terms are synonyms for public works directors, and the roles that are reserved for the engineering staff are more distinct. Project development is often handled with a special engineering staff using outside consultants and contractors. After the project is completed it is turned over to the operating staff.

Maintaining the quality of construction is critical to ensuring that investments in infrastructure pay off. There is no more serious breach of the public trust than for a responsible public works official to accept shoddy construction work or to engage in corrupt practices, yet this is one of the problems facing the infrastructure field. Project management is complex and has led many engineer–managers to consider the special requirements needed to succeed in managing projects.

Construction is sometimes regarded as an engineering function, but many skilled construction managers are not engineers; in fact, there are some very effective academic programs in place to train such managers. The American Council for Construction Education lists the academic programs at which construction management can be studied. These include engineering colleges, technology colleges, schools of architecture, and such other units as the Colorado State University Department of Manufacturing Technology and Construction Management. Obviously, management is a function that can be approached by different disciplines.

Operations Management

After a project is built, it must be operated and maintained. This requires operations management, which means to focus on the operational strategy of any business or organization. Operations management includes production management, facilities management, maintenance management, and information management. When the organization is operating, it is fulfilling its basic mission. In public service organizations this guards against straying from fundamental purpose and becoming ossified with bureaucracy; in private sector organizations, it keeps the focus on the bottom line—the essential elements of survival and growth. The following are important operational areas for a well-functioning organization:

- A clearly stated organizational purpose
- A valid and effective organizational structure, with good communication and information flow
- Operational missions and objectives for the subunits of the organization
- Job descriptions throughout the hierarchy of the organization
- Plans and production targets for the subunits of the organization
- A work management system
- A method for checking performance
- Procedures for making changes

Operations improvement has led to the field of scientific management, which was brought to the industrial world in the late nineteenth and early twentieth centuries by persons such as Frederick Taylor. Taylor was a famous engineer who became an efficiency expert and was a pioneer of industrial engineering, the branch of engineering concerned with measuring work and making it more efficient. In the early days of scientific management there was contention between owners and labor; this contention led to some of the labor movements that sought to provide for greater quality of work for laborers and less exploitation by owners. Vladimir Lenin, a father of Soviet communism, referred to the measurement of work in the scientific sense as inhuman, treating workers as animals (Grigg 1988). These facts come to bear on the reasons there is still resistance in implementing such programs as effectiveness measurement, especially in government.

In operations management, there is a system to be operated with certain objectives. The system can be an infrastructure service, such as transportation, water, buildings, or solid waste, or it could be other types of services such as a bank or restaurant. The system is managed by the control system, monitored by the data collection system, and decisions are made in the headquarters with the aid of the decision support system. The essence of the items is captured by the military term *C3I*, which provides for decision making and the issuance of control orders. Control means the capability to actually manipulate the system, such as through a functioning organization equipped with the right control devices. Communications includes all data flow, telecommunications, written orders, and other forms of communication necessary to operate the system. Intelligence is the collection of data necessary for management and decision making.

Productivity is a tool for evaluating how well an organization is doing. It measures the output resulting from such input factors as work units, materials, energy, and cost. An example can be seen in public transit. The overall objective of public transit is to maintain a system that provides access to places where citizens want to go in a safe, quick, comfortable, pleasant, convenient, and reliable manner and that helps minimize pollution, congestion, and energy consumption in the community. Each of the emphasized characteristics becomes an objective (e.g., quickness is measured by rapid movement of an objective). The main quality characteristic of this is travel times, measured by actual travel times from the schedules. To keep track of this requires data of actual schedule compliance (Grigg 1988).

The pertinent questions in production are these: What is produced? What are the quantity and quality of the output? What is the cost, and what are the external impacts? These questions are easier to identify when the operation is a private business and the products are sold in the marketplace, but when the product is a public service it must be ana-

lyzed using different approaches that center around defining the service levels needed and supplied.

Productivity measurement for infrastructure categories would generally use such parameters as cost per 1000 gallons of water delivered, tons of solid waste collected per work-hour, cost per mile of street cleaned, cost to maintain a certain amount of the street network, and related parameters.

Effectiveness means doing the right thing efficiently. Efficiency alone is not enough to evaluate an enterprise because it does not test whether the right goals are being pursued. The bottom line of productivity and program evaluation is to ensure that the operation is performing effectively. Effectiveness measures for infrastructure services allow analysts to consider their use in program evaluation and related planning. An Urban Institute report lists some 11 types of performance measures (Hatry and Peterson 1984):

- Cost
- Workload accomplished
- Effectiveness/quality
- Efficiency/productivity
- Cost:workload ratios
- Efficiency/effectiveness
- Resource utilization
- Productivity indexes
- Pseudomeasures
- Cost:benefit ratios
- Comprehensive performance evaluation

Management audits for operations ask questions such as what are the goals of the operation, how can the success of the enterprise be measured, and what are the numeric parameters. Ideally, performance of the infrastructure systems should be audited regularly.

Maintenance is a key support activity for operations and requires an MMS to determine whether the system is working as it should. As discussed in Chapter 5, maintenance involves four separate functions: condition assessment, inventory, preventive maintenance, and corrective maintenance. The condition assessment activity is a link between the operation and the maintenance function and illustrates why the two functions must be unified. Preventive maintenance is intended to head off problems. Corrective maintenance involves repair, replacement, and rehabilitation of facilities.

Operations and maintenance have different but related information needs. Information related to operations subdivides into the part that deals with facilities (hardware) and the part that deals with workers (software). Operations managers need information and reports on how well the systems are doing. The logical extension of operational information

systems is movement toward automatic control. Maintenance information should support MMSs and provide information for budgeting as well as management. There are a number of commercial software packages for maintenance management.

In public works organizations the engineering function is responsible for the studies and designs necessary to construct and reconstruct facilities. The engineering department would normally be responsible for numerous records, especially as-built drawings of newly constructed or reconstructed facilities. Also, any system maps would be the responsibility of the engineering department. There is an obvious link with the information needs of operations and maintenance, and a common database should be available.

Quality Management

Quality management and control are concepts that have become important to industry, which has learned that high product quality is essential and that the best way to have high quality is to do things right the first time. The concept of QC has expanded into a wider view of quality in all aspects of management (that is, having it improve continually). QC means to ensure that quality of product, whatever it is, is within acceptable limits, as defined for that particular product. Sometimes QA is used in place of QC.

Quality control functions are easy to envision in a water treatment plant that must meet regulatory requirements. If the goal of the utility is to deliver service that involves water of certain quality, with certain pressures, and during certain time periods, it would need an inspection program, a quality control sampling effort, laboratory work, and record keeping. Another example might deal with storm water. If the goal is to prevent a certain level of flooding, the indicator might be the absence of complaints but the organization could have an assessment program.

There is much to learn about management from quality improvement. One version is called total quality management. Bill Creech, authority on management, wrote this about total quality management: "Product is the focal point for organizational purpose and achievement. Quality in the product is impossible without quality in the process. Quality in the process is impossible without the right organization. The right organization is meaningless without the proper leadership. Strong, bottom-up commitment is the support pillar for all the rest. Each pillar depends on the other four, and if one is weak all are" (Creech 1994).

W. Edwards Deming became famous for his suggestions about improving quality of businesses through the Deming method, which has been reported in many places. The Deming principles include the following: (1) create consistency of purpose with product and service; and (2) instead of focusing solely on making money, focus on staying in busi-

ness and providing more jobs through innovation, research, constant improvement, and maintenance. The principles Deming presents apply to all organizations (Grigg 1988):

- Adopt the new philosophy.
- Cease dependence on mass inspection.
- End the practice of awarding business on price tag alone.
- Improve constantly and forever the system of production and service.
- Institute training.
- Institute leadership.
- Drive out fear.
- Break down barriers between staff areas.
- Eliminate slogans, exhortations, and targets for the work force.
- Eliminate numeric quotas.
- Remove barriers to pride of workmanship.
- Institute a vigorous program of education and retraining.
- Take actions to accomplish the transformation.

Program Assessment and Management Audits

Just as you can have a financial audit, a management or performance audit can identify ways in which management effectiveness can be improved. One of the functions of a board of directors is actually to bring an outside view to an organization. Because they will be evaluated, management and staff should stay on their toes. Management consultants can be used for this task, and a team of them can visit an organization for a short period to assess the organization's purpose, customers, goals, procedures, and results. It is amazing how much insight outsiders can bring to the operation of a program that the insiders understand but have come to take for granted. A management audit is like an annual review of an employee but is applied to an organization. Methods can include visits, interviews, surveys, inspections, document review, financial studies, and other tools available to management to assess performance.

Facilities Management

Facilities management is an operational phrase that means operation and management of capital facilities, which depend on planning and maintenance. Due to financial constraints, there is interest in making existing facilities last longer and operate better. The need to make infrastructure facilities work better is illustrated by the three Rs programs used by public works agencies around the nation, which focus on repair, rehabilitation, and replacement of facilities. There is also a four-R high-

way program (resurfacing, rehabilitation, repair, and replacement). These principles may seem elementary, but it is surprising how many engineers involved in public works have not dealt with the important questions of operations and maintenance tools of management.

Marketing and Public Relations

Marketing and public relations are two key areas in business and management, and while they are primarily used in the for-profit world, they also apply to nonprofit organizations. Even churches use some aspects of marketing and public relations. Marketing includes a spectrum of activities and is not limited to sales alone. It begins with identification of the market and the business's customers and the products or services they would like to have, then proceeds through the sequence of product and service development, pricing, promotion, advertising, selling, and distribution.

Public relations is a closely allied field that includes identification of target audiences, use of media to achieve objectives with them, and work with organizations to achieve objectives. A few of the techniques that are used in public relations are news releases and media relations, feature articles, newsletters, annual reports, special events coordination, celebrity speakers, fliers, invitations to events, and other ad material such as posters and signs.

Until recently, it was considered unethical for professionals (such as lawyers and engineers) to advertise other than a notice in the phone book. Today, some professionals advertise freely, especially some categories of attorneys. Engineers still do not, for the most part, "advertise," but they certainly engage in public relations. For example, a new engineering firm will have brochures, business cards, a web site, newsletters, receptions, and other publications, events, and notices designed to attract the attention of customers.

Personal Management Skills

Young civil engineers have a lifetime of professional development ahead, with education just the start of personal development. In addition to an education, civil engineers should recognize the importance of developing personal management skills as well as skills that can be used to manage an organization. A number of recent books aim to guide professional people in becoming more effective. These books cover such topics as goal setting, time management, getting a personal vision, negotiation, and interpersonal relations.

Maslow's hierarchy of human needs (Table 6-1) demonstrates how to assess personal management skills. This assessment begins with basic

survival needs and ends with self-actualization and personal fulfillment needs. People continue to seek something (e.g., achieving a goal) even after satisfying their basic needs. When people feel fulfilled, they believe they are successfully following the right path for their lives. They also believe they are effective in achieving goals. The key is to have a plan in place and to identify the goals.

Jimmy Carter, in *Why Not the Best?: The First Fifty Years*, discussed his interview with Admiral Rickover, legendary developer of America's nuclear Navy. Rickover asked Carter whether he had done his best at Annapolis. After thinking for a minute, Carter said "No, sir." After the interview, Rickover left Carter with the question, "Why not?" This experience gave Carter something to think about and affected his whole life. What Rickover was really asking was, "Do you know what you are supposed to do, and have you prepared for and determined to do your best to achieve that?" (Carter 1996).

Improving personal management skills involves a whole system of activities: knowing your purpose, clarifying your values, getting your vision right, assessing your strengths, setting goals, thinking and strategizing, getting motivated and committed, taking action, and assessing results. In many ways, personal management is the individual version of strategic planning, and some management gurus have compared the two by suggesting that every individual should have a personal mission statement.

Like other aspects of management, the personal management system has several components, including planning, organizing, and controlling. Planning is the process of setting goals and developing strategies. Every person must apply planning in a unique way. An artist will have less use for personal planning than will a businesswoman who supervises many projects. Even an artist must use time well, however. Developing a plan and having the right goals require a recognition of one's purpose and a personal vision of life. Every person needs a compass to direct his or her life. Understanding one's full potential requires an understanding of individual purpose and skills. Having this compass right is a key point of author Steven Covey in his best-selling *Principle-Centered Leadership* (Covey 1991).

Knowing which direction on the compass to follow requires a personal vision. Vision is the way one sees or conceives how life will unfold, the foundation or root of personal motivation—in effect, a life plan. Unfortunately, many people lack a personal vision, and finding one can be a complex task—especially later in life after a person has missed opportunities to be mentored, advised, and encouraged. There are many sources of confusion and discouragement. It is important not to become confused or discouraged. It is also important to know how to develop personal values and purpose. Techniques that can be used to assess vision and effectiveness include writing an autobiography, writing an epitaph, keeping a running journal, and taking personality tests.

Goals flow from vision. A person must be an organized thinker and planner in order to set goals. Goals must be set for both the long and short term. Obtaining a college degree is a long-term goal; a daily "to-do" list contains short-term goals. Short-term goals should be those that will lead to achievement of long-term goals. Today, personal calendars and software are loaded with tools to help people set goals. Setting goals is not enough, however, without a strategy to achieve them. Developing a strategy involves specific goals and actions. Imagine that part of your vision is to help people achieve their purposes through improved education and your goal is to become a teacher. Depending on your age and education, you will need a college degree in education and a plan to get a job as a teacher. Each of these goals and actions will require a series of steps, which, if followed, will enable you to achieve your goal and fulfill your vision.

Personal management skills can help but not ensure success in goal achievement. Personal skills in planning, organization, time management, and finance are described in numerous books, magazines, audiotapes, and seminars. Sometimes these skills are presented as panaceas in solving problems, but each is simply a tool. Personal management tools are not enough to achieve success because a person also needs a good attitude, commitment, principles, and the will to follow through. These are, to some extent, character traits, which can be learned as well. A positive attitude and good motivation are critical ingredients to success. Getting encouragement and a mentor can help.

Character Building

Good character traits are essential to success, and this is being recognized in the United States today with renewed emphasis on character education. In 1999, for example, Colorado State University was recognized as one of the country's top universities that encourage character development. Some of the university's character development programs and actions include a commitment to helping students lead ethical and civic-minded lives; a volunteer service program; help for students to strengthen their values, moral reasoning skills, and ethical decision-making skills; and guidance for moving across cultural boundaries and acting ethically in an increasingly complex global society.

Individual Professional Development Plan

Just as there is a curriculum to follow in college, it is important to have a personal professional development plan. This plan can include goals, vision, and a personal mission statement; associations to join and men-

tors to work with; a personal assessment plan; learning goals and plans; a personal journal; identification of role models; a reading list; a pocket calendar or personal organizer; a time management system; learning a language or new skill; a deliberate plan to get new experiences; skill-building courses, such as public speaking; a professional portfolio and resume; and exercise, conditioning, and wellness programs.

Entrepreneurship

At some point in their careers, engineers might begin to yearn for something different (e.g., to start a business, implement some kind of innovation). Some engineers are entrepreneurs. An entrepreneur is someone who is willing to take risks to innovate or get something accomplished. An entrepreneur in business will take risks to start an enterprise. Perhaps the best known and certainly the wealthiest entrepreneur today is Bill Gates, founder of Microsoft. Entrepreneurs can also work in the nonprofit world. For example, the entrepreneur's vision might be to start a new outreach organization to meet a pressing need, such as world hunger.

An innovation is performing some action with a new or better method. Innovators are highly valued in organizations. Suggestion boxes were meant to glean valuable suggestions from people for improvements. Recognizing that technology, computers, and systems analysis have much to offer, there have been many attempts to innovate in public works management in recent years. Sometimes innovation works; sometimes it does not. For example, systems analysis helped us get to the moon, but when introduced into the public sector it elicited negative comments. "If we can land a man on the moon, we can certainly pick up the garbage in New York," meant that it is harder to pick up the garbage in New York than to land on the moon. Although made tongue in cheek, this statement underlines the difficulty of public works in some settings.

During the 1970s, there were public technology programs and cities got public funding for technology agents. Public Technology Inc. was formed to apply technology to cities. Innovation did result, but much of it was private initiative rather than government funding. Government funding, however, can provide incentives for private entrepreneurs.

Volunteer Organizations, Community Service, and Networking

One of the helpful aspects of management is the opportunity to be involved with leadership figures from the community, professional societies, other businesses and organizations, and nonprofit groups. To become involved with these organizations, it is good to become involved

in civic and business activities such as the chamber of commerce, service clubs (e.g., Rotary, Lions, Kiwanis), and professional societies. To the extent that engineers can find the time, they can gain from seeking leadership positions (e.g., committee chair) in organizations such as ASCE, the chamber of commerce, business organizations, and civic groups.

A main advantage of such involvement is the fact that it expands the engineer's circle of contacts. To manage this circle, it is well to have a database of contacts for networking. Periodically contacting the most important people in the database (regardless of whether there is an immediate need) helps to maintain this network.

Beyond the immediate benefits of volunteer work, there are many societal needs that must be met. Philanthropy exists to help to meet these needs, which go far beyond what government can handle. Because of their service orientation, engineers are often drawn to the nonprofit world. Examples of organizations they might support include technical societies, emergency response charities, international development agencies, and environmental organizations. For example, the American Water Works Association helped to spin off the humanitarian nonprofit organization Water For People. This organization is "a nonprofit, charitable organization in the United States and Canada that helps people in developing countries obtain safe drinking water."

Frontiers of Management: Peter Drucker, Management Guru

Management guru Peter Drucker turned 90 in 1999. Drucker crystallized the discipline of management with his 1954 seminal text *The Practice of Management* (Drucker 1954). Drucker displayed remarkable insight about management and called it the "least understood of social institutions." He understood that if people could learn management, ordinary people could achieve better results and organizations would become part of the fabric of society. To get a perspective on this, consider that before 1900, organizations were not at all prevalent. At that time, 80% of people worked on farms or with their hands, usually working alone and not in teams. Today, knowledge workers, engaged in technical and professional specialties, are the largest group of workers. Drucker showed how management articulates an organization's purpose and translates it into performance. He is famous for asking such questions as "What is our business?," Who is the customer?," and What does the customer value?" This became the theory of the business. Profit indicates whether the theory works. It is the equivalent of the scientific method in business, where hypotheses are tested in action, then revised. Drucker defined the challenge of the twenty-first century as raising the productivity of knowledge workers, including engineers.