PART IV

GLOBAL AWARENESS AND CAREER CHOICE

We have not been seeing our Spaceship Earth as an integrally-designed machine which to be persistently successful must be comprehended and serviced in total.

Buckminster Fuller

We must hold a man amenable to reason for the choice of his daily craft or profession. It is not an excuse any longer for his deeds, that they are the custom of his trade. What business has he with an evil trade?

Ralph Waldo Emerson

The rate of progress is such that an individual human being, of ordinary length of life, will be called upon to face novel situations which find no parallel in his past. The fixed person for the fixed duties, who in older societies was such a godsend, in the future will be a public danger.

Alfred North Whitehead

CHAPTER 7

GLOBAL ISSUES

On December 3, 1984, the operators of Union Carbide's plant in Bhopal, India, became alarmed by a leak and overheating in a storage tank. The tank contained methyl isocyanate, a toxic ingredient used in pesticides . Within an hour the leak exploded in a gush that sent 40 tons of deadly gas into the atmosphere. The result was the worst industrial accident in history: nearly 3,000 people killed, 10,000 permanently disabled, and 100,000 others injured (Shrivastava, 1987).

The disaster was caused by a combination of extremely lax safety procedures and gross judgment errors by plant operators, as we shall see in more detail later. Union Carbide had transferred legal responsibility for safety inspections to the overseas operators, even though it retained general management and technological control. Was this legal transfer morally responsible? Should Carbide have done more to ensure safety standards in dealing with such dangerous material? In general, what are the responsibilities of engineering corporations and engineers doing business in foreign countries?

The word "global" in the title of this chapter refers both to the international context of engineering and to the increasingly wide social dimensions of engineers' work. As responsible social experimenters, engineers need to take these dimensions into account in making engineering decisions and career choices. In this chapter, we will explore these dimensions by discussing four topics: multinational business, the environment, computer ethics, and weapons development.

MULTINATIONAL CORPORATIONS

Multinational corporations do extensive business in more than one country. For example, Union Carbide in 1984 operated in 38 countries, and it is only a medium-sized "giant" corporation, ranking thirty-fifth in size among U.S. corporations. Generally multinationals establish foreign subsidiaries, such as Union Carbide of India, retaining 51 percent of the stock and allowing foreign investors to own the remainder.

The benefits to U.S. companies of doing business in less-developed countries are clear: inexpensive labor, availability of natural resources, favorable tax arrangements, and fresh markets for products. The benefits to the participants in developing countries are equally clear: new jobs, jobs with higher pay and greater challenge, transfer of advanced technology, and an array of social benefits from sharing wealth.

Yet moral difficulties arise, along with business and social complications. Who loses jobs at home when manufacturing is taken "offshore"? What does the host country lose in resources, control over its own trade, and political independence? And what are the moral responsibilities of corporations and individuals operating in less-developed countries? This last is the question we shall focus on here.

Three Senses of "Relative"

According to one popular cliché, deciding how corporations and individuals ought to act in foreign countries is not too difficult. "Values are relative, so when in Rome do as the Romans do." However, the claim that values are relative is ambiguous, and it may be true or false depending on what is meant.

There are many versions of relativism, depending upon how, and with respect to what, values are supposed to be relative (Taylor, 1975 13–30). Here are three versions.

Ethical conventionalism: Actions are morally right when (and because) they are approved by law, custom, or other conventions.

Descriptive relativism: Value beliefs and attitudes differ from culture to culture.

Moral relationalism: Moral judgments should be made in relation to factors that vary from case to case, usually making it impossible to formulate rules which are both simple and absolute (i.e., exceptionless).

The first version of relativism was discussed in Chap. 2. As we said there, that view is clearly false since it implies absurdities. It would justify government-supported cruelty, such as practiced in Nazi Germany, Stalinist Russia, and nineteenth-century U.S. slave states. Laws and conventions are not morally self-certifying. Instead, they are always open to criticism in light of moral reasons concerning human rights, the public good, duties to respect people, and virtues.

The second version, Descriptive Relativism, is obviously true. It merely says there are differences between the moral beliefs and attitudes of various cultures. Descriptive Relativism does not entail Ethical Conventionalism, as is sometimes thought. Mere diversity in what people believe hardly shows there is no objective truth—truth which holds across cultural boundaries. The fact that nearly everyone once believed the earth to be flat is irrelevant to determining the earth's actual shape. Likewise, the mere fact that other cultures accept moral beliefs differing from our own does not mean there is no objective truth which can be used in evaluating customs and laws.

Early cultural anthropologists tended to overemphasize the extent of moral differences between cultures. Preoccupied with exotic practices like head-hunting, human sacrifice, and cannabalism, they moved too quickly from "Moral views differ greatly" to "Morality is simply what a culture says it is." More recent anthropologists have drawn attention to underlying similarities between cultural perspectives. They have noted that virtually all cultures show some commitment to promoting social cooperation and to protecting their members against needless death and suffering. And beneath moral differences often lie differences in circumstances and in beliefs about facts, rather than differences in moral attitude.

For example, the Eskimos and some American Indians used to leave their elderly to die. At first glance this seems radically inconsistent with our notions of respect for human life. Yet the Eskimos and Indians lived under harsh conditions requiring migration and rationing if the group was to survive. In such circumstances the elderly would voluntarily agree to abandonment out of respect for the group and a wish not to be a burden to their families. Or again, the Aztecs' practice of human sacrifice seems a sign of cruelty and lack of concern for life. But a deeper examination reveals that they believed their gods required such sacrifice to ensure the survival of their people as a whole, and it was considered an honor for the victims.

Most of us will also readily endorse the third version of relativism, Moral Relationalism. It is a reminder that moral judgments are made *in relation to* a wide variety of variable factors, and that as a result it is usually impossible to formulate simple and absolute moral rules. A rule like "Lying is immoral," for example, has many exceptions. Special circumstances can arise where people have to lie in order to save a life or to protect their privacy from mischievous intruders.

Virtually all philosophers have accepted Moral Relationalism (with the exception of Kant and some divine command ethicists). Contemporary duty and rights ethicists, for example, emphasize how everyday rules such as "Don't lie" and "Keep promises" can have valid exceptions when they conflict with other rules (creating moral dilemmas). To respect people requires being sensitive to special circumstances. Utilitarians emphasize that in assessing good and bad consequences attention must be paid to the context of conduct. And virtue ethicists stress the role of practical wisdom in identifying facts relevant to assessment of virtuous conduct.

Relationalism readily allows that the customs of cultures may be morally pertinent considerations that require us to adjust moral judgments and conduct. For example, we should remove our shoes before entering the home of a traditional Japanese family since in that context that is a sign of respect, even though it is not in other situations.

Relationalism is important in multinational engineering contexts involving different conventions encountered around the world. However, it is also important to realize that Relationalism only says that foreign customs may be morally *relevant*. It does not say they are always *decisive* in determining what should be done. This crucial difference sets it apart from Ethical Conventionalism.

"When in Rome"—or South Africa

Which standards should guide engineers' conduct when working in foreign countries? Ethical Conventionalism supports the maxim, "When in Rome do as the Romans do." That is, it would have us believe there is no real problem: One should just drift with the conventions dominant in the local area. An equally extreme opposite view would have one retain precisely the same practices endorsed at home, never making any adjustments to a new culture. Both of these choices, however, seem to us unacceptable.

Consider the choice faced by engineering firms and other companies doing business in Italy, where they are confronted with a tax system which differs strikingly from the American one. According to one account, corporations routinely submit a tax return showing profits of only 30 to 70 percent of their actual levels (Kelly, 1983, 37–39). Government officials generally estimate any corporation's taxes at several times over what that corporation claims it owes. Then the two sides negotiate the final figure as a compromise. The Italian revenue agents take as their "fee" an unreported cash payment directly from the representative for the corporation. The size of this payment influences how much or how little the revenue agent will demand in taxes for the Italian government.

Anything like such a practice, of course, would be considered corrupt in the United States. It involves misrepresenting actual profits, secret payments, and an open door to biased tax assessments. Some would describe it in terms of deception, dishonesty, bribes, and conflicts of interest. Yet companies doing business in Italy that accurately report their profits would be assessed taxes much higher than they deserve. It would simply be unworkable to try doing business while refusing to participate in the practice.

Of course such "pragmatic" considerations concerning workability do not automatically justify participation in a practice. But several features should be noted.

First, the practice is both officially sanctioned by the government and also tolerated by the Italian people. A shared understanding exists as to its legitimacy within Italy. Second, in some respects the practice is analogous to bargaining in the market square and bluffing in poker. It could at least be argued that sometimes deception is permissible when all participants accept it and no serious moral harm comes from it. Third, and perhaps most important, no basic human rights are violated by the practice. To be sure, the custom is in many ways undesirable because it lends itself to abuses our own system tries to discourage. And doubtless it encourages laxity about truthfulness in public life and may lessen the public trust needed for effective government. Yet it is not obvious that foreign companies participating in it are actually doing any harm.

Next consider the very different problem posed by the political situation in the Republic of South Africa, a country whose political and economic institutions are based on the system of racial separation called *apartheid* (Callaghan, 1978, 325–359). The economic aspects of the system include differential wage scales, with black workers paid considerably less than the wages paid to whites for similar work. Advancement to high managerial positions within companies has either been limited to whites or made much more difficult for black employees. Segregation has extended to rest rooms, lounge areas, and assembly lines.

These economic aspects of apartheid are backed by political repression. Black people constitute over 70 percent of the population, but they are allowed to live permanently on only 13 percent of the land, generally the least desirable, barren areas. Male workers must leave their families to seek work far away. No black person has the right to vote, to free expression and association, or to participate fully in government. Attempts to gain political rights have resulted in brutal suppression. In 1976, for example, police killed over 700 demonstrators in Soweto, over two dozen after they were arrested and placed in detention.

A number of international engineering firms do business in South Africa. Most of them, although not all, have in the past adopted at least some of the South African policies. Was this morally permissible? Were they perhaps even obligated to conform to the dominant foreign customs? Was profit a sufficient justification, especially given that American subsidiaries in South Africa often made twice the profits of their American counterparts?

We take the view that it was neither obligatory nor, in most cases, permissible to do so. Racial discrimination was wrong in the United States even during the time it was accepted by the majority of citizens. It is equally wrong now, and seriously so. Few practices so clearly violate fundamental moral principles of human equality, dignity, and rights.

The major ethical theories can be invoked to support this judgment. From Kant's duty perspective, the practice constitutes treating the black Africans as a mere means to promoting the advantages of the white minority and foreign corporations seeking inexpensive labor. From Locke's rights perspective, it amounts to a blatant infringement of human rights. From a utilitarian perspective, the immense suffering of the black majority in South Africa outweighs the financial benefits of the already advantaged groups, so that the practice does not produce the most good for the most people. From a virtue ethics perspective, the virtue of justice prohibits supporting grossly unjust systems.

Is our harsh judgment applicable in all instances? Might there be mitigating circumstances? Our earlier comments on relationalism would require us to look more closely at the practices of particular American companies before making unqualified condemnations. Are they taking steps to increase wages for black workers—steps that follow a definite timetable so that equal work will eventually be rewarded by equal pay? Are they working toward bringing more blacks into management positions by offering them the required training now? To the extent that such efforts are underway and indeed constitute more than tokenism, any judgment of blame would have to be qualified.

More than 100 of the American companies doing business in South Africa did attempt to bring about positive change by adopting the Sullivan Principles. These principles were set forth in 1977 by Reverend Leon Sullivan, a black minister in Philadelphia and a member of General Motors' board of directors. The principles called for nonsegregation at the workplace, equal pay for the same job, and equal promotion opportunities. When adhered to, these principles were more than token gestures: They went far beyond the South African conventions and violated South African law, although the government decided to indulge them.

In 1987, however, Reverend Sullivan disavowed his principles. He noted that many companies who professed the principles found ways around them. For example, different job titles would be given to blacks and whites doing essentially the same work, thereby permitting the company to use differential pay scales. Again, companies took down racial segregation signs, but maintained segregation by assigning separate work areas to salaried workers (mostly white) and hourly workers (mostly black). Even when the principles were adhered to in good faith, Reverend Sullivan concluded, the apartheid system was being supported, not improved, by American business. American tax dollars, technology, jobs, and prestige all worked to the advantage of the South African government.

The examples of Italian tax laws and South African apartheid suggest it is neither always right nor always wrong to work within parameters set by the undesirable customs of other countries. In general, foreign customs provide morally relevant data which should enter into our ethical deliberations. But neither they nor current U.S. practice automatically dictates how engineers and corporations ought to act in unusual social settings. Each case, or at least each type of case, must be examined on its own merits.

Technology Transfer and Appropriate Technology

Before returning to the Bhopal disaster, it will be helpful to introduce the concepts of technology transfer and appropriate technology. *Technology trans-*

fer is the process of moving technology to a novel setting and implementing it there (Heller, 1985). Technology includes both hardware (machines and installations) and technique (technical, organizational, and managerial skills and procedures). A *novel setting* is any situation containing at least one new variable relevant to the success or failure of a given technology. The setting may be within a country where the technology is already used elsewhere, or a foreign country, which is our present interest. A variety of agents may conduct the transfer of technology: governments, universities, private volunteer organizations, consulting firms, and multinational corporations.

In most instances, the transfer of technology from a familiar to a new environment is a complex process. The technology being transferred may be one that originally evolved over a period of time and is now being introduced as a ready-made, completely new entity into a different setting. Discerning how the new setting differs from familiar contexts requires the imaginative and cautious vision of "cross-cultural social experimenters" (Heller's phrase).

The expression *appropriate technology* is widely used, but with a variety of meanings. We use it in a generic sense to refer to identification, implementation, and transfer of the most suitable technology for a new set of conditions. Typically the conditions include social factors that go beyond routine economic and technical engineering constraints. Identifying them requires attention to an array of human values and needs that may influence how a technology affects the novel situation. Thus,

> appropriateness may be scrutinized in terms of scale, technical and managerial skills, materials/energy (assured availability of supply at reasonable cost), physical environment (temperature, humidity, atmosphere, salinity, water availability, etc.), capital opportunity costs (to be commensurate with benefits), but especially human values (acceptability of the end-product by the intended users in light of their institutions, traditions, beliefs, taboos, and what they consider the good life) (Heller, 1985, 119).

As examples, we may cite the introduction of agricultural machines and long-distance telephones. A country with many poor farmers can make better immediate use of small, single- or two-wheel tractors which can serve as motorized ploughs, pull wagons, or drive pumps than it can of huge diesel tractors which require collectivized or agribusiness-style farming. On the other hand, the same country may benefit more from the latest in microwave technology to spread its telephone service over long distances than it can from old-fashioned transmission by wire.

Appropriate technology overlaps with, but is not reducible to, *intermediate technology*, which lies between the most advanced forms available in industrialized countries and comparatively primitive forms in less-developed countries (Schumacher, 1973). The British economist E. F. Schumacher argued that intermediate technologies are preferable because the most advanced technologies usually have harmful side-effects, such as causing mass migrations from rural areas to cities where corporations tend to locate. These migrations cause overcrowding, and with it poverty, crime, and disease. Far more appropriate, he argued, are smaller-scale technologies replicated throughout a less-developed country, using low capital investment, labor intensiveness to provide needed jobs, local resources where possible, and simpler techniques manageable by the local population given its education facilities.

We mention intermediate technology, and the movement inspired by Schumacher, not in order to offer a general endorsement (often it has been dramatically beneficial, at other times not particularly effective), but to emphasize that it is only one conception of appropriate technology. "Appropriate technology" is a generic concept which applies to all attempts to emphasize wider social factors when transferring technologies. As such, it reinforces and amplifies our view of engineering as social experimentation.

Bhopal

In retrospect it is clear that greater sensitivity to social factors was needed in transferring chemical technology to India (Shrivastava, 1987; Everest, 1985). By the late 1970s, Union Carbide had transformed its pesticide plant in Bhopal from a formulation plant (mixing chemicals to make pesticides) to a production plant (manufacturing chemical ingredients). It was fully aware of the hazards of the new technology it transferred. For years its West Virginia plant had made methyl isocyanate, the main toxin in two popular pesticides used in India and elsewhere. As a concentrated gas, methyl isocyanate burns any moist part of bodies with which it comes in contact, scalding throats and nasal passages, blinding eyes, and destroying lungs.

Yet, in designing the Bhopal plant Union Carbide did not transfer all the safety mechanisms available. For example, whereas computerized instruments controlled the safety systems and detected leaks at the West Virginia plant, Bhopal's safety controls were all manual and workers were asked to detect leaks with their eyes and noses.

The government of India required the Bhopal plant to be operated entirely by Indian workers. Hence Union Carbide at first took admirable care in training plant personnel, flying them to the West Virginia plant for intensive training. It also had teams of U.S. engineers make regular on-site safety inspections.

But in 1982 financial pressures led Union Carbide to relinquish its supervision of safety at the plant, even though it retained general financial and technical control. The last inspection by a team of U.S. engineers occurred that year, despite the fact that the team warned of many of the hazards that contributed to the disaster.

During the following 2 years safety practices eroded. One source of the erosion had to do with personnel: high turnover of employees, failure to properly train new employees, and low technical preparedness of the Indian labor pool. Workers handling pesticides, for example, learned more from personal experience than from study of safety manuals about the dangers of the pesticides. But even after suffering chest pains, vomiting, and other symptoms they would sometimes fail to wear safety gloves and masks because of high temperatures in the plant—the result of lack of air-conditioning.

The other source of eroding safety practices was the move away from U.S. standards (contrary to Carbide's written policies) toward lower Indian standards. By December of 1984 several extreme hazards, in addition to many smaller ones, were present.

First, the tanks storing the methyl isocyanate gas were overloaded. Carbide's manuals specified they were never to be filled to more than 60 percent of capacity; this was so that in emergencies the extra space could be used to dilute the gas. The tank which was to cause the problem was in fact more than 75 percent full.

Second, a stand-by tank that was supposed to be kept empty for use as an emergency dump tank already contained a large amount of the chemical.

Third, the tanks were supposed to be refrigerated to make the chemical less reactive if trouble should arise. But the refrigeration unit had been shut down 5 months before the accident as a cost-cutting measure, making tank temperatures 3 to 4 times what they should have been.

Six weeks before the catastrophe, production of methyl isocyanate had been suspended because of an oversupply of the pesticides it was used to make. Workers were engaged in routine plant maintenance. A relatively new worker had been instructed by a new supervisor to flush out some pipes and filters connected to the chemical storage tanks. Apparently the worker properly closed valves to isolate the tanks from the pipes and filters being washed, but he failed to insert the required safety disks to back up the valves in case they leaked. (He knew that valves leaked, but he did not check for leaks: "It was not my job." The safety disks were the responsibility of the maintenance department, and the position of second-shift supervisor had been eliminated.)

Two of four valves that should have been open to allow water flow were clogged. The resulting extra pressure was enough to force water to leak into a tank. For nearly 3 hours chemical reactions occurred, generating enormous pressure and heat in the tank.

By the time the workers noticed a gauge showing the mounting pressure and began to feel the sting of leaking gas, they found their main emergency procedures unavailable. The primary defense against gas leaks was a vent-gas scrubber designed to neutralize the gas. It was shut down (and was turned on too late to help), because it was assumed to be unnecessary during times when production was suspended.

The second line of defense was a flare tower that would burn off escaping gas missed by the scrubber. It was inoperable because a section of the pipe connecting it to the tank was being repaired. Finally, workers tried to minimize damage by spraying water 100 feet into the air. The gas, however, was escaping from a stack 120 feet high.

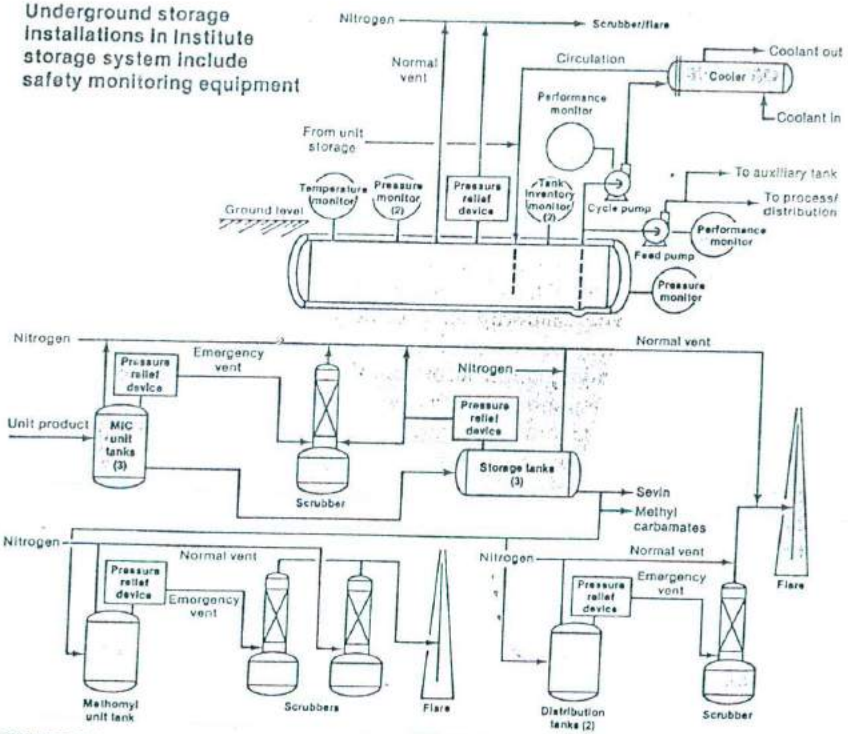


FIGURE 7-1
Diagram of Bhopal system. (*From Ward Worthy, "Methyl Isocyanate: The Chemistry of a Hazard," C & EN February 11, 1985.*)

Within 2 hours most of the chemicals in the tank had escaped to form a deadly cloud over hundreds of thousands of people in Bhopal. As was common in India, desperately poor migrant laborers had become squatters—by the tens of thousands—in the vacant areas surrounding the plant. They had come with hopes of finding any form of employment, as well as to take advantage of whatever water and electricity was available.

Virtually none of the squatters had been officially informed by Union Carbide or the Indian government of the danger posed by the chemicals being produced next door to them. (The only voice of caution was that of a concerned journalist, Rajukman Keswani, who had written articles on the dangers of the plant and had posted warnings: "Poison Gas. Thousands of Workers and Millions of Citizens are in Danger.") There had been no emergency drills, and there were no evacuation plans: the scope of the disaster was greatly increased because of total unpreparedness.

Study Questions

1 Following the disaster at Bhopal, Union Carbide argued that officials at its U.S. corporate headquarters had no knowledge of the violations of Carbide's official safety procedures and standards. This has been challenged as documents were uncovered showing they knew enough to have warranted inquiry on their part, but let us assume they were genuinely ignorant. Would ignorance free them of responsibility for all aspects of the disaster? (In answering this question distinguish between the various senses of "responsibility" set forth in Chap. 2. If possible consult one or more of the many articles and books written about the disaster.)

2 Export of hazardous technologies to less-developed countries is motivated in part by cheaper labor costs, but another factor is that workers are willing to take greater risks. It has been argued that taking advantage of this willingness need not be unjust exploitation if several conditions are met: (1) Workers are informed of the risks. (2) They are paid more for taking the risks. (3) The company takes some steps to lower the risks, even if not to the level acceptable for U.S. workers (DeGeorge, 1986, 368–369). Do you agree with this view? How would you assess Union Carbide's handling of worker safety? Take into account the remarks of an Indian worker interviewed after the disaster. The worker was able to stand only a few hours each day because of permanent damage to his lungs. During that time he begged in the streets while he awaited his share of the legal compensation from Union Carbide. (The Indian government asked Carbide for $3 billion in compensation.) When asked what he would do if offered work again in the plant knowing what he knew now, he replied: "If it opened again tomorrow I'd be happy to take any job they offered me. I wouldn't hesitate for a minute. I want to work in a factory, any factory. Before 'the gas' [disaster] the Union Carbide plant was the best place in all Bhopal to work" (Bordewich, 1987).

3 During 1972 and 1973 the President of Lockheed, A. Carl Kotchian, authorized secret payments totaling around $12 million beyond a contract to representatives of Japan's Prime Minister Tanaka. Later revelations of the bribes helped lead to the resignation of Tanaka and also to new laws in this country forbidding such payments. Mr. Kotchian believed at that time it was the only way to assure sales of Lockheed's TriStar airplanes in a much needed market.

In explaining his actions, Mr. Kotchian cited the following facts (Kotchian, 1977, 67–75): (1) There was no doubt in his mind that the only way to make the sales was to make the payments. (2) No U.S. law at the time forbade the payments. (3) The payments were financially worthwhile, for they totalled only 3 percent of an expected $430 million income for Lockheed. (4) The sales would prevent Lockheed layoffs, provide new jobs, and thereby benefit workers' families and their communities as well as the stockholders. (5) He himself did not personally initiate any of the payments, which were all requested by Japanese negotiators. (6) In order to give the TriStar a chance to prove itself in Japan, he felt he had to "follow the functioning system" of Japan. That is, he viewed the secret payments as the accepted practice in Japan's government circles for this type of sale.

a Drawing on the distinctions made in this section, explain the several senses in which someone might claim that how Mr. Kotchian ought to have acted is a "relative" matter. Which of these senses, in your view, would yield true claims and which false?

b Develop the strongest moral argument you can think of in favor of Mr. Kotchian's actions, then the strongest argument you can against his actions. Draw upon the ethical theories presented in the previous section: either act-utilitarianism, rule-utilitarianism, Kant's duty-ethics, or Locke's rights-ethics. Then indicate which argument you find most compelling and why you disagree with the opposing view.

4 In 1977 the Foreign Corrupt Practices Act was signed into law. It makes it a crime for American corporations to accept payments from or to offer payments to foreign governments for the purpose of obtaining or retaining business, although it does not forbid "grease" payments to low-level employees of foreign governments (such as clerks), which are part of routine business dealings. Critics are urging repeal of the act because there is no question that it has adversely affected American corporations trying to compete with countries that do not forbid paying business extortion. Is damage to profits a sufficient justification for repealing the act?

5 Some U.S. companies have refused to promote women to positions of high authority in their international operations in Asia, the Middle East, and South America. Their rationale is that business will be hurt because some foreign customers do not wish to deal with women. It might be contended that this practice is justified out of respect for the customs of countries which discourage women from entering business and the professions.

Circuit Judge Warren J. Ferguson argued, however, that such practices are wrong. He ruled that sex stereotypes are not to be used in formulating job qualifications, and that customer preferences do not justify sex discrimination. He added that while our legal system cannot be used to force other countries to stop sex discrimination, other countries cannot dictate sex discrimination for citizens of our country (Mayer, 1981, 2).

Present and defend your view as to whether Judge Ferguson's ruling is morally justified.

ENVIRONMENTAL ETHICS

As human beings we share a common environment, a common ecosphere. Concern for that environment must increasingly become an urgent and united commitment that cuts across national boundaries. It is thus appropriate that thinkers from many disciplines have begun to explore a new branch of applied ethics called *environmental* or *ecological ethics*. This field overlaps with engineering ethics at many points, only a few of which can be mentioned here.*

Many observers warn us that we are misusing our scarce resources, fouling our environment, and in general practicing growth in consumption and population which will eventually make "spaceship earth" too small for us. Others think the situation may not be so bleak. Nature itself, they point out, is continually changing the face of the earth and human activity creates at best a small perturbation. But it is generally agreed that industrial activity does affect the biosphere: It denudes the land, pollutes the waters and the atmosphere, and threatens fragile species. But how damaging such effects are in the long run, or to what extent we can develop countermeasures in time, is difficult to assess. As Herman Kahn, William Brown, and Leon Martel point out:

> It may yet turn out that future man will marvel at the paradoxical combination of hubris and modesty of 20th century man, who, at the same time, so exaggerated his ability to do damage and so underestimated his own ability to adapt to or solve such problems. Or it could be that future man, if he exists, will wonder at the recklessness and callousness of 20th century scientists and governments (Kahn, Brown, and Martel, 1970, 180).

While we do not share the pessimists' views of inevitable doom, we also do not subscribe to the optimists' views that new technologies will invariably spring up to deliver us from the traps set by the older technologies. We do recognize that we cannot turn back the clock, that we have to live with some unalterable changes and have already learned to do so. Nevertheless, we observe that technology and its practitioners have engaged us in an ongoing global experiment that needs to be monitored and guided lest we permit it to cause many unacceptable changes of an irrevocable nature.

Engineers need to be aware of their role as agents of change, as experimenters. There are questions every engineer should ask, whether at the time of choosing a career or when entering a new sphere of activity. To what extent does a particular industry affect the environment? To what extent can those effects be controlled physically or regulated politically? Have all reasonable abatement measures been implemented? Can I be effective as an engineer in helping to assure a decent environment for the generations that will follow? What are my responsibilities in all this?

We begin by sampling a few kinds of the myriad environmental issues of concern to engineers. The first two examples have to do with releasing harmful substances into air and water, the third with using toxic substances in

*The following books provide useful starting points for studying environmental ethics: *Environmental Ethics for Engineers*, edited by Alastair S. Gunn and P. Aarne Vesilind; *Earthbound*, edited by Tom Regan; *Ethics and the Environment*, edited by Donald Scherer and Thomas Attig; *Respect for Nature*, by Paul W. Taylor; and *People, Penguins, and Plastic Trees: Basic Issues in Environmental Ethics*, edited by Donald VanDeVeer and Christine Pierce.

food processing, and the last two with disrupting land and water balances. Following these illustrative cases we will touch upon some foundational issues in environmental ethics and some economic and political means of controlling harm to the environment.

Acid Rain

The disaster at Bhopal occurred with numbing terror during a few hours and days. Other disasters, such as the Chernobyl nuclear plant explosion, have involved longer-term environmental effects, but the patterns of damage are still relatively clear. Some ecological tragedies, however, are far more subtle in their impact. Few may turn out to be comparable to the devastation currently being caused by acid rain and acid deposition.

Normal rain has a pH of 5.6, but the typical rain in the northeastern areas of North America is now 3.9 to 4.3. This is 10 to 100 times more acidic than it should be—about as acidic as lemon juice. In addition, the snowmelt each spring releases huge amounts of acid which were in frozen storage during the winter months. Soil which contains natural buffering agents counteracts the acids. But large parts of the northeastern United States and eastern Canada lack natural buffers.

The results? "Acid shock" from snowmelt is thought to cause annual mass killings of fish. Longer-term effects of the acid harm fish eggs and food sources. Deadly quantities of aluminum, zinc, and many other metals leached from the soil by the acid rain also take a toll as they wash into streams and lakes. In the higher elevations of the Adirondack Mountains over half the lakes that were once pristine can no longer support fish. Hundreds of other lakes are dying in the United States and Canada. Forests have also been steadily killed, larger animals have suffered dramatic decreases in population, and some farmlands and drinking-water sources are damaged.

These results have occurred during only a few decades. The next decades will multiply them many times over. It is believed that North America is just slightly behind Scandinavia, where thousands of lakes have been "killed" by acid rain. In both locations the cause is now clear: the burning of fossil fuels which release large amounts of sulfur dioxide (SO_2)—the primary culprit—and nitrogen oxides (NO_X). In both instances major sources of the pollutants are located hundreds and even thousands of miles away, with winds supplying a deadly transportation system to the damaged ecosystems. Much of Sweden's problem, for example, is traceable to the industrial plants of England and northern Europe. Acid rain problems in Canada and the northeastern United States derive in large measure from the utilities of the Ohio Valley, the largest source of sulfur dioxide pollution in this country.

Much remains to be learned about the mechanisms involved in the processes pictured in Figure 7.2. It is still impossible to link specific sources with

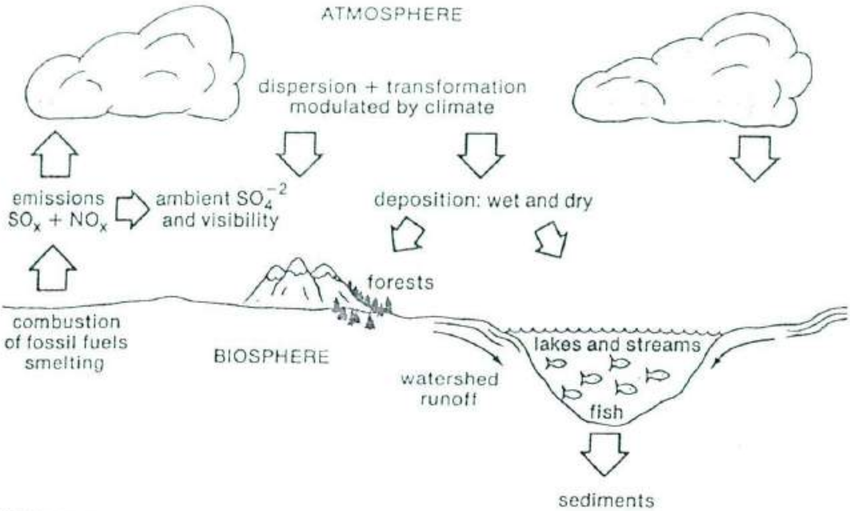


FIGURE 7-2
Acid deposition: diagram of sources and affected ecosystems. (*National Research Council, 1986, p. 11.*)

specific damage. More research into shifting wind patterns and the air transport of acids is needed. Nor is there a reliable estimate of current damage. For example, many believe that microorganisms in soil are being affected in ways that are potentially devastating, but no one knows for sure. Groundwater is undoubtedly being polluted, but it is unclear what that means for human health. Much underground water currently being used was deposited by rainfall over a hundred years ago, and current acid rain may have its main effects on underground water a century from now. Effects on human food sources are also largely unknown (Adams, 1985; National Research Council, 1986; Schmandt, 1985).

Other examples can be given of amorphous patterns of ecological damage, like those of acid rain. Worldwide use of fossil fuels by industrial nations is causing a buildup of carbon dioxide in the atmosphere which could result in a greenhouse effect damaging the entire earth. Similarly, damage to the protective ozone layer of the earth's atmosphere resulting from the release of freon is related to technological products used by the populations of those same nations. And rivers amass pollutants as they wind their way through several states or countries, eventually to dump their toxic contents into an ocean. The Rhine is such a river, and the North Sea, now a "special protection area," is such an ocean.

If all environmental damage were on such a massive scale, the work of engineers would be a continual nightmare. Fortunately, most environmental impacts remain relatively local, as we shall now illustrate.

PCBs and Kanemi's Rice-Oil—Japan, 1968 A decade of rapid industrial growth in Japan had taken its toll of the environment. City dwellers fell ill from air pollution. Some rivers were covered with dead fish floating on the surface. The dreadful Minamata disease, traceable to mercury pollution of a nearby bay by the Chisso Company and a food chain involving shellfish taken from that bay, was continuing to fell its victims (there would be 46 deaths and 75 disabilities by 1970). In May the itai-itai ("ouch-ouch") disease, which is painful and causes bone crumbling, was the first illness to be designated as pollution-generated by the Japanese government. Observed on and off since 1920 at various sites, the latest outbreak was placed at the doors of a Mitsui Mining and Smelting facility which let cadmium escape into a river, whence the pollutant found its way into the food chain via rice paddies and rice. The thalidomide drug tragedy was still on everyone's mind. The severely malformed children of women who had taken that drug during their pregnancies were still not cared for by either the Dainippon Pharmaceutical Company or the government, and schools refused to accept them (Ui, 1972; Iijima, 1979).

Then, in the summer of 1968, a disease of unknown origin made its appearance in southern Japan. Victims suffered from disfiguring skin acne and discoloration, from fatigue, numbness, respiratory distress, vomiting, and loss of hair. Eventually 10,000 people were stricken and some died. What was the cause? An investigation of 121 cases was conducted, with 121 healthy individuals matched to the victims by age and sex being used as a control group. All 242 were questioned regarding their diets, personal habits, and places of work. When it was discovered that the only significant difference between the two groups was in the amount of fried foods eaten, the disease was traced to rice oil produced by the Kanemi Company (Grundy, Weisbrod, and Epstein, 1974, 111).

It took another 7 months to find the specific agent in the oil. Autopsies performed on victims revealed the presence of PCBs, polychlorinated byphenyls (Iijima, 1979, 268). Oil made from rice bran at the Kanemi plant was heated at low pressure to remove objectionable odors. The heating pipes were filled with hot Kanechlor, a PCB containing fluid, but the pipes were corroding and tiny pinholes in them allowed PCBs to leak directly into the oil. In fact, Kanemi had been in the habit of replenishing about 27 kg of lost PCBs a month for some time.

There are other, less direct paths by which the extremely toxic PCBs can reach humans. For example, the Kanemi rice oil had also been used as an additive to chicken feed. In early 1968, 1 million chickens were given this feed and every second chicken died. In the United States 140,000 chickens were slaughtered in the state of New York on one occasion when data collected by the Campbell's Soup Company revealed more than the permitted level of PCBs in chickens raised by certain growers. The source of PCBs was found to be plastic bakery wrappers mixed in with ground-up stale bread from bakeries used as feed. On another occasion PCBs leaked from a heating system into fishmeal in a North Carolina pasteurization plant. About 12,000 tons of fishmeal were contaminated and 88,000 chickens, already fed this fishmeal, had to be destroyed when the product was recalled (Grundy, Weisbrod, and Epstein, 1974, 112).

PCBs were not used only in heat exchangers. They are a good hydraulic fluid and an excellent dielectric. They also decompose very slowly. These properties made them a good choice for insulating oil in capacitors and transformers. But they are no longer considered suitable for such applications—or any other where they can find their way into the environment. Their hardiness accounts for the fact that they are found in the oceans in larger quantities than DDT, although they enter the oceans initially in much lesser amounts (Murdoch, 1979, 286–287). Even a total shutdown of all possible sources of PCB contamination—responsible for about 28,000 tons of PCBs escaping into air, land, and water every year—would not result in an immediate decrease in its presence. Meanwhile, even the present burden of PCBs on the environment is not fully understood (Grundy, Weisbrod, and Epstein, 1974, 112–113).

Asbestos in the Air; Asbestos in Drinking Water? Although the use of PCBs in food and feed-processing plants might not have been a problem in the above instances if the heat transfer systems employing the toxic oil had been secure and closed, one should never be as optimistic as to expect a leakproof piping system; and when foodstuffs are involved, one should not even contemplate a substantial use of toxic materials for any reason. There are other processes, however, where even an approximation to a closed system could have great benefits. One such example is ore processing as practiced by the Reserve Mining Company, a subsidiary of Armco and Republic steel companies, when it first started its huge taconite (iron ore) plant at Silver Bay, Minnesota in 1955 (Bartlett, 1980; Lawless, 1977, 297–307).

Reserve was invited to open operations by the state of Minnesota; it employed over 3000 workers; and it was also making a contribution to the nation by utilizing abundant but low-grade ore to produce much needed iron and steel. Taconite contains only 25 to 30 percent iron oxide. It is crushed and washed in steps to form a powder from which the iron is extracted by electromagnets. Everything at Reserve was on a large scale—size, cost ($350 million), power consumption, and water usage. Rather than utilizing settling basins and recycling the used water as is done in smaller plants, fresh water was drawn from Lake Superior and wastewater was discharged into it at the rate of half a million gallons per minute. Despite assurances from the University of Minnesota's experiment station that the fine taconite powder would settle out, it did not. The lake became discolored by the discharge of about 67,000 tons of taconite tailings a day, and fishers complained about the disappearance of fish.

The company was not doing anything very different from what industry had always been doing. In Sweden, paper mills were polluting the Baltic Sea, in the Soviet Union unique Lake Baikal was being similarly disfigured. But the managers of Reserve had not counted on the fact that times—and public attitudes—had changed. In the 1960s concerns about the environment were gradually being taken more seriously. The federal government and eventually the state of Minnesota took the company to court since it would not voluntarily change its practices and retrofit its extraction process to a closed system with no discharge of wastes into the lake. Private citizens had become active and were influential in causing the government agencies to act.

The court proceedings, including appeals, were lengthy (14 years) and replete with contradictory testimony from experts representing the opposing sides. It was not until asbestoslike fibers were found to be entering the air and the lake from the Reserve operations that a more definite link to a real hazard could be established. However, the amounts entering the drinking-water supplies of cities ringing Lake Superior, and the levels considered to be harmful, could not be established with any degree of precision. Accordingly, Reserve's taconite beneficiation plant was not closed down but ordered to switch over to a land disposal site as soon as possible.

Land Subsidence

> Roads began cracking like china. Railroad tracks buckled. Sewer lines burst. Oil drillers saw their pipes twist and bend like spaghetti. Pacific tides washed over harbor bulkheads.... (Marx, 1977, 140)

An earthquake? Not quite. Just a gradual but steady land subsidence, inadvertently caused by human beings, played back at rapid speed. Wesley Marx continues as follows in his book *Acts of God, Acts of Man* with a description of the geologic subversion of Long Beach during 1941 to 1945:

> The Long Beach naval shipyard wondered if it could stay intact long enough to help end World War II. Some areas sank as much as twenty-nine feet, or enough to reach the groundwater table.... Gravity no longer provided drainage free of charge.... When would the sinking stop? Some industrialists didn't care to find out. They were prepared to climb out of their inverted landscape and never return (Marx, 1977, 140).

When it was discovered that extensive pumping of oil fields in the vicinity was draining the underground reservoirs and reducing underground pressure, water was reinjected into those reservoirs and the lowering of the land surface was greatly reduced. Water pumping can cause similar subsidence, as many cities and areas have experienced, from Tokyo, Osaka, and Nagoya in Japan to the 3000-square-mile area between Houston and Galveston, Texas. Houses will then lean and lowered land will experience severe flooding during typhoons and hurricanes.

Water is injected underground not only to prevent subsidence, but also to force oil out of aging wells. In 1963, such high-pressure injection in oil fields near Baldwin Dam in Los Angeles caused the bottom of the reservoir to crack open along an old fault line. The crack reached all the way to the foundation of the dam. The 12-year-old dam had been designed to withstand earthquakes but not such surprises. The released waters killed five people and did $14 million worth of damage to property (Marx, 1977, 141; Sowers and Sowers, 1970, 535).

The examples of land subsidence illustrate how human activity can change our environment in many different ways. Some effects may be local and reparable, but loss of life and property can result when hidden changes lead to unexpected events.

Too Little Water for the Everglades The great marshes of southern Florida have attracted farmers and real estate developers since the beginning of the century. When drained, they present valuable ground. From 1909 to 1912 a fraudulent land development scheme was attempted in collusion with the then U.S. Secretary of Agriculture. Arthur Morgan blew the whistle on that situation, jeopardizing not only his own position as a supervising drainage engineer with the U.S. Department of Agriculture, but also that of the head of the Office of Drainage Investigation. An attempt to drain the Everglades was made again by a Florida governor from 1926 to 1929. Once more Arthur Morgan, this time in private practice, stepped in to reveal the inadequacy of the plans and thus discourage bond sales.

But schemes affecting the Everglades were not over yet. Beginning in 1949, the U.S. Army Corps of Engineers started diverting excess water from the giant Lake Okeechobee to the Gulf of Mexico to reduce the danger of flooding to nearby sugar plantations. As a result the Everglades, lacking water during the dry season, were drying up. A priceless wildlife refuge was falling prey to humanity's appetite. In addition, the diversion of waters to the Gulf and the ocean also affected human habitations in southern Florida. Cities which once thought they had unlimited supplies of fresh groundwater found they were pumping salt water instead as ocean waters seeped in (Morgan, 1971, 370–389).

Southern Florida represents a complex environmental unit with a delicate balance. Any intrusion by human engineering must be seen as an experiment which must be conducted with great care. Unfortunately too many public agencies view any change in plans as unacceptable once a course has been charted. As Arthur Morgan points out in his book *Dams and Other Disasters*, the Corps was particularly prone to such an attitude, which was fostered by the crisis-oriented training at West Point Military Academy (Morgan, 1971, 37).

Why should the Everglades be preserved? We leave this as a study question for later. But first let us set a wider context by considering some views of our place in nature.

Living Things and Views of Nature

A fundamental issue in environmental ethics is whether morality is exclusively *anthropocentric*, that is, human-centered. Western religions have generally regarded nature as an unrestricted gift to be ruled and exploited. Likewise, traditional secular worldviews have drawn a sharp line between the human and nonhuman world, making the latter mere means to satisfying human ends.

Increasingly, human-centered views of nature have shifted away from an exploitative to a conservationist attitude. Recognition of the limits of natural resources has inspired awareness of the need to conserve for the sake of both present and future generations of human beings. But the assumption remains that only human beings have intrinsic moral worth, possess rights, and are owed duties of respect. Conservation is justified in terms of human needs for a livable environment. Or it is justified by appeal to the human right to life, which implies a right to have a livable environment (Blackstone, 1974).

Nonanthropocentric or nature-centered views of nature, by contrast, begin with the premise that humans are only part of nature and that human worth must be understood from a holistic ecological perspective. One such approach views the natural environment as having intrinsic value—value in and of itself, quite apart from any value humans place on it. According to this view, there is a direct moral imperative to *preserve*, not just conserve, the environment. This approach was voiced by the naturalists Aldo Leopold (1887–1948) and John Muir (1838–1914, founder of the Sierra Club).

Aldo Leopold's "land ethic" was founded on the principle that acts are good insofar as they preserve the integrity, stability, and beauty of the community of natural things. John Muir's naturalism took a mystic direction in ascribing elements of the divine to nature.

> Watch the sunbeams over the forest awakening the flowers, feeding them every one, warming, reviving the myriads of the air, setting countless wings in motion—making diamonds of dewdrops, lakes, painting the spray of falls in rainbow colors. Enjoy the great night like a day, hinting the eternal and imperishable in nature amid the transient and material (Muir, 1980, 113).

Muir would have felt at home in Japan, where an inspiring, lively waterfall or a quiet rock may be accorded the respect due a deity.

A different approach to a nature-centered ethics focuses on sentient animals, rather than all of nature. Sentient animals are those which feel pain and pleasure and have desires. Utilitarians have often extended their theory (that right action maximizes goodness for all affected) to sentient animals as well as humans. Most notably, Peter Singer developed a utilitarian perspective in his influential book, *Animal Liberation*. (Somewhat ironically this book has been called the bible of the animal rights movement: Singer does not ascribe rights to animals, although other philosophers have [Regan, 1983].)

Singer insists that moral judgments must take into account the effects of our actions on sentient animals. Failure to do so is a form of discrimination akin to racism and sexism—what he labels "speciesism." Thus, in building a dam that will cause flooding to grasslands, engineers should take into account the impact on animals living there. Singer allows that sometimes animals' interests have to give way to human interests, but their interests should always be considered and weighed.

There is a gulf between the human-centered and nature-centered perspectives, but its extent should not be exaggerated. Most agree that human interests have some priority over those of animals and plants. Most agree that nature should not be denuded but instead left in a recoverable state as a safe exit and for the benefit of later generations to enjoy. Moreover, even if animal interests are not counted anywhere near on a par with human interests, it remains abhorrent to inflict needless suffering on animals who share our capacity for pain.

The point of all this is that not everything of importance fits neatly into cost-benefit analyses with limited time horizons; much must be accounted for by means of constraints or limits which cannot necessarily be assigned dollar signs.

The Commons and a Livable Environment

Aristotle once remarked that what is common to the most people gets the least amount of care. Common sense confirms the frequent tendency of people to be thoughtless about things they do not own and which seem to be in unlimited supply. William Foster Lloyd was an astute observer of this phenomenon. In 1833 he described what the ecologist Garrett Hardin would later call "the tragedy of the commons" (Hardin, 1968, 254).

Lloyd observed that cattle in the common pasture of a village were punier and more stunted than those kept on private land. The common fields were themselves more bare-worn than private pastures. His explanation began with the premise that each farmer is understandably motivated by self-interest to enlarge his or her herd by one or two cows, claiming that the overall effect is minuscule. Yet the combined effects of all the farmers behaving this way is overgrazing of the pasture, even though it is true that each act taken by itself does negligible damage.

In this century, increasing population and decreasing natural resources have prompted similar thinking about ourselves in relation to nature. The same kind of competitive, unmalicious, but unthinking exploitation arises with respect to all natural resources held in common: air, land, forests, lakes, and oceans. Indeed, increasingly we must regard the entire biosphere as our "commons."

Few today would endorse past arguments by land developers, road builders, forest harvesters, and manufacturers that they should be left completely unhindered because the damage they do to the environment is minuscule. Economic rights have limits when the public good has been put at risk by cumulative small effects. Some have even argued that fundamental democratic rights can be invoked to justify controls on environmental harms. The basic right to life entails a right to a livable environment at a time when pollution and resource depletion has reached alarming proportions (Blackstone, 1974).

In addition to voluntary conservation efforts, there is a need for a shared effort to exercise democratic and international controls responsibly. Such controls involve some coercion. Only the naive would think that the short-term, profit-seeking orientation of most corporations could otherwise be sufficiently influenced by environmental appeals. Indeed, within limits businesses are eager for controls which require all competitors to be guided by similar restrictions that maintain fairness in competition.

Democratic controls can take many forms. They include passing laws, internalizing costs, and relying on technology assessment in approving projects.

Guilty until Proven Innocent?

The examples just given cover barely a fraction of the many environmental issues which might arise in engineering practice. But they suffice to raise some key questions of ethical import: *Who* is affecting *whom*—and *where, when*, and *how?*

In the mercury, cadmium, and PCB pollution cases in Japan the question was: Who is releasing toxic substances? In all instances the polluting companies refused to acknowledge their mistakes and rejected claims by the victims. The government did not intercede on behalf of those affected. It took long and costly court battles to win partial victories. Without volunteer activists little progress would have been made. Is this the way it ought to be?

The victims of pollution in Japan were easily identified, the offenders less so. In the Reserve Mining Company episode, the reverse occurred. The taconite facility was an obvious polluter in some respects even though its more harmful emissions could not be detected with the naked eye and were not introduced as evidence until later in the trial. But there were no identifiable victims because the ill effects of asbestos take time to develop. And it would also be difficult to determine where around Lake Superior the contamination would be most serious in the long run.

These difficulties are multiplied many times in the case of acid rain. How can control of Ohio utilities be instituted when it is still impossible to link them to specific harms in New York and Canada? If it is believed that massive controls should be imposed now in order to prevent unmanageable disasters ahead, who should pay the costs, which by all estimates will be in the billions each year? Is it fair to pass laws that burden already heavily regulated utilities, or should the costs of installing more effective scrubbers be borne by us all?

Any search for answers as to how the responsibility for environmental degradation should be shared will invariably lead us to further questions about how polluters and pollutants should be controlled. The first recourse recommended in all these matters is usually the judicial system. Let the courts decide who is guilty and how they are to be stopped! We have already described some of the shortcomings of this approach in Chap. 3. To reiterate: The courts move slowly, few individuals (whether plaintiff or defendant) can afford the process, and overreliance on the law promotes minimal compliance. In environmental cases the difficulties are compounded. A judge cannot be expected to be a specialist on health, safety, and the environment, nor can he or she usurp the powers of the legislature and prescribe control mechanisms. The most a judge can do is to guarantee a fair legal process.

Assuring a fair legal process is in itself a major undertaking. Technical information supportive of either the plaintiff or the defendant must be provided by expert testimony. Invariably both sides in a dispute will succeed in marshaling expert witnesses whose testimony will be contradictory. This should not surprise us because in spite of a professed adherence to rationality and commitment to truth, the engineer or scientist testifying will rely on a personal value system in selecting and presenting his or her information, mistrusting other interpretations. Earlier we had occasion to stress the importance of stating one's biases when serving as a legal witness or consultant. In an adversary hearing, admissions of bias and—perhaps more significantly—admissions of uncertainty can be exploited by the opposing side to such an extent that many specialists have become hesitant about giving evidence, to the detriment of all concerned. Rachel Carson, the embattled author of *Silent Spring*, described the consequences of this problem in a letter to a friend:

> I'm convinced there is a psychological angle in all this that people, especially professional men, are uncomfortable about coming out against something, especially if they haven't absolute proof that "something" is wrong, but only a good suspicion. So they will go along with a program about which they privately have acute misgivings (quoted in Graham, 1970, 23).

Those experts who agree to testify open themselves to a barrage of hostile questions which can become personal in nature. Considerable embarrassment can occur if the truth is stretched or hidden. In the Reserve Mining Company trials some of the witnesses did not fare well. One expert who had served as a consultant to the plaintiffs later testified for the defendant, whom he could furnish with inside information. One expert claimed to have a Ph.D. degree from Purdue when in fact he did not. One consultant to Reserve was removed from a National Academy of Sciences committee studying the effects of asbestos in drinking water when it was disclosed he had agreed to provide Reserve with information on the confidential deliberations of the committee. There were conflicts of interest linking individual employees and offices of the State of Minnesota, the University of Minnesota, and Reserve, as well as the judges hearing the case. How believable can expert testimony be under such circumstances?

With so many uncertainties, one approach would be not to release a new product or process until it is shown to be risk-free. Industry and its engineers might claim that this is tantamount to declaring something to be guilty merely because innocence cannot be established. Is this not against our legal principles? Why does the U.S. Department of Agriculture declare poultry with 5 parts per million (ppm) or more of PCBs to be unfit for human consumption? The 5-ppm limit would be difficult to justify, just as a higher limit would be dangerous to defend, on strictly scientific grounds (Grundy, Weisbrod, and Epstein, 1974, 112). Where should the burden of proof lie? It is estimated that victims of Kanemi rice-oil disease had taken in at least 500 mg of PCBs. Translated into pounds of chicken contaminated with 5 ppm of PCBs, this would amount to 220 pounds of chicken or over 4 pounds of chicken consumed per week for a year. If this seems like a lot of chicken to eat, how much less would suffice to poison people with PCBs? In addressing the problem of where the burden of proof should lie, Garrett Hardin states:

> In criminal law, as practiced in Britain and America, a man is "innocent until proven guilty...." Scientists, however, see things otherwise. Science is an occupation in which most experiments fail.... Confronted with any new, untried, nostrum, a scientist, if called upon to place a bet, will bet that it won't work. Such is the conservative judgment (Hardin, 1968, 58–59).

Engineers have more confidence in their projects and will therefore chafe at such an interpretation. But they would have to be omniscient if they could foresee all the environmental effects of their work. And they would have to think themselves omnipotent if they hoped to control those consequences without redesigns or retrofits. Accordingly, they must adopt the viewpoint of engineering as experimentation. The guilty-until-proven-innocent approach will then appear less unreasonable. Indeed it is not threatening since it applies to things and not to persons. If the expected benefit of a project or product is so great that prolonged testing seems an unreasonable cost, a preliminary release could be authorized—provided that "safe exits" existed and funds were available for subsequent corrective action, should it become necessary.

Internalizing Costs of Environmental Degradation

When we are told how efficient and cheap many of our products and processes are—from agriculture to the manufacture of plastics—the figures usually include only the direct costs of labor, raw materials, and use of facilities.

If we are quoted a dollar figure, it is at best an approximation of the price. The true cost would have to include numerous indirect factors such as the effects of pollution, the depletion of energy and raw materials, and social costs. If these, or an approximation of them, were internalized—that is, added to the price—then those for whose benefit the environmental degradation had occurred could be charged directly for corrective actions. The problem with the "technofix" approach—using technology to repair the damages of technology—is not so much with physical realization as it is with the financial burden. As taxpayers are beginning to revolt against higher levies, the method of having the user of a service or product pay for all its costs is gaining more favor. The engineer must join with the economist, the natural and physical scientists, the lawyer, and the politician in an effort to find acceptable mechanisms for pricing and releasing products so that the environment is protected through truly self-correcting procedures rather than adequate-appearing yet often circumventable laws. But again, as we did in our discussion on designing for safety in Chap. 4, we wish to point out here that good design practices may in themselves provide the answers for environmental protection without added real cost. For example, consider the case of a lathe which was redesigned to be vibration-free and manufactured to close tolerances. It not only met occupational safety and health standards with regard to noise, which its predecessor had not, but it also was more reliable, more efficient, and had a longer useful life, thus offsetting the additional costs of manufacturing it (Melman, 1982, 176).

Technology Assessment

The Congress of the United States of America has an Office of Technology Assessment. It prepares studies on the social and environmental effects of technology in areas such as cashless trading (via bank card), nuclear war, or pollution. At the federal and state levels, many large projects must be examined in terms of their environmental impact before they are approved. The purpose of all this activity is praiseworthy. But how effective can it be?

Engineers, it is often said, tend to find the right answers to the wrong questions. The economist Robert Theobald made the following comment on education:

> The university is ideally designed to insure that you remain certain that you know the answers to questions that other people posed long ago. The problem today is that the questions we should be answering are not yet known. Unfortunately the process required for discovering the right questions is totally different from the process of discovering the right answers (quoted in Thrall and Starr, 1972, 17).

It should be quite apparent that it is not easy to know what questions to ask. And technology assessment and other forecasting methods suffer because of this.

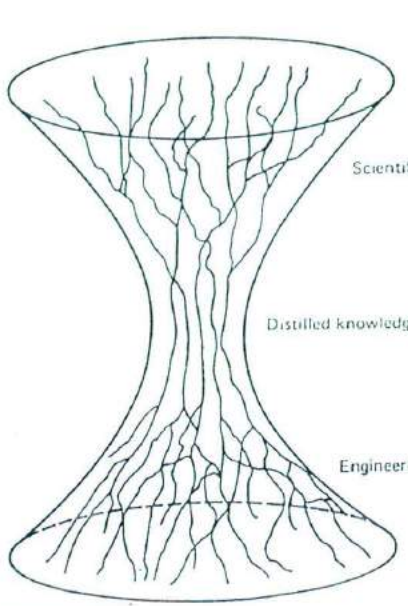


FIGURE 7-3
Distilling and applying knowledge.

When scientists conduct experiments, they endeavor to distill some key concepts out of their myriad observations. As shown in Fig. 7-3, a funnel can be used to portray this activity. At the narrow end of the funnel we have the current wisdom, the state of the art. Engineers make use of it to design and build their projects. These develop in many possible directions, as shown by the shape of the lower, inverted funnel. The difficult task of technology assessment and environmental impact analyses is to explore the extent of this spread and to separate the more significant among the possibly adverse effects.

The danger in any assessment of technology is that some serious risks can easily be overlooked while the studies and subsequent reports, properly authenticated by the aura of scientific methodology, assure the decision maker that nothing is amiss—or perhaps that perceived risks are more serious than they really are. We do not wish to belittle such efforts and we think that they are worthwhile, if only because of those questions they raise—and answers they uncover—that otherwise might not have surfaced. But there is a danger in believing that no further action is required once the reports have been approved and filed. Our contention remains that engineering must be understood as social experimentation and that the experiment continues, indeed enters a new phase, when the engineering project is implemented. Only by careful monitoring will it be possible to gather a more complete picture of the tangled web of effects encompassed in Fig. 7-3 within the inverted, lower funnel.

Study Questions

1 Describe how products or processes in an engineering field of interest to you can damage the environment, including human beings. Then examine pertinent laws designed to protect the environment at the local, state, and national levels and determine their effectiveness. Discuss alternatives to the regulatory approach.

2 Write an essay on the topic "Why Save Endangered Species?" or "Why Save the Everglades?" You may wish to discuss some of the following points: Is it reasonable to put much effort into saving endangered species from extinction? What, if any, moral theories apply to plant and animal life and our relation thereto? Are we duty bound to preserve all forms of natural life, or does such life enjoy an intrinsic right to exist? (Compare with Rescher, 1980, essay 7; and with Regan, 1984).

3 Are there any moral reasons why landowners may on occasion be constrained from doing to their properties what they please?

4 Phosphate detergents were alternately promoted and banned between 1947 and 1971. This caused great confusion in some communities (Lawless, 1977, 450). Critically examine the use of phosphate detergents as an experiment involving the environment.

5 Environmentalists are often accused of being elitists who wish to preserve the environment for their own enjoyment without regard for the needs of others. Granted that environmental controls may be necessary to preserve our habitat in the long run, do rich people (or nations) have the right to impose such controls now when they will harm poor people (or nations) more in the short run than they harm the rich?

6 Consider the following example of environmental side effects cited by Garrett Hardin:

> The Zambesi River...was dammed...to create the 1700-square-mile Lake Kariba. The effect *desired:* electricity. The "side-effects" *produced:* (1) destructive flooding of rich alluvial agricultural land above the dam; (2) uprooting of long-settled farmers from this land to be resettled on poorer hilly land that required farming practices with which they were not familiar; (3) impoverishment of these farmers...[and various other social disorders]; (6) creation of a new biotic zone along the lake shore that favored the multiplication of tsetse flies (Hardin, 1968, 68).

Similar problems have occurred when dams were built in the United States and when the Aswan Dam was erected on the Nile. One might ask if the original purpose may not itself begin to look like merely a side effect. If so, Hardin asks, can we *never* do anything? Describe under what conditions you think a dam such as the one on the Zambesi River should be built and operated. To whom is the engineer in charge of its construction ultimately responsible?

7 On January 15, 1919, a large wooden tank, 58 feet high and over 90 feet in diameter and holding over 2.5 million gallons of molasses, suddenly burst open. The immediate vicinity around this tank, which stood in the north end of Boston, was quickly

covered by a stream of molasses which reached up to the second floor of many buildings. Numerous people were trapped by the sticky fluid and drawn down into it. What simple measure could have prevented the fluid from spreading and creating such an unusual "molasses environment"? Even today there are tanks holding vast quantities of water, oil, or liquefied natural gas where no adequate measures have been taken to protect the public from the dangers they present.

COMPUTER ETHICS

Computers have become the technological backbone of our society. Their degree of sophistication, range of applications, and sheer numbers continue to increase. Through networks they span the globe. Yet electronic computers are still only a few decades old, and it is difficult to foresee all the moral problems which will eventually surround them.

The present state of computers is sometimes compared to that of the automobile in the early part of this century. At that time the impact of cars on work and leisure patterns, pollution, energy consumption, and sexual mores was largely unimagined. If anything, it is more difficult to envisage the eventual impact of computers since they are not limited to any one primary area of use comparable to a car's function in transportation.

It is already clear, however, that computers will cause or contribute to a variety of moral problems. To deal with these problems a new area of applied ethics called *computer ethics* is developing (Johnson, 1985; Johnson and Snapper, 1985). Computer ethics has special importance for the new groups of professionals emerging with computer technology—for example, designers of computers, programmers, systems analysts, and operators. To the extent that engineers design, manufacture, and apply computers, computer ethics is a branch of engineering ethics. But the many professionals who use and control computers share the responsibility for their applications.

Some of the issues in computer ethics concern shifts in power relationships resulting from the new capacities of computers. Others concern abuse of existing installations, as when computers are used in criminal activities and invasions of privacy. Still others relate to assessments of the desirable directions of new computer applications. As we shall see, the issues are sometimes similar to ones we have discussed earlier, but here the computer connection gives them a special flavor.

Power Relationships

Computers dramatically increase the ability of centralized bureaucracies to manage enormous quantities of data, involving multiple variables, and at astonishing speed. During the 1960s and 1970s social critics became alarmed at the prospect that computers would concentrate power in a few centralized bureaucracies of big government and big business, thereby eroding democratic systems by moving toward totalitarianism.

These fears were not unwarranted, but they have lessened due to recent developments in computer technology. In the early stages of computer development there were two good reasons for believing that computers would inevitably tend to centralize power (Simon, 1979). Early large computers were many times cheaper to use when dealing with large tasks than were the many smaller computers it would have taken to perform similar tasks. Thus it seemed that economics would favor a few large and centrally located computers, suggesting concentration of power in a few hands. Moreover, the large early computer systems could only be used by people geographically close to them, again implying that relatively few people would have access to them.

The invention, development, and proliferation of microcomputers changed all this. Small computers became increasingly powerful and economically competitive with larger models. Furthermore, remote access and time sharing allowed computer users in distant locations to share the resources of large computer systems. These changes opened new possibilities for decentralized computer power.

For example, it was once feared that computers would give the federal government far greater power to control nationally funded systems, such as the welfare and medical systems, lessening control by local and state governments. But in fact data systems have turned out to be two-way, allowing both small governments and individuals to have much greater access to information resources amassed at the federal level.

Computers are powerful tools which do not by themselves generate power shifts. They contribute to greater centralization or decentralization insofar as human decision makers so direct them.

This is not to say that computers are entirely value-neutral. For in addition to their hardware there is software—and programs can quite easily be biased, just as can any form of communication or way of doing things. For example, a computerized study of the feasibility of constructing a nuclear power plant can easily become biased in one direction or another if the computer program is developed by a group entirely pro- or anti-nuclear energy (Johnson, 1985, 81).

Computer Abuse

The term "computer abuse" does not refer merely to the damaging of computers, although it includes that kind of problem. As we will define it, computer abuse is any unethical or illegal conduct in which computers play a central role (whether as instruments or objects), as opposed to their playing an incidental or peripheral role. The distinction between central and incidental roles is somewhat rough, but a few examples will help to clarify it.

Computers are only incidentally involved when extortion is attempted via a phone which is part of a computerized telephone system (Kling, 1980, 408). By contrast, computers are centrally involved when an extortionist disguises his voice by means of a computer as he talks into a phone. And computers are even more centrally involved when an unauthorized person uses a telephone computer system to obtain private phone numbers, or when someone maliciously alters or scrambles the programming of a telephone computer, or when a private or governmental hit squad uses computers to identify fingerprints of its intended victims.

Finally there are "hackers" who compulsively challenge any computer security system. Some carry their art to the point of implanting "time bombs" or "Trojan horses" or "viruses" that will "choke networks with dead-end tasks, spew out false information, erase files, and even destroy equipment." (Marshall, 1988).

Computer Theft and Fraud

Some of the most commonly discussed cases of computer abuse are instances of outright theft and fraud. There are many forms of computer theft and fraud. For example: (1) stealing or cheating by employees at work; (2) stealing by nonemployees or former employees; (3) stealing from or cheating clients and consumers; (4) violating contracts for computer sales or service; (5) conspiring to use computer networks to engage in widespread fraud; (6) advertising "next-generation" computers in a misleading manner; (7) extortion practiced by the sole programmer or operator of a computer installation who has a unique knowledge of how it works or is programmed.

Public interest has often been drawn to the glamorous capers of computer criminals (Whiteside, 1978). Enormous sums of money have been involved. The average amount stolen in conventional embezzlement is $19,000. The amount for an average computer-related embezzlement is $430,000, and many millions are often involved. Yet the giant thefts uncovered are believed to be only a small fraction of computer theft—less than 1 percent (T. Logsdon, 1980, 163–164).

Crime by computer has proven to be unusually inviting to many. Computer crooks tend to be intelligent and to view their exploits as intellectual challenges. In addition, the computer terminal is both physically and psychologically far removed from face to face contact with the victims of the crimes perpetrated. Unlike violent criminals, computer criminals find it easy to deceive themselves into thinking they are not really hurting anyone, especially if they see their actions as nothing more than pranks. In addition there are often inadequate safeguards against computer crime. The technology for preventing crime and catching criminals has lagged behind implementation of new computer applications. Computers reduce paperwork, but this has the drawback of removing the normal trail of written evidence involved in conventional white-collar crime (forgeries, receipts, etc.) Finally, the penalties for computer crime, as for white-collar crime in general, are mild compared to those for more conventional crimes.

Computer crime raises obvious moral concerns related to basic issues of honesty, integrity, and trust. It also forces a rethinking of public attitudes about crime and its punishment. Is it fair that the penalty for breaking into a gas station and stealing $100 should be the same as for embezzling $100,000 from a bank? How should society weigh crimes of minor violence against nonviolent crimes involving huge sums of money?

The potential for computer crime should enter significantly into the thinking of engineers who design computers. In fact, protection against criminal abuse has become a major constraint for effective and successful design of many computer systems and programs. Engineers must envisage not only the intended context in which the computer will be used, but both likely and possible abuses.

For some time secret computer passwords have been used as a security feature. More recently introduced, and still of limited effectiveness, is data encryption. This technique is widely employed to prevent theft from funds transfer systems. In data encryption, messages are scrambled before transmission and unscrambled after reception according to secret codes. Such devices, of course, require special precautions in maintaining confidentiality and security, and engineers have a major role to play in making recommendations in these areas.

Privacy

Storage, retrieval, and transmission of information using computers as data processors has revolutionized communication. Yet this very benefit poses serious moral threats to the right to privacy. By making more data available to more people with more ease, computers make privacy more difficult to protect. Here we will discuss privacy and confidentiality in regard to individuals, but the issues are similar in relation to corporations.

In the Chap. 6 discussion of employee rights, we defined the right to privacy as the right to control access to and use of information about oneself. We indicated that the right was vitally important for a variety of reasons, and could be grounded within each of the major types of ethical theories. Here we will take note of some of the threats to that right from computerized data centers.

Imagine that you are arrested for a serious crime you did not commit—for example, murder or grand theft. Records of the arrest, any subsequent criminal charges, and information about you gathered for the trial proceedings might be placed on computer tapes easily accessible to any law enforcement officer in the country. Prospective employers doing security checks could gain access to the information. The record clearly indicates that you were found innocent legally. Nevertheless that computerized record could constitute a standing bias against you for the rest of your life, at least in the eyes of many people with access to it.

The same bias could exist if you had actually committed some much less serious crime—say a misdemeanor. If you were arrested when you were 15 for drinking alcohol or swearing at an officer, for example, the record could stay with you. Or imagine that medical data about your visits to a psychiatrist during a period of depression could be accessed through a data bank. Or that erroneous data about a loan default were placed in a national credit data bank to which you had limited access. Or merely suppose that your tastes in magazine subscriptions were known easily to any employer or ad agency in the country.

The potential abuses of information about us are unlimited and become more likely with the proliferation of access to that information. For this reason a series of new laws has been enacted (Rule, McAdam, Stearns, and Uglow, 1981). For example, the 1970 Fair Credit Reporting Act restricted access to credit files. Information can be obtained only by consumer consent or a court order, or for a limited range of valid credit checks needed in business, employment, and insurance transactions or investigations. The act also gave consumers the right to examine and challenge information about themselves contained in computerized files.

The Privacy Act of 1974 extended this right of inspection and error correction to federal government files. It also prohibited the information contained in government files from being used for purposes beyond those for which it was originally gathered unless such use was explicitly agreed to by the person whose file it is. Numerous other laws have been passed and are being considered to extend protection of individual privacy within private business and industry.

Such laws are expensive to implement, sometimes costing tens and hundreds of millions of dollars to enforce. They also lessen economic efficiency. In special circumstances they can have harmful effects on the public. There is little question, for example, that it would save lives if medical researchers had much freer access to confidential medical records. And it would be much more convenient to have one centralized National Data Center. This idea was proposed in the mid-1960s and is still alive in the minds of many. But privacy within a computerized world can apparently be protected only by making it inconvenient and expensive for others to gather data bank information on us.

Earlier we mentioned that inadvertent errors in data banks can also constitute a serious problem. Consider the following episode reported in the French press in 1979 and recounted by Jacques Vallee.

The three young men who bought gas at a filling station outside of Paris, France, did not look trustworthy to Mr. Nicholas, the station owner. Something about their clothes, the mended license plate, and the hurriedly scrawled signature on the check spurred him to call the police after the trio had left. Sure enough, police files queried by a computer revealed that the car had been stolen. A special police team was dispatched, and the stolen car was intercepted at a red light. Two plainclothes police officers approached the suspects, the only one in uniform remaining in the patrol car. One of the young men, Marcel Seltier, reported, "We did not understand anything. We saw the one with the gun aim at Claude. A moment later a shot rang out.

The bullet went through the windshield and hit Claude's face just under the nose. We thought they were gangsters."

This is the case of the trigger-happy police who in 1979 dispensed justice on the spot under the erroneous impression that the suspects were dangerous. Undoubtedly the lawmen discharged their weapons in response to some inadvertently suspicious movements on the part of the three young men still in the car. The car had indeed been stolen several years earlier. In the meantime, it had been recovered and resold by the insurance company (Vallee, 1982; Schinzinger, 1986).

The error of not recording the final sale cannot be blamed on the computerized data file as such. Nevertheless, a system which combines rapid remote access to information with instant life and death decisions is ill conceived if its users are not trained to expect occasional human or machine errors and act accordingly. A sobering thought concerns error corrections, even when they are undertaken in good faith. To quote Vallee:

> When data is "expunged" or deleted from a computer (following a judge's order to purge a certain record, for example), it is generally *not* true that the data can also be deleted from the older "back-up" versions of that computer's memory, which are kept in a secure vault somewhere in case the information ever needs to be reconstructed after a system failure. Thus, the "expunged" data could still be examined if someone really had the inclination to search for it (Vallee, 1982, 30).

Instant reaction to wrong information—computer-generated and imbued with the aura of authenticity—should also make us worry about military reliance on fully automated missile warning and delivery systems, regardless of where in the world we may live.

Further Social Issues

Crime, privacy, and power shifts have been the focus of most discussions about computer ethics. More attention, however, is now being given to a variety of other social and professional issues. Let us survey some of these, beginning with social issues.

1 Selective disclosure of their views by politicians has always occurred. In a speech to a conservative group a candidate for senator will tend to say very different things from what he or she tells a liberal group. Different topics may be discussed, different emphases given, and inconsistent remarks made. Computers make it possible to turn this political maneuver into a science. Dozens of types of letters can be worded to appeal to different kinds of groups. Each type reveals only a fraction of the candidate's views—just that portion which will be most attractive to a selected sociopolitical group.

The information about these groups of people is obtained by computer from public records. The characterizations of the groups' attitudes and norms are computer-generated. The letters sent to them are personalized by computer. And the mailing process is also computerized. With electronic accuracy and efficiency, politicians are enabled to have many different faces when viewed by different groups.

Several moral issues are raised by this possible application of technology: (1) Does such selective disclosure constitute deception? (2) Does filtering the truth about a politician's views undermine the autonomy of voters in making decisions? (3) Since use of computers is expensive, is it fair that the rich have more extensive access to this technology, or should equal-time laws for television be extended to computers? (Maner, 1980, 2–8).

2 Many new occupations have been created by computers: data processing, programming, information science, key punch operating, computer systems analysis, computer sales positions, and so forth. Should the importance of responsible behavior by these groups lead the public to seek their full professionalization and require licensing, registration, or continuing education? What should the public demand by way of accountability from professional organizations representing these groups?

3 Most existing professional groups are finding their work altered by computers. This will have subtle effects on areas of personal accountability. For example, it was once clear that doctors were fully responsible for the diagnoses they made: Errors in judgment were *their* errors. Increasingly, however, diagnoses and other medical decisions are and will come to be made with varying degrees of computer assistance. Health data on patients may be collected with computerized instruments and then entered into a computer which is programmed to diagnose illness on the basis of the medical symptoms entered. Under such conditions, when would a doctor be responsible for a mistaken diagnosis that resulted from a computer error? When would a doctor be blameworthy for overreliance on a mistaken computer diagnosis?

4 Computers have led and will continue to lead to elimination of jobs. What employer attitudes are desirable in dealing with this situation? No employer, of course, can afford to pay people for doing no work. Yet especially within large corporations it is often possible to readjust work assignments and work loads and to wait for people to retire or to change jobs voluntarily before laying off employees. Such benign employment practices have often been embraced from prudential motives to prevent a public and employee backlash against introduction of computer technologies which eliminate jobs (Kling, 1979, 10), but moral considerations relating to human costs should be weighed even more heavily.

5 There are also questions concerning public accountability of businesses using computer-based services. It can be made very difficult or relatively simple for a consumer to notice and correct computer errors or computer-printed errors. For example, a grocery-store receipt can itemize items by obscure symbols or simple words understandable to a customer. Here again moral reasons reinforce long-term good business sense in favoring policies beneficial to consumer needs and interests.

6 Program trading is the automatic, hands-off trading by computer of stocks, futures, and options on the stock market. Did this practice contribute to the "meltdown on Black Monday" (October 19, 1987), when the U.S. stock market took a precipitous plunge, and should it be controlled?

7 The U.S. Department of Defense is supporting the creation of autonomous weapons which can be aimed and fired by on-board computers which make all necessary decisions, including enemy identification. Computer scientists and engineers are divided over the advisability of such a major step toward automation of the battlefield.

8 There is a dangerous instability in computerized defense systems even if they are working perfectly. Let us assume then that all the nuclear warning software works without error, and that the hardware is fail-safe. Nevertheless, the combination of two such correctly functioning but opposing systems together is unstable. This is because secrecy prevents either system from knowing exactly what the other is doing, which means that any input which could be interpreted as a danger signal must be responded to by an increase in readiness on the receiving side. That readiness change, in turn, is monitored by the opposing side which then steps up its readiness, and so on. This feedback loop triggers an escalating spiral. Does the possibility of an entirely unprovoked attack triggered by the interaction of two perfectly operating computer-based systems as described by Raushenbakh (1988) enhance security?

Professional Issues

Many of the issues in engineering ethics which we have dealt with earlier arise again within the context of computer work. New variations or new difficulties may be involved, often owing to the high degree of job complexity and required technical proficiency introduced by computers. Such was the case, for example, in the whistle-blowing case of Virginia Edgerton given as a study question in Chap. 6. A number of interesting case studies have been collected by Donn Parker in his excellent book, *Ethical Conflicts in Computer Science and Technology*. The following examples are based on some of Parker's cases.

Safety Dependence on computers has intensified the division of labor within engineering. For example, civil engineers designing a flood control system have to rely on information and programs obtained from systems analysts and implemented by computer programmers. Suppose the systems analysts refuse to assume any moral or legal responsibility for the safety of the people affected by the flood control plans, arguing that they are merely providing tools whose use is entirely up to the engineers. Should the civil engineers be held accountable for any harm caused by poor computer programs? Presumably their accountability does extend to errors resulting from their own inadequate specifications which they supply to the computer experts. Yet should not the engineers also be expected to contract with computer specialists who agree to be partially accountable for the end-use effects of their program? (Parker, 1979, 34–38)

Ownership Rights Consider an engineer who develops a program used as a tool in developing other programs assigned to her. Subsequently she changes jobs and takes the only copy of the first program with her for use on her new job. Suppose first that the program was developed on company time under the first employer's explicit directives. Taking it to a new job without the original employer's consent would be a violation of that employer's right to the product (and possibly a breach of confidentiality). As a variant situation, however, suppose the program was not written under direct assignment from the first employer, but was undertaken by the engineer at her own discretion to help her on her regular work assignments. Suppose also that to a large extent the program was developed on her own time on weekends, although she did use the employer's facilities and computer services. Did the employer own or partially own the program? Was she required to obtain the employer's permission before using it on the new job? (Parker, 1979, 72–74)

Whistle-Blowing An engineer working as a computer programmer played a minor role in developing a computer system for a state department of health. The system stored medical information on individuals identified by name. Through no fault of the engineer, few controls had been placed on the system to limit easy access to it by unauthorized people. Upon learning of this the engineer first informed his supervisor and then higher management, all of whom refused to do anything about the situation because of the anticipated expense required to correct it. In violation of the rules for using the system, the programmer very easily obtained a copy of his own medical records. He then sent them to a state legislator as evidence for his claims that the right of citizens to confidentiality regarding such information was threatened by the system. Was his behavior improper? Was his subsequent firing justified? (Parker, 1979, 90–93)

Employer Authority and Professional Rights A project leader working for a large retail business was assigned the task of developing a customer billing and credit system. The budget assigned for the project appeared at first to be adequate. Yet by the time the system was half completed it was clear the funds were not nearly enough. The project leader asked for more money, but the request was denied. He fully informed management of the serious problems which were likely to occur if he had to stay within the original budget. He would be forced to omit several important program functions relating both to convenience and to safety: for example, efficient detection and correction mechanisms for errors, automatic handling and reporting of special customer exceptions, and audit controls. Management insisted that these functions could be added after the more minimal system was produced and installed in stores. Working under direct orders, the project leader completed the minimal system, only to find his worst fears realized after it was installed. Numerous customers were given incorrect billings or ones they could not understand. It was easy for retail salespersons to take advantage of the system to steal from the company, and several did so. Within a year the company's profits and business were beginning to drop. This led to middle-level management changes, and the project leader found himself blamed for designing an inadequate system.

Did the project leader have an obligation either to clients or to the company to act differently than he did? Did he have a moral right to take further steps in support of his original request or later to protect himself from managerial sanctions? (Parker, 1979, 109–111)

Parker's example comes close to illustrating a common failing among computer experts: Selling the customer (or the boss) on a more complex system than is warranted or promising more capacity and faster delivery than is achievable. The latter was the case with a revolutionary, computer based system for trust accounts that the Bank of America had to abandon after buying it for $20 million, spending another $60 million trying to make it work, and wasting several years in the process. (Frantz, 1988)

Informed Consent A team of engineers and biomedical computer scientists develop a system for identifying people from a distance of up to 200 meters. A short tube attached to a sophisticated receiver and computer, and aimed at a person's head, reads the individual's unique pattern of brain waves when standard words are spoken. The team patents the invention and forms a company to manufacture and sell it. The device is an immediate success within the banking industry. It is used to secretly verify the identification of customers at tellers' windows. The scientists and engineers, however, disavow any responsibility for such uses of the device without customer notification or consent. They contend that the companies which buy the product are responsible for its use. They also refuse to be involved in notifying public representatives about the product's availability and the way it is being used.

Does employing the device without customer awareness violate the right to privacy or to informed consent? Do the engineers and scientists perhaps have a moral obligation to market the product with suggested guidelines for its ethical use? Should they be involved in public discussions about permissible ways of using it? (Parker, 1979, 126–128)

Study Questions

1 Present and defend your answers to the questions raised about the cases based on Parker's examples.

2 Look up the following terms in a legal dictionary: fraud, theft, extortion, sabotage, vandalism, burglary. Then imagine and briefly describe an example of a computer crime falling under the definition of each.

3 Write a short research paper exploring the threats to privacy posed by data banks. In your essay comment on some specific advantages and disadvantages of having one centralized national data bank which pools all available government information on citizens.

4 The U.S. Office of Technology Assessment has reported that new rules may soon be needed for computer services concerning the prediction of criminal and financially negligent behavior. People are likely in the future to be denied credit, employment, and insurance because they fall into certain categories based on statistical correlations developed by computers.

Comment on who you think should establish these new rules, and give any examples of rules you would favor. For example, do you think it would be fair to allow race or sex to be used as a variable in this context?

5 Tracy Kidder's Pulitzer Prize–winning book, *The Soul of a New Machine,* recounts the human drama behind the development of a minicomputer by Data General Corporation (Kidder, 1981). Read the book, and as you do so, identify any moral issues which may arise in the course of creating a new computer system and bringing it to market.

6 The following warning to parents whose children use home computers was carried by the Associated Press (*Los Angeles Times,* 25 Dec. 1987, p. I-47): "In recent years more sexually oriented materials have been showing up for home computers—some on floppy disks with X-rated artwork and games, and other accessed by phone lines from electronic bulletin boards... with names like Cucumber,... Orgy, Nudepics, Porno, Xpics, and Slave."

Discuss the ethical issues raised by pornography in this new medium. Should there be controls? How can access be denied to children? Are there any parallels with constraints on the use of the postal service?

7 In 1985 computer scientist David L. Parnas resigned from an advisory panel on computing in support of battle management, a nine-member group established by the Strategic Defense Initiative office in the Department of Defense. He explained his position in a position paper (Parnas, 1985) and a year later, in response to criticism, in a letter in which he writes:

> I resigned... when it became clear to me that the panel would not give serious consideration to the question of feasibility. Even at that time I did not go public. I sent copies of my position to Government officials, not to the press. After copies had been leaked to the press by others, it became clear to me that the SDI management's response was damage control, not serious consideration of the issues that I had raised. Only then did I agree to explain my position in public (Parnas, 1986).

Seek further information on this case and write a report on Parnas's actions. Did he act as whistle-blower? If so, as a responsible one?

WEAPONS DEVELOPMENT

Much of the world's technological activity has a military focus. Based just on size of expenditures, direct or indirect involvement of engineers, and startling new developments, military technology would deserve serious discussion in these pages. The moral problems it raises, however, are of a magnitude which makes the other cases we have treated so far pale in comparison. The continuing automation of the battlescene has made military activity seem less troublesome and more appealing to technologically advanced nations, while the real horrors of total war—whether fought with classical weapons, hydrogen bombs, or biochemical agents—are too far beyond the comprehension of many diplomats, engineers, and younger generals to guide their decisions.

Let us first take a leap back into history and see what has not changed, which lessons we have not learned. When Xerxes reached the Hellespont on his westward march, he had a bridge built over the waterway. It is said that the bridge succumbed to a storm, the engineers were beheaded, the water was given a ceremonial flogging, and a second bridge was ordered. This time no chances were taken as 674 galleys in two rows were tied together with flax ropes weighing 50 pounds to the foot. The roadbed of planks, brush, and earth withstood the crossing of 150,000 soldiers and several times that number of noncombatants (De Camp, 1963, 89).

There are several reasons for an engineer to do his or her best on a military job. High among them are patriotism and prudential interest. The latter can be occasioned by threats from an easily displeased ruler or by the lure of commercial success. Xerxes' bridge builders certainly had compelling reasons to build a good bridge. With their experience they might even have benefited from staying on at the site, offering to build bridges for other armies who came along. (Indeed, the next that came along was Xerxes' army on retreat.)

The Weapons Seesaw

The trade in arms and military know-how has a long tradition. Today military expenditures throughout the world total about $900 billion dollars annually. Of this amount, one-quarter is earmarked for purchases of weapons and related equipment, 17 percent of which are traded internationally.

Among the world's most successful arms merchants and manufacturers was the family Krupp. Krupp was an expert at exploiting the defensive-offensive weapons seesaw. This is how it worked, according to William Manchester in his book *The Arms of Krupp:*

> Having perfected his nickel steel armor, Fritz advertised it in every chancellery. Armies and navies invested in it. Then he unveiled chrome steel shells that would pierce the nickel steel. Armies and navies invested again. Next—this was at the Chicago fair, and was enough in itself to justify the pavilion—he appeared with a high-carbon armor plate that would resist the new shells. Orders poured in. But just when every general and admiral thought he had equipped his forces with invincible shields Fritz popped up again. Good news for the valiant advocates of attack: it turned out that the improved plate could be pierced by "capped shot" with

> explosive noses, which cost like the devil. The governments of the world dug deep into their exchequers, and they went right on digging. Altogether thirty of them had been caught in the lash and counterlash. Fritz showed the figures to the emperor, who chuckled. He would have gagged if he had known the truth: he himself was being trapped in a variation of the seesaw (Manchester, 1970, 248).

In the Far East the firm of Krupp (Germany) was joined by Vickers (Great Britain) and Schneider (France) in supplying arms to the Chinese, the Japanese, and the Russians. Sir William White, chief designer of the British Admiralty and later director of warship construction at Armstrong, Whitworth and Co., was said not to be unwilling

> to play the part of the *honnete coutier* by pointing out the growth of the Japanese navy to his Chinese clients, or of the Chinese to their indomitable rivals.... By such means he was able to increase the profits of the great company which employed him, and to extend what is, perhaps, the most important of our national industries, and to kindle in the hearts of two Asiatic peoples the flames of an enlightened and sacred patriotism (Seldes, 1934, 36).

Everything worked out quite well for the arms merchants when after both the Japanese and Russian fleets had been outfitted, the latter was badly battered during the Russo-Japanese War in 1905, requiring new orders to rehabilitate it.

Japan won the war, but its troops had suffered terrible bloodbaths on land caused by Russian use of Maxim's machine guns. The American inventor Hiram S. Maxim had by then joined forces with the Swedish weapons manufacturer Nordenfeldt and its master salesperson, Boris Zaharoff, who was known as the Mystery Man of Europe and the Merchant of Death. It was Zaharoff who set off an arms race in the Balkans. Among other feats he sold one of Nordenfeldt's clumsy, 1881 model steam-powered submarines to the Greek government as a novelty, "then two to the Turks as a counter to the Greek threat, then two more to the Greeks, and so on" (Slade, 1986).

But back to the Krupps in Essen, Germany. While Krupp men were busy with their steel, Krupp wives did good deeds among the workers' families. This was good stuff for satire, superbly used in George Bernard Shaw's portrayal of the Krupps in *Major Barbara*. Berta Krupp once expressed horror at the fact that the Essen Works would manufacture "bomb cannons." She is said to have been assured that few would dare get into the way of such a cannon—thus it would promote peace. By World War I, heavy ordnance took the form of 420-millimeter howitzers lofting 1-yard-long shells weighing 1 ton each over 9 miles, and of 210-millimeter cannons which fired 264-pound shells at Paris from 76 miles away. Both types of guns were occasionally dubbed Dicke (Big) Berta, some say in honor of Berta Krupp, others say in memory of the monk Berthold Schwarz, the reinventor of gun powder in the western world.

Big Berta was superseded in World War II by Big Dora, two stories high with a barrel 90 feet long and a bore of 840 millimeters. This monster could fire 8-ton shells up to 30 miles. But by then the big guns were no longer as useful. Mobile delivery of destructive force by tanks and aircraft had been perfected, to be followed by rockets and nuclear weapons.

This change in technology was accompanied by a change in strategy. Where armies once faced each other in battle, bombs could now be delivered far beyond the front lines on the enemy's population centers. The scene of battle was thus moved, and the change is reflected in the work of Erich Maria Remarque, whose *All Quiet on the Western Front* dealt with the sufferings of the soldier in the front lines of World War I, but whose World War II novel *A Time to Live, a Time to Die* centered on the home front and dealt with the effects of war on the civilian population.

In the early months of World War II the chiefs of staff of the warring countries would still agonize over the question of whether or not to bomb targets in civilian population centers at night. Toward the end of the war, night raids had become common practice and civilians themselves had become the targets. The agonizing decisions were now up to them: Which child or children do you leave behind if the asphalt roads are so soft from the heat that you cannot possibly escape the flames if you carry all?

To us the atom bombs dropped on Hiroshima and Nagasaki are horrible not only because of the many deaths they caused (single air raids during World War II had killed larger numbers of people), nor because of the ghastly medical consequences for survivors, nor because they were unnecessary (Cousins, 1987, 40-50), but mostly because they ushered in the age of rapid, irretrievable delivery of destructive power in immense concentrations. To deliver the equivalent explosive effect of the Hiroshima bomb would have required 20,000 tons of explosives (TNT). Loaded on railroad hopper cars this would have filled 267 cars making a train 2 miles long, just for one bomb. It would have taken 740 of today's B-52 bombers to carry this load in conventional explosives.

In the early 1960s the Soviet Union exploded hydrogen bombs in the 50- and 60-megaton range for test purposes. Each of those bombs had two to three thousand times the destructive power of the Hiroshima bomb, and it would take a train 4000 to 6000 miles long to carry the TNT required to produce an explosion equivalent to that produced by any one of them. You would have to wait at a railroad crossing for close to 100 hours to let such a train pass. Or if carried by bombers, you would see the sky darkened with one and a half million planes. The total megatonnage of nuclear weapons available to the two major superpowers for instant departure toward targets is about 3300 megatons for the United States (in 10,800 warheads on 2000 launchers, including bombers) and 5800 megatons for the U.S.S.R. (in 9500 warheads on 2700 launchers, including bombers). (Mayers, 1986, 63)

Today's bombs are smaller (though often clustered), mostly carried by missiles, and targetable with great exactness. Countermeasures are being developed and the offensive-defensive seesaw is exercised in the same manner as a century ago. The Office of Technology Assessment of the U.S. government estimates that a large-scale nuclear exchange between the United States and the U.S.S.R. could kill more than 250 million people outright in those two countries alone, let alone those who would suffer lingering illnesses and later deaths from starvation, exposure, or disease. The effects of a nuclear winter created by the reduction in sunlight reaching the earth could spread disaster to all parts of the world, thus affecting nonwarring nations as well.

Those consequences are not disputed. What occupies the best minds are questions regarding national policy: Is the threat of mutual annihilation an effective deterrent for the future? Would unilateral disarmament, or disarmament without adequate safeguards, be an effective indicator of trust which could bring about a deescalation of the arms race and a reduction of the potential for nuclear war? In the meantime the nuclear arsenal becomes bigger and more technically perfect. A comparison of the total tonnage of explosives unleashed by all sides during World War II with what is ready to be used now in an all-out war is graphically portrayed in Fig. 7-4. Over 6000 times more destructive power than was used during the 6 years of World War II could be delivered within hours during a full exchange of hostilities between today's members of the nuclear club.

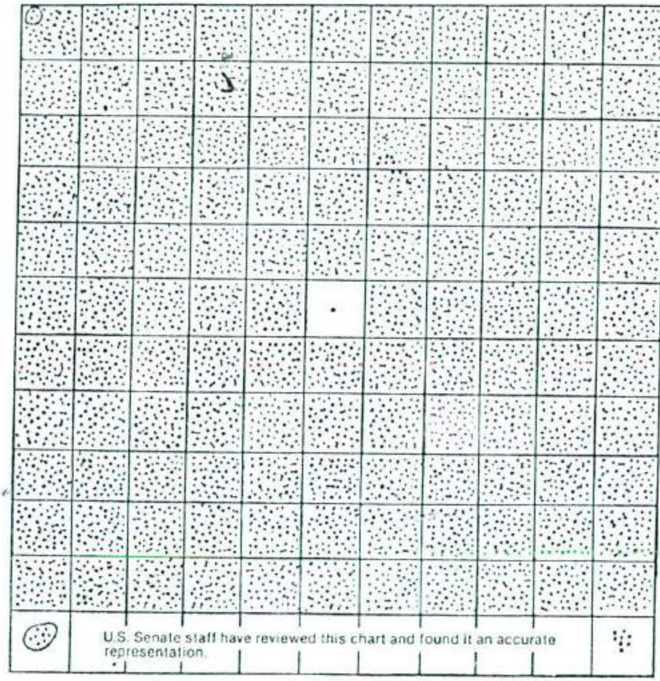
The Engineer's Involvement in Weapons Work

Instruments of torture leave little to the imagination. Descriptions of the use of the rack, the thumbscrew, and the electric prod convey instant sensations of pain and suffering. Our modern weapons of war, however, at first seem more remote. Unless one has experienced or studied their consequences, they appear quite guiltless in themselves. Even those who deliver their deathly charges against the enemy mostly do so at a distance, making their use seem more acceptable—or at least less unsettling.

How do the men and women who design weapons, manufacture them, and use them feel about their work? Most have reservations about it, but those who stay in it also have reasons to support their continued involvement. The following cases involve real weapons. The people are composites who represent the various positions taken by typical citizens who are also engineers.

1 Bob's employer manufactures antipersonnel bombs. By clustering 665 guava-sized bomblets and letting them explode above ground, an area covering the equivalent of ten football fields is subjected to a shower of sharp fragments. Alternatively the bombs can be timed to explode hours apart after delivery. Originally the fragments were made of steel; now less easily detected plastics are sometimes used, making the treatment of wounds, including the location and removal of the fragments, more time-consuming for the surgeon. Recently another innovation was introduced: By coating the bomblets with phosphorus the fragments could inflict internal burns as well. Thus the antipersonnel bomb does its job quite well without necessarily kill-

Firepower to Destroy a World...Plus



The dot in the center square represents all the firepower of World War II—3 megatons. The other dots represent the firepower in existing nuclear weapons—18,000 megatons (equal to 6,000 WW IIs). About half belong to the Soviet Union, the other half to the U.S.

The top left circle represents the weapons on just one Poseidon submarine—9 megatons (equal to the firepower of 3 WW IIs)—enough to destroy over 200 of the largest Soviet cities. The U.S. has 31 such subs and 10 similar Polaris subs. The lower left circle represents one new Trident sub—24 megatons (equal to the firepower of 8 WW IIs)—enough to destroy every major city in the northern hemisphere. The Soviets have similar levels of destructive power.

Another interpretation: The single dot is the bomb on Hiroshima. If a defensive shield repels only 99 percent of incoming missiles or planes, all the other dots are Hiroshima-rated warheads which get through in an all-out exchange among all nuclear powers.

Researched and drawn by James Geier and Sharyl Green for Parents and Teachers for Social Responsibility. May be copied freely.

FIGURE 7-4

ing in that it ties up much of the enemy's resources in treating the wounded who survive its explosion.

Bob himself does not handle the bombs in any way, but as an industrial engineer he enables the factory to run efficiently. He does not like to be involved in making weapons, but then he tells himself that someone has to produce them. If he does not do his job, someone else will, so nothing would change. Furthermore, with the cost of living being what it is, he owes his family a steady income.

2 Mary is a chemical engineer. A promotion has gotten her into napalm manufacturing. She knows it is nasty stuff. She remembers Professor Wald, a Nobel laureate in biology from Harvard, berating the chemical industry for producing this "most brutal and destructive weapon that has ever been created." But this was when she was in college, during the Vietnam war. Civilians were forever not leaving the fighting zone and then there were complaints about them being hurt or killed. She abhors war like most human beings, but she feels that the government knows more than she does about international dangers and that it is better to fight a war abroad than on our shores. If everyone were to decide on her or his own what to do and what not to do, then there would be utter chaos. Perhaps society can tolerate a few oddballs with their own ideas, but companies certainly should be prepared to manufacture the weapons our armed forces need. Incidentally, if Mary continues to perform well on her job she will be promoted out of her present position into working on a commercial product with much growth potential.

3 Ron is a specialist in missile control and guidance. He is proud to be able to help his country through his efforts in the defense industry. The missiles he works on will carry single or multiple warheads with the kind of dreadful firepower which, in his estimation, has kept any potential enemy in check since 1945. At least there has not been another world war—the result of mutual deterrence, he believes.

4 Marco's foremost love is physical electronics. He works in one of the finest laser laboratories. Some of his colleagues do exciting research in particle beams. That the laboratory is interested in developing something akin to the "death ray" described by science fiction writers of his youth is of secondary importance. More bothersome is the secrecy which prevents him from freely exchanging ideas with experts across the world. But why change jobs if he will never find facilities like those he has now?

5 Joanne is an electronics engineer whose work assignment includes avionics for fighter planes which are mostly sold abroad. She has no qualms about such planes going to what she considers friendly countries, but she draws the line at their sale to potentially hostile nations. Joanne realizes that she has no leverage within the company, so she occasionally alerts journalist friends with news she feels all citizens should have. "Let the voters direct the country at election time"—that is her motto.

6 Ted's background and advanced degrees in engineering physics gave him a ready entry into nuclear bomb development. As a well-informed citi-

zen he is seriously concerned with the dangers of the ever growing nuclear arsenal. He is also aware of the possibilities of an accidental nuclear exchange. In the meantime he is working hard to reduce the risk of accidents such as the thirty-two "broken arrows" (near catastrophic accidents) reported by the Pentagon—or the many others that he knows have occurred worldwide. Ted continues in his work because he believes that only specialists, with firsthand experience of what modern weapons can do, can eventually turn around the suicidal trend represented by their development. Who else can engage in meaningful arms control negotiations?

Our names are fictitious, as are the specific jobs described. But all over the world talented people engage in weapons work. Surely everyone who accepts a job in a war-related industry should also seriously consider his or her motives in doing so. Prudential self-interest is not sufficient to guarantee responsible participation in what must be regarded as humankind's most crucial engineering experiment. Only those who have arrived at morally autonomous, well-reasoned positions for either engaging in or abstaining from weapons work can be counted on to carefully monitor the experiment and try to keep it from running a wild course.

Defense Industry Problems

Across the globe we find nations which confer special privileges on their defense industries without giving sufficient thought to the problems which can accompany large military buildups. Unethical business practices, for instance, occur as in all massive projects, but the urgency of completing a weapons system before it becomes obsolete and the secrecy which surrounds it makes proper oversight particularly difficult.

This is one of the examples we describe briefly below. The other cases address problems which are more serious because they are not as easily recognized. Thus the second example has to do with "technology creep"—the development of new weapons, such as the cruise missile, which can alter diplomatic arrangements even as they are being negotiated. We then examine the issue of secrecy in different contexts. As a last example we take up the overall effect of defense spending on a nation's economy and the distortions it can produce. Our discussion may reveal a United States perspective, but the underlying problems are of a global nature.

The following cases illustrate the various problems just enumerated and should give pause for ethical reflection by both critics and ardent supporters of weapons manufacturing and development.

1 The problem of waste and cost overruns is a continuing one in the defense industry (A. E. Fitzgerald, 1972; Gansler; 1980; Melman, 1970). In Chap. 6 we mentioned one example—the $2 billion cost overruns on development of the C5-A transport plane, overruns reported to the public by Ernest Fitzgerald. Fitzgerald, who is a deputy for management systems in the Pentagon, has been a significant critic of how the defense industry has operated at efficiencies far below commercial standards. He has described how contractors' work forces were swelled with underutilized engineers and high-salary sales personnel, resulting in lavish overhead fees. Or how small contractors were willing to comply with cost-cutting plans, but large suppliers felt secure in not complying. (At present, twenty-five firms hold 50 percent of all defense contracts in the United States, and eight firms conduct 45 percent of all defense research.)

High cost and poor quality were encouraged in various ways: Planned funding levels were leaked to prospective contractors. Cost estimates were based on historical data, thus incorporating past inefficiencies. Costs were cut when necessary by lowering quality, especially when component specifications were not finalized until the contract was completed. Sole-supplier policies gave a contractor the incentive to "buy in" with an artificially low bid, only to plead for additional funds later on. And those funds were usually forthcoming, since the Department of Defense has historically accepted what it knows to be optimistically low development-cost estimates because they stand a better chance of being approved by Congress (Gansler, 1980, 296).

2 In Goethe's poem *Der Zauberlehrling*, the sorcerer's apprentice employs his master's magic incantation to make the broom fetch water. When he cannot remember the proper command to stop the helpful broom, however, he comes near to drowning before the master returns. Technology, as the slave in service of the arms race, resembles the sorcerer's broom. Not only has the world's arsenal grown inordinately expensive (even without graft), and not only does it contribute to a steadily worsening inflation, it has also gained a momentum all its own. George Kennan, a former ambassador to the Soviet Union, has stated:

> I see this competitive buildup of armaments conceived initially as a means to an end but soon becoming the end itself. I see it taking possession of men's imagination and behavior, becoming a force in its own right detaching itself from the political differences that initially inspired it, and then leading both parties, invariably and inexorably, to the war they no longer know how to avoid (Kennan, 1981).

The arsenal is not only growing in size, it is also getting "better." Diplomats may be striving to avert a major conflict, but all the while an exuberance for new developments creates a technology creep which can at times postpone or even upset all negotiations. Nations are suddenly seen to shift to new positions as new devices to more accurately target missiles, or perhaps an entirely new weapon, are reported to be in the offing. This can destabilize (and occasionally stabilize) the political process. Meanwhile, as Jerome Wiesner and Herbert York have written:

> ...both sides in the arms race are...confronted by the dilemma of steadily decreasing national security. *It is our considered professional judgment that this dilemma has no technical solution.* If the great powers continue to look for solutions

in the area of science and technology only, the result will be to worsen the situation (Wiesner and York, 1964, 27).

The technological imperative that innovations must be implemented should give advocates of preparedness for conventional, limited war some cause for concern as well. Giving in to the excitement of equipping and trying out weapons employing the latest in technology may provide added capability to sophisticated, fully automatic systems such as intercontinental ballistic missiles. But if tactical, humanly operated weapons fall prey to the gadget craze, a less than optimal system may result. The F-15 fighter illustrates this problem of preoccupation with prestige-boosting modernism. The plane was the fastest and most maneuverable of its kind, yet 40 percent of the F-15s were not available for service at any one time because of defects, difficulty of repair, and lack of spare parts. We observe that faddishness is not restricted to the world of fashion—it occurs in technology as well. The engineer must constantly be on guard not to fall prey to it.

3 This example concerns peacetime secrecy in work of military import. Norbert Wiener, the founder of cybernetics, was moved to write in answer to a request for information on some of his wartime work in missile control, "that to provide information is not necessarily an innocent act." He refused to give the information because too often the scientist places "unlimited powers in the hands of people he is least inclined to trust with their use" (Wiener, 1947, 46).

Secrecy poses problems for engineers in various ways. Should discoveries of military significance always be made available to the government? Can they be shared with other researchers, with other countries? Or should they be withheld from the larger scientific and public community altogether? If governmental secrecy in weapons development is allowed to become all-pervasive, on the other hand, will it also serve to mask corruption or embarrassing mistakes within the defense establishment? Can secrecy contribute to the promotion of particular weapon systems, such as the x-ray laser, without fear of criticism? (Adam, 1988) There are no easy answers to these questions and they deserve to be discussed more widely.

4 Of particular importance is that we ask ourselves how long a nation can divert tremendous resources (funds, materials, talent) into an economically noncontributing sector without overburdening the economy (Dumas, 1986). Every dollar, ruble, or cruzeiro spent on defense produces fewer jobs than an equal allocation for typically neglected sectors such as education or roads. At a time when most nations' true security lies in a stronger economy, redirection or "economic conversion" becomes mandatory. This entails retraining of defense industry engineers and managers so their designs, manufacturing processes, and sales techniques can bring reasonably priced, competitive civilian goods on an open market with a chance of success. A changeover requires careful planning so no communities suffer from major dislocations. The key to success is to start now while such a "safe exit" still exists.

Study Questions

1 Is it right to ask whether a weapons system is cost-effective? What does it matter how expensive it is when the nation's security is at stake and the weapons work as intended?

2 In a farewell address to the nation in 1961, outgoing President Dwight Eisenhower sounded a warning about the emerging military-industrial complex. He told his listeners that we cannot immediately tool up for massive weapons production should another major war occur, that our arms must thus be ready and mighty, and that therefore we must have a large peacetime defense establishment. But he went on to say:

> This conjunction of an immense military establishment and a large arms industry is new in the American experience. The total influence, political, even spiritual, is felt in every city, every State house, every office of the Federal Government. We recognize the imperative need for this development. Yet we must not fail to comprehend its grave implications. Our toil, resources and livelihood are all involved; so is the very structure of our society.

What implications did Eisenhower have in mind? Are there ethical implications as well? Of what kind?

3 Earl Louis Mountbatten spoke the following words shortly before his assassination:

> Next month I enter my eightieth year. I am one of the few survivors of the First World War who rose to high command in the second and I know how impossible it is to pursue military operations in accordance with fixed plans and agreements. In warfare the unexpected is the rule and no one can anticipate what an opponent's reaction will be to the unexpected.... There are powerful voices around the world who still give credence to the old Roman precept—if you desire peace, prepare for war. This is absolute nuclear nonsense and I repeat—it is a disastrous misconception to believe that by increasing the total uncertainty one increases one's own certainty (address on the occasion of being awarded the Louise Weiss Foundation prize; delivered at Strasbourg in 1979 to the Stockholm International Peace Research Institute).

Interpret Mountbatten's words from the viewpoint of those who see modern war as a technological experiment.

4 Consider the following blunt pronouncements by statesmen and generals (Schwartz, 1971, 203). Is there any message in them for engineers?

a Douglas MacArthur (commencement speech at Michigan State University, 1961): "Global war has become a Frankenstein to destroy both sides. If you lose you are annihilated. If you win, you stand only to lose. No longer does it possess even the chance of the winner of a duel. It contains only the germs of double suicide."

b Dwight D. Eisenhower, from a speech before the American Society of Newspaper Editors, April 16, 1953: "Every gun that is made, every warship launched, every rocket fired signifies, in the final sense, a theft from those who hunger and are not fed, those who are cold and are not clothed. This world in arms is not spending money alone. It is spending the sweat of its laborers, the genius of its scientists, the hopes of its children."

c Dwight D. Eisenhower, after the collapse of the 1960 summit meeting: "All of us know that, whether started deliberately or accidentally, global war would leave civilization in a shambles. In a nuclear war there can be no victors—only losers."

d Nikita Khrushchev, when Premier of the U.S.S.R.: "Only madmen and lunatics can now call for another world war. As for the men of sound mind—and they account for the majority even among the most deadly enemies of communism—they cannot but be aware of the fatal consequences of another war."

e John F. Kennedy, addressing the United Nations: "The weapons of war must be abolished before they abolish us."

6 The Just-War theory considers a war to be acceptable when it satisfies several stringent criteria: The war must be fought for a just *cause*, the *motives* must be good, it must follow a call from higher *authority* to legitimize it, and the use of *force* must be based on necessity (Hehir, 1980, 368–369). Central to notions of a just war are the principles of noncombatant immunity and proportionality. Noncombatants are those who will not be actively participating in combat and therefore do not need to be killed or restrained. Proportionality addresses the extent of damage or consequences allowable in terms of need and cost. Describe a scenario for the conduct of a just war and describe the kinds of weapons engineers might have to develop to wage one.

7 On what ethical grounds could the nuclear stockpile and/or the Strategic Defense Initiative (SDI, or "Star Wars") be justified or found not to be justified? You may include what you consider stabilizing or destabilizing effects. Possible sources: U.S. Catholic Bishops (1982), Kavka (1984); both are reprinted in Sterba (1985).

8 The following problem is taken from an article by Tekla Perry in the *IEEE Spectrum* [although it involves the National Aeronautics and Space Administration rather than the Defense Department, many of the actors (companies and government) involved in space research are also involved in weapons development]:

> Arthur is chief engineer in a components house. As such, he sits in meetings concerning bidding on contracts. At one such meeting between top company executives and the National Aeronautics and Space Administration, which is interested in getting a major contract, NASA presents specifications for components that are to be several orders of magnitude more reliable than the current state of the art. The components are not part of a life-support system, yet are critical for the success of several planned experiments. Arthur does not believe such reliability can be achieved by his company or any other, and he knows the executives feel the same. Nevertheless, the executives indicate an interest to bid on the contract without questioning the specifications. Arthur discusses the matter privately with the executives and recommends that they review the seemingly technical impossibility with NASA and try to amend the contract. The executives say that they intend, if they win the contract, to argue midstream for a change. They remind Arthur that if they don't win the contract, several engineers in Arthur's division will have to be laid off. Arthur is well-liked by his employees and fears the lay-offs would affect some close friendships. What should Arthur do? (Perry, 58)

After you have prepared your answer, you might wish to consult Perry's article for various other reactions to the dilemma it presents.

9 Prepare a case study on any one of the following weapons, all of which faced serious development problems: the M-16 rifle (Squires, 1986), Sergeant York Gun

(Adam 1987), Bradley infantry vehicle (Cousins, 1987). The references are listed only to get you started; seek more material on your own.

10 Discuss the topic "Technology and war—which promotes which?" One reference might be the anthology *Military Enterprise and Technological Change* recently assembled by M. R. Smith (1985) and discussed by S. W. Leslie in *Science* (17 Jan. 1986, pp. 277–278). Another is an essay by David Noble (1985).

11 To what extent is the economy helped or hurt by military spending? Read and report on *Our Depleted Society* (Melman, 1965) or *The Overburdened Economy* (Dumas, 1986) and present opposing views as expressed in publications of the U.S. Department of Defense.

SUMMARY

Engineering is increasingly a social experiment on an international scale, requiring engineers to achieve wider perspective on their endeavors as employees of multinational corporations, and in dealing with the environment, computers, and weapons development.

The maxim "When in Rome do as the Romans do" is inadequate as a guide to conduct in foreign countries. It implies Ethical Conventionalism, which is the false view that morality is merely a matter of local customs—as if it were all right to be a racist when working in South Africa, or to allow the unsafe practices which led to the disaster at Bhopal. Yet foreign customs often are morally relevant factors which should be taken into account in making moral judgments, especially about how to appropriately transfer technology from one setting to another. As Moral Relationalism says, moral judgments need to be made in relation to many factors which can vary from situation to situation, and moral rules which are both simple and exceptionless are rare.

The world is an ecosphere, an international "commons" of air, water, and other basic resources. The natural environment is not tightly segmented by national boundaries. Acid rain and other pollutants cause problems that require international cooperation. Even when the environmental impacts are more localized, their subtlety and complexity demand that the social experimenter exercise an imaginative and cautious vision. Human-centered and nature-centered visions of the world offer alternative ways of approaching environmental ethics.

Computer ethics is the branch of engineering ethics dealing with moral issues in computer technology. It is becoming increasingly important as computers become the technological backbone of contemporary society. Many issues arise over the possibility of computer abuse—unethical or illegal conduct in which computers are made to play a central role, as in theft, fraud, and violation of privacy rights. Some issues are merely special examples of those we have dealt with earlier: for example, whistle-blowing, safety, informed consent, ownership rights, and conscientious refusal to engage in unethical activity. But still others have to do with the effects of the widespread use of computers in our society: for example, the elimination and transformation of jobs, or the use of computers in surveillance and political campaigns.

There are special moral problems intrinsic to the defense industry, such as those related to planned cost overruns, uncritical proliferation of new weapons, and secrecy in military work. Yet those issues appear insignificant compared with the problem of war and peace. And overshadowing all other issues dealt with in this book is the possibility of a nuclear holocaust. Certainly the decision to enter or avoid weapons development as a career is among the most important confronting engineers. It is also one of the most deeply personal decisions one can make and should involve a searching examination of both one's individual conscience and the social and political issues of weapons technology.

CHAPTER 8

CAREER CHOICE AND PROFESSIONAL OUTLOOK

On February 2, 1976, three engineers made news headlines when they resigned from General Electric (G.E.) to protest the nuclear energy industry in which they had worked for years. Each of the engineers was married and had three children. Each left a comfortable job to work full time and without pay for a nuclear protest group. Greg Minor had worked 16 years for General Electric and was manager of advanced control and instrumentation for the nuclear energy division of G.E.'s San Jose plant. Dale G. Bridenbaugh had worked 23 years with General Electric and was manager of performance evaluation and improvement. And Richard Hubbard, at age 38, was manager of quality assurance in the control and instrumentation department.

The three gave as the reason for their resignations the extreme danger they believed to result from the way nuclear energy was being developed. In his resignation letter Greg Minor expressed their shared sentiments:

> My reason for leaving is a deep conviction that nuclear reactors and nuclear weapons now present a serious danger to the future of all life on this planet. I am convinced that the reactors, the nuclear fuel cycle and waste storage systems are not safe (quoted in Barnett, 1976, 34).

Beyond the element of public protest involved, the episode illustrates a dimension of ethics in engineering with which we have not yet dealt. Moral considerations often do and should play a central role in decisions about career choice and career changes. In some ways career decisions are among the most morally important decisions a person makes. At the same time they are very personal decisions. Just as some engineers have decided on moral grounds that they ought not to participate in nuclear energy development, many others have seen supporting it as a moral imperative, considering it as the best solution to the energy crisis and the best way to remove dependence on foreign oil, both of which have wide repercussions for the well-being of our society.

In this chapter we begin by exploring some general connections between morality and career decisions, stressing how one's work affects one's sense of self-worth as a professional and as a human being. We then move on to an examination of how engineering work is fragmented through separation by functions, how those who are affected (favorably or unfavorably) by engineered products also fall into different groups, and why it is important that engineers and their managers maintain a global, integrative outlook.

This book stresses the ethical issues faced by the employed engineer, but in this chapter we devote a section to the consulting engineer. The problems under discussion here are related closely to business practices; accordingly we cover some of what engineering ethics was all about several decades ago.

In a section on the responsibility of and to the profession we depart from our earlier emphasis on the individual engineer and his or her options as an autonomous ethical agent. Here we examine the role of the profession as a whole and its collective responsibilities.

The chapter ends with a short summary of the main themes we have presented in this book.

ETHICS AND VOCATION

At first sight it may seem odd to think of career decisions as having any special connection with morality. In choosing careers we consider prospects of job offers, advancement, security, salary, prestige, life style, personal challenge, and personal satisfaction. These factors apparently have more to do with prudence in seeking personal happiness than with morality.

Perhaps, as Kant thought, there is a kind of indirect moral duty to achieve our own happiness (Kant, 18). If we are depressed and unhappy, we may be unwilling to pursue our moral duties. Or as Erich Fromm, Abraham Maslow, and other recent humanistic psychologists have said, people are unable to be genuinely concerned about others if they are unable to care about themselves. But this line of thought would establish only a very tenuous connection between careers and morality.

Before identifying more direct connections, however, let us elaborate on the aspects of engineering mentioned above which relate to seeking personal happiness.

Existential Pleasures of Engineering

Happiness can be viewed, following Aristotle, as self-realization, rather than mere contentment (Aristotle, 1104). Self-realization, in turn, comes through the exercise of one's highest talents, interests, skills, and virtues. Within limits, the greater the complexity and challenge to one's talents, the greater one's happiness tends to be. Now engineering is a complex and challenging discipline. Moreover, the undergraduate curriculum for engineering is acknowledged to be more rigorous and difficult than the majority of academic disciplines. Combining these generalizations, we might guess that students are attracted to engineering at least in part because of the challenge it offers to intelligent people.

Do empirical studies back up this somewhat flattering portrayal? To a significant extent, yes. Typical students are motivated to enter engineering primarily by a desire for interesting and challenging work. They have an "activist orientation" in the sense of wanting to create concrete objects and systems—to make them and to make them work. They are more intelligent than average college students, although they tend to have a low tolerance for ambiguities and uncertainties which cannot be measured and translated into figures (Perrucci and Gerstl, *Profession Without Community: Engineers in American Society*, 27–52).

What is it that is so appealing and challenging in making technological products? Perhaps no one has so elegantly conveyed the excitement of engineering as Samuel Florman in his book *The Existential Pleasures of Engineering*. By "existential pleasures" Florman means deep-rooted and elemental satisfactions. He portrays engineering as essentially an attempt to obtain and apply an understanding of the universe so as to fulfill human needs and desires. This attempt calls forth some of the finest aspirations and deepest impulses of human beings.

The first existential pleasure Florman distinguishes resides in the act of personally changing the world. By nature, humans are compelled to improve the world. There is no end to the possibilities for achieving improvements, and the allure of "endless vistas bewitches the engineer of every era" (Florman, 1976, 120–121).

Changing the world brings with it the second type of existential pleasure: the joy of creative effort. This includes planning, designing, testing, producing, selling, constructing and maintaining. In contrast with the scientist's, whose main interest is in discovering new knowledge, the engineer's greatest enjoyment derives from creatively solving practical problems (Florman, 1976, 143).

Yet the engineer shares, as a third type of pleasure, the scientist's joy in understanding the laws and riddles of the universe. Both may experience "quasi-mystical moments of peace and wonder" (Florman, 1976, 141).

A fourth pleasure relates specifically to size in the world. The magnitude of natural phenomena—oceans, rivers, mountains, and prairies—both intimidates and inspires. In response, engineers conceive immense ships, bridges, tunnels, and other "mammoth undertakings [which] appeal to a human passion that appears to be inextinguishable" (Florman, 1976, 122).

A fifth pleasure relates to regularly being in the presence of machines. A mechanical environment can generate a comforting and absorbing sense of a manageable, controlled, and ordered world. "For a period of time, personal concerns, particularly petty concerns, are forgotten, as the mind becomes enchanted with the patterns of an orderly and circumscribed scene" (Florman, 1976, 137).

Concern for Humanity

Florman concludes his inventory of the existential pleasures of engineering with what he says is the primary and most important one of all: "a strong sense of *helping*, of directing efforts toward easing the lot of one's fellows" (Florman, 1976, 145). "The main existential pleasure of the engineer," he writes, "will always be to contribute to the well-being of his fellow man" (Florman, 1976, 147).

This paramount source of existential pleasure and motivation suggests one straightforward connection between morality and career decisions in engineering. Virtually every traditional characterization of the nature and goals of engineering has emphasized the contribution it makes to improving human life. This is not mere propaganda unrelated to what really concerns engineers on the job. The same theme is sounded in the personal testimony of many engineers as they reflect on what their careers have meant to them (Florman, 1976, 94–95).

This needs to be borne in mind when interpreting empirical studies of students' main motives for entering engineering. The technical challenge it offers is always seen by them against the background of participating in a socially useful and important enterprise. Engineering would not attract students if it were viewed by them as generally directed toward immoral ends.

Our interest here is in the possibility of this implicit background of moral concern becoming more explicit in thinking about career decisions. One might well ask what moral aims one's career has or might have. From such a perspective, ethics does not need to be viewed negatively as a burden or a constraint on one's career. Rather it offers positive ideals for expressing natural moral interests in concrete ways in one's professional life. We are led to consider what has been called the ethics, or moral philosophy, of vocation.

Philosophy of Vocation

William Frankena, a leading contemporary ethicist, has attempted to state the fundamental tenets of a moral philosophy of vocation. Four of his suggestive ideas may be summarized as follows (Frankena, 1976, 393–408).

First, according to Frankena, each person has the important duty of selecting a vocation. Most vocations are jobs which enable people to earn a living, whether or not a given individual needs the income from his or her job. But they are also, and more essentially, types of work which enable people to find senses of identity, personal worth, and meaning, and which promote feelings of contributing to the good of others. Thus the work of raising children qualifies as a vocation, even though in fact no income is usually obtained from it. Selecting a vocation is a duty, according to Frankena, both because of the moral importance of seeking self-fulfillment and because of the good that can be achieved for others through pursuing a vocation.

Second, vocations carry with them a set of specific duties. Fulfilling those is the main way in which a person fulfills the general duty of doing good for others. Utilitarians might say that the amount and kind of good one has a duty to produce is largely determined by the nature of one's vocation. This could be called "vocation-utilitarianism," in which good consequences are weighed largely in respect to the role of a vocation rather than in respect to individual acts (act-utilitarianism) or general rules (rule-utilitarianism).

Frankena is not a utilitarian, but as a duty ethicist he admits that one fundamental duty is the principle of beneficence: to create good and prevent harm. The amount of good people are obligated to create is partly determined by the nature of their vocations. This is because concrete moral obligations are specified in part by a direct appeal to professional duties, as well as by an appeal to foundational ethical theories. Presumably professional duties are themselves grounded in the more general ethical principles, as we have suggested throughout this book.

Third, while there is a duty to have a vocation, there is normally no specific vocation one is obligated to pursue. Rather, people should be free to select their own careers as an aspect of their autonomous self-expression. This is because both personal self-realization (what Frankena calls "the good life") and the morally good life are based on autonomous decision making.

Fourth, and last, there are objective considerations which ought to be weighed in making career choices. Most important are the prospects of happiness and self-fulfillment. One must ask which available vocation, or type of vocation, it would be rational to choose in order to best express one's main talents and basic interests. Also very important, however, are the moral values to which one is committed. For it is largely in and through one's vocation that those values will be expressed and realized.

These four tenets can be developed with respect to the choice of engineering as a vocation. No one is obligated to become an engineer, for that should be a matter of free personal decision. Yet the decision to enter engineering should be made on the basis of a searching assessment of one's talents and interests, and also on the basis of relating engineering to one's basic moral values.

Engineering involves a particular set of professional duties specified in terms of practical ways to prevent harm and promote good. A reasonable decision to enter engineering entails a prior weighing of those duties against one's general values and ideals. Does an engineering career promise an avenue for self-realization and is it compatible with one's moral concern?

Frankena's line of thought can also be extended to decisions about entering branches of engineering and areas of engineering work. To use an example already mentioned, people contemplating a career having to do with the development of nuclear energy ought to investigate the types of moral issues and dilemmas they might have to confront. A serious investigation may involve coursework related to the social ramifications of nuclear engineering.

This last point relates to the implications of a philosophy of vocation for education. Frankena says his views require that education be both liberal and vocational. It should be vocational in the sense of preparing people for the vocations he thinks they are obligated to pursue. But it should be a liberal arts education as well, in order to enable them to choose their vocations autonomously and with wisdom. Education should foster both self-knowledge and serious reflection upon the nature and function of values.

Work Ethics

Frankena's views provide the theoretical basis for what is commonly called a *work ethic*. This idea calls for comment. There is, in fact, no one work ethic. There are many different ones which different people embrace, and no doubt there are several morally legitimate and some unjustified perspectives on work (Cherrington, 1980, 19–30).

One version was identified by the sociologist Max Weber in *The Protestant Ethic and The Spirit of Capitalism*. The Protestant work ethic, according to Weber, provides the psychological explanation for the rise of modern capitalism. In brief, it was the idea that financial success is a sign that predestination has ordained one as favored by God. This was thought to imply that making maximal profits is a duty mandated by God. Profit becomes an end in itself rather than a means to other ends. It is to be sought rationally, diligently, and without compromise with other values.

Carried to an extreme, this idea can lead to the life and ideology of the workaholic. Whether out of religious or secular concerns, workaholics are compulsive overworkers. Their entire energies are devoted to work, to the point of unhealthy addiction. As with other addicts, workaholics are said to be pushed by uncontrolled and unconscious urges: anxiety, guilt, insecurity, or a sense of inferiority. As a result their behavior is irrational. They neglect their families, have few personal relationships not tied to their work, and seem unable to fill leisure time with meaningful activity. Death tends to come early, often from heart attack (Cherrington, 1980, 253–274).

Focusing on this irrational extreme should not lead to a rejection of the possibility of a reasonable work ethic. There is a difference between a compulsive workaholic and a healthy hard worker who also has a wide range of additional interests. Major professions, like engineering, make substantial demands upon those engaged in them which require the virtues of discipline, initiative, and keeping up to date in regard to knowledge and skills. To this extent professional ethics merges with a work ethic which emphasizes attitudes and virtues needed for fulfilling professional obligations.

Beyond this point, there is a range of general attitudes which may enter into an individual's personal work ethic. Several of those attitudes might be summarized as follows:

1 Work is intrinsically valuable to the extent that it is enjoyable or meaningful in allowing personal expression and self-fulfillment. Meaningful work is worth doing for its own sake and for the sense of personal identity and self-esteem it brings.

2 Work is the major instrumental good in life. It is the central means for providing the income needed to avoid economic dependence on others, for obtaining desired goods and services, and for achieving status and recognition from others.

3 Work is a necessary evil. It is the sort of thing one must do in order to avoid worse evils, such as dependency and poverty. But it is mind-numbing, degrading, and a major source of anxiety and unhappiness.

As we noted earlier, most people enter engineering for its inherent challenge. This presupposes that they seek a vocation warranting attitudes in the first category, although the second type of attitude is also important. They hope to find in engineering a vocation which evokes the pride and self-esteem of the craftsperson. Meaningful tasks are to be accomplished because of their intrinsic importance, not because a supervisor is watching.

Alienation, Integrity, and Self-Respect

Engineers, like all professionals and other workers, are vulnerable to periodic alienation from their work. To be alienated from one's work is to be separated from it in ways harmful to one's identity, integrity, and self-respect. Usually this involves painful feelings, such as depression, anxiety, anger, and hatred, although it can also occur without these emotions. Essentially it is the state of not identifying with what one does, not seeing the work as a personal expression of oneself.

The concept of *worker alienation* was introduced by Karl Marx (1818–1883) as part of his critique of capitalism. Alienation occurs when work becomes a commodity sold to an employer, rather than an expression of one's personal nature. Work becomes a humiliating "necessary" evil, as the third attitude above suggests.

> What constitutes the alienation of labor? First, that the work is *external* to the worker, that it is not part of his nature; and that, consequently, he does not fulfill himself in his work but denies himself, has a feeling of misery rather than well being, does not develop freely his mental and physical energies but is physically exhausted and mentally debased. The worker therefore feels himself at home only during his leisure time, whereas at work he feels homeless.... It is not the satisfaction of a need, but only a *means* for satisfying other needs (K. Marx, 98).

For Marx, work should be central to our identity—to our sense of who we are. The many hours invested in it should be experienced overall as evoking and developing our talents and highest potentials. Alienation from work activities instead leads to self-estrangement—to not being able to identify with ourselves insofar as we are our work. Furthermore, it is usually accompanied by two other forms of alienation: alienation from the product of our labor and from other workers. Product alienation is the inability to identify with and affirm the worth of the products or services we provide. Alienation from other workers means not identifying with other human beings engaged in related activities. Whereas fulfilling work involves seeing oneself embodied in the products of one's labor and also feeling a part of a group effort in which one is unified with other workers, alienation severs these connections with the physical world and with the community of workers.

Marx argued that alienation from products, productive activity, and other workers was an inevitable result of capitalism with its emphasis on consumerism and mass accumulation of private property and power in the hands of the middle class. In our view, these claims had some plausibility from the perspective of nineteenth-century industrial society, in which worker exploitation was widespread. Today, however, the sources of worker alienation are more complex, and are apparent in communist societies as well, although Marx's clarification of the concept of alienation is still useful.

Certainly one major cause of worker alienation involves morality: a gap between one's fundamental moral values and work. This is a loss of moral integrity—a loss of the unity of moral concern in one's life. It occurs when work becomes flagrantly cut off from one's primary moral ideals. Thus, persons committed to a humane world where people show concern for other people will experience a loss of moral unity in their lives when they spend their working hours manufacturing needlessly polluting and hazardous plastics for use in making dangerous toys (Nielsen, 1987). This will also bring lowered self-respect, that is, a lessened sense of one's own worth as a human being.

Most alienation arises on a smaller scale and may be temporary as one rethinks particular roles and job assignments that threaten one's integrity. This rethinking is a periodic need for all professionals concerned with maintaining a sense of self-respect throughout a career. It is made complicated by the fact that few (if any) jobs allow a perfect mesh between one's personal ideals and one's work activities. Most professionals testify that some *compromise* is an inescapable, and even desirable, aspect of their careers.

"Compromise" can mean two things. In one sense it means to undermine integrity by violating one's fundamental moral principles. In another sense, the one intended here, it means to settle differences by mutual concessions or to reconcile conflicts through adjustments in attitude and conduct. In this sense, compromises are sometimes good and sometimes bad. They may be reasonable ways to sustain relationships in the face of deep differences, or valuable ways to carry on with a life in the face of hardship and difficulty. Or they may lead to so severe a conflict between the working and private life that the engineer had better seek work elsewhere.

Models of Professional Roles

Models and metaphors often serve to organize thinking and crystallize attitudes. It was with this in mind that we earlier suggested the model of engineering as social experimentation and the engineer as an experimenter. Many other models have been advocated in connection with the social and moral roles of engineering and engineers. In concluding this section, we list some of those models which at times have seemed attractive to some engineers. We leave for a study question the assessment of the models in connection with thinking about career goals. Those who wish to examine the influence of several of them in the first half of this century are referred to Edwin Layton's masterful study *The Revolt of the Engineers*.

1 *Savior*. Plato believed a philosopher-king was needed in order to create the ideal society. Others have believed that engineers hold the key to creating a utopian society. In part this is to be achieved through technological developments which lead to material prosperity. In part it is to arise through creation of a technocracy in which engineering ways of thinking are applied to large-scale social planning. The representative engineer is a savior who will redeem society from poverty, inefficiency, waste, and the drudgery of manual labor.

2 *Guardian*. Perhaps engineers cannot usher in utopia. Yet it is they who know best the directions in which, and pace at which, technology should develop. Accordingly, they should be given positions of high authority based on their expertise in determining what is in the best interests of society (Veblen, 1965, 52–82).

3 *Bureaucratic servant*. Within the corporate setting in which engineers work, management should make the decisions about the directions of technological development. The proper role of the engineer is to be the servant or handmaiden who receives and translates the directives of management into concrete achievements. The engineer is the loyal organization man or woman whose special skills reside in solving problems assigned by management, within the constraints set by management.

4 *Social servant*. The role of engineers lies exclusively in obedient service to others, but their true master is society. Society expresses its interests either directly through purchasing patterns, or indirectly through government representatives and consumer groups. Engineers in cooperation with management have the task of receiving society's directives and satisfying society's desires.

5 *Social enabler and catalyst*. This is a variation on model 4. Service to society includes, but is not exhausted by, carrying out social directives. Ultimate power and authority lie with management, but nevertheless the engineer plays a vital and active role beyond mere order-following. Sometimes engineers are needed to help management and society understand their own needs and to make informed decisions about desirable ends and means of technological development (Fruchtbaum, 1980, 258).

6 *Game player*. Engineers are neither servants nor masters of anyone. Instead they play by the economic game rules that happen to be in effect at a given time. Their aim, like that of managers, is to play successfully within organizations, enjoying both the pleasures of technological work and the satisfaction of winning and moving ahead in a competitive world (Maccoby, 1978).

Study Questions

1 The following widely discussed case study was written by a leading British philosopher, Bernard Williams. While the case is about a chemist, the issues it raises are equally relevant to engineering.

> George, who has just taken his Ph.D. in chemistry, finds it extremely difficult to get a job. He is not very robust in health, which cuts down the number of jobs he might be able to do satisfactorily. His wife has to go out to work to keep [i.e., to support] them, which itself causes a great deal of strain, since they have small children and there are severe problems about looking after them. The results of all this, especially on the children, are damaging. An older chemist, who knows about this situation, says that he can get George a decently paid job in a certain laboratory, which pursues research into chemical and biological warfare. George says that he cannot accept this, since he is opposed to chemical and biological warfare. The older man replies that he is not too keen on it himself, come to that, but after all George's refusal is not going to make the job or the laboratory go away; what is more, he happens to know that if George refuses the job, it will certainly go to a contemporary of George's who is not inhibited by any such scruples and is likely if appointed to push along the research with greater zeal than George would. Indeed, it is not merely concern for George and his family, but (to speak frankly and in confidence) some alarm about this other man's excess of zeal, which has led the older man to offer to use his influence to get George the job.... George's wife, to whom he is deeply attached, has views (the details of which need not concern us) from which it follows that at least there is nothing particularly wrong with research into CBW. What should he do? (Williams, 97–98)

In defending your answer, make reference to several ethical theories, including act-utilitarianism and virtue ethics.

2 Do you agree with Frankena that there is a duty to have a vocation, in his sense of the term "vocation"? Respond to the criticism that individuals have a moral right to do whatever they want with their lives, as long as they do not hurt others, and that this makes it all right for people who inherit wealth not to have vocations.

3 Formulate a work ethic which expresses your own attitudes about work.

4 Assess the positive and negative implications of each of the following models for engineers: savior, guardian, bureaucratic servant, social servant, social enabler and catalyst, and game player. Which best captures the type of engineer you would like to be or would like engineers to be? Develop your answer, tracing its social implications, by applying the model(s) to one of the main topics discussed in the last chapter: multinational corporations, environmental ethics, computer ethics, or weapons development.

5 Read and report on "Individual Choices: What You Can Do," Chapters 8-11 in *Career Development for Engineers and Scientists* by Morrison and Vosburgh (1987).

OVERCOMING FRAGMENTATION

Engineers can be classified by the products they create as chemical, civil, electrical, or mechanical engineers, and so on. This is also the way they are educated, certified, and grouped in major professional societies. More important for our purposes is a division of engineers by function, because it is within their functions and where those functions overlap that engineers face most of their ethical dilemmas. This division, which is practiced by most engineering organizations, can also result in a fragmentation of awareness to the point where few engineers retain a global outlook on their products and on the settings in which these products will be put to use.

A classification according to function will typically divide engineering activities into design, manufacture, operation, and phase-out. These are listed as column headings in Table 8-1. In our tabulation the design function incorporates research, development, de novo design, and modification of earlier designs. Manufacturing also includes repair, while operation of equipment includes maintenance and periodic inspection. We have left out sales engineering because the ethical issues associated with it are generally not unique to engineering. Service or field engineers are not listed separately because their main activities of maintenance and repair are subsumed under operation and manufacture. On the other hand, Table 8-1 introduces an activity rarely seen as a separate classification: phase-out. We have added it because of the growing need for planning orderly shutdown of major projects. This can include such tasks as decommissioning a nuclear power plant, stocking spare parts for a popular product which is being replaced by a newer model, and disposing of toxic substances which are the by-product of a manufacturing process or which leave the plant as an inherent component of the product.

Orthogonally to the ordering by function or activity one could also classify engineers according to the mix of clients and employers they serve, yielding groups such as industry engineers, public works engineers, consulting engineers, teaching engineers, and so forth. We have chosen instead to concentrate on a broader classification by groups of people which are affected by engineering projects. These are the parties interested in the safe progress and outcome of a project. The Table 8-1 row headings list these groups. First there are the workers in the manufacturing plant or on the construction site. They can be hurt by unsafe equipment, collapsing structures, and toxic substances. But they are not users of the product as yet. The user/client is listed next, also any worker employed by the user/client who operates or is exposed to the engineered product. The user can be an active consumer (homemaker, hobbyist, or car owner or driver) or a passive consumer (an air traveler who has little choice as to the particular plane being used). Finally we have the "innocent" bystanders: people and the environment. The environ-

TABLE 8-1

A TAXONOMY OF MALFUNCTIONS, THEIR CAUSES AND EFFECTS

Affected party		Origin of deficiency			
		1 Design	2 Manufacture	3 Operation	4 Phase-out
A	Worker (Production/ construction)	(a) Mechanization (314) (b) Chernobyl (151)	(a) Milford Haven (66) (b) Quebec Bridge (114)	(a) Grain silo (118) (b) Train wrecks	Radioactive isotopes (78)
B	Active consumer (Client's worker)	(a) Sugar mill (315) (b) Ford Pinto (143)	(a) Heart valve (315) (b) Oil rig (118)	(a) *Challenger* (185) (b) TMI (146)	Spare parts shortage
C	Passive client (No choice)	(a) DC-10 (43) (b) *Titanic* (63)	Building collapse (313)	Transport (air, land, sea)	Declining water quality (318)
D	Bystander (Near or distant)	Loss of privacy through data bank	(a) Buffalo Creek (102) (b) Molasses (277)	(a) Bhopal (258) (b) Police file (282)	(a) Air pollution (b) Love Canal (315)
E	Nature (Fauna, flora, view)	(a) Everglades (269) (b) Eiffel Tower (315)	Loss of topsoil to development	(a) Acid rain (264) (b) Ozone layer (265)	(a) River pollution (b) North Sea (315)

Examples described in the text are followed by parentheses in which the respective page numbers are indicated. The other examples are mentioned in this chapter or are self-explanatory.

ment stands for nature and the rights of future generations for a livable natural world.

A Taxonomy of Malfunctions

Most engineering projects are successful and serve their purposes well without malfunctions or adverse effects on the social and natural ecologies. Among those that fail, the majority fail safely without hurting people physically (though possibly financially) because defects are being caught early on through periodic checks—which are part of the monitoring responsibility of engineers as experimenters. Listed as entries in Table 8-1 are engineering projects (experiments) which failed because of insufficient knowledge (gaps in the state of the art), lack of concern for safety, or too much concern for institutional posture and profit.

Each malfunction is related to the activity primarily responsible for its occurrence by the column in which it appears, and to the group of people affected (interested party) by its row. The examples used are from cases which appeared earlier in this book or which will be explained briefly below. They include both dramatic and everyday failures.

The construction industry has gathered interesting data on the causes of structural failures. A study by the Building Research Association (Great Britain) revealed that 58 percent of failures could be attributed to faulty design and 35 percent to faulty execution. Other reasons (note that there is some overlap between these and the former two) were that materials or components failed to meet accepted standards (12 percent of cases) and that users expected more than the designers had anticipated (11 percent of cases) (Ransom, 1981).

Another study, performed at the Swiss Federal Institute of Technology in Zurich (ETH), indicated that the causes of 800 structural failures—responsible for 504 deaths and 592 people injured—were primarily the results of "human mistakes, errors, carelessness, and so on. . . ." Where engineers were at fault the causes were mostly insufficient knowledge (36 percent), underestimation of environmental influence (16 percent), ignorance, carelessness, and/or negligence (14 percent), forgetfulness and/or error (13 percent), and relying upon others without sufficient control (9 percent) (Matousak, 1977, cited in Florman, 1987, 102–103).

The uncertainties which led us to propose our model of engineering projects as experiments are reflected in the studies cited above by the categories of insufficient design knowledge (but not plain ignorance), unexpected influences of application and environment, and variations in materials. The human failings, such as ignorance, negligence, carelessness, forgetfulness, and errors reflect a certain lack of "virtue" which managers sensitive to the issues could correct by good supervision of technical tasks and training so as to turn safety concerns into a habit.

Before we further examine the entries in Table 8-1, we should mention that the classifications we have adopted have a certain arbitrariness in that clear boundaries between functions cannot be drawn except on organization charts. But it is precisely because such artificial, institutional boundaries exist in industry, where they are supposed to provide efficient division of labor and make managing easier, that we have drawn them here as well. To some extent the same can be said about the classifications outlined in the rows in Table 8-1. There the arbitrariness stems from our desire to avoid clutter in the table.

A Look at the Examples

In the following we shall refer to entries in Table 8-1 by row-column-position. We begin with the examples labeled "Mechanization" (A-1-a) and "Sugar Mill" (B-1-a) in the left upper part of the tabulation and then move directly to "Love Canal" (D-4-b) and "North Sea" (E-5-b) in the lower right corner. This will take us from one of the earliest cases in the industrial revolution to one of the currently pressing problems.

The introduction of machines into the textile industries of England created angry reaction from those who saw their jobs, livelihoods, and ways of life (hard but free) threatened. Here are the numbers reported in the British Parliamentary Papers of 1840 of the men replaced by various textile machines. Spinning jenny: 9 of 10 warp spinners and 13 of 14 weft spinners; scribbling engine: 15 of 16 scribblers; gig mill: 11 of 12 shearmen; shearing frame: 3 of 4 shearmen. The effect on the communities can be fathomed only when one reads that scribblers constituted about 10 percent of the preindustrial adult work force and shearmen about 15 percent (Randall, 1986). Early and continuing opposition known as the Wiltshire Outrage was followed by the more forceful tactics of the Luddites in Yorkshire. The workers and the textile mill owners both insisted on the moral foundations of their respective positions, but the execution of some of the followers of the legendary Ned Ludd showed who had the power. In addressing the problem of Ludd's destruction of frames, Lord Byron asked Parliament in 1812: "Can you commit a whole country to their own prisons? Will you erect a gibbet in every field, and hang up men like scarecrows?" (Quoted by Winner, 1977, 127)

Today the methods of maintaining industrial peace have improved, but the debate continues as computers and robots take over many routine jobs. In the long run the lot of the worker should improve, but little is done to remedy the short-term dislocations which hurt many communities because too few employers assume any responsibility for such matters. Another area in which early industrial technology exacted a great price was in work-related injuries. At first they were ignored because there was an unlimited supply of labor. The second step was to do everything possible to prevent injuries from slowing production. It is said that in eighteenth-century Caribbean sugar mills, axes were kept ready "to amputate a slave's arm should he be caught in the inrunning nip point of the rollers used to crush the sugar cane"

(Roberts, 1984). In England, where children's working conditions were regulated in 1802, safety guards on belt transmissions were not required until 1844.

Slowly those threats which could be perceived by our senses were contained, until today we are finally addressing the problem of toxic wastes, which escape easy detection or jurisdiction. Examples are the Love Canal case and North Sea pollution. Around 1946 the Hooker Chemical Co. stopped depositing pesticide wastes in a landfill which was subsequently sold. In the early 1970s it was found that 82 different chemicals were leaking from their buried 55-gallon drums into the basements of houses which had been built on the landfill. This situation gave rise to a major controversy because of uncertainty as to the extent of damage, questions regarding responsibility for resettlement, and withholding of information. With respect to the latter it was revealed that Hooker officials had learned of leakages as early as 1958—by which time the land had been sold to the Niagara Falls school board—but claimed they did not want to subject the new owner to any litigation. The North Sea, meanwhile, is being polluted by the effluents carried into it by many rivers, some of which pass through several countries where they pick up toxic wastes. Jurisdictional difficulties led the adjoining countries to adopt in 1987 an informal compact to do the best they can to reduce further deterioration.

The Eiffel Tower (E-1-b) is listed as a scenic despoiler only to remind us that tastes will differ. When it was built, many Parisians consoled themselves with the thought that it would not last longer than 20 years. De Maupassant disliked the tower but often ate in its restaurant (although the food was not good) because "it's the only place in Paris where I don't have to see it" (Meisler, 1987). Today no one would think of demolishing the Eiffel tower except for safety reasons.

"Heart Valve" (B-2-a) refers to a widely used, and initially very successful, mechanical heart valve developed and manufactured by Shiley Inc. (now part of Pfizer). The valve has a tilting disk which is held in place by two metal struts. In 147 patients a strut has broken, preventing normal operation of the valve; death has resulted in 65 percent of the cases where this has happened. The strut breaks at a weld that would be unnecessary if both struts were fabricated as a single piece. Statistically the risk of strut fracture is less than the risk of death from surgery to replace a valve, but this is not much of a consolation for valve implant recipients. It is also unsettling for them to know that problems were recognized a long time before this type of valve was withdrawn (Steinbrook, 1985).

One interesting case for which there is no suitable slot in Table 8-1 is that of the stun gun. The stun gun is used by police in place of a club or firearm to subdue suspects who resist arrest. It produces an electric shock wherever it touches the victim's body. Unlike the laser gun, which administers a single shock via a projectile connected to a conducting wire, the stun gun is capable of repeated discharges. While this nonlethal weapon was at first welcomed by most legal and law enforcement professionals, there are now second thoughts after reports of its misuse as a device of torture. We mention this example to underline two facts: (1) no arrangement of things or activities can encompass all of them satisfactorily and (2) there are many more examples than we can possibly cover. They are left for the reader to find in the current and archival literature.

Global View: A Management Priority

An examination of Table 8-1 reveals that malfunctions of engineered products or systems can originate in one or more engineering functions and can affect one or more groups of people. Where the errors will occur and who will be hurt cannot be predicted easily. It is therefore necessary that engineers and their managers adopt a broad outlook which permits them to scan the totality of activities within the manufacturing establishment, as well as outside the establishment among the users and the general public.

We have already referred to the arbitrariness in the lines of demarcation between the columns and rows of Table 8-1. It is one of the important roles of engineering management to remove these boundaries as much as possible. All too often, engineers in design are isolated from engineers in manufacturing and sales; all too often, the architect-engineer is not represented at the construction site. Only firms with project-oriented teams show some promise of integration. And even then their view of the product environment is frequently too narrowly focused on the client's point of view, allowing scant attention to the interests of other parties who may be affected by the product.

Earlier we mentioned management's responsibility for creating a work environment in which the "virtues" of engineering can blossom: responsibility, acquisition of knowledge, truthfulness, and so forth. Here we urge management to take on a more difficult, but also more structured duty—the duty to provide overall integration of the processes leading from design to manufacture to operation of a product, an integration which results in fewer serial and more parallel operations. Engineers must be given the opportunity to reach beyond their cubicles so safety concerns can be looked at jointly and passed on more naturally. Otherwise one has a situation similar to what happens when different regulatory agencies share responsibility over a product but act independently (see Study Question 12, p. 145).

Fortunately many engineers see the need for wider concerns. If they find safety issues that need addressing, they must be provided the avenues for bringing them to the attention of management at whatever level necessary to get action. In many organizations there are ombudspeople to provide such access. Procedures of this type serve prudential ends as well, since they "not only protect management from lawsuits, but also help it retain capable, ethical employees" (Matley et al., 1987).

We do not consider it sufficient, however, merely to enact organizational changes to remedy failure-proneness. Structural changes could be necessary but may not be sufficient. When we asked what might be amiss in academe when so many professors are aware of or suspect scientific fraud in some of their colleagues' work (Study Question p. 224), we did not intend to single out that profession. As Matley and coauthors found through a survey of chemical engineers (Matley et al., 1987), 16 percent of respondents admitted to having done something unethical in their work, but 49 percent indicated knowing of others who did. Engineers should feel free to actively participate in the reduction of ethical problems where they exist, and management must give them the opportunity to do so.

Optimization

It is often said that engineers can do for ten dollars what everyone else can do for a thousand. In other words, engineers not only provide needed products and services, they do so at the best possible price. "Price" should be seen as a conglomerate of attributes: monetary value, safety, reliability, aesthetics, and other performance criteria. Not all desiderata can be met simultaneously. When engineers practice "optimization," it is therefore not the single-minded pursuit of a narrow goal but a search for the best possible solution under constraints imposed by society and nature.

One of the greatest dangers in engineering is suboptimization. This is the practice of finding the best solution for only part of the problem. Such a solution may force the rest of the problem into a less than satisfactory solution mode. It is the habit of suboptimization which is partly responsible for the saying that engineers find all the right answers to the wrong problems. It is our view that the kind of management which integrates engineering functions and assesses the effects of an engineered product on the social and natural ecologies is best suited to combat the suboptimization habit. Allowing its professional employees to adopt a global outlook which detects more than the obvious constraints should be one of management's top priorities.

Let us dwell a moment on the subject of constraints. A number of constraints were discussed implicitly in earlier chapters. Safety is one of them. It should be recalled that an important feature of a safe product or system is its feature for safe exit of workers, users, or innocent bystanders. Another constraint had to do with the disposal of harmful wastes which accrue during manufacture or use. We have also pointed to economic loss as a possible effect of product malfunction. It must not be overlooked since loss of livelihood can be as hurtful as (and lead to) loss of health. The level of acceptability which sets the limit in a constraint inequality (say, speed to be no greater than 65 mph) must be established with the consent of those who become the human subjects of the experiment.

The two constraints which we have not emphasized so far have to do with the natural environment. The world's resources are limited. Even if there seems to be enough around for us now, the rising expectations of developing nations will lead to stiff competition later on. We cannot always count on a technofix which will get us out of a bind through new discoveries or inventions. If nothing else, wasteful use of raw materials and depletable energy sources now will drive their prices unaffordably high for future generations.

Drawing on nature's bounty should be viewed as an economic experiment, or as the economic portion of an engineering experiment. Part of the experimental procedure would be to regard natural resources as capital rather than as commodities (Schumacher, 1973). When it comes to water, we often regard it only as a readily available service. The case of water introduces another type of constraint which must not be overlooked: what is abundantly available and of good quality now may not be so in the future. Water, for instance, may remain available in a given location, but it may become unusable in the future because of poor quality. This is happening to some groundwater basins.

Another aspect of the economic model is life-cycle cost. *Life-cycle cost* includes the cost of operation and maintenance over the life of the product and the cost of its disposal afterwards. All this may be difficult to calculate when exact interest figures are not available, but there is no excuse for leaving out of consideration those costs or constraints which cannot be evaluated easily. It is appropriate to mention in this connection the need to internalize the costs of pollution, waste production, and other side effects which burden the social and natural ecologies. All too often they are not ascribed to the process which produced them—i.e., they are not counted as part of the total cost for that process.

The human-centered view of nature as a treasure trove into which we may dip at pleasure to satisfy all our wants is of Faustian dimensions. Faust's deal with the devil provided for satisfaction now, payment later. Goethe's version of Faust has been described as an alchemistic drama from beginning to end (C. G. Jung, 1946). The economist Binswanger has successfully interpreted Goethe's drama as a critique of our economic system which strives for constant expansion. In the first part of the play, the alchemist Mephistopheles (the devil) provides Faust with the golden drink (the love potion) which rejuvenates him, but love turns out to have only momentary and not lasting value. In the second part of the drama, Faust finally achieves satisfaction through a land reclamation project of major proportions (complete with risks of flooding) through the machinations of Mephistopheles who opens the way to mortgaging the future for present gain. The present gain is capital—in the form of paper money. "To accomplish this one needs the vision of the inventor, the engineer, the entrepreneur, who through new ideas, projects,and investments changes the world to make it an object of trade and monetary value" (Binswanger, 1985). Here Binswanger speaks of the modern alchemist. Too late Faust realizes that he has created a future in which there is no room for concern and caring.

A final set of constraints—one which should remain in clear view and never be hidden—is composed of standards, rules, and laws. These constraints should be interpreted broadly and adhered to in their intended spirit.

The minimalist's view that no more should be done than absolutely required cannot ensure true safety and will eventually breed more, stricter, and less palatable regulations. Once again we encounter a cost which should be taken into account now but is forgotten until it haunts us later.

Optimization under constraints is not unlike reaching the best possible compromise with society and nature acting as your "adversary." A compromise in which hidden conditions are overlooked is not a good compromise. So it is with optimization when it turns into suboptimization because competing objectives or constraints have been neglected.

Study Questions

1 Are there any entries (examples) in Table 8-1 which are misplaced or for which you can offer better sample cases?

2 How do you think engineering education does, or should, prepare engineers to think globally? Are the prescriptions laid out in this section unrealistic? Too stiff or too ambiguous? In a student's program, what is the proper allocation of effort to analysis, design, experimentation, and nontechnical subjects? Discuss this with professors, other students, and practicing engineers.

3 Discuss what were (seem to have been and should have been) the criterion of optimality and the set of constraints in one of the following projects: space shuttle *Challenger*, Ford Pinto, St. Lawrence Seaway (not discussed in this book), or a case selected by you.

4 Select and discuss an engineering product or service that appears to have been "suboptimized."

5 Alasdair MacIntyre says that law should be used only as a last resort. Continuous resort to law is a sign that some deeper moral relationship has broken down (A. MacIntyre, 1980). At what level of law (standards, regulations, statutory law, litigation) would you say this applies to engineering?

CONSULTING ENGINEERING

Consulting engineers operate in private practice. They are compensated by fees for the services they render, and not by salaries received from employers. Because of this, they tend to have greater freedom to make decisions about the projects they undertake. Yet their freedom is not absolute: They share with salaried engineers the need to earn a living.

Here we will raise questions in four areas—advertising, competitive bidding, contingency fees, and provisions for resolution of disputes—which illustrate some of the special responsibilities of consulting engineers. We will also note how in safety matters consulting engineers may have greater responsibility than salaried engineers, corresponding to their greater freedom.

Advertising

Some corporate engineers are involved in advertising because they work in product sales divisions. But within corporations, advertising of services, job openings, and the corporate image are left primarily to advertising executives and the personnel department. By contrast, consulting engineers are directly responsible for advertising their services, even when they hire consultants to help them.

Prior to a 1976 Supreme Court decision, competitive advertising in engineering was considered a moral issue and was banned by professional codes of ethics. As in law and medicine, anything beyond a tasteful notification of the availability of one's services was thought to be "unprofessional." It was deemed unfair to colleagues to win work through one's skill as an advertiser rather than through one's earned reputation as an engineer. It was also felt that competitive advertising caused friction among those in the field and lessened their mutual respect and that vigorous advertising damaged the profession's public image by placing engineering on a par with purely money-centered businesses.

However, the Supreme Court disagreed with that view. According to its ruling, as well as other rulings by the Federal Trade Commission, general bans on professional advertising are improper restraints of competition. They serve to keep prices for services higher than they might otherwise be, and they also reduce public awareness of the range of professional services available.

These rulings have shifted attention away from whether professional advertising is moral or not toward whether it is honest or not. Deceptive advertising normally occurs when products or services are made to look better than they actually are. This can be done in many ways: (1) by outright lies, (2) by half-truths, (3) through exaggeration, (4) by making false innuendos, suggestions, or implications, (5) through obfuscation created by ambiguity, vagueness, or incoherence, (6) through subliminal manipulation of the unconscious, etc. (Leiser, 1979).

There are notorious difficulties in determining whether specific ads are deceptive or not. Clearly it is deceptive for a consulting firm to claim in a brochure that it played a major role in a well-known project when it actually played a very minor role. But suppose the firm makes no such claim and merely shows a picture of a major construction project in which it played only a minor role? Or, more interestingly, suppose it shows the picture along with a footnote which states in fine print the true details about its minor role in the project? What if the statement is printed in larger type and not buried in a footnote?

As another example, think of a photograph of an engineering product (say, an electronics component) used in an ad to convey the impression that the item is routinely manufactured and available for purchase, perhaps even "off the shelf," when in actuality the picture shows only a preliminary prototype or mockup and the item is just being developed. To what extent, then, should the buyer—as the subject or participant of an "experiment" conducted by the manufacturer—be protected from misleading information about a product?

Advertisers of consumer products are generally allowed to suppress negative aspects of the items they are promoting and even to engage in some degree of exaggeration or "puffery" of the positive aspects. Notable exceptions are ads for cigarettes and saccharin products, which by law must carry health warnings. By contrast, norms concerning the advertising of professional services are much stricter. For example, the code of the National Society of Professional Engineers (NSPE) forbids all of the following:

> ...the use of statements containing a material misrepresentation of fact or omitting a material fact necessary to keep the statement from being misleading; statements intended or likely to create an unjustified expectation; statements containing prediction of future success; statements containing an opinion as to the quality of the Engineer's services; or statements intended or likely to attract clients by the use of showmanship, puffery, or self-laudation, including the use of slogans, jingles, or sensational language format (*NSPE Code of Ethics*, Sec. 3b).

Is there sufficient warrant for these tougher restrictions? Do they perhaps suppress vigorous competitive advertising which could be beneficial to the public? How are reasonable restrictions on the manner of advertising to be justified in terms of ethical theories? These are questions which deserve to be addressed within engineering ethics.

Active solicitation of clients through advertising or personal contacts has been considered especially unprofessional when it takes work away from other engineers. Yet here again one may ask whether some degree of solicitation serves the public interest by encouraging healthy competition. The dangers of allowing it, of course, must also be weighed carefully. Does it open the door to those who are dishonest and who might in very subtle ways unfairly criticize the work of other engineers whom they seek to supplant, or to those who might exaggerate the merits of their work? Certainly strong restrictions on misleading advertising in this area are especially important.

Competitive Bidding

For many years codes prohibited consulting engineers from engaging in competitive bidding, that is, from competing for jobs on the basis of submitting proposed fees. The following statement, for example, formerly appeared in the code of the American Society of Civil Engineers:

> It shall be considered unprofessional and inconsistent with honorable and dignified conduct and contrary to the public interest for any member of the American Society of Civil Engineers to invite or submit priced proposals under conditions that constitute price competition for professional services (quoted in Alger, Christensen, and Olmsted, 1965, 35).

It was considered permissible for industrial and construction firms to use competitive bidding because they could formulate cost estimates with some accuracy based on fixed design specifications. By contrast, the job of the consulting engineer is generally to develop creative designs for solving novel problems. Often there is no way to make precise bids. Allowing competitive bidding in such cases, it was felt, would open the door to irresponsible engineering in that inaccurate bids would encourage either cutting safety and quality (in the case of low bids) or padding and overdesigning (in the case of high bids).

However, in 1978 the Supreme Court ruled that professional societies were unfairly restraining free trade by banning competitive bidding. The ruling still left several loopholes, though. In particular, it allowed state registration boards to retain their bans on competitive bidding by registered engineers. It also allowed individual consulting firms to refuse to engage in competitive bidding. Thus fee competition where creative design is involved has remained a lively ethical issue. Is it in the best interests of clients and the public to encourage the practice?

If the use of competitive bidding is widely rejected by engineering firms, clients will have to rely almost exclusively on reputation and proven qualifications in choosing between them. This raises the problem of how the qualifications are to be determined in an equitable way. Is the younger, but still competent, consulting engineer placed at an unfair disadvantage? Or is it reasonable to view this disadvantage as justifiable, given the general importance of experience in consulting work?

Contingency Fees

Consulting engineers play the primary role in making arrangements about payment for their work. Naturally this calls for exercising a sense of honesty and fairness. But what is involved specifically?

As one illustration of the kinds of problems which may arise, consider the following entry in the code of the National Society of Professional Engineers:

> An Engineer shall not request, propose, or accept a professional commission on a contingent basis under circumstances in which his professional judgment may be compromised, or when a contingency provision is used as a device for promoting or securing a professional commission (*NSPE Code of Ethics*, Sec. 11b).

A *contingency fee* or *commission* is one which is dependent upon some special condition beyond the normal performance of satisfactory work. Typically, under a contingency-fee arrangement the consultant is paid only if she or he succeeds in saving the client money. Thus a client may hire a consultant to uncover cost-saving methods which will save 10 percent on an already contracted project. If the consultant does not succeed in doing so, no fee is paid. The fee may be either an agreed-upon amount or a fixed percentage of the savings to be realized.

In many contingency-fee situations it is easy for the consultant's judgment to become biased. For example, the prospects of winning the fee may tempt the consultant to specify inferior materials or design concepts in order to cut construction costs. Hence the point of the NSPE code entry. But even allowing for this problem, is the thoroughgoing ban on such fees in the NSPE code warranted? There is, after all, a point to their use. They are intended to help stimulate imaginative and hopefully responsible ways of saving costs to clients or the public, and presumably this consideration deserves some weight.

Resolving the issue calls for balancing out the potential gains against the potential losses that result from allowing or banning the practice. In this respect it is like many other issues in engineering ethics which call for reasonable judgments based on both past experience and foresight. And philosophical ethical theories can be useful in making those judgments by providing a general framework for assessing the morally relevant features of the problems under consideration.

Safety and Client Needs

The greater amount of job freedom enjoyed by consulting engineers as opposed to salaried engineers leads to wider areas of responsible decision making concerning safety. It also generates special difficulties.

Very often, for example, consulting engineers have the option of accepting or not accepting "design-only projects." A design-only project is one where the consultant contracts only to design something, but not to have any role—even a supervisory one—in its construction. Design-only projects are sometimes problematic because of difficulties encountered in implementing the designing engineer's specifications and because that engineer is often the only individual really well qualified to identify the areas of difficulty (Alderman and Schultz, 8–12). For example, clients or contractors may lack adequately trained inspectors of their own. In fact, when novel projects are being undertaken, clients may not even know that their own inspectors are unsatisfactory. Again, a contractor may be unable or unwilling to spot areas where the original design needs to be modified so as to best serve the client. The designer is often the person best able to ensure that the client's needs are met, as well as the safety needs of the project, yet he or she may not be around to do so.

The importance of having the designer involved in on-site inspection is illustrated by the following example:

> An engineering firm designed a flood control project for the temporary retention of storm water in a nearby city. Included in the project were some high reinforced concrete retaining walls to support the earth at the sides of the retention basin. Although the consulting engineer had no responsibility for site visits or inspection, one of the designers decided to visit the site, using part of his lunch hour to see how it was progressing. He found that the retaining wall footings had been poured and the wall forms were placed. He was shocked, however, to find that the reinforcing steel extended from the footings into the walls only a small fraction of the specified distance. He immediately returned to his office and the client was notified of the situation. The inspectors responsible were disciplined and correc-

tive measures taken with respect to the steel reinforcement. There is no question that in the first heavy rain the walls would have collapsed had the designer not discovered this fault. The result would have been heavy property loss, waste of resources, environmental damage and possible injury, even loss of life (Alderman and Schultz, 11).

It is thus a significant area of inquiry to determine when consulting engineers should or should not accept design-only projects. And when they do accept them, are they not obligated to make at least occasional on-site inspections later, in order "to monitor the experiment" they have set in motion? That is, are there at least some minimal moral responsibilities in this context which reach beyond the legal responsibilities specified in the contract?

In the course of making on-site inspections consulting engineers may notice unsafe practices which endanger workers. For example, they may notice the absence of a sufficient number of secondary support struts for a building or bridge. They may know from their past experience that this could cause a partial collapse of the structure while construction workers are on the job. Of course job safety is the primary responsibility of the contractor who has direct control over the construction. Yet for the consultant to do nothing would be negligent, if not callous. But how far do the consultant's responsibilities extend? Is a letter to the construction supervisor sufficient? Or is the consultant morally required to follow through by checking to see that the problem is corrected? It should be noted that an engineer who does point out construction deficiencies on one occasion—even if not contractually required to—but refrains from doing so on other occasions can be held liable for complicity in any damages resulting from unreported deficiencies. (Review Study Question 3, pp. 50-51.)

Provision for Resolution of Disputes

Large and complex engineering projects involve many participants at different levels of responsibility within the organizations representing the owner, the consulting engineer, and the construction firm. Overlapping responsibilities, fragmented control, indecision, delays, and an inability to resolve disputes quickly and amicably characterize many projects. To forestall potential liabilities in such situations, the various parties involved usually devote much time to protecting themselves when it could more profitably be used to improve the quality of the project. Resolution of disagreements is made more difficult when construction lasts several years and personnel changes occur during that period, because mutual trust and understanding are not easily nurtured under such conditions.

It has been observed by engineers engaged in construction projects that

> ...owners often initiate polarization from the outset by placing liability on engineers, vendors, and constructors without categorization or regard to which, or under what conditions faults may arise.... The engineer extends the chain by prepar-

ing tighter specifications, employing every exculpatory phrase at his command, and inviting the constructor to nominate his best "sea-lawyer" as project manager. All this leads to the compounding of heavy contingency factors—where possible—or further assumption of risk by the implementing entities (P. Smith, 1978, 33).

The position of owners is not difficult to understand, as they have the most to lose. Thus the tendency to shift risks onto others. Engineers are tied to the contract provisions. They will be reluctant to innovate, preferring instead to stick to the tried and true ways of doing things. Contractors are used to taking large risks, but they are quick to recognize conditions "beyond their control."

Litigation has increased considerably in recent decades, and the character of litigation has changed as well. The construction industry is no exception, and its experience, as described by a panel of experts, serves as a good illustration of the kinds of legal problems consulting engineers now sometimes face:

> Traditionally law suits were fairly clear cut and involved matters directly related to the construction process; suits by owners were relatively uncommon; the design professional had to contend with virtually no litigation; and disputes were almost entirely confined to participants in the construction process.
>
> Today not only has the number of lawsuits dramatically increased but the nature of the lawsuits and the participants also have changed. Third forces, historically external to the process, today are the motivating factors behind a great many suits (Buehler, 1978, 94).

The third forces mentioned above typically are citizen intervenors or regulatory commissions.

Since litigation is time-consuming and costly, the consulting engineer should arrange contractually for methods of resolving conflicts. Quite apart from defining how risks are to be apportioned and payment of fees to be made, there should be contractual provisions for dispute-solving vehicles (designed to avoid costly court battles) such as mediation-arbitration in which a mediator attempts to resolve a dispute first, and if that is not fruitful, to act as the final, binding arbitrator. It should also be specified contractually that the National Joint Board for Settlement of Jurisdictional Disputes will be called upon to provide a hearing board and appeals board.

Engineering practice today does not regularly provide for clear-cut arbitration or conflict resolution. We believe that the consulting engineer is the proper party to assume the obligation of assuring that such clauses are included in contracts and are adhered to by everyone involved. This responsibility arises from the engineer's close contacts with both the owner and the constructor of a project and from the "social experimentation" nature of engineering. While contractual arrangements cannot solve problems caused by third-party intervenors, they can forestall a great many conflicts the origins of which can easily be foreseen and provided for.

Study Questions

1 Locate three advertisements: one for a technological product; one for the services of a consulting engineer; and one for positions in an engineering firm. Critique each ad in terms of whether the information or pictures included are misleading or deceptive in any way (be specific).

2 State why you agree, or why you disagree, with the following positions regarding advertising in local telephone directories. The first three examples comprise Case No. 72-1 of the *NSPE: Opinions of the Board of Ethical Review* (vol. IV, 1976). The fourth is our adaptation of a case involving a dentist and the dentists' association in San Francisco.

a "Are bold face listings in the classified section of local telephone directories consistent with the Code of Ethics?" The NSPE says "no."

b "Are bold face listings in the regular section of local telephone directories consistent with the Code of Ethics?" The NSPE says "yes."

c "Are professional card-type listings (set off by lines or blank space) in the classified section of local telephone directories consistent with the Code of Ethics?" The NSPE says "no."

d Mr. Zebra is a consulting engineer whose firm, Zebra Associates, appears last in the telephone directory's classified listing of engineers. In order to gain a more advantageous position in the yellow pages and in other directories, he changes the name of his firm to Antelope and Zebra. Antelope is a purely fictitious partner. Is this ethical?

In a similar case a dentists' board of review said "no."In considering the first three cases you may wish to consult the reasoning of the NSPE Board of Ethical Review. Also, examine some of the other numerous rulings by that board.

3 Is there anything unethical about the conduct of the engineer employee described in the following?

> A firm in private practice handles many small projects for an industrial client, averaging 20 to 30 projects a year. The firm has a signed agreement with the industrial client which does not obligate the client to give the firm any work, but does establish the respective responsibilities, terms of payment and other contractual details when the client does use the firm's services. The actual assignments are made by means of purchase orders referring to the agreement. An engineer employee of the firm resigns his employment and establishes his own firm and then actively solicits the industrial client of his former employer without any prior indication of interest by the client (*NSPE: Opinions of the Board of Ethical Review,* Case No. 73-7, vol. IV, 1976).

4 Is the decision of the consulting firm in the following example the morally obligatory one?

> A large civil engineering consulting firm completed a comprehensive arterial highway plan for a large, midwestern metropolitan area. The area appropriated funds for the next phase of the program: the preparation of a design report covering the recommended highways. The officials concerned, not knowing what a reasonable fee would be for the design report work, felt that it was necessary to invite proposals from various consultants. The consulting firm explained that it could not participate if the selection were to be made on the basis of engineering fees. The officials replied that, although price would not be the only consider-

ation, it would be a very important one. They could not explain to their constituents why the work was awarded to Engineer X if Engineer Y offered to do it for 2 percent less. The civil engineering company declined to participate (Alger, Christensen, and Olmsted, 1965, 49).

5 In the following case are Doe's presentation and offer entirely ethical?

> John Doe, P.E., a principal in a consulting engineering firm, attended a public meeting of a township board of supervisors which had under consideration a water pollution control project with an estimated construction cost of $7 million. Doe presented a so-called "cost-saving plan" to the supervisors under which his firm would work with the engineering firm retained for the project to find "cost-saving" methods to enable the township to proceed with the project and thereby not lose the federal funding share because of the township's difficulty in financing its share of the project.
>
> Doe further advised the supervisors that his company contemplated providing his "cost-saving" services on the basis of being paid ten percent of the savings; his firm would not be paid any amount if it did not achieve a reduction in the construction cost. Doe added that his firm's value engineering approach would be based on an analysis of the plans and specifications prepared by the design firm and that his operation would not require that the design firm be displaced (*NSPE: Opinions of the Board of Ethical Review*, Case No. 77-10, *Professional Engineer*, vol. 48, no. 6, June 1978, p. 52).

6 Should Engineer A in the following example take any further action, and if so what type?

> During an investigation of a bridge collapse, Engineer A investigates another similar bridge, and finds it to be only marginally safe. He contacts the governmental agency responsible for the bridge and informs them of his concern for the safety of the structure. He is told that the agency is aware of this situation, and has planned to provide in next year's budget for its repair. Until then, the bridge must remain open to traffic. Without this bridge, emergency vehicles such as police and fire apparatus would have to use an alternate route which would increase their response time about twenty minutes.
>
> Engineer A is thanked for his concern and asked to say nothing about the condition of the bridge. The agency is confident that the bridge will be safe (unpublished case study written up by and used with permission of L. R. Smith and Sheri Smith).

7 Examine and assess some recent disputes over whether fee competition among consulting engineers is ethical. A good place to begin is with the articles by Crawford Greene and Gerald Swenson listed in the Bibliography.

RESPONSIBILITIES OF AND TO THE PROFESSION

Throughout this book we have focused on the responsibilities of engineers *in* their work—that is, the responsibilities they have for the projects on which they work and for related aspects of their jobs. Yet it is important to avoid any suggestion that we have made an exhaustive survey of the issues in engineering ethics. Hence we conclude with a sketch of a few of the topics we have either omitted or mentioned only in passing, and which can be gathered under the unifying theme of responsibilities of and to the profession. Many of the points we raise here will be stated in the form of questions in order to challenge readers to continue further inquiry.

There are important issues pertaining to the responsibilities of the engineering profession as a whole. Many of those issues have to do with the collective responsibilities of professional and technical societies. There are also related issues having to do with the responsibilities of engineers to their profession, to peers, and to the world in which they live as citizens. In addition, there are questions about moral ideals that should be promoted in order to inspire desirable conduct that goes beyond the call of duty.

Collective Responsibilities of the Profession

It makes sense to praise or blame a profession as a whole for either establishing or failing to establish appropriate standards, and for either fostering or discouraging appropriate ideals. It also makes sense to praise or criticize its general role in society. This presupposes that there are general obligations and ideals which a profession as a collective body should pursue.

For one thing, making general appraisals of professions entails examining their "macroeconomics": that is, examining how they do and should function as a group within contemporary society. For example, to what extent is it desirable for the engineering profession as a whole to set standards in such areas as disposal of toxic wastes? (Ladd, 1980, 158)

Or, to take another kind of topic, is the trend toward increasing rule-making on behalf of professionalism within engineering in the public interest? Here many issues are involved, at least given the model of professionalism derived from developments in medicine and law:

1 Should the engineering profession be allowed to have the authority to decide which students and how many students will be admitted to schools of engineering? Should laypersons representing the public have a say?

2 Should registration and licensing of all engineers be mandatory, as they are for doctors and lawyers? There would be potential benefits: for example, greater assurance that minimal standards of training and skill would be met by all engineers. But there would also be drawbacks, if only that bureaucratic red tape would increase.

3 Should continuing education be mandatory for all engineers?

These and related issues are given regular, detailed examination at professional conferences. A sample of how they are typically approached can be found in *Ethics, Professionalism, and Maintaining Competence*, edited by Russel C. Jones et al., which is a collection of papers presented at a civil engineering conference. And many professional journals regularly carry articles treating these topics: for example, *Engineering Education*, *Professional Engineer*, *Engineering Issues (ASCE)*, *Chemical Engineering*, and *IEEE Spectrum*. A stimulating study of historical and sociological backgrounds for dealing with these topics is *The Credential Society* (Collins, 1964). However, there have as yet been few attempts to approach the issues within a framework of philosophical ethical theory.

Responsibilities of Professional Societies

Many of the large-scale social and economic issues involved in engineering ethics relate directly to professional societies. Professional societies help unify a profession. They also act on behalf of the profession, or at least on behalf of a large segment of the profession. A number of responsibilities ascribed to professions as collectives transfer directly to existing professional societies.

Many of the current tensions in professional societies exist because of uncertainties about their involvement in moral issues. This was illustrated in the BART case, as we saw in Chap. 6. One chapter of the California Society of Professional Engineers felt it should play a role in supporting the efforts of the three engineers who sought to act outside normal organizational channels in serving the public. Another chapter felt it was inappropriate for the society to do so.

It is unlikely that existing professional societies will, and perhaps undesirable that they should, take any univocal proemployee or promanagement stand. Their memberships, after all, are typically a mixture of engineers in management, supervision, and nonmanagement. Yet professional societies can, should, and are increasingly playing a role in conflicts involving moral issues, although rank and file engineers remain skeptical because they still consider the societies management-dominated (Flores, 1982, 80). Through membership participation on committees, they provide a sympathetic and informed forum for hearing opposing viewpoints and making recommendations. Through their guidelines for employment practice and conflict resolution they can help forestall debilitating disputes within corporations. Details concerning the desirable extent and form of such activities deserve ongoing discussion within engineering ethics.

Certainly we might expect professional societies increasingly to foster the study of engineering ethics. They are ideal groups for sponsoring ethics workshops, conducting surveys on matters of ethical concern, informing their members of developments related to ethics, and encouraging schools of engineering to support regular and continuing education courses in engineering ethics. Unfortunately a study of the activities of professional societies concluded that "little attention and only minimal resources have been directed toward professional ethics matters" (Chalk, Frankel, and Chafer, 1980, 101). As at least two other observers have pointed out, progress needs to be made before a genuine community based on a sense of shared values exists in the engineering profession (Perrucci and Gerstl, *Profession without Community: Engineers in American Society*, 176).

Another set of issues concerns the role professional societies should play in political decisions related to engineering and technological development. Should there be lobbying groups at the state and national levels seeking legislation on issues like engineering registration, continuing education requirements, and engineers' rights? Opinions are still sharply divided.

There is also the question of the direction and course of existing and possible new professional organizations. Perhaps it is desirable to have greater unity among engineering societies and thus to encourage newer and higher-level umbrella organizations to arise (such as the recently established American Association of Engineering Societies). Yet there are risks in seeking more unified power and action. Would a single powerful engineering society comparable to the American Medical Association or the American Bar Association be in the public interest?

Ultimately these "macro" issues lead back to the "micro" issues related to individual responsibility. For it is individuals involved in their professional societies who are the ultimate loci of action. An interesting area of engineering ethics would be to examine the typical situations in which individuals might be called upon to perform special services within their professional societies, and how far they are obligated to do so.

This leads us to the related topic of the obligations engineers have to their profession.

Obligations to the Profession

The code of ethics of the Accreditation Board for Engineering and Technology suggests that engineers should obey the code in order to "uphold and advance the integrity, honor and dignity of the engineering profession." Similarly, the preamble to the code of the National Society of Professional Engineers suggests that the code should be followed in part "to uphold and advance the honor and dignity of the engineering profession." Should such statements be dismissed as representing remnants of the natural esprit de corps of an emerging major profession? Or are there special professional obligations to the engineering profession which engineers should recognize?

It can be argued that engineers have an obligation to participate in technical societies in order to keep themselves up to date in their field and to help assure the continuation of such societies. That obligation derives from another obligation to clients, employers, and the public to advance their own and their colleagues' skills and knowledge. And at the very least it is highly desirable for engineers to be active in the ethics-related activities of their professional societies.

Are there additional obligations to defend the honor of the engineering profession against attacks from its critics? Would not the public and the profession itself be better served through a constant effort to seek truth and fairness in assessments of the engineering profession, and through a willingness to raise trenchant criticisms as conscience dictates? The legitimate honor of any profession as a whole can only be earned through its members acting with integrity in meeting their professional responsibilities.

Surely something can also be said in defense of the idea of a duty to respect and defend the honor of the profession. Effective professional activity, whether in engineering or any other profession, requires a substantial degree of trust from clients and the public. Total absence of such trust would undermine the possibility of making contracts, engaging in cooperative work, exercising professional autonomy free of excessive regulation, and working under humane conditions. Building and sustaining that trust is an important responsibility shared by all engineers.

This does not mean glossing over the genuine problems and faults one may encounter as the member of a profession. Nor does it mean always endorsing the more optimistic view of one's profession. But it does mean taking seriously the fact that appearances and reputation are important and should be given balanced and fair attention. Just what this amounts to in practice for engineers is a legitimate area of study for engineering ethics.

We might add that there is always the danger that the idea of an obligation to one's profession can become perverted into a narrow, self-interested concern. Such would be the case, for example, if a profession deliberately limited the number of its practitioners so as to create a greater demand for them and hence manipulate their salaries or fees upward. For this reason it may be preferable to understand talk about "obligations to the profession" as shorthand for certain obligations to the public. Engineers as individuals and as a group owe it to the public to sustain a professional climate conducive to meeting their other obligations to the public.

Collegiality and Obligations to Peers

A significant and neglected topic in professional ethics is that of relationships with peers, both coworkers and other members of one's profession. While engineering codes of ethics mention this topic, they often mention only the negative aspects. The NSPE code, for example, states that

> Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice or employment of other engineers, nor indiscriminately criticize other engineers' work. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action (Sec. III-8).

Insistence on not defaming colleagues unjustly and on not condoning unethical practice is important, since professionals are often overly reluctant to criticize peers responsibly. But this insistence needs to be balanced with an emphasis on the positive role of *collegiality* among professionals in promoting the moral aims of professions.

What is collegiality? In a recent essay which approaches collegiality as a fundamental professional virtue, Craig Ihara offers the following definition:

"Collegiality is a kind of connectedness grounded in respect for professional expertise and in a commitment to the goals and values of the profession, and..., as such, collegiality includes a disposition to support and cooperate with one's colleagues" (Ihara, 1988, 60). In other words, the central elements of collegiality are respect, commitment, connectedness, and cooperation.

Respect is the positive attitude involved in valuing one's peers for their professional expertise and their devotion to the social goods promoted by the profession. In the case of engineering this means affirming the worth of other engineers engaged in producing socially useful and safe products. Like friendship, collegial respect ought to be reciprocal (that is, mutual, rather than one-sided), but unlike friendship it need not involve personal affection.

Commitment means sharing a devotion to the moral ideals inherent in the practice of engineering. Even where there is fierce competition among professionals working for profit-making corporations, there should be a sense that other engineers share a concern for the overall good made possible through this competition. This is analogous to how members of competing teams in sports (hopefully) maintain a sense of underlying values beyond winning.

Connectedness is "an awareness of being part of a cooperative undertaking created by shared commitments and expertise" (Ihara, 58). It is more than acting in ways that show respect for peers. One must do so with an appropriate attitude of affirming their worth and with a sense of being united with them in an enterprise defined by common goals. This sense of unity with other engineers evokes *cooperation* and mutual support.

Why is collegiality a virtue—that is, a valuable trait of character which ought to be encouraged among engineers and other professionals? Ihara offers two answers. Viewed from the perspective of society, collegiality is an instrumental value; it is good as a means to promoting professional aims. By enlivening one's sense of shared commitment with others, collegiality supports personal efforts to act responsibly in concert with colleagues. Hence it strengthens one's motivation to live up to professional standards.

Viewed from the perspective of professionals, collegiality is intrinsically valuable. It is part of what defines the *professional community*—in this case, the engineering community—as comprised of many individuals jointly pursuing the public good. Such a community cannot continue without some shared awareness of mutual commitment to professional ideals.

Understood in this way, collegiality is a professional virtue deserving further attention. There is a need to explore how it can be distorted and misused, such as when peers appeal to it in urging silence about corporate corruption. Collegiality is not an excuse nor a justification for shielding irresponsible conduct. In fact, as Ihara suggests, peers who engage in gross misconduct cease to be "colleagues" in the moral sense analyzed above, for they are no longer worthy of respect and support. Again, collegiality can degenerate into mere group self-interest, rather than shared devotion to the public good. Preoccupation with cutthroat competitiveness also threatens collegiality, as does a narrow focus on the corporate goal of maximizing profit in disregard of the public good.

Responsibilities of Engineer-Citizens

Do engineers as a group and as individuals have special responsibilities as citizens which go beyond those of nonengineer-citizens? For example, should they participate more actively than others in social debates concerning industrial pollution, automobile safety, and disposal of nuclear waste?

Answering this question would require a clarification of the obligations citizens in general have concerning public policy issues. But even here there is considerable disagreement. One view holds that no one is strictly obligated to participate in public decision making. Instead, such participation is a moral ideal which it is desirable for citizens to embrace and pursue as their time allows. A contrasting view holds that all citizens have an obligation to devote some of their time and energies to public policy matters. Minimal requirements for everyone are to stay informed about issues that can be voted on, while stronger obligations arise for those who by professional background are well grounded in specific issues as well as for those who have the time to train themselves as public advocates.

Engineers are not as well represented on many legislative and advisory bodies as they might be. Perhaps they are too modest about offering their services or maybe they see a number of complications arising from service of this kind.

For engineers in private practice, the latter consideration can be particularly troubling. For example, there is the matter of advertising: While an engineer who is employed by a company will bring recognition and honor to the company through volunteer activities, any such efforts on the part of a self-employed engineer could be interpreted as self-serving attempts to gain publicity and perhaps even to secure valuable inside information.

Ideals of Voluntarism

Should the engineering profession encourage the pro bono, voluntary giving of engineering services without fee or at reduced fees to especially needy groups? Is this an ideal which is desirable for engineering professional societies to embrace and foster among individuals and corporations?

Voluntarism of this sort has long been encouraged in medicine, law, and education. By sharp contrast, engineering codes of ethics have either been silent on this question or taken stands that discourage voluntarism. For example, the ECPD (now ABET) code was revised during the 1960s to state: "Engineers shall not undertake nor agree to perform any engineering service on a free basis." Most other codes also insisted that engineers are obligated to require "adequate" compensation for their work—meaning compensation at the present fee scale. Such statements are now being revised in light of Supreme Court rulings suggesting they restrain free trade. Nevertheless, there continues to be a sentiment against encouraging engineers to donate their services without full compensation.

Robert Baum has challenged this sentiment (Baum, 1985). He acknowledges that engineers have fewer opportunities to donate their services as individuals than do doctors and lawyers. This is because engineering services tend to require shared efforts and to demand the resources of the corporations for which most engineers work. But this merely shows that engineers might best help the needy through group efforts. (It is also true that increasing numbers of doctors and lawyers work for corporations).

Is the providing of engineering services to the needy an important matter, as is the providing of legal and medical services? Yes, for two reasons. On the one hand, meeting some legal and medical needs requires supplementation by engineering services. For example, Baum argues that Native Americans (American Indians) often lack the resources for the engineering studies needed in dealing with the Bureau of Land Management, which has authority to grant leases on Native American land. There is money for lawyers, but no money for costly environmental impact studies required for, say, challenging a proposed government project that is harmful in the view of a Native American group. There are similar problems associated with health issues raised by polluted water and soil on reservations.

On the other hand, there are financially disadvantaged groups, especially the elderly and some minorities living in both urban and rural areas, whose minimal needs are at present not met—needs for running water, sewage systems, electrical power, and inexpensive transportation. This could be remedied if access to engineering services were made available at lower than normal costs.

There are many options that the profession of engineering might explore. These include encouraging engineers to serve in government programs like VISTA, urging government to expand the services of the Army Corps of Engineers, encouraging engineering students to focus their senior projects on service for disadvantaged groups, and encouraging corporations to offer 5 percent or 10 percent of their services free or at reduced rates for charitable purposes.

Is there an obligation for professional societies to foster voluntarism among engineers in providing engineering services as reduced fees? Baumleaves the question open. His main concern was to argue that needy groups ought to have access to engineering services, but not to resolve the question of who should provide them (groups of engineers, corporations, local government, federal government, etc.). He suggests, however, that engineers do have one important duty concerning services for the needy: "to participate in dialogues concerning the needs of specific individuals and groups and the possible ways in which these needs might be met" (Baum, 1985, 133).

Baum feels that through initiating discussion between representatives of the engineering profession and of disadvantaged groups solutions may be found.

We would add that a morally concerned engineering profession should recognize the rights of corporations and individual engineers to voluntarily engage in philanthropic engineering service. Furthermore, it would be desirable for professional societies to endorse the voluntary exercise of this right as being a desirable ideal—an ideal of generosity that goes beyond the call of duty. While good deeds beyond the scope of one's primary work cannot compensate for unethical conduct inside it, a profession fully dedicated to the public good should recommend participation by engineers in all aspects of community life. Many individual engineers and some engineering societies are already engaged in such volunteer services. They range from tutoring disadvantaged students in mathematics and physics, to "urban technology" interest groups and senior engineering students who advise local governments on their engineering problems.

Study Questions

1 Most states do not require engineers employed by industrial corporations to be registered or licensed by the state (based on meeting certain minimal requirements of education, knowledge, and experience), although some require registration of engineers in charge of design and manufacturing processes that affect the public health and safety. This "industrial exemption" has come under increasing criticism. Do you agree or disagree with the following reasons for abolishing the industrial exemption and for requiring industrial engineers to be licensed? Are they all good moral reasons for requiring registration?

a Registered engineers assure the company of the services of those who have met the prescribed statutory requirements of the law enacted to protect the public health, safety, and welfare.

b An engineering staff composed of registered professional engineers enhances the prestige and public relations potential of the firm.

c Engineering registration improves morale of the engineer by attesting to his qualifications, competence, and professional attitude. It also encourages the engineer to take full responsibility for his work.

d Engineering registration improves company-client relations by attesting to engineering staff competence and satisfies the legal requirements of many states and municipalities requiring project control under a registered engineer.

e Engineering registration promotes high standards of professional conduct, ethical practice, integrity, and top-quality job performance (Kettler, 1983, 534).

2 Currently only state, not national, registration is possible for engineers, and even that is frequently optional. Assess the following views concerning the desirability of requiring national registration of all engineers. Are there other reasons for and against national registration?

a "The method of obtaining national registration as well as the approach would act as a vehicle for elevating the engineering profession to standards that doctors and lawyers now enjoy" ("Comments from Professional Engineers: National Registration," 1964, 26).

b "I feel that a national registration law administered by a Federal agency would be very detrimental to the engineering profession because it would transfer our local responsibilities and authority to a Federal power. ... [In] practice I think it would become a dictorial agency, administering the law for its own purposes, with very little regard for the engineering profession" ("Comments from Professional Engineers: National Registration," 1964, 26).

3 An engineer learns that a friend and coworker has for several years gone to professional society meetings primarily for vacation purposes. The trips are billed to the employer, and the friend attends at most one or two sessions at the meetings (to put in an appearance) before going out on the town for a relaxing time. This clearly violates company policy. What should the engineer do?

4 Identify and discuss any moral duties, rights, and ideals pertinent to the following example.

An engineer who had also had experience as a carpenter-contractor was asked by his church to assist in the construction of a new building. He finally served as the general contractor, the engineer-inspector, and the construction foreperson. He used labor donated by members of the church, including many carpenters, painters, cement finishers, and so on, even though they were not members of the skilled trades. No salaries were paid to any church members, but credit for labor was allowed against a pledge made by each member.... Before the engineer accepted the multiple responsibilities, bids from general contractors had been taken, and all were out of reach of the church group (Alger, Christensen, and Olmsted, 1965, 236).

5 Defend your view as to whether engineers have special obligations beyond those of nonengineers to enter into public debates over technological development. If you think they do not have special obligations, is it nevertheless especially desirable (as a moral ideal) for them to contribute to these debates? Should professional societies encourage such participation?

6 Examine several recent issues of professional engineering journals to locate articles on ethics. Report on the types of issues being addressed in those articles.

SUMMARY OF CHAPTER 8

Engineering offers a variety of "existential pleasures": for example, the delights of changing the world, being creative, understanding the physical universe, and promoting the good of others. It also offers economic rewards. Yet in addition there is a direct moral dimension related to the decisions to enter engineering as a profession, to specialize in a particular field of engineering, and to pursue a specific type of work within engineering. How best to meet the demands of one's personal conscience, as well as how best to secure one's personal happiness, should be considered in deciding.

Thus the notion of an ethics of vocation, or a moral philosophy of work, is relevant to career decisions. William Frankena has argued that there is a duty to pursue a vocation. Whether or not that is so, there clearly are special moral duties attached to specific professional roles within engineering. Career decisions involve relating one's basic moral convictions to such professional duties and also to the specific types of activities one will pursue.

Related to an ethics of vocation is the notion of a personal work ethic: that is, the values and ideals according to which one pursues one's career. Another aspect, as applied to engineering, is the assessment of various proposed models for the social role of engineers: for example, savior, guardian, bureaucratic servant, social servant, social enabler and catalyst, and game player.

Engineering is a process with stages (design, manufacture, sales, operation) which have no clear demarcations. As in ethics, where there are no sharp boundaries between conceptual and normative inquiries or between the foundational ethical principles, we must work our way through the forest of possible actions and outcomes. Clarity is achieved through this process more than from the final resting place in the forest. But to be successful one must not lose sight of the forest for the trees. It is management's task to structure engineering functions in such a way that the global outlook is never lost.

Consulting engineers have greater freedom than most salaried engineers. They also must deal with a wider variety of moral concerns since they are responsible for their own business decisions. Honesty in advertising may be difficult to maintain in the face of pressures to promote their business. Controversy still exists concerning the legitimacy of competitive bidding and accepting contingency fees. And special problems arise in determining the extent of responsibility in such areas as making safety inspections and arriving at ways to settle disputes.

Engineers are responsible to society not only through their individual activities but also through their profession. Their professional societies support the furtherance of technical knowledge, represent engineers collectively, and encourage volunteer assistance. But they can only be as effective as engineers will help them be through their support.

OVERVIEW AND CONCLUDING REMARKS

Before he was elected President of the United States, Herbert Hoover was the engineer-president of the American Institute of Mining Engineers and also of the former Federated American Engineering Societies. Serving in those capacities he had a significant impact on the development of the profession of engineering (Layton, 1971, 179–218). In his memoirs he describes the honors and liabilities of engineering:

> It is a great profession. There is the fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes to men. Then it elevates the standards of living and adds to the comforts of life. That is the engineer's high privilege.
>
> The great liability of the engineer compared to men of other professions is that

> his works are out in the open where all can see them. His acts, step by step, are in hard substance. He cannot bury his mistakes in the grave like the doctors. He cannot argue them into thin air or blame the judge like the lawyers. He cannot, like the architects, cover his failures with trees and vines. He cannot, like the politicians, screen his shortcomings by blaming his opponents and hope that the people will forget. The engineer simply cannot deny that he did it. If his works do not work, he is damned (Hoover, 1961, 132–133).

Hoover is reflecting on a time when engineering was still dominated, at least in outlook, by the independent craftsperson and consultant. When a bridge fell or a ship sank, the particular engineers responsible could be more easily identified. This made it easier to endorse Hoover's vision of individualism in regard both to creativity and personal accountability within engineering.

Today the products of engineering are as much "out in the open" as in Hoover's time. In fact, mass communication assures that mistakes are given even closer public scrutiny. And there are more engineers than ever. Yet despite their greater numbers, the engineers of today are less visible to the public than those of that earlier era. Technological progress is taken for granted as being the norm, and technological failure is blamed on corporations. And in the public's eye, the representative of any corporation is its top manager, who is often far removed from the daily creative endeavors of the company's engineers.

This "invisibility" of engineers makes it difficult for them to retain a sense of mutual understanding with and accountability to the public. The dominant image of engineers, even for many engineers themselves, has become that of a servant to organizations rather than a public guardian.

We have explored a number of the additional threats to a sense of personal responsibility coming from within organizations. Some of those arise inevitably from the context of contemporary competitive enterprise: fragmentation of work, pressured time schedules, tight budgets. But others are not inevitable: overly rigid lines of authority, disregard of the individual's conscience, suppression of free expression of professional judgment. The latter can be and are being changed as both employee rights and the public responsibilities of corporations receive greater attention.

There is no need to review here the many issues we have explored concerning the responsibilities of engineers. A rereading of the chapter summaries will suffice for that. Yet it is worthwhile to summarize briefly a few of the main themes which have surfaced throughout this book.

We have emphasized the personal moral autonomy of individuals. We did so with the conviction that responsible conduct is important in all aspects of living, not the least of which is work, and that it cannot be transferred away to employers, code writers, or lawmakers. Yet moral autonomy, as we have treated it, is vastly different from unrestrained individual whim. Autonomous moral agents are sensitive to the legitimate claims of employer authority and the need for reasonable laws and some codified ethical rules. At the same time they are sufficiently concerned to critically assess laws, codes, and directives in the light of reasoned value principles.

We have also emphasized the obligations of engineers to the public based on the public's right to make informed decisions about the risks affecting it. Meeting this obligation requires that engineers working within corporations and other large organizations be given the freedom to express and act on their professional judgment. Thus we were led to stress the importance of employee rights for engineers.

Those rights are limited by the legitimate authority of employers. While we explored several morally relevant aspects of that authority, we offered no simple algorithm for precisely determining its limits. Here, as elsewhere, there is room for disagreement among reasonable people. Engineers would be dogmatic if they always insisted their views were the correct ones. Managers would be equally dogmatic and abusive of their authority if they gave no recognition to the conscientious concern engineers often display and action they sometimes take in disputed areas. There is a need for appeal groups, both within the employing organizations (ombudspersons, ethics committees, etc.) and outside them (confidential review committees of professional societies or the government). Above all there is the need for mutual understanding among engineers and management about the need to cooperatively resolve value conflicts.

These themes can be integrated within a conception of engineering as an experiment on a societal scale involving human subjects. We can restate the points previously made within the framework of this paradigm: As subjects of the "experiment," clients and the public have a right to make informed decisions concerning the risks they will be subject to. As central participants in the "experiment," engineers have a special responsibility to respect those rights. To do so they must be allowed the freedom to conduct the "experiment" in a professional manner, which includes freedom from actions on the part of managers and supervisors that would seriously violate their consciences. On the other hand, managers play an equally central role in engineering "experiments." They have the legitimate authority to guide many areas of the work lives of engineers, although they should avoid undue restrictions on work and (as just noted) refrain from violating the consciences of those they supervise. But it must be kept in mind that moral dilemmas involving competing obligations to employers and the public are virtually inevitable for engineers. Resolving those dilemmas requires both autonomous moral reasoning about and tolerance and sensitivity to different views concerning areas of disagreement that can arise among responsible moral agents.

SAMPLE CODES AND GUIDELINES

ABET : CODE OF ETHICS
GUIDELINES
FAITH OF THE ENGINEER

AAES : MODEL GUIDE FOR
PROFESSIONAL CONDUCT

NSPE : CODE OF ETHICS

IEEE : CODE OF ETHICS

*Accreditation Board for Engineering and Technology**

CODE OF ETHICS OF ENGINEERS

THE FUNDAMENTAL PRINCIPLES

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

I. using their knowledge and skill for the enhancement of human welfare;

II. being honest and impartial, and serving with fidelity the public, their employers and clients;

III. striving to increase the competence and prestige of the engineering profession; and

IV. supporting the professional and technical societies of their disciplines.

THE FUNDAMENTAL CANONS

1. Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.

2. Engineers shall perform services only in the areas of their competence.

3. Engineers shall issue public statements only in an objective and truthful manner.

4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.

5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.

6. Engineers shall act in such a manner as to uphold and enhance the honor, integrity and dignity of the profession.

7. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those engineers under their supervision.

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*Formerly Engineers' Council for Professional Development. (Approved by the ECPD Board of Directors, October 5, 1977)

AB-54 2/85

Accreditation Board for Engineering and Technology*

SUGGESTED GUIDELINES FOR USE WITH THE FUNDAMENTAL CANONS OF ETHICS

1 Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.

a Engineers shall recognize that the lives, safety, health and welfare of the general public are dependent upon engineering judgments, decisions and practices incorporated into structures, machines, products, processes and devices.

b Engineers shall not approve nor seal plans and/or specifications that are not of a design safe to the public health and welfare and in conformity with accepted engineering standards.

c Should the Engineers' professional judgment be overruled under circumstances where the safety, health, and welfare of the public are endangered, the Engineers shall inform their clients or employers of the possible consequences and notify other proper authority of the situation, as may be appropriate.

(1) Engineers shall do whatever possible to provide published standards, test codes and quality control procedures that will enable the public to understand the degree of safety or life expectancy associated with the use of the design, products and systems for which they are responsible.

(2) Engineers will conduct reviews of the safety and reliability of the design, products or systems for which they are responsible before giving their approval to the plans for the design.

(3) Should Engineers observe conditions which they believe will endanger public safety or health, they shall inform the proper authority of the situation.

d Should Engineers have knowledge or reason to believe that another person or firm may be in violation of any of the provisions of these Guidelines, they shall present such information to the proper authority in writing and shall cooperate with the proper authority in furnishing such further information or assistance as may be required.

1 They shall advise proper authority if an adequate review of the safety and reliability of the products or systems has not been made or when the design imposes hazards to the public through its use.

2 They shall withhold approval of products or systems when changes or modifications are made which would affect adversely its performance insofar as safety and reliability are concerned.

e Engineers should seek opportunities to be of constructive service in civic

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affairs and work for the advancement of the safety, health and well-being of their communities.

f Engineers should be committed to improving the environment to enhance the quality of life.

2 Engineers shall perform services only in areas of their competence.

a Engineers shall undertake to perform engineering assignments only when qualified by education or experience in the specific technical field of engineering involved.

b Engineers may accept an assignment requiring education or experience outside of their own fields of competence, but only to the extent that their services are restricted to those phases of the project in which they are qualified. All other phases of such project shall be performed by qualified associates, consultants, or employees.

c Engineers shall not affix their signatures and/or seals to any engineering plan or document dealing with subject matter in which they lack competence by virtue of education or experience, nor to any such plan or document not prepared under their direct supervisory control.

3 Engineers shall issue public statements only in an objective and truthful manner.

a Engineers shall endeavor to extend public knowledge, and to prevent misunderstandings of the achievements of engineering.

b Engineers shall be completely objective and truthful in all professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony.

c Engineers, when serving as expert or technical witnesses before any court, commission, or other tribunal, shall express an engineering opinion only when it is founded upon adequate knowledge of the facts in issue, upon a background of technical competence in the subject matter, and upon honest conviction of the accuracy and propriety of the testimony.

d Engineers shall issue no statements, criticisms, nor arguments on engineering matters which are inspired or paid for by an interested party, or parties, unless they have prefaced their comments by explicitly identifying themselves, by disclosing the identities of the party or parties on whose behalf they are speaking, and by revealing the existence of any pecuniary interest they may have in the instant matters.

e Engineers shall be dignified and modest in explaining their work and merit, and will avoid any act tending to promote their own interests at the expense of the integrity, honor and dignity of the profession.

4 Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.

a Engineers shall avoid all known conflicts of interest with their employers or clients and shall promptly inform their employers or clients of any business association, interest, or circumstances which could influence their judgment or the quality of their services.

b Engineers shall not knowingly undertake any assignments which would knowingly create a potential conflict of interest between themselves and their clients or their employers.

c Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, nor for services pertaining to the same project, unless the circumstances are fully disclosed to, and agreed to, by all interested parties.

d Engineers shall not solicit nor accept financial or other valuable considerations, including free engineering designs, from material or equipment suppliers for specifying their products.

e Engineers shall not solicit nor accept gratuities, directly or indirectly, from contractors, their agents, or other parties dealing with their clients or employers in connection with work for which they are responsible.

f When in public service as members, advisers, or employees of a governmental body or department, Engineers shall not participate in considerations or actions with respect to services provided by them or their organization in private or product engineering practice.

g Engineers shall not solicit nor accept an engineering contract from a governmental body on which a principal, officer or employee of their organization serves as a member.

h When, as a result of their studies, Engineers believe a project will not be successful, they shall so advise their employer or client.

i Engineers shall treat information coming to them in the course of their assignments as confidential, and shall not use such information as a means of making personal profit if such action is adverse to the interests of their clients, their employers or the public.

(1) They will not disclose confidential information concerning the business affairs or technical processes of any present or former employer or client or bidder under evaluation, without his consent.

(2) They shall not reveal confidential information nor findings of any commission or board of which they are members.

(3) When they use designs supplied to them by clients, these designs shall not be duplicated by the Engineers for others without express permission.

(4) While in the employ of others, Engineers will not enter promotional efforts or negotiations for work or make arrangements for other employment as principals or to practice in connection with specific projects for which they have gained particular and specialized knowledge without the consent of all interested parties.

j The Engineer shall act with fairness and justice to all parties when administering a construction (or other) contract.

k Before undertaking work for others in which Engineers may make improvements, plans, designs, inventions, or other records which may justify copyrights or patents, they shall enter into a positive agreement regarding ownership.

l Engineers shall admit and accept their own errors when proven wrong and refrain from distorting or altering the facts to justify their decisions.

m Engineers shall not accept professional employment outside of their regular work or interest without the knowledge of their employers.

n Engineers shall not attempt to attract an employee from another employer by false or misleading representations.

o Engineers shall not review the work of other Engineers except with the knowledge of such Engineers, or unless the assignments/or contractual agreements for the work have been terminated.

(1) Engineers in governmental, industrial or educational employment are entitled to review and evaluate the work of other engineers when so required by their duties.

(2) Engineers in sales or industrial employment are entitled to make engineering comparisons of their products with products of other suppliers.

(3) Engineers in sales employment shall not offer nor give engineering consultation or designs or advice other than specifically applying to equipment, materials or systems being sold or offered for sale by them.

5 Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.

a Engineers shall not pay nor offer to pay, either directly or indirectly, any commission, political contribution, or a gift, or other consideration in order to secure work, exclusive of securing salaried positions through employment agencies.

b Engineers should negotiate contracts for professional services fairly and only on the basis of demonstrated competence and qualifications for the type of professional service required.

c Engineers should negotiate a method and rate of compensation commensurate with the agreed upon scope of services. A meeting of the minds of the parties to the contract is essential to mutual confidence. The public interest requires that the cost of engineering services be fair and reasonable, but not the controlling consideration in selection of individuals or firms to provide these services.

(1) These principles shall be applied by Engineers in obtaining the services of other professionals.

d Engineers shall not attempt to supplant other Engineers in a particular employment after becoming aware that definite steps have been taken toward the others' employment or after they have been employed.

(1) They shall not solicit employment from clients who already have Engineers under contract for the same work.

(2) They shall not accept employment from clients who already have Engineers for the same work not yet completed or not yet paid for unless the performance or payment requirements in the contract are being litigated or the contracted Engineers' services have been terminated in writing by either party.

(3) In case of termination of litigation, the prospective Engineers before

accepting the assignment shall advise the Engineers being terminated or involved in litigation.

e Engineers shall not request, propose nor accept professional commissions on a contingent basis under circumstances under which their professional judgments may be compromised, or when a contingency provision is used as a device for promoting or securing a professional commission.

f Engineers shall not falsify nor permit misrepresentation of their, or their associates', academic or professional qualifications. They shall not misrepresent nor exaggerate their degree of responsibility in or for the subject matter of prior assignments. Brochures or other presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, joint ventures, or their past accomplishments with the intent and purpose of enhancing their qualifications and work.

g Engineers may advertise professional services only as a means of identification and limited to the following:

(1) Professional cards and listings in recognized and dignified publications, provided they are consistent in size and are in a section of the publication regularly devoted to such professional cards and listings. The information displayed must be restricted to firm name, address, telephone number, appropriate symbol, names of principal participants and the fields of practice in which the firm is qualified.

(2) Signs on equipment, offices and at the site of the projects for which they render services, limited to firm name, address, telephone number and type of services, as appropriate.

(3) Brochures, business cards, letterheads and other factual representations of experience, facilities, personnel and capacity to render service, providing the same are not misleading relative to the extent of participation in the projects cited and are not indiscriminately distributed.

(4) Listings in the classified section of telephone directories, limited to name, address, telephone number and specialties in which the firm is qualified without resorting to special or bold type.

h Engineers may use display advertising in recognized dignified business and professional publications, providing it is factual and relates only to engineering, is free from ostentation, contains no laudatory expressions or implication, is not misleading with respect to the Engineers' extent of participation in the services or projects described.

i Engineers may prepare articles for the lay or technical press which are factual, dignified and free from ostentations or laudatory implications. Such articles shall not imply other than their direct participation in the work described unless credit is given to others for their share of the work.

j Engineers may extend permission for their names to be used in commercial advertisements, such as may be published by manufacturers, contractors, material suppliers, etc., only by means of a modest dignified notation acknowledging their participation and the scope thereof in the project or product described. Such permission shall not include public endorsement of proprietary products.

k Engineers may advertise for recruitment of personnel in appropriate publications or by special distribution. The information presented must be displayed in a dignified manner, restricted to firm name, address, telephone number, appropriate symbol, names of principal participants, the fields of practice in which the firm is qualified and factual descriptions of positions available, qualifications required and benefits available.

l Engineers shall not enter competitions for designs for the purpose of obtaining commissions for specific projects, unless provision is made for reasonable compensation for all designs submitted.

m Engineers shall not maliciously or falsely, directly or indirectly, injure the professional reputation, prospects, practice or employment of another engineer, nor shall they indiscriminately criticize another's work.

n Engineers shall not undertake nor agree to perform any engineering service on a free basis, except professional services which are advisory in nature for civic, charitable, religious or non-profit organizations. When serving as members of such organizations, engineers are entitled to utilize their personal engineering knowledge in the service of these organizations.

o Engineers shall not use equipment, supplies, laboratory nor office facilities of their employers to carry on outside private practice without consent.

p In case of tax-free or tax-aided facilities, engineers should not use student services at less than rates of other employees of comparable competence, including fringe benefits.

6 Engineers shall act in such a manner as to uphold and enhance the honor, integrity and dignity of the profession.

a Engineers shall not knowingly associate with nor permit the use of their names nor firm names in business ventures by any person or firm which they know, or have reason to believe, are engaging in business or professional practices of a fraudulent or dishonest nature.

b Engineers shall not use association with non-engineers, corporations, nor partnerships as 'cloaks' for unethical acts.

7 Engineers shall continue their professional development throughout their careers, and shall provide opportunities for the professional development of those engineers under their supervision.

a Engineers shall encourage their engineering employees to further their education.

b Engineers should encourage their engineering employees to become registered at the earliest possible date.

c Engineers should encourage engineering employees to attend and present papers at professional and technical society meetings.

d Engineers should support the professional and technical societies of their disciplines.

e Engineers shall give proper credit for engineering work to those to whom credit is due, and recognize the proprietary interests of others. Whenever possible, they shall name the person or persons who may be responsible for designs, inventions, writings or other accomplishments.

f Engineers shall endeavor to extend the public knowledge of engineering, and shall not participate in the dissemination of untrue, unfair or exaggerated statements regarding engineering.

g Engineers shall uphold the principle of appropriate and adequate compensation for those engaged in engineering work.

h Engineers should assign professional engineers duties of a nature which will utilize their full training and experience insofar as possible, and delegate lesser functions to subprofessionals or to technicians.

i Engineers shall provide prospective engineering employees with complete information on working conditions and their proposed status of employment, and after employment shall keep them informed of any changes.

Accredation Board for Engineering and Technology
345 East 47th Street
New York, NY 10017

Engineers' Council for Professional Development

FAITH OF THE ENGINEER

I AM AN ENGINEER. In my profession I take deep pride, but without vainglory; to it I owe solemn obligations that I am eager to fulfill.

As an Engineer, I will participate in none but honest enterprise. To him that has engaged my services, as employer or client, I will give the utmost of performance and fidelity.

When needed, my skill and knowledge shall be given without reservation for the public good. From special capacity springs the obligation to use it well in the service of humanity; and I accept the challenge that this implies.

Jealous of the high repute of my calling, I will strive to protect the interests and the good name of any engineer that I know to be deserving; but I will not shrink, should duty dictate, from disclosing the truth regarding anyone that, by unscrupulous act, has shown himself unworthy of the profession.

Since the Age of Stone, human progress has been conditioned by the genius of my professional forbears. By them have been rendered usable to mankind Nature's vast resources of material and energy. By them have been vitalized and turned to practical account the principles of science and the revelations of technology. Except for this heritage of accumulated experience, my efforts would be feeble. I dedicate myself to the dissemination of engineering knowledge, and, especially to the instruction of younger members of my profession in all its arts and traditions.

To my fellows I pledge, in the same full measure I ask of them, integrity and fair dealing, tolerance and respect, and devotion to the standards and the dignity of our profession; with the consciousness, always, that our special expertness carries with it the obligation to serve humanity with complete sincerity.

Prepared by the Ethics Committee

* Now the Accrediting Board for Engineering and Technology (ABET).

MODEL GUIDE FOR PROFESSIONAL CONDUCT
AMERICAN ASSOCIATION OF ENGINEERING SOCIETIES

Preamble

Engineers recognize that the practice of engineering has a direct and vital influence on the quality of life for all people. Therefore, engineers should exhibit high standards of competency, honesty and impartiality; be fair and equitable; and accept a personal responsibility for adherence to applicable laws, the protection of the public health, and maintenance of safety in their professional actions and behavior. These principles govern professional conduct in serving the interests of the public, clients, employers, colleagues and the profession.

The Fundamental Principle

The engineer as a professional is dedicated to improving competence, service, fairness and the exercise of well-founded judgment in the practice of engineering for the public, employers and clients with fundamental concern for the public health and safety in the pursuit of this practice.

Canons of Professional Conduct

Engineers offer services in the areas of their competence and experience, affording full disclosure of their qualifications.

Engineers consider the consequences of their work and societal issues pertinent to it and seek to extend public understanding of those relationships.

Engineers are honest, truthful and fair in presenting information and in making public statements reflecting on professional matters and their professional role.

Engineers engage in professional relationships without bias because of race, religion, sex, age, national origin or handicap.

Engineers act in professional matters for each employer or client as faithful agents or trustees, disclosing nothing of a proprietary nature concerning the business affairs or technical processes of any present or former client or employer without specific consent.

Engineers disclose to affected parties known or potential conflicts of interest or other circumstances which might influence—or appear to influence—judgment or impair the fairness or quality of their performance.

Engineers are responsible for enhancing their professional competence throughout their careers and for encouraging similar actions by their colleagues.

Engineers accept responsibility for their actions; seek and acknowledge criticism of their work; offer honest criticism of the work of others; properly credit the contributions of others; and do not accept credit for work not theirs.

Engineers perceiving a consequence of their professional duties to adversely affect the present or future public health and safety shall formally advise their employers or clients and, if warranted, consider further disclosure.

Engineers act in accordance with all applicable laws and the ____________________[1] rules of conduct, and lend support to others who strive to do likewise.

[1] AAES Member Societies are urged to make reference here to the appropriate code of conduct to which their members will be bound.

Approved by AAES Board of Governors 12/13/84

CODE OF ETHICS For Engineers

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS FOUNDED 1934

PREAMBLE

Engineering is an important and learned profession. The members of the profession recognize that their work has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness and equity, and must be dedicated to the protection of the public health, safety and welfare. In the practice of their profession, engineers must perform under a standard of professional behavior which requires adherence to the highest principles of ethical conduct on behalf of the public, clients, employers and the profession.

I FUNDAMENTAL CANONS

Engineers, in the fulfillment of their professional duties, shall:

1 Hold paramount the safety, health and welfare of the public in the performance of their professional duties.
2 Perform services only in areas of their competence.
3 Issue public statements only in an objective and truthful manner.
4 Act in professional matters for each employer or client as faithful agents or trustees.
5 Avoid deceptive acts in the solicitation of professional employment.

II RULES OF PRACTICE

1 Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.
- a Engineers shall at all times recognize that their primary obligation is to protect the safety, health, property and welfare of the public. If their professional judgment is overruled under circumstances where the safety, health, property or welfare of the public are endangered, they shall notify their employer or client and such other authority as may be appropriate.
- b Engineers shall approve only those engineering documents which are safe for public health, property and welfare in conformity with accepted standards.
- c Engineers shall not reveal facts, data or information obtained in a professional capacity without the prior consent of the client or employer except as authorized or required by law or this Code.

d Engineers shall not permit the use of their name or firm name nor associate in business ventures with any person or firm which they have reason to believe is engaging in fraudulent or dishonest business or professional practices.

e Engineers having knowledge of any alleged violation of this Code shall cooperate with the proper authorities in furnishing such information or assistance as may be required.

2 Engineers shall perform services only in the areas of their competence.

a Engineers shall undertake assignments only when qualified by education or experience in the specific technical fields involved.

b Engineers shall not affix their signatures to any plans or documents dealing with subject matter in which they lack competence, nor to any plan or document not prepared under their direction or control.

c Engineers may accept assignments and assume responsibility for coordination of an entire project and sign and seal the engineering documents for the entire project, provided that each technical segment is signed and sealed only by the qualified engineers who prepared the segment.

3 Engineers shall issue public statements only in an objective and truthful manner.

a Engineers shall be objective and truthful in professional reports, statements or testimony. They shall include all relevant and pertinent information in such reports, statements or testimony.

b Engineers may express publicly a professional opinion on technical subjects only when that opinion is founded upon adequate knowledge of the facts and competence in the subject matter.

c Engineers shall issue no statements, criticisms or arguments on technical matters which are inspired or paid for by interested parties, unless they have prefaced their comments by explicitly identifying the interested parties on whose behalf they are speaking, and by revealing the existence of any interest the engineers may have in the matters.

4 Engineers shall act in professional matters for each employer or client as faithful agents or trustees.

a Engineers shall disclose all known or potential conflicts of interest to their employers or clients by promptly informing them of any business association, interest, or other circumstances which could influence or appear to influence their judgment or the quality of their services.

b Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed to, and agreed to by, all interested parties.

c Engineers shall not solicit or accept financial or other valuable consideration, directly or indirectly, from contractors, their agents, or other parties in connection with work for employers or clients for which they are responsible.

d Engineers in public service as members, advisors or employees of a governmental body or department shall not participate in decisions with respect to professional services solicited or provided by them or their organizations in private or public engineering practice.

e Engineers shall not solicit or accept a professional contract from a governmental body on which a principal or officer of their organization serves as a member.

5 Engineers shall avoid deceptive acts in the solicitation of professional employment.

a Engineers shall not falsify or permit misrepresentation of their, or their associates', academic or professional qualifications. They shall not misrepresent or exaggerate their degree of responsibility in or for the subject matter of prior assignments. Brochures or other presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, joint venturers or past accomplishments with the intent and purpose of enhancing their qualifications and their work.

b Engineers shall not offer, give, solicit or receive, either directly or indirectly, any political contribution in an amount intended to influence the award of a contract by public authority, or which may be reasonably construed by the public of having the effect or intent to influence the award of a contract. They shall not offer any gift, or other valuable consideration in order to secure work. They shall not pay a commission, percentage or brokerage fee in order to secure work except to a bona fide employee or bona fide established commercial or marketing agencies retained by them.

III PROFESSIONAL OBLIGATIONS

1 Engineers shall be guided in all their professional relations by the highest standards of integrity.

a Engineers shall admit and accept their own errors when proven wrong and refrain from distorting or altering the facts in an attempt to justify their decisions.

b Engineers shall advise their clients or employers when they believe a project will not be successful.

c Engineers shall not accept outside employment to the detriment of their regular work or interest. Before accepting any outside employment, they will notify their employers.

d Engineers shall not attempt to attract an engineer from another employer by false or misleading pretenses.

e Engineers shall not actively participate in strikes, picket lines, or other collective coercive action.

f Engineers shall avoid any act tending to promote their own interest at the expense of the dignity and integrity of the profession.

2 Engineers shall at all times strive to serve the public interest.
   a Engineers shall seek opportunities to be of constructive service in civic affairs and work for the advancement of the safety, health and well-being of their community.
   b Engineers shall not complete, sign or seal plans and/or specifications that are not of a design safe to the public health and welfare and in conformity with accepted engineering standards. If the client or employer insists on such unprofessional conduct, they shall notify the proper authorities and withdraw from further service on the project.
   c Engineers shall endeavor to extend public knowledge and appreciation of engineering and its achievements and to protect the engineering profession from misrepresentation and misunderstanding.

3 Engineers shall avoid all conduct or practice which is likely to discredit the profession or deceive the public.
   a Engineers shall avoid the use of statements containing a material misrepresentation of fact or omitting a material fact necessary to keep statements from being misleading or intended or likely to create an unjustified expectation; statements containing prediction of future success; statements containing an opinion as to the quality of the Engineers' services; or statements intended or likely to attract clients by the use of showmanship, puffery, or self-laudation, including the use of slogans, jingles, or sensational language or format.
   b Consistent with the foregoing, Engineers may advertise for recruitment of personnel.
   c Consistent with the foregoing, Engineers may prepare articles for the lay or technical press, but such articles shall not imply credit to the author for work performed by others.

4 Engineers shall not disclose confidential information concerning the business affairs or technical processes of any present or former client or employer without his consent.
   a Engineers in the employ of others shall not without the consent of all interested parties enter promotional efforts or negotiations for work or make arrangements for other employment as a principal or to practice in connection with a specific project for which the Engineer has gained particular and specialized knowledge.
   b Engineers shall not, without the consent of all interested parties, participate in or represent an adversary interest in connection with a specific project or proceeding in which the Engineer has gained particular specialized knowledge on behalf of a former client or employer.

5 Engineers shall not be influenced in their professional duties by conflicting interests.
   a Engineers shall not accept financial or other considerations, including free engineering designs, from material or equipment suppliers for specifying their product.
   b Engineers shall not accept commissions or allowances, directly or indi-

rectly, from contractors or other parties dealing with clients or employers of the Engineer in connection with work for which the Engineer is responsible.

6 Engineers shall uphold the principle of appropriate and adequate compensation for those engaged in engineering work.

a Engineers shall not accept remuneration from either an employee or employment agency for giving employment.

b Engineers, when employing other engineers, shall offer a salary according to professional qualifications.

7 Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable methods.

a Engineers shall not request, propose, or accept a professional commission on a contingent basis under circumstances in which their professional judgment may be compromised.

b Engineers in salaried positions shall accept part-time engineering work only to the extent consistent with policies of the employer and in accordance with ethical consideration.

c Engineers shall not use equipment, supplies, laboratory, or office facilities of an employer to carry on outside private practice without consent.

8 Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice or employment of other engineers, nor untruthfully criticize other engineers' work. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.

a Engineers in private practice shall not review the work of another engineer for the same client, except with the knowledge of such engineer, or unless the connection of such engineer with the work has been terminated.

b Engineers in governmental, industrial or educational employ are entitled to review and evaluate the work of other engineers when so required by their employment duties.

c Engineers in sales or industrial employ are entitled to make engineering comparisons of represented products with products of other suppliers.

9 Engineers shall accept responsibility for their professional activities; provided, however, that Engineers may seek indemnification for professional services arising out of their practice for other than gross negligence, where the Engineer's interests cannot otherwise be protected.

a Engineers shall conform with state registration laws in the practice of engineering.

b Engineers shall not use association with a nonengineer, a corporation, or partnership, as a "cloak" for unethical acts, but must accept personal responsibility for all professional acts.

10 Engineers shall give credit for engineering work to those to whom credit

is due, and will recognize the proprietary interests of others.

a Engineers shall, whenever possible, name the person or persons who may be individually responsible for designs, inventions, writings, or other accomplishments.

b Engineers using designs supplied by a client recognize that the designs remain the property of the client and may not be duplicated by the Engineer for others without express permission.

c Engineers, before undertaking work for others in connection with which the Engineer may make improvements, plans, designs, inventions, or other records which may justify copyrights or patents, should enter into a positive agreement regarding ownership.

d Engineers' designs, data, records, and notes referring exclusively to an employer's work are the employer's property.

11 Engineers shall cooperate in extending the effectiveness of the profession by interchanging information and experience with other engineers and students, and will endeavor to provide opportunity for the professional development and advancement of engineers under their supervision.

a Engineers shall encourage engineering employees' efforts to improve their education.

b Engineers shall encourage engineering employees to attend and present papers at professional and technical society meetings.

c Engineers shall urge engineering employees to become registered at the earliest possible date.

d Engineers shall assign a professional engineer duties of a nature to utilize full training and experience, insofar as possible, and delegate lesser functions to subprofessionals or to technicians.

e Engineers shall provide a prospective engineering employee with complete information on working conditions and proposed status of employment, and after employment will keep employees informed of any changes.

"By order of the United States District Court for the District of Columbia, former Section 11(c) of the NSPE Code of Ethics prohibiting competitive bidding, and all policy statements, opinions, rulings or other guidelines interpreting its scope, have been rescinded as unlawfully interfering with the legal right of engineers, protected under the antitrust laws, to provide price information to prospective clients; accordingly, nothing contained in the NSPE Code of Ethics, policy statements, opinions, rulings or other guidelines prohibits the submission of price quotations or competitive bids for engineering services at any time or in any amount."

Statement by NSPE Executive Committee In order to correct misunderstandings which have been indicated in some instances since the issuance of the Supreme Court decision and the entry of the Final Judgment, it is noted that in its decision of April 25, 1978, the Supreme Court of the United States declared: "The Sherman Act does not require competitive bidding."

It is further noted that as made clear in the Supreme Court decision:

1 Engineers and firms may individually refuse to bid for engineering services.

2 Clients are not required to seek bids for engineering services.

3 Federal, state, and local laws governing procedures to procure engineering services are not affected, and remain in full force and effect.

4 State societies and local chapters are free to actively and aggressively seek legislation for professional selection and negotiation procedures by public agencies.

5 State registration board rules of professional conduct, including rules prohibiting competitive bidding for engineering services, are not affected and remain in full force and effect. State registration boards with authority to adopt rules of professional conduct may adopt rules governing procedures to obtain engineering services.

6 As noted by the Supreme Court, "nothing in the judgment prevents NSPE and its members from attempting to influence governmental action. . . ."

Note: In regard to the question of application of the Code to corporations vis-à-vis real persons, business form or type should not negate nor influence conformance of individuals to the Code. The Code deals with professional services, which services must be performed by real persons. Real persons in turn establish and implement policies within business structures. The Code is clearly written to apply to the Engineer and it is incumbent on a member of NSPE to endeavor to live up to its provisions. This applies to all pertinent sections of the Code.

NSPE Publication No. 1102 as revised January 1987

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS

CODE OF ETHICS

PREAMBLE

Engineers, scientists and technologists affect the quality of life for all people in our complex technological society. In the pursuit of their profession, therefore, it is vital that IEEE members conduct their work in an ethical manner so that they merit the confidence of colleagues, employers, clients and the public. This IEEE Code of Ethics represents such a standard of professional conduct for IEEE members in the discharge of their responsibilities to employers, to clients, to the community and to their colleagues in this Institute and other professional societies.

ARTICLE I

Members shall maintain high standards of diligence, creativity and productivity, and shall:

1 Accept responsibility for their actions;

2 Be honest and realistic in stating claims or estimates from available data;

3 Undertake technological tasks and accept responsibility only if qualified by training or experience, or after full disclosure to their employers or clients of pertinent qualifications;

4 Maintain their professional skills at the level of the state of the art, and recognize the importance of current events in their work;

5 Advance the integrity and prestige of the profession by practicing in a dignified manner and for adequate compensation.

ARTICLE II

Members shall, in their work:

1 Treat fairly all colleagues and co-workers, regardless of race, religion, sex, age or national origin;

2 Report, publish and disseminate freely information to others, subject to legal and proprietary restraints;

3 Encourage colleagues and co-workers to act in accord with this Code and support them when they do so;

4 Seek, accept and offer honest criticism of work, and properly credit the contributions of others;

5 Support and participate in the activities of their professional societies;

6 Assist colleagues and co-workers in their professional development.

ARTICLE III

Members shall, in their relations with employers and clients;

1 Act as faithful agents or trustees for their employers or clients in professional and business matters, provided such actions conform with other parts of this Code;

2 Keep information on the business affairs or technical processes of an employer or client in confidence while employed, and later, until such information is properly released, provided such actions conform with other parts of this Code;

3 Inform their employers, clients, professional societies or public agencies or private agencies of which they are members or to which they may make presentations, of any circumstance that could lead to a conflict of interest;

4 Neither give nor accept, directly or indirectly, any gift, payment or service of more than nominal value to or from those having business relationships with their employers or clients;

5 Assist and advise their employers or clients in anticipating the possible consequences, direct and indirect, immediate or remote, of the projects, work or plans of which they have knowledge.

ARTICLE IV

Members shall, in fulfilling their responsibilities to the community:

1 Protect the safety, health and welfare of the public and speak out against abuses in these areas affecting the public interest;

2 Contribute professional advice, as appropriate, to civic, charitable or other nonprofit organizations;

3 Seek to extend public knowledge and appreciation of the profession and its achievements.

Approved February 18, 1979, by the Board of Directors of the Institute of Electrical and Electronics Engineers, Inc.

* Some revisions have been made to this code. Please contact the IEEE headquarters for this ormation.