's or master's degree programs in business administration, public administration, or engineering management, but the following applies, as Babcock has observed elsewhere:

The knowledge need not be obtained only in such formal programs. It may be acquired by personal study, in-house employee education programs, seminars by all kinds of consultant entrepreneurs, or programs of many professional societies. Sometimes this formal or informal education is obtained before promotion [into] the management hierarchy, but often it occurs after promotion. A very small proportion of the broad range of managers belong to management-specific organizations such as the American Management Association, the Academy of Management, or (for engineers) the American Society for Engineering Management. They are more likely (especially in technical areas) to belong to management divisions or institutes within discipline-oriented professional societies. Considerations of standards, ethics, certification, and the like become those of the parent societies, not the management subset.

The engineering manager is distinguished from other managers because he [or she] possesses both an ability to apply engineering principles and a skill in organizing and directing people and projects. He is uniquely qualified for two types of jobs: the management of *technical functions* (such as design or production) in almost any enterprise, or the management of broader functions (such as marketing or top management) in a *high-technology enterprise*.

Herbert Hoover, a very successful mining engineer and manager, recognized the importance of the American engineering manager in an address to engineers the year he was elected president of the United States:

Three great forces contributed to the development of the engineering profession. The first was the era of intense development of minerals, metallurgy, and transportation in our great West.... Moreover, the skill of our engineers of that period owes a great debt to American educators. The leaders of our universities were the first of all the educators of the world to recognize that upon them rested the responsibility to provide fundamental training in the application of science to engineering under the broadening influence and cultivation of university life. They were the first to realize that engineering must be transformed into a practice in the highest sense, not only in the training and character but that the essential quality of a profession is the installation of ethics.... A third distinction that grew in American engineering was the transformation from solely a technical profession to a profession of administrators—the business manager with technical training.

nel when they apply for positions and rate their later performance. Further, they will better understand the nature and motivation of the technical specialist and can more easily gain their respect, confidence, and loyalty. George H. Heilmeyer, president and CEO of Bellecore (and an electrical engineer), makes clear the advantages of an understanding of technology in top management:

Competition is global, and the ability to compete successfully on this scale is fostered by corporate leaders who can do the following:

- Really understand the business.
- Understand both the technology that is driving the business today and the technology that will change the business in the future.
- Treat research and development as an investment to be nurtured, rather than an expense to be minimized.
- Spend more time on strategic thinking about the future as they rise higher in the corporation.
- Are dedicated to solving a customer's problem or satisfying a need, which is how I would define true marketing as opposed to sales.
- Place a premium on innovation.

Management and the Engineering Career

A National Engineers Registry Survey conducted in 1969 analyzed the extent to which engineers were employed in management. This survey revealed that about 18 percent of engineers had no regular supervisory responsibility and another 18 percent provided only indirect or staff supervision. The remainder (almost two-thirds) were acting as managers: 12 percent over a team or unit; 22 percent over a project or section; 20 percent over a major department, division, or program; and 10 percent in the general (top) management of an organization. This survey is now almost