CHAPTER THREE

Responsibility in Engineering

Main Ideas in This Chapter

- **Responsibility has to do with accountability, both for what one does in the present and future and for what one has done in the past.**
- **The responsibilities of engineers require not only adhering to regulatory norms and standard practices of engineering but also satisfying the standard of reasonable care.**
- **Engineers can expect to be held accountable, if not legally liable, for intentionally, negligently, and recklessly caused harms.**
- **Responsible engineering practice requires good judgment, not simply following algorithms.**
- **A good test of engineering responsibility is the question: "What does an engineer do when no one is looking?" This makes evident the importance of *trust* in the work of engineers.**
- **Responsible engineering requires taking into account various challenges to appropriate action, such as blind spots, normalized deviance, bounded ethicality, uncritical acceptance of authority, and groupthink.**

ON JANUARY 16, 2003, AT 10:39 A.M. Eastern Standard Time, the *Columbia* lifted off at Kennedy Space Center, destined for a 16-day mission in space.[1] The seven-person *Columbia* crew was scheduled to conduct numerous scientific experiments and return to earth on February 1. Only 81.7 seconds after lift-off, a briefcase-size piece of the brownish-orange insulating foam that covered the large external tank broke off and hit the leading edge of the orbiter's left wing. Unknown to the *Columbia* crew or the ground support staff, the foam knocked a 10-inch hole in the leading edge of the wing.

Cameras recorded the foam impact, but the images provided insufficient detail to determine either the exact point of impact or its effect. Several engineers, including Rodney Rocha, requested that attempts be made to get clearer images. There were even requests that the *Columbia* crew be directed to examine the wing for possible damage. However, it had become a matter of faith at NASA that foam strikes, although a known problem, could not cause significant damage and were not a safety-of-flight issue, so management rejected this request. The astronauts were not told of the problem until shortly before reentry, when they were informed that the foam strike was inconsequential, but that they should know about it in case they were asked about the strike by the press on return from their mission.

Upon reentry into the Earth's atmosphere, a snaking plume of superheated air, probably exceeding 5,000 degrees Fahrenheit, entered the breach in the wing and began to consume the wing from the inside. The destruction of the spacecraft began when it was over the Pacific Ocean and grew worse when it entered U.S. airspace. Eventually, the bottom surface of the left wing began to cave upward into the interior of the wing, finally causing *Columbia* to go out of control and disintegrate, mostly over east Texas. The entire crew, along with the spacecraft, was lost.

3.1 INTRODUCTION

This tragic event, which has many striking similarities with the *Challenger* disaster 17 years earlier, illustrates many of the issues surrounding notions of responsibility in the engineering profession. Engineers obviously played a central role in making the *Columbia* flight possible and in safeguarding the spaceship and its travelers. From the outset of the launch, engineers had a special eye out for possible problems. Rodney Rocha and other engineers on NASA's Debris Assessment Team became concerned about flying debris. Noticing and assessing such details was their responsibility. If they did not handle this well, things could go very badly. Even if they did handle this well, things could go very badly. The stakes were high.

As Box 3.1 indicates, ideas of responsibility are many faceted. Responsibility may focus primarily on legal liabilities, job-defined roles, expectations of professional engineering societies, commonly accepted standards of engineering competency, or self-imposed moral standards. Furthermore, although legal and ethical concepts are distinct from each other, they are also interrelated. For example, the legal obligations of engineers help inform their moral obligations. Under its I. Fundamental Canons, NSPE Code of Ethics says that engineers shall "6. Conduct themselves honorably, responsibly, ethically, and *lawfully* so as to enhance the honor, reputation, and usefulness of the profession [emphasis added]."

As professionals, engineers are expected to commit themselves to high standards of conduct.[2] As noted in Chapter 1, the Preamble of NSPE's Code of Ethics emphasizes the importance of engineers being committed to honesty, integrity, fairness, and the protection of public safety, health, and welfare. This is based on the special roles engineers assume in their work and the crucial impact that this work has on our lives. We can refer to this as *role-responsibility.*

Our dependence on the responsible exercise of engineering expertise points

BOX 3.1 Responsibility as Accountability

Applied to:

- individual engineers;
- teams of engineers;
- divisions or units within organizations;
- organizations themselves.

Understood in terms of:

- legal accountability (which sometimes includes *strict* [no fault] liability);
- moral accountability (which does not include *strict* [no fault] liability).

BOX 3.2 Desirable Qualities in Engineers

- Basic engineering competence
- Professional integrity
- Honesty
- Willingness to make self-sacrifice
- Working well with others
- Imaginativeness
- Perseverance
- Communicating clearly with others
- Commitment to objectivity
- Openness to acknowledging and correcting mistakes
- Commitment to quality
- Ability to see "the big picture," as well as minute details
- Civic-mindedness

to the need to place our trust in the reliable performance of engineers, both as individual engineers and as members of teams of engineers and others who work together. In turn, when given opportunities to provide services to others, engineers need to conduct themselves in ways that do not generate distrust. This has important implications for a professional's approach to his or her responsibilities. In general, we can think of possible approaches to responsibility along a spectrum. At one end of the spectrum is the attitude of doing as little as one can get away with while still staying out of trouble, keeping one's job, and the like. Clearly, this minimalist attitude falls far short of the basic requirements of the NSPE code, most of which prohibit the violation of standards that require much more from engineers. At the other end of this spectrum are attitudes and dispositions that may take one "above and beyond the call of duty" (sometimes referred to as the *supererogatory*, or as "going the extra mile"). NSPE code also encourages (but does not require) such aspirations. For example, provision 2a, under section III (Professional Obligations) says: "Engineers are encouraged to participate in civic affairs; career guidance for youths; and work for the advancement of the safety, health, and well-being of their community." Provision 2.c. says: "Engineers are encouraged to extend public knowledge and appreciation of engineering and its achievements." Finally, 2.d. says: "Engineers are encouraged to adhere to the principles of sustainable development in order to protect the environment for future generations."

What sorts of attitudes and dispositions might employers look for in engineers if they want to hire those who take seriously both what the NSPE code requires and encourages?[3] Box 3.2 lists some leading candidates, all of which are at least implicitly endorsed in engineering codes of ethics such as NSPE's.

3.2 ENGINEERING STANDARDS

Like other engineering codes of ethics, the NSPE code also requires that the work of engineers satisfies "applicable engineering standards." See Box 3.3.

Regulatory and procedural standards and the standard of care are intended to provide some assurance of quality, safety, and efficiency in engineering. It is important to realize, however, that they also leave considerable room for professional discretion in engineering design and practice. There are few algorithms for engineers to follow here. So, the need for engineering *judgment* must be emphasized.[5]

BOX 3.3 Applicable Engineering Standards

- Regulatory: specifying technical requirements (e.g., for safety)
- Procedural: e.g., procedures to be followed for determining measurable quality or level of safety
- Standard of Care: that level or quality of service ordinarily provided by other normally competent practitioners, contemporaneously providing similar services in the same locality and under the same circumstances[4]
- Judgment: needed because regulatory and procedural standards, and the standard of care still require the exercise of good judgment

Although the NSPE Code of Ethics is the product of the collective reflection of members of one particular professional society of engineers, it seems intended to address the ethical responsibilities of all practicing engineers. Given this, the standards endorsed by the code should be supportable by reasons other than the fact that NSPE members publically commit themselves to those standards. That is, the standards should be supportable by reasons that apply to all engineers, not just those who are members of NSPE. Are they?

In answering this question, it is important to note that the Preamble does not single out NSPE members, as distinct from other engineers, when prescribing how engineers ought to conduct themselves. Instead, it depicts the general role that engineering plays in society, along with more specific standards of conduct suitable for fulfilling that role responsibly. Presumably, this depiction is apt regardless of whether or not engineers are members of NSPE.

Engineers and nonengineers alike can readily agree that engineers do play the sort of vital societal role depicted by the Preamble, which emphasizes that engineers are required to use their specialized knowledge and skills in ways that benefit employers, clients, and the public and that they do not betray the trust placed in them. This is a matter of, we will say, *obligation-responsibility*. Assessments of how well engineers handle their obligation-responsibilities are typically in terms of praise and blame.

Unfortunately, we seem more inclined to blame shortcomings and failures than to praise everyday competent, if not exceptional, engineering practice. (We *expect* our cars to start, the elevators and trains to run, and the traffic lights to work.) In any case, we speak of engineers as being responsible for mistakes or accidents. This is a fundamentally negative and backward-looking concept of responsibility. Let us refer to it as *blame-responsibility*. However, it is important not to forget that assessments can be positive as well as negative.

We shall next discuss obligation-responsibility in relation to what is commonly called the *standard of care*, a standard of engineering responsibility accepted both in law and engineering practice. Then, we will turn to the more negative notion of blame-responsibility and its relation to the standard of care. We shall consider issues of responsibility in regard to failures in the design or functioning of engineered products. These issues are complicated by the organizational structures within which most engineers work. Whether organizations themselves (as distinct from individuals) can sensibly be held morally responsible for harms is a controversial question. However, they can be (and are) held liable in law, and this can have important implications for the moral responsibilities of their employees, including engineers.

3.3 THE STANDARD OF CARE

Engineers have a professional obligation to conform to the standard operating procedures and regulations that apply to their profession and to fulfill the basic obligation-responsibilities of their job as defined by the terms of their employment. Sometimes, however, it is not enough to follow standard operating procedures and regulations. Unexpected problems can arise that standard operating procedures and current regulations are not well equipped to handle. In light of this, engineers are expected to satisfy a more demanding norm, the *standard of care*. To explain this idea, we will first turn to codes of ethics.

Codes of ethics of professional engineering societies attempt to identify in a structured, comprehensive way standards its members believe should govern their conduct as engineers. However, because particular situations cannot be anticipated in all their relevant nuances, applying these standards requires professional judgment. For example, although sometimes it is obvious what would constitute a failure to protect public, health, and safety, often it is not. But not actively protecting public safety will fail to satisfy the public safety standard only if there is a responsibility to provide that level of safety. Still, since no engineering product can be expected to be “absolutely” safe (at least, not if it is to be a useful product), and since there are economic costs associated with safety improvements, there can be some uncertainty about what a reasonable standard of safety is for this or that product. Box 3.4 provides similarities of corporations to individual agents.

Rather than leave the determination of what counts as safe solely in the hands of individual engineers and their employers, safety standards are set by government agencies (such as the National Institute of Standards and Technology, the Occupational Safety and Health Administration, and the Environmental Protection Agency) or nongovernmental organizations (such as professional engineering societies and the International Organization for Standardization). Nevertheless, standards of safety, as well as standards of quality, may still leave room for considerable engineering discretion. Although some standards have a high degree of specificity (e.g., minimal requirements regarding the ability of a structure to withstand winds of a certain velocity that might strike that structure at, say, a 90 degree angle), some simply require that unspecified standard processes be developed, followed, and documented.[6]

Engineering codes of ethics typically make general statements about engineers being required to conform to accepted standards of engineering practice. What such standards come to in actual practice depends, of course, on the area of engineering practice in question, along with whatever formal regulatory standards may be in place. However, underlying all of this is a broader standard of care in engineering practice, a standard appealed to in law and about which experienced, respected engineers can be called upon to testify in the courts in particular cases.

Joshua B. Kardon presents a useful characterization of the standard of care.[7]

BOX 3.4 Similarities of Corporations to Individual Moral Agents

1. Corporations make decisions
2. Corporations like people have decision-making policies
3. Corporations have “interests” that are distinct from those of corporations executives and employee

He says that although some errors in engineering judgment and practice can be expected to occur as a matter of course, not all errors are acceptable. He explains:

> An engineer is not liable, or responsible, for damages for every error. Society has decided, through case law, that when you hire an engineer, you buy the engineer's normal errors. However, if the error is shown to have been worse than a certain level of error, the engineer is liable. That level, the line between non-negligent and negligent error is the "standard of care."

How is this line determined in particular cases? It is not up to engineers alone to determine this, but they do play a crucial role in assisting judges and juries in their deliberations. Kardon continues:

> A trier of fact, a judge or jury, has to determine what the standard of care is and whether an engineer has failed to achieve that level of performance. They do so by hearing expert testimony. People who are qualified as experts express opinions as to the standard of care and as to the defendant engineer's performance relative to that standard.

For this legal process to be practicable and reasonably fair to engineers, it is necessary that there be an operative notion of accepted practice in engineering that is well understood by competent engineers in the areas of engineering under question. As Kardon puts it:[8]

> A good working definition of the standard of care of a professional is: that level or quality of service ordinarily provided by other normally competent practitioners of good standing in that field, contemporaneously providing similar services in the same locality and under the same circumstances.

Given this, we should not expect to find a formal statement of what specifically satisfies the standard. Rather, an appeal is made to what is commonly and ordinarily done (or not done) by competent engineers. So, the legally recognized standard of care might best be seen as representing the highest *shared* standard among competent, responsible engineers in the relevant areas of practice.

3.4 BLAME RESPONSIBILITIY AND CAUSATION

Now let us turn to the more negative concept of responsibility, blame-responsibility. We can begin by considering the relationship of responsibility for harm to causation of harm. When the *Columbia* Accident Investigation Board looked at the *Columbia* tragedy, it focused on what it called the "causes" of the accident. It identified two principal causes: the "physical cause" and the "organizational causes." The physical cause was the damage to the leading edge of the left wing by the foam that broke loose from the external tank. The organizational causes were defects in the organization and culture of NASA that led to an inadequate concern for safety.[9] The board also made reference to individuals who were "responsible and accountable" for the accident. The board, however, did not consider its primary mission to be the identification of individuals who should be held responsible and perhaps punished.[10] Thus, it identified three types of explanations of the accident: the physical cause, organizational causes, and individuals responsible or accountable for the accident.

The concept of cause is related in an interesting way to that of responsibility. Generally speaking, the more we are inclined to speak of the physical cause of

BOX 3.5 Holding Organizations Responsible

1. For causing harms
2. For making reparations for wrong done
3. For making reforms

something, the less we are inclined to speak of responsibility—and the more we are inclined to speak of responsibility, the less inclined we are to focus on physical causes. When we refer only to the physical cause of the accident—namely, the damage produced by the breach in the leading edge of the orbiter's left wing—responsibility is not yet in the picture. Physical causes, as such, cannot be responsible agents. The place of responsibility with respect to organizations and individuals raises more complex issues. Let us turn first to organizations (Box 3.5).

The relationship of organizations to the concepts of causation and responsibility is controversial. The *Columbia* Accident Investigation Board preferred to speak of the organization and culture of NASA as a cause of the accident. With respect to the physical cause, the board said:[11]

> The physical cause of the loss of the *Columbia* and its crew was a breach in the Thermal Protection System on the leading edge of the left wing, caused by a piece of insulating foam which separated from the left bipod ramp section of the External Fuel Tank at 81.7 seconds after launch, and struck the wing in the vicinity of the lower half of Reinforced Carbon-Carbon panel number 8.

With respect to the organizational causes of the accident, the board said:[12]

> The organizational causes of this accident are rooted in the Space Shuttle Program's history and culture, including the original compromises that were required to gain approval for the Shuttle, subsequent years of resource constraints, fluctuating priorities, schedule pressures, mischaracterization of the Shuttle as operational rather than developmental, and lack of an agreed national vision for human space flight. Cultural traits and organizational practices detrimental to safety were allowed to develop, including: reliance on past successes as a substitute for sound engineering practices (such as testing to understand why systems were not performing in accordance with requirements); organizational barriers that prevented effective communication of critical safety information and stifled professional differences of opinion; lack of integrated management across program elements; and the evolution of an informal chain of command and decision-making processes that operated outside the organization's rules.

With respect to the relative importance of these two causes, the board concluded:[13]

> In the Board's view, NASA's organizational culture and structure had as much to do with this accident as the External Tank foam. Organizational culture refers to the values, norms, beliefs, and practices that govern how an institution functions. At the most basic level, organizational culture defines the assumptions that employees make as they carry out their work. It is a powerful force that can persist through reorganizations and reassignments of key personnel.

If organizations can be causes, can they also be morally responsible agents, much as humans can be? Some theorists believe it makes no sense to say that organizations (such as General Motors or NASA) can be morally responsible agents.[14] An organization is not, after all, a human person in the ordinary sense. Unlike human persons, corporations do not have a body, cannot be sent to jail, and have an indefinite life. On the other hand, corporations are described as "artificial persons" in the law. According to *Black's Law Dictionary*, "the law treats the corporation itself as a person which can sue and be sued. The corporation is distinct from the individuals who comprise it (shareholders)."[15] Corporations, like persons, can also come into being, pass away, and be fined.

Philosopher Peter French argues that corporations can, in a significant sense, be morally responsible agents.[16] Although French focuses on corporations, his arguments can also be applied to governmental organizations such as NASA. Corporations have three characteristics that can be said to make them very similar to moral agents. First, corporations, like people, have a decision-making mechanism. People can deliberate and then carry out their decisions. Similarly, corporations have boards of directors and executives who make decisions for the corporation, and these decisions are then carried out by subordinate members of the corporate hierarchy. Second, corporations, like people, have policies that guide their decision-making. People have moral rules and other considerations that guide their conduct. Similarly, corporations have corporate policies, including, in many cases, a corporate code of ethics. In addition to policies that guide conduct, corporations also have a "corporate culture" that tends to shape their behavior, much as personality and character shape the actions of individuals. Third, corporations, like people, can be said to have "interests" that are not necessarily the same as those of the executives, employees, and others who make up the corporation. Corporate interests include making a profit, maintaining a good public image, staying out of legal trouble, and so forth.

Consider an example of a corporate decision. Suppose an oil corporation is considering beginning a drilling operation in Africa. A mountain of paperwork will be forwarded to the chief executive officer (CEO), other top executives, and probably the board of directors. When a decision is made, according to the decision-making procedure established by the corporation, it can properly be called a "corporate decision." It was made for "corporate reasons," presumably in accordance with "corporate policy," to satisfy "corporate interests," and guided by "corporate ethics."

Regardless of whether organizations, as such, are seen as moral agents, organizations can be held responsible in at least three senses.[17] First, they can be criticized for causing harms, just as the *Columbia* Accident Investigation Board criticized NASA. Second, an organization that harms others can be asked to make reparations for wrong done. Finally, an organization that has harmed others is in need of reform, just as the board believed NASA needs reform.

One worry about treating organizations as morally responsible agents is the fear that individual responsibility might be displaced. However, there need be no incompatibility in holding both organizations and the individuals within them accountable for what they do. We will now turn to the responsibilities of individuals.

3.5 LEGAL LIAILITY

Although engineers and their employers might try to excuse apparent failure to provide safety and quality by pointing out that they have met existing regulatory standards, it is evident that the courts will not necessarily agree. As already noted in Section 3.3, the standard of care recognized in law is not adequately explained solely in terms of regulations. A better explanation of the standard of care is found in the legal case *Coombs v. Beede*:[18]

> The responsibility resting on an architect is essentially the same as that which rests upon the lawyer to his client, or upon the physician to his patient, or which rests upon anyone to another where such person pretends to possess some special skill and ability in some special employment, and offers his services to the public on account of his fitness to act in the line of business for which he may be employed. The undertaking of an architect implies that he possesses skill and ability, including taste, sufficient enough to enable him to perform the required services at least ordinarily and reasonably well; and that he will exercise and apply, in the given case, his skill and ability, his judgment and taste reasonably and without neglect.

As noted earlier, Joshua B. Korden points out that this does mean that all failure to provide satisfying services is wrongful injury. Even when reasonable care is exercised, this cannot guarantee that no injuries will ever occur, especially in areas of innovative technology. Given the desirability of encouraging innovative engineering design, it is unrealistic for the public to regard all failures and mishaps to be blameworthy; at the same time, it is incumbent on engineers to do their best to anticipate and avoid failures and mishaps as innovations are introduced and tested.

It should be noted that *Coombs v. Beede* does not say that professionals need only conform to the already established standards and practices of their field of expertise. Those standards and practices may be in a state of change, and they may not be able to keep pace with advancing knowledge of risks in particular areas. Furthermore, as many liability cases have shown, reasonable people often disagree about precisely what those standards and practices should be taken to be.

3.6 HARMS: LEGAL LIABILITY AND MORAL RESPONSIBILITY

Legal liability and moral responsibility for harms parallel each other in several ways, but they are importantly different as well. We begin with the similarities. For an individual to be held legally liable for causing harm is to be judged as either warranting punishment, or as being obligated to make restitution for that harm. Liability for harm ordinarily implies that the person caused the harm, but it also implies something about the conditions under which the harm was caused (Box 3.6). These conditions ordinarily include such "mental" elements as malicious intent, recklessness, or negligence. In examining these elements, we shall see that although the concept of causing harm is present, it is the notions of liability and responsibility that are the focus of attention.[19]

First, a person can *intentionally*, or knowingly and deliberately, cause harm. If an assailant stabs someone in the back to steal that person's money, the assailant is both legally liable and morally responsible for deliberately causing injury or death. The causal component in this case is the physical assault, and the mental component is the intention to do serious harm.

Second, someone can *recklessly* cause harm, not by aiming, or intending to cause harm but by being aware that harm is likely to result. If someone recklessly causes harm, the causal factor is present, so the reckless person is both legally liable and morally responsible for the harm. In reckless behavior, although there is not an intent to harm, there is an intent to engage in behavior that is known to place others at risk of harm. Furthermore, the person exhibits a reckless attitude, one which disregards the well-being of others, and perhaps even oneself. This attitude may result in serious injury, or even death, as in car accidents caused by reckless driving. Reckless drivers may not intend to cause an accident, but they do intend to drive fast, and they are not heeding their own safety or that of others. If their reckless action causes harm, then they are legally liable and morally responsible for the harms caused.

BOX 3.6 Legal and Moral Responsibility for Causing Harm

- Intentionally (or knowingly and deliberately) causing harm
- Recklessly causing harm—awareness of likelihood of causing harm, but not intending or aiming at harm
- Negligently causing harm—overlooking or not noticing risk of harm, failure of due care
- Strict liability for causing harm, even without fault: legal but not moral liability

A third kind of legal liability is associated with *negligently* causing harm. Unlike recklessness, where an element of deliberateness or intent is involved (such as a decision to drive fast) in negligent behavior, the person may simply overlook something, or not even be aware of the factors that could cause harm. The person is responsible because of a failure to exercise *due care*, which is the care that would be expected of a reasonable person in the circumstances. In law, a successful charge of negligence must meet three conditions:

1. A legal obligation to conform to certain standards of conduct is applicable.
2. The person charged with negligence fails to conform to the standards.
3. There is a reasonably close causal connection between the conduct and any resulting harm.

The first condition also applies to moral responsibility, except that we must substitute "moral obligation" for "legal obligation." Also, it is assumed that the standards of conduct in question are morally, and not just legally, binding. Professions such as engineering have recognized standards of professional practice, both technical and moral. Professional negligence, therefore, is the failure to perform duties that professionals have implicitly or explicitly assumed by virtue of being professionals. If engineers do not exercise standard care according to the recognized standards of their profession, and are therefore negligent, then they can be held responsible for any resulting harm.

One important difference between legal liability and moral responsibility is that, whereas the former typically requires actual harm, the latter does not. Whether or not harm is involved may be a matter of luck. However, the good fortune of not actually causing harm does not relieve one of moral responsibility, as one's sense of guilt, or of falling short morally, is still operative, as is the critical assessment of others.

There is one concept of legal liability that seems to have no parallel in moral responsibility. In some areas of the law, there is *strict liability* for harms caused; there is no attribution of fault or blame, but there is a legal responsibility to provide compensation, make repairs, or the like. Strict liability is directed at corporations rather than individual engineers within the organization. However, insofar as they have a duty to be faithful and loyal employees, and perhaps even as a matter of specifically assigned duties, engineers can have a moral responsibility to their employer to help minimize the likelihood that strict liability will be imposed on the organization. So even strict liability at the corporate level can have moral implications for individual engineers.

However, litigation that seeks redress from harm commonly appeals to the law of torts, which deals with harm to someone caused by another, usually as a result of fault or negligence on the part of the injuring party. The standard of proof in tort law is the *preponderance of evidence*, meaning that there is more and better evidence in favor of the plaintiff than the defendant. This is a weaker standard than in criminal law, which calls for proof *beyond reasonable doubt*. Appreciating this difference can be important for engineers who have a responsibility to try to minimize their company's liabilities falling under either sort of law.

Finally, even if certain engineers are not responsible in any of the earlier discussed ways for harms attributable to their organization, their managers may assign them responsibility for fixing the problems that were none of their making.

3.7 SHIFTING TO THE POSITIVE

Focusing attention on *failure* to satisfy the standard of care can easily result in overemphasizing the harms that can come from engineering practice. What about engineering *success* in satisfying this standard? As Coombs v. Beede stresses, professionals are expected to provide their services "at least ordinarily and reasonably well" and to exercise their "judgment and taste reasonably and without neglect." Success in this regard is no mean achievement. However, especially in the case of engineers, we are inclined to take this success for granted. We routinely and without question carry on our daily activities, assuming that our bridges are safe, that our elevators are reliable, and that our heating systems are efficient and safe—unless, or until, something goes wrong. We know how badly such things could go. In fact, it is stories of occasional mishaps rather than successes that receive the most media attention.

Although the standard of care plays a prominent role in law, it is important to realize that it encompasses a broader notion of moral responsibility. Dwelling on its role in law alone may suggest to some a more calculative, "legalistic" consideration of reasonable care. Regarding the standard of care as only a guide to protecting oneself (or one's employer or company) from legal liability hardly does justice to its moral underpinnings. Ideally, the standard of care reflects a concern to protect others from harm and wrongdoing. This captures a sense of at least minimal moral concern for others. However, the spectrum of responsibility we introduced earlier in this chapter can embrace much more.

We have already mentioned in Chapter 1 air bag pioneer Carl Clark, who continued after retirement to try to develop air bags for car bumpers and wearable air bags for the elderly to prevent broken hips when they fall. He did this without pay. This is what we call superogatory work on his part—work that goes "beyond the call of duty." A second example of such work is that of Michael Stoline, a statistician with strong interests in environmental issues. He volunteered to help analyze data to determine whether it was safe for residents in Love Canal, near Buffalo, New York, to return to their homes after being ordered to leave because of the likelihood that toxic wastes in the area posed a serious health risk. Although modestly compensated for his services, he realized that there were many more lucrative consulting opportunities. Asked why he accepted this task instead, he said: "Analyzing data just for the money doesn't mean anything to me. I want it to do some good."[20]

These two examples illustrate dedication that goes well beyond what can be ordinarily, and rightfully, expected of others, whether in their regular place of employment or elsewhere. Although we appreciate the fact that these individuals have taken on additional responsibilities, we do not think that they had a *duty* to assume them in the first place. Even though *they* might say to themselves, "This is what I ought to be doing," it is unlikely that we would feel it is appropriate for *us* to tell them that they ought to be doing what they are doing. Instead, we praise them for their good works and admire their enlarged sense of responsibility.

Such exemplary work can be undertaken by groups as well as individuals. In the late 1930s, a group of General Electric engineers worked together to develop the sealed beam headlamp, which promised to reduce sharply the number of fatalities caused by night driving.[21] To accomplish this, it was necessary to involve engineers in research, design, production, economic analysis, and governmental regulation. Although the need for headlight improvement was widely acknowledged, there was also widespread skepticism about its technical and economic feasibility. By 1937, the General Electric team proved the technical feasibility of the sealed beam headlamp. However, the remaining task was to persuade car builders and designers to cooperate with each other in support of the innovation, as well as to convince regulators of its merits.

There is little reason to suppose that the General Electric engineers were simply doing what they were told—namely to come up with a more adequate headlamp. Apparently, the virtual consensus was that this could not be done, so the engineers had to overcome considerable resistance. This was no ordinary task, as evidenced by the remarks of another engineer of that era:

> The reaching of the consensus embodied in the specifications of the Sealed Beam Headlamp is an achievement which commands the admiration of all who have any knowledge of the difficulties that were overcome. It is an achievement not only in illuminating engineering, but even more in safety engineering, in human engineering, in the art of cooperation.[22]

The difficulties faced by this group of engineers remind us that enthusiasm for such undertakings needs to be tempered with realism. Other demands and constraints may discourage undertaking such projects. Nevertheless, looking for opportunities to go beyond what is standardly required, as well as taking advantage of these opportunities when they arise, is a desirable trait in an engineer. It is easy not to notice that such exemplary work commonly occurs in engineering practice. Those involved may view themselves as simply doing what needs to be done. They may see important tasks that we fail to notice, and they quietly do them. Or we may grow accustomed to how they approach their work and simply take their dedication and accomplishments for granted. Furthermore, once they take on a responsibility and the work is underway, it often is appropriate to hold them accountable for completing the work. What we may overlook is that taking on the responsibility in the first place was their choice.

3.8 RESPONSIBILITY IN DESIGN

As we have noted, most engineering codes of ethics insist that, in designing products, engineers are expected to hold considerations of public safety paramount. However, there is likely more than one way to satisfy safety standards, especially when stated broadly. But if there is more than one way to satisfy safety standards, how are designers to proceed?

If we are talking about the overall safety of a product, there may be much latitude, a latitude that, of course, provides space for considerations other than safety (e.g., overall quality, usability, cost). For example, in the late 1960s, operating under the constraints of coming up with an appealing automobile that weighed under 2,000 pounds that would cost consumers no more than $2,000, Ford engineers decided to make more cargo space by putting the Pinto's gas tank in an unusual place.[23] This raised a safety question regarding rear end collisions. Ford claimed that the vehicle passed the current standards. However, some Ford engineers urged that a protective buffer should be inserted between the gas tank and protruding bolts. This, they contended, would enable the Pinto to pass a more demanding standard that it was known would soon be imposed on newer vehicles. They warned that, without the buffer, the Pinto would fail to satisfy the new standard, a standard that they believed would come much closer to meeting the standard of care enforced in tort law.

Ford decided not to put in the buffer. It might have been thought that satisfying the current safety standard ensured that courts and their juries would agree that reasonable care was exercised. However, this turned out to be a mistaken view. As noted earlier in the text, the courts can determine that existing technical standards are not adequate, and engineers themselves are sometimes called upon to testify to that effect.

Given the bad publicity Ford received regarding the Pinto and its history of subsequent litigation, Ford might regret not having heeded the advice of those engineers who argued for the protective buffer. This could have been included in the original design, or perhaps there were other feasible alternatives during the early design phases. However, even after the car was put on the market, a change could have been made. This would have involved an expensive recall, but this would not have been an unprecedented move in the automotive industry.

These possibilities illustrate a basic point about regulatory standards, accepted standards of engineering practice, and engineering design. Professional standards for engineers underdetermine design. In principle, if not in practice, there will be more than one way to satisfy the standards. This does not mean that professional standards have no effect on practice. As Stuart Shapiro points out:[24]

> Standards are one of the principal mechanisms for managing complexity of any sort, including technological complexity. Standardized terminology, physical properties, and procedures all play a role in constraining the size of the universe in which the practitioner must make decisions.

For a profession, the establishment of standards of practice is typically regarded as contributing to professionalism, thereby enhancing the profession in the eyes of those who receive its services. At the same time, standards of practice can contribute both to the quality and safety of products in industry. Still, standards of practice have to be applied in particular contexts that are not themselves specified in the standards. Shapiro notes:[25]

> There are many degrees of freedom available to the designer and builder of machines and processes. In this context, standards of practice provide a means of mapping the universal onto the local. All one has to do is think of the great variety of local circumstances for which bridges are designed and the equally great variety of designs that result.... Local contingencies must govern the design and construction of any particular bridge within the frame of relative universals embodied in the standards.

Shapiro's observation focuses on how standards of practice allow engineers freedom to adapt their designs to local, variable circumstances. This often brings surprises, not only in design but also in regard to the adequacy of formal standards of practice. As Louis L. Bucciarelli points out, standards of practice are based on the previous experience and testing of engineers. Design operates on the edge of "the new and the untried, the unexperienced, the ahistorical."[26] Thus, as engineers come up with innovative designs, we should expect formal standards of practice themselves sometimes to be challenged and found to be in need of change. All the more reason why courts of law are unwilling simply to equate the standard of care with current formal standards of practice.

3.9 THE RANGE OF STANDARDS OF PRACTICE

Some standards of practice are clearly only local in their scope. The New York City building code requirement that high-rise structures be tested for wind resistance at 90 degree angles applied only within a limited geographic region. Such specific code requirements are local in their origin and applicability. Of course, one would expect somewhat similar requirements to be in place in comparable locales in the United States as well as in other high-rise locales around the world. This suggests that local codes, particularly those that attempt to ensure quality and safety, reflect more general standards of safety and good engineering practice.

One test of whether we can meaningfully talk of more general standards is to ask whether the criteria for engineering competence are only local (e.g., New York City civil engineers, Chicago civil engineers), statewide, or national. Philosopher Vivian Weil has argued that there is good reason to believe that professional standards of engineering practice can cross national boundaries.[27] She offers the example of the early twentieth-century Russian engineer Peter Palchinsky. Critical of major engineering projects in Russia, Palchinsky was nevertheless regarded to be a highly competent engineer in his homeland. He also was a highly regarded consultant in Germany, France, England, the Netherlands, and Italy. Although he was regarded as politically dangerous by Russian leaders at the time, no one doubted his engineering abilities—either in Russia or elsewhere.[28]

Weil also reminds readers of two fundamental principles of engineering that Palchinsky applied wherever he practiced:[29]

> Recall that the first principle was: gather full and reliable information about the specific situation. The second was: view engineering plans and projects in context, taking into account impacts on workers, the needs of workers, systems of transportation and communication, resources needed, resource accessibility, economic feasibility, impacts on users and on other affected parties, such as people who live downwind.

Weil goes on to point out that underlying Palchinsky's two principles are principles of common morality, particularly respect for the well-being of workers—a principle that Palchinsky argued was repeatedly violated by Lenin's favored engineering projects.

We have noted that the codes of ethics of engineering societies typically endorse principles that seem intended to apply to engineers in general rather than only to members of those particular societies. Common morality was suggested as providing the ground for basic provisions of those codes (e.g., concern for the safety, health, and welfare of the public). Whether engineers who are not members of professional engineering societies actually do, either explicitly or implicitly, accept the principles articulated in a particular society's code of ethics is, of course, another matter. However, even if some do not, it could be argued that they *should*. Weil's point is that there is no reason, in principle, to believe that supportable international standards cannot be formulated and adopted. Furthermore, this need not be restricted to abstract statements of ethical principle. As technological developments and their resulting products show up across the globe, they can be expected to be accompanied by global concerns about quality, safety, efficiency, cost-effectiveness, and sustainability. This, in turn, can result in uniform standards in many areas regarding acceptable and unacceptable engineering design, practice, and products. In any case, in the context of an emerging global economy, constructive discussions of these concerns should not be expected to be only local.

3.10 IMPEDIMENTS TO RESPONSIBILITY

So far in this chapter, we have tried to explain different aspects of engineering responsibility, both legal and moral. However, it is one thing to have a basic understanding of engineering responsibility, but it is quite another to apply this understanding in actual engineering practice, especially when addressing questions of wrongdoing. Unfortunately, many impediments can stand in the way of handling one's responsibilities as well as one should. Box 3.7 lists some of the more significant ones we will be discussing.

The Problem of Many Hands

Individuals often attempt to evade personal responsibility for wrongdoing. Perhaps the most common way this is done, especially by individuals in large organizations, is by pointing out that many individuals had a hand in causing the harm. The argument here goes as follows: "So many people are responsible for what happened that it is irrational and unfair to pin the responsibility on any individual person, including me." Let us call this the *problem of fractured responsibility* or (preferably) the *problem of many hands*.[30] In response to this argument, philosopher Larry May has proposed the following principle to apply to the responsibility of individuals in a situation where many people are involved in causing harm, either through inaction or through action. First, consider harm through collective inaction. May suggests, "[I]f a harm has resulted from collective inaction, the degree of individual responsibility of each member of a putative group for the harm should vary based on the role each member could, counterfactually, have played in preventing the inaction."[31] Let us call this the *principle of responsibility for inaction in groups*. Our slightly modified version of

BOX 3.7 Common Impediments to Responsibility

- The problem of many hands (or fractured responsibility)
- Blind spots
  - self-deception
  - willful blindness
  - inattentional blindness
- Normalizing deviance
- Egoistic perspectives (self-interest first)
- Egocentric perspectives (assuming others see matters as we do)
- Microscopic vision (seeing fine details, but missing the bigger picture)
- Uncritical deference to authority
- Groupthink
  - illusion of invulnerability of group
  - shared stereotypes
  - rationalizations
  - illusion of morality
  - self-censorship
  - illusion of unanimity
  - direct pressure to agree
  - mind-guarding (keeping dissenters away from the group)

this principle reads as follows: In a situation in which a harm has been produced by collective inaction, the degree of responsibility of each member of the group depends on the extent to which the member could reasonably be expected to have tried to prevent the action. The qualification "the extent to which each member could reasonably be expected to have tried to prevent the action" is necessary because there are limits to reasonable expectation here. If a person could have prevented an undesirable action only by taking his own life, sacrificing his legs, or harming someone else, then we cannot reasonably expect him to do it.

A similar principle can apply to collective action that causes harm. Let us call it the *principle of responsibility for action in groups*: Here, the degree of responsibility of each member of the group depends on the extent to which the member caused the action by some action reasonably avoidable on his part. Again, the reason for the qualification is that if an action causing harm can only be avoided by extreme or heroic action on the individual's part (such as taking his own life, sacrificing his legs, or harming someone else), then we may find reason for not holding the person responsible, or at least holding him less responsible.

These two principles are not easy to apply in complex organizations, where much that goes on is not clearly explainable in terms that enable one to determine just what this or that individual did or did not do. Still, for the individuals in question, seriously imagining that they bear *no* responsibility for what happened may be quite questionable.

Blind Spots

Those who drive automobiles are familiar with *blind spots*. Applying this term to organizational and business arenas, Dennis Moberg draws an analogy between business blind spots and those we experience when driving.[32] Once regular attention is given to the deficit area, driving habits can be developed to help compensate for this perceptual deficit. In the case of driving, such adaptations are welcomed by all. However, in the business arena, blind spots often protect us from having to face unwelcome information.

Max H. Bazerman and Ann E. Tenbrunsel, authors of *Blind Spots*, contend that although nearly all of us want to think of ourselves as ethically decent, our blind spots result in a tendency to overestimate how ethical we actually are.[33] This blindness should not be confused with unethical intent. We are capable of this, too, of course. But Bazerman and Tenbrunsel are more interested in explaining how otherwise decent, well-intentioned people can, without consciously intending to do so, lend support to ethically unacceptable outcomes.

Self-deception is a key to much of this. Although we might well be sincerely opposed to wrongdoing and not want to be complicit in it, we may also be highly motivated, perhaps through fear or lack of courage, to turn the other way. Taking action against wrongdoing may risk unpopularity, censorship, or even retaliation (e.g., demotion or job loss). But we cannot take action against that which we do not notice. Not noticing may in many instances be what we might call *willful blindness*.[34] Ignorance of vital information is an obvious barrier to responsible action. If an engineer does not realize that a design poses a safety problem, for example, then he or she will not be in a position to do anything about it. Sometimes such a lack of awareness is willful avoidance—a turning away from information in order to avoid having to deal with the challenges it may pose. However, often it results from a lack of imagination, from not looking in the right places for necessary information, from a failure to persist, or from the pressure of deadlines. Although there are limits to what engineers can be expected to know, these examples suggest that ignorance is not always a good excuse.

Still, the pervasiveness, and limitations, of selective attention are effectively illustrated in the perceptual experiments of Ulric Neisser in the mid-1970s.[35] In one experiment, participants watched a short video in which a group of people passed a basketball to one another. The viewers were asked to count the number of passes that were completed. On their first viewing, very few noticed a woman carrying an open umbrella walking between those passing the ball. When the video was replayed, attention was easily focused on the woman, but at the expense of not being able to count the number of completed passes. This "selective looking," as Neisser called it, is now labeled *inattentional blindness*. Neisser's simple experiment effectively illustrates that typically what we see is a function of what we are looking for and that this selectivity blinds us to things "right before our eyes." So, we need to be ready to refocus in order to notice what is readily available to take into account if only we will do this.

Normalizing Deviance

In the case of the *Columbia* disaster, Rodney Rocha accused NASA managers of "acting like an ostrich with its head in the sand."[36] NASA managers seemed to him to have convinced themselves that past successes are an indication that a known defect would not cause problems, instead of deciding the issue on the basis of testing and sound engineering analysis. Often, instead of attempting to remedy the problem, they simply engaged in the practice of *normalizing deviance*, which enlarges the boundaries of acceptable risk without sound engineering basis.[37] Instead of attempting to eliminate foam strikes or doing extensive testing to determine whether the strikes posed a safety-of-flight issue, managers "increasingly accepted less-than- specification performance of various components and systems, on the grounds that such deviations had not interfered with the success of previous flights."[38] Enlarging on the issue, the *Columbia* Accident Investigation Board observed: "With each successful landing, it appears that NASA engineers and managers increasingly regarded the foam-shredding as inevitable, and as either unlikely to jeopardize safety or simply an acceptable risk."[39]

Finally, there was a subtle shift in the burden of proof with respect to the shuttle. Instead of requiring engineers to show that the shuttle was safe to fly or that the foam strike did not pose a safety-of-flight issue, "[T]he engineers found themselves in the unusual position of having to prove that the situation was unsafe—a reversal of the usual requirement to prove that a situation is safe." As the Board observed, "Imagine the difference if any Shuttle manager had simply asked, 'Prove to me that Columbia has not been harmed.'"[40]

An important lesson is that organizations need continually to determine whether important factors are being underestimated, or even overlooked, and whether this is the result of time pressures, viewing matters only in the short term, or some other shortcoming. In any case, once an organization has identified such problems, possible remedies need aggressively to be sought. Key questions here are as follows: First, what role might engineers play in *identifying* serious problems? Second, how might they best *communicate* these problems to managers who have responsibilities in these areas? Third, what promising ways of *resolving*, or at least minimizing, these problems can they suggest?

In the case of the *Columbia*, it seems that NASA managers were often ignorant of serious problems associated with the shuttle. One of the reasons for this is that as information made its way up the organizational hierarchy, more and more of the dissenting viewpoints were filtered out, resulting in an excessively sanitized version of the facts. According to the *Columbia* Accident Investigation Board, there was a kind of "cultural fence" between engineers and managers. This resulted in high-level managerial decisions that were based on insufficient knowledge of the facts.[41]

Egoistic and Egocentric Perspectives

A common feature of human experience is that we tend to interpret situations from very limited perspectives, or "mindsets," and it takes special efforts to acquire a more inclusive viewpoint.[42] Although these limited perspectives can sometimes be narrowly self-interested (or *egoistic*), they need not be. It is not just self-interest that interferes with our ability to understand things from larger perspectives. For example, we may have good intentions for others but fail to realize that their perspectives are different from ours in important ways. This is commonly called *egocentric* thinking, especially characteristic of very young children, but something that even adults never overcome completely. For example, some people may not want to hear bad news about their health. They may also assume that others are like them in this respect. So, if they withhold bad news from others, this is done with the best of intentions—even if others would prefer hearing the bad news. Similarly, an engineer may want to design a useful product but fail to realize how different the average consumer's understanding of how to use it is likely to be from those who design it. This is why test runs with typical consumers are desirable.

Microscopic Vision

Michael Davis warns of the danger of what he calls *microscopic vision*. Precise and accurate as it may be, microscopic vision greatly limits our field of vision. When we look into a microscope, we see things that we could not see before—but only in the narrow field of resolution on which the microscope focuses. We gain accurate, detailed knowledge—at a microscopic level. At the same time, we cease to see things at the more ordinary level. This is the price of seeing things microscopically. Only when we lift our eyes from the microscope will we see what is obvious at the everyday level. Every skill, says Davis, involves microscopic vision to some extent:

> A shoemaker, for example, can tell more about a shoe in a few seconds than I could tell if I had a week to examine it. He can see that the shoe is well or poorly made, that the materials are good or bad, and so on. I can't see any of that. But the shoemaker's insight has its price. While he is paying attention to people's shoes, he may be missing what the people in them are saying or doing.[43]

Just as shoemakers need to raise their eyes and listen to their customers, engineers sometimes need to raise their eyes from their world of scientific and technical expertise and look around them in order to understand the larger implications of what they are doing.

Large organizations, especially, tend to foster microscopic thinking. Each person has his or her own specialized job to do, and he or she is not responsible, from the organizational standpoint, for the work of others. This was evidently generally true of the NASA organizational structure. It may also have been a contributing factor to the *Columbia* accident.

Authority Versus Autonomy

Engineering codes of ethics emphasize the importance of engineers attempting to exercise independent, objective judgment in performing their functions. This is sometimes called professional *autonomy*. At the same time, the codes of ethics insist that engineers have a duty of fidelity to their employers and clients. Independent consulting engineers may have an easier time maintaining professional autonomy than the vast majority of engineers, who work in large, hierarchical organizations. Most engineers are not their own bosses, and they are expected to defer to authority in their organizations.

An important finding of the research of social psychologist Stanley Milgram is that a surprisingly high percentage of people are inclined to defer uncritically to authority.[44] In his famous obedience experiments during the 1960s, Milgram asked volunteers to administer electric shocks to "learners" whenever they made a mistake in repeating word pairs (e.g., nice/day and rich/food) that volunteers presented to them earlier. He told volunteers that this was an experiment designed to determine the effects of punishment on learning. No shocks were actually administered, however. Milgram was really testing to determine the extent to which volunteers would continue to follow the orders of the experimenter to administer what they believed were increasingly painful shocks. Surprisingly (even to Milgram), nearly two-thirds of the volunteers continued to follow orders all the way up to what they thought were 450-volt shocks—even when shouts and screams of agony were heard from the adjacent room of the "learner." The experiment was replicated many times to make sure that the original volunteers were a good representation of ordinary people rather than especially cruel or insensitive people.[45]

In the Milgram experiments, the volunteers were told that the "learners" would experience pain but no permanent harm or injury. Perhaps volunteers who were engineers would have had doubts about this as the apparent shock level moved toward the 450-volt level. This would mean only that the numbers need to be altered for engineers, not that they would be unwilling to administer what they thought were extremely painful shocks.

One of the interesting variables in the Milgram experiments was the respective locations of volunteers and "learners." The greatest compliance occurred when "learners" were not in the same room with the volunteers. Volunteers tended to accept the authority figure's reassurances that he would take all the responsibility for any unfortunate consequences. However, when volunteers and "learners" were in the same room and in full view of one another, volunteers found it much more difficult to divest themselves of responsibility.

Milgram's studies seem to have special implications for engineers. As previously noted, engineers tend to work in large organizations in which the division of labor often makes it difficult to trace responsibility to specific individuals. The combination of the hierarchical structure of large organizations and the division of work into specialized tasks contributes to the sort of "distancing" of an engineer's work from its consequences for the public. This tends to decrease the engineer's sense of personal accountability for those consequences. However, even though such distancing might make it easier psychologically to be indifferent to the ultimate consequences of one's work, this does not really relieve one from at least partial responsibility for those consequences.

One further interesting feature of Milgram's experiments is that volunteers were less likely to continue to administer what they took to be shocks when they were in the presence of other volunteers. Apparently, they reinforced each other's discomfort at continuing, and this made it easier to disobey the experiment. However, as discussed in the next section, group dynamics do not always support critical response. Often quite the opposite occurs, and only concerted effort can overcome the kind of uncritical conformity that so often characterizes cohesive groups.

Groupthink

A noteworthy feature of the organizational settings within which engineers work is that individuals tend to work and deliberate in groups. This means that an engineer will often participate in group decision making rather than function as an individual decision maker. Although this may contribute to better decisions ("two heads are better than one"), it also creates well-known but commonly overlooked tendencies to engage in what Irving Janis calls *groupthink*—situations in which groups come to agreement at the expense of critical thinking.[46] Janis documents instances of groupthink in a variety of settings, including a number of historical fiascos (e.g., the bombing of Pearl Harbor, the Bay of Pigs invasion, and the decision to cross the 38th parallel in the Korean War).[47] Concentrating on groups that are characterized by high cohesiveness, solidarity, and loyalty (all of which are prized in organizations), Janis identifies eight symptoms of groupthink:

- An *illusion of invulnerability* of the group to failure
- A strong "we-feeling" that views outsiders as adversaries or enemies and encourages *shared stereotypes* of others
- *Rationalizations* that tend to shift responsibility to others
- An *illusion of morality* that assumes the inherent morality of the group and thereby discourages careful examination of the moral implications of what the group is doing
- A tendency of individual members toward *self-censorship*, resulting from a desire not to "rock the boat"
- An *illusion of unanimity*, construing silence of a group member as consent
- An application of *direct pressure* on those who show signs of disagreement, often exercised by the group leader who intervenes in an effort to keep the group unified
- *Mindguarding*, or protecting the group from dissenting views by preventing their introduction (e.g., by outsiders who wish to present their views to the group)[48]

Traditionally, engineers have prided themselves on being good team players, which compounds the potential difficulties with groupthink. How can the problem of groupthink be minimized for engineers? Much depends on the attitudes of group leaders, whether they are managers or engineers (or both). Janis suggests that leaders need to be aware of the tendency of groups toward groupthink and take constructive steps to resist it. He notes that after the ill-advised Bay of Pigs invasion of Cuba, President John F. Kennedy began to assign each member of his advisory group the role of critic. He also invited outsiders to some of the meetings, and often absented himself from meetings to avoid influencing unduly its deliberations.

Many of NASA's *Columbia* engineers and managers may have been affected with the groupthink mentality. Commenting on management's decision not to seek clearer images of the leading edge of the left wing of the shuttle in order to determine whether the foam strike had caused damage, one employee said, "I'm not going to be Chicken Little about this."[49] The *Columbia* Accident Investigation Board described an organizational culture in which "people find it intimidating to contradict a leader's strategy or a group consensus," evidently finding this characteristic of the NASA organization.[50] The general absence of a culture of dissent that the board found at NASA could have encouraged the groupthink mentality.

To overcome the problems associated with the uncritical acceptance of authority, organizations need to establish a culture in which dissent is accepted and even encouraged. The *Columbia* Accident Investigation Board cites organizations in which dissent is encouraged, including the U.S. Navy Submarine Flooding Prevention and Recovery program and the Naval Nuclear Propulsion programs. In these programs, managers have the responsibility, not only of encouraging dissent, but also of coming up with dissenting opinions themselves if such opinions are not offered by their subordinates. According to the Board, "program managers [at NASA] created huge barriers against dissenting opinions by stating preconceived conclusions based on subjective knowledge and experience, rather than on solid data." Toleration and encouragement of dissent, then, was noticeably absent in the NASA organization. If dissent is absent, then critical thinking is absent.

Another widely discussed instance in which groupthink may have been operative involves the production of General Motors' Corvair automobile in the early 1960s. Safety differences were heatedly discussed among engineers and management. The car was released for public sale even though some engineers insisted the Corvair had stabilizing problems.[51] The first models (1960–1963) had a swing-axle suspension design which was prone to "tuck under" in certain circumstances. An anti-roll bar was needed to stabilize the vehicle.[52] Yet, it was decided to solve the problem by requiring higher tire pressure at a level that was outside the tire manufacturer's recommended tolerances. Additionally, according to Ralph Nader, a strong critic of the car, the tire pressure changes were not clearly stated to Chevrolet salespeople and Corvair owners.[53] There was a failure to recognize the seriousness of the engineering problems with the car. Nader claimed that rather than making the necessary stabilizing change, the General Motors team added styling features to the dashboard. These shiny dashboard features caused a visual impediment in the form of windshield glare, allegedly triggering crashes because of flashes obstructing the driver's vision. These styling changes cost $700. It was estimated that the safety changes needed would have only cost about 23 cents.[54] John DeLorean was an engineer and vice president with General Motors at the time. He believed that individually the executives were "moral men." However, thinking as a group, he concluded that they made immoral decisions.[55]

3.11 CHAPTER SUMMARY

Engineers are responsible for exercising a standard of care in their work. They need to be concerned with complying with the law, adhering to norms and practices commonly accepted by competent engineers who exercise reasonable care in their work in relevantly similar areas, and avoiding wrongful behavior. But this may not be good enough. The standard of care view insists that existing regulatory standards may be inadequate, for these standards may fail to address problems that have yet to be taken adequately into account. This suggests that particularly in areas of technological innovation, engineers need to exercise imaginative, critical thinking in trying to anticipate and address new risks before they become serious problems.

We might wish for some sort of algorithm for determining what our responsibilities are in particular circumstances. But this is an idle wish. Even the most detailed codes of ethics of professional engineering societies can provide only general guidance. The determination of responsibilities and how they should be pursued in particular circumstances depend on discernment and judgment on the part of engineers. The manner in which one approaches one's work-related responsibilities may exceed what can reasonably be required, but be important, nonetheless. Some "good works" fall entirely beyond one's standard job description. However, once undertaken, they carry obligations with them.

Blame-responsibility can be applied to individuals and perhaps to organizations. If we believe organizations can be morally responsible agents, it is because we believe the analogies between undisputed moral agents (people) and organizations are stronger than the disanalogies. In any case, organizations can be criticized for the harms they cause, be asked to make reparations for harm done, and be assessed as needing to be reformed.

Understanding concepts of responsibility needs to be accompanied by efforts at actually satisfying the requirements of one's responsibilities. These efforts need to address the challenges posed by blind spots, the normalization of deviancy, deference to authority, groupthink, and other impediments to responsibility.

NOTES

1. This account is based on three sources: *Columbia Accident Investigation Board*, vol. 1 (Washington, DC: National Aeronautics and Space Administration, 2003); "Dogged Engineer's Effort to Assess Shuttle Damage," *The New York Times*, September 26, 2003, p. A1; William Langewiesche, "Columbia's Last Flight," *Atlantic Monthly*, November 2003, pp. 58–87.
2. The next several paragraphs and some later segments of this chapter are based on Michael S. Pritchard, "Professional Standards for Engineers," in *Handbook Philosophy of Technology and Engineering Sciences*, ed. A. Meijers, Part V, "Normativity and Values in Technology," Ibo van de Poel, ed. (Elsevier Science, 2010).
3. The list that follows is based on interviews of engineers and managers conducted by James Jaksa and Michael S. Pritchard and reported in Michael S. Pritchard, "Responsible Engineering: The Importance of Character and Imagination," *Science and Engineering Ethics*, 7, no. 3, 2001, pp. 394–395.
4. See, for example, the Association for Computing Machinery: ACM Code of Ethics and Professional Conduct, 2.2 Acquire and maintain professional competence.
5. This is a major theme of Stuart Shapiro's, "Degrees of Freedom: The Interaction of Standards of Practice and Engineering Judgment," *Science, Technology, & Human Values*, 22, no. 3, Summer 1997.
6. Shapiro, "Degrees of Freedom," p. 290.
7. Joshua B. Kardon, "The Structural Engineer's Standard of Care," presented at the OEC International Conference on Ethics in Engineering and Computer Science, March 1999. This article is available at http://www.onlineethics.org.
8. Ibid. Kardon bases this characterization on *Paxton v. County of Alameda* (1953) 119c.C.A. 2d 393, 398, 259P 2d 934.
9. *Columbia Accident Investigation Board*, p. 6.
10. Nevertheless, the investigation eventually resulted in the displacement of no less than a dozen key people at NASA, as well as a public vindication of Rocha for doing the right thing.
11. Ibid., p. 9.
12. Ibid.
13. Ibid., p. 177.
14. For discussions of this issue see, for example, Peter French, *Collective and Corporate Responsibility* (New York: Columbia University Press, 1984); Kenneth E. Goodpaster and John B. Matthews, Jr., "Can a Corporation Have a Conscience?" *Harvard Business Review*, 60, January–February 1982, pp. 132–141; and Manuel Velasquez, "Why Corporations Are Not Morally Responsible for Anything They Do," *Business and Professional Ethics Journal*, 2, no. 3, Spring 1983, pp. 1–18.
15. *Black's Law Dictionary*, 6th ed. (St. Paul, MN: West 1990), p. 340.
16. See Peter French, "Corporate Moral Agency" and "What Is Hamlet to McDonnell-Douglas or McDonnell-Douglas to Hamlet: DC-10," in *Ethical Issues in Professional Life*, ed. Joan C. Callahan (New York: Oxford University Press, 1988), pp. 265–269,

274–281. The following discussion has been suggested by French's ideas, but it diverges from them in several ways.

17. These three senses all fall on the blame-responsibility side. A less explored possibility is that corporations can be morally responsible agents in positive ways.
18. *Coombs v. Beede*, 89 Me. 187, 188, 36 A. 104 (1896). This is cited and discussed in Margaret N. Strand and Kevin Golden, "Consulting Scientist and Engineer Liability: A Survey of Relevant Law," *Science and Engineering Ethics*, 3, no. 4, October 1997, pp. 362–363.
19. We are indebted to Martin Curd and Larry May for outlining parallels between legal and moral notions of responsibility for harms and their possible applications to engineering. See Martin Curd and Larry May, *Professional Responsibility for Harmful Actions*, Module Series in Applied Ethics, Center for the Study of Ethics in the Professions, Illinois Institute of Technology (Dubuque, IA: Kendall/Hunt, 1984).
20. Personal communication with statistician Michael Stoline at Western Michigan University.
21. This account is based on G. P. E. Meese, "The Sealed Beam Case," *Business & Professional Ethics*, 1, no. 3, Spring 1982, pp. 1–20.
22. H. H. Magsdick, "Some Engineering Aspects of Headlighting," *Illuminating Engineering*, June 1940, p. 533, cited in Meese, p. 17.
23. Information on Ford Pinto here is based on a case study prepared by Manuel Velasquez, "The Ford Motor Car," *Business Ethics: Concepts and Cases*, 3rd ed. (Englewood Cliffs, NJ: Prentice-Hall, 1992), pp. 110–113.
24. Shapiro, "Degrees of Freedom," p. 290.
25. Ibid., p. 293.
26. Louis L. Bucciarelli, *Designing Engineers* (Cambridge, MA: MIT Press, 1994), p. 135.
27. Vivian Weil, "Professional Standards: Can They Shape Practice in an International Context?" *Science and Engineering Ethics*, 4, no. 3, 1998, pp. 303–314.
28. For more on the life and career of Peter Palchinsky, see Loren Graham's, *The Ghost of an Executed Engineer: Technology and the Fall of the Soviet Union* (Cambridge, MA: Harvard University Press, 1993).
29. Ibid., p. 306. Similar principles are endorsed by disaster relief specialist Frederick Cuny and his Dallas, Texas, engineering relief agency. Renowned for his relief efforts around the world, Cuny's principles of effective and responsible disaster relief are articulated in his *Disasters and Development* (New York: Oxford University Press, 1983).
30. The phrase "the problem of many hands" is suggested by Helen Nissenbaum in "Computing and Accountability" in Deborah G. Johnson and Helen Nissenbaum, eds., *Computers, Ethics, and Social Values* (Upper Saddle River, NJ: Prentice-Hall, 1995), p. 529.
31. Larry May, *Sharing Responsibility* (Chicago: University of Chicago Press, 1992), 106. For a more nuanced discussion of these notions, as well as notions of responsibility in engineering, see Michael Davis, "Ain't No One Here but Us Social Forces," *Science and Engineering Ethics*, 18, no. 1, March 2012, pp. 13–34.
32. Dennis Moberg, "Ethics Blind Spots in Organizations: How Systematic Errors in Person Perception Undermine Moral Agency," *Organizational Studies*, 27, no. 3, 2006, p. 414.
33. Max H. Bazerman and Ann E. Tenbrunsel, *Blind Spots: Why We Fail to Do What's Right and What to Do About It* (Princeton: Princeton University Press, 2011), p. 29.
34. For an excellent discussion of various forms this can take, see Margaret Heffernan, *Willful Blindness* (Princeton, NJ: Walker and Company, 2011).
35. For more on Ulric Neisser's, Google him on Wikipedia.See also his groundbreaking *Cognitive Psychology* (Englewood Cliffs: Prentice-Hall, 1967). He and N. Harsch are also noted for their, "Phantom Flashbulbs: False Recollections of Hearing the News About Challenger," in *Affect and Accuracy in Recall: Studies of 'Flashbulb' Memories*, eds., E. Winograd and U. Neisser, (New York: Cambridge University Press, 1992), pp. 9–31.

36. “Dogged Engineer’s Effort to Assess Shuttle Damage,” p. A1.
37. The notion of “normalizing defiance” is featured in Diane Vaughn’s, *The Challenger Launch Decision* (Chicago: University of Chicago Press, 1996), esp. pp. 409–422. We discuss this in more detail in our chapter on risk.
38. *Columbia Accident Investigation Board*, p. 24.
39. Ibid., p. 122
40. Ibid., p. 198
41. Ibid., p. 168, 170, 198.
42. The challenges these and other limited perspectives, or “mindsets,” pose to sound, ethical decision making are discussed in detail in Patricia H. Werhane et al., *Obstacles to Ethical Decision-Making* (Cambridge, UK: Cambridge University Press, 2013).
43. This expression was introduced into engineering ethics literature by Michael Davis. See his “Explaining Wrongdoing,” *Journal of Social Philosophy*, now retain 1 & 2, Spring–Fall 1989, pp. 74–90. Davis applies this notion to the *Challenger* disaster, especially when Robert Lund was asked to take off his engineer’s hat and put on his manager’s hat.
44. Stanley Milgram, *Obedience to Authority* (New York: Harper & Row, 1974).
45. It might be thought that after a series of unpopular wars and a variety of social protest movements, Milgram’s results could not be replicated today—we are less likely to defer, uncritically to authority. However, a recent replication of much of the Milgram experiment suggests that this is not so. See Jerry Bulger, “Replicating Milgram: Would People Obey Today?” *American Psychologist*, 64, no. 1, 2009, pp. 1–11.
46. Irving Janis, *Groupthink*, 2nd ed. (Boston: Houghton Mifflin, 1982).
47. The most recent edition of the McGraw-Hill video *Groupthink* features the *Challenger* disaster as illustrating Janis’s symptoms of groupthink.
48. Ibid., pp. 174–175.
49. “Dogged Engineer’s Effort to Assess Shuttle Damage,” p. A1.
50. *Columbia Accident Investigation Board*, p. 203.
51. J. Patrick Wright, *On a Clear Day You Can See General Motors* (Detroit, MI: Wright Enterprises, 1979), p. 237.
52. Ibid.
53. Ralph Nader, *Unsafe at Any Speed* (New York: Grossman Publishers, 1965), p. 14.
54. Ibid.
55. Wright, *On a Clear Day*, p. 237.