WHAT ENGINEERING SOCIETIES CAN DO ABOUT ETHICS

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Recently, I had the opportunity to address the ethics session of a national engineering society meeting in Chicago. During the question period, I asked how many in the audience had discussed an issue of professional ethics with management. To my surprise, not one hand was raised. I asked some more questions. Did they not have managers? Did no ethics issues occur in their work? I was soon told that raising an ethics issue with a manager was difficult at best. A manager might not understand. He might well react hostilely or at least wonder whose team the engineer was on.

I am always happy for an opportunity--like that I have tonight--to address a group of working engineers. Hearing how engineers respond to what I say usually gives me much think about. But my audience that night gave me more to think about than usual: Most engineers are not solo practitioners. They work in large organizations. Large organizations are generally run by managers, not engineers. If most managers are hostile, or even just indifferent, to engineering ethics, what happens to engineering ethics?

That's a large question. Tonight I can do no more than sketch a partial answer and draw one practical conclusion. My topic really is, as promised, "What Engineering Societies Can Do About Ethics", but I shall reach that topic by what may seem at times a round-about route. Please bear with me.

As you know, I am not engineer. Most of what I know about the ethical problems of engineers, I have learned from three sources: 1) the major (and therefore well-documented) engineering scandals of the last three decades; 2) the more common newspaper stories about lesser miscarriages of

engineering; and 3) the common anecdotes engineers tell more or less off the record. These three sources seem to be in remarkable agreement. Let me begin with the scandals.

A few of the major engineering scandals resemble those of other professions. For example, a scandal in Maryland in the early 1970's resulted from civil engineers bribing officials, including a vice president of the United States, to obtain state public-works contracts. Their profession's code of ethics, like yours, prohibited bribing public officials to obtain work. They violated that prohibition. This is the typical pattern in scandals concerning other professions. The professionals themselves engage in the scandalous activity.

With a few exceptions, however, major engineering scandals seem to have a quite different pattern. Among those I have in mind are the following: the Pinto's exploding gas tank, the Goodrich A7D airbrakes, the crash of the DC-10 because of a design flaw in its rear cargo door, the controversy concerning the Bay Area Transit Authority's computer operated trains, the complex of problems we now call Three Mile Island, and, most recently, the explosion of the Challenger.

These scandals differ in some ways: For example, some involved government contractors while others did not; some involved highly sophisticated technologies, some did not; the engineers involved range from automotive engineers in the Pinto case to electricals in the BART case. There are, however, at least three important similarities. First, each involved engineers working for a large organization. Second, each involved a potentially life-threatening failure in engineering, either of design or implementation. And, third, in each, the failure occurred in something like this way: Staff engineers identified a technical problem and made certain recommendations that were overruled in part at least

because of cost, time, or "political" constraints; the engineers pressed their objections until management told them to pipe down. Sometimes the engineers did pipe down after recording their concerns in lengthy reports. Sometimes they pressed on and were fired, or quit and became whistleblowers, or just quit in disgust.

This pattern would be important even if it were rare. But I have talked to few experienced engineers who did not have a story or two about a company in which the only significant difference seemed to be that luckily nothing went went wrong or at least nothing serious went wrong. So, I have come to believe that these scandals merely illustrate a pervasive problem. The problem concerns the relation between engineers and managers. In each scandal, the staff engineers, though seldom heroic, behaved more or less as their professional code required. In each scandal, an engineering disaster was a result of managers overruling an engineering recommendation.

There is, of course, nothing unusual about managers overruling engineering recommendations. That happens every day and often, no doubt, the managers are right to do so. Managers may have more information than the ordinary engineer. They may see the engineering recommendation in a wider context. Certainly, managers generally have a better sense of what is institutionally possible than engineers do. But, in the major scandals, something seems to have gone wrong and even the managers now seem to wish that they had decided differently.

What might that "something" be? If we can tell anything from textbooks, most of these scandals are seldom discussed in engineering ethics classes. The reason, I think, is that, as cases of engineering ethics, they are relatively straightforward. The public interest is clear. The engineers stood up for the public interest. For

engineers, what went wrong was that the managers did not give due weight to safety. The only interesting question of engineering ethics these scandals seem to raise is whether and, if so, when and how, the engineers should have blown the whistle.

Though all this may seem obvious, it is only obvious to engineers (and the public). These cases have a different place in a course in business ethics. Many students in such courses at first can see nothing wrong with what the manager did. What they see is a manager making a difficult "trade-off" between profit and safety, something managers do "all the time". The only difference they see between this management decision and most others is that things didn't work out. The engineering recommendation is treated as a mere technical recommendation.

Business ethics texts are not much help here. I have yet to find one that points out that engineers have a professional duty to put the public safety first, that they can generally be counted on to recommend accordingly, and that they are likely to view the overruling of such a recommendation as something worse than just another management decision. Since business ethics as a course tends to reflect the best one can expect of managers, I think it safe to say that few managers understand the professional ethics of those they manage.

So, from the engineer's perspective, one thing that may have gone wrong in these cases is that the managers misunderstood the engineer's recommendation. They understood it as just another technical recommendation when it was something more than that. This would be an important thesis even if the reason the managers misunderstood the recommendation was that they were ignorant of engineering ethics. But, I'm afraid, ignorance cannot be the whole explanation. In many of these scandals, the managers

involved were trained as engineers. Such managers must have tacitly known about as much engineering ethics as those whose recommendation they overruled. Yet, they did not behave as if they did. Consider, for example, the decisive events on the night before the Challenger exploded:

The Space Center was counting down for a launch the next morning. Lund, vice president for engineering at Morton Thiokol, had earlier presided at a meeting of engineers that unanimously recommended against the launch. He had concurred and informed his boss, Jerald Mason. Mason informed the Space Center. Lund had expected the flight to be postponed. The Center's safety record was good. It was good because the Center would not allow a launch unless the technical people approved.

Lund had not approved. He had not approved because the temperature at the launch site would be close to freezing at lift-off. The Space Center was worried about the ice already forming here and there on the boosters, but Lund's worry was the "O-rings" that sealed the booster's segments. They had been a great idea, permitting Thiokol to build the huge rocket in Utah and ship it in pieces to the Space Center two thousand miles away. Building in Utah was so much more efficient than building on-site that Thiokol had been able to underbid the competition. The shuttle contract had earned Thiokol $150 million in profits.

But the O-rings were not perfect. Data from previous flights indicated that the rings tended to erode in flight, with the worst erosion occurring on the coldest preceding lift-off. Experimental evidence was sketchy but ominous. Erosion seemed to increase as the rings lost their resiliency and resiliency decreased with temperature. At some temperature, the rings could lose so much resiliency that one would fail to seal properly. If a ring failed in flight, the shuttle could explode.

Unfortunately, almost no testing had been done below $40^{o}F$ and no lift-off had occurred after a night as cold as this one. The engineers had had to extrapolate. But, with the lives of seven astronauts at stake, the decision seemed clear enough: Safety first.

Or so it had seemed clear earlier in the day. Now Lund was not so sure. The Space Center had been "appalled" by the sketchy evidence on which the no-launch recommendation was based. They wanted to launch. They didn't say why, but certainly they had many reasons. Previous delays had put them well behind their launch schedule already. The President's State of the Union message was only two days away. If they did not launch tonight, they would have to wait another month.

The Space Center wanted to launch, but they would not launch without Thiokol's approval. They urged Mason to reconsider. He re-examined the evidence and decided the rings should hold at the expected temperature. Joseph Kilminster, Thiokol's vice president for shuttle programs, was ready to sign a launch approval, but only if Lund approved. Lund was now all that stood in the way of launching.

Lund's first response to the request to reconsider was to repeat his objections. The staff engineers present, especially Roger Boisjoly, agreed. Nothing had happened to change their no-launch recommendation. But then Mason had drawn the managers to one side of the meeting room and said something that made Lund think again. Mason had urged Lund to (and this is a direct quote) "take off your engineering hat and put on your management hat". Lund did and changed his mind. The next morning the shuttle exploded during lift-off, killing all aboard. An O-ring had failed.

When I discuss a case like this in class, at least one student, usually one of the better ones, will suggest that

"there must be another side of the story" and want me to tell him what it is. Yet, typically, there is only one side. Consider the Challenger, for example. The explosion was a disaster. Lund could have prevented it and did not. Even Morton Thiokol did not act as if there were another side. Mason immediately took early retirement. Kilminster and Lund were moved to new offices, told they would be "reassigned" later, and left to read the handwriting on the wall. Thiokol's defense consisted largely of lame excuses, attempts to suppress embarrassing information, and similar self-convicting maneuvers--"damage control", "crisis management", and "cover-up", not another side of the story. In retrospect, everyone could see that something had gone dreadfully wrong.

Everyone could see that something had gone wrong and, from the perspective of engineering ethics, it is easy to see what that was. Lund, an engineer holding a position in part because of his status as an engineer, had a professional duty to act like an engineer. He had no right to take off his engineering hat to put on any other. Seven people died, in part at least, because he did not live up to his professional duty as an engineer.

We can, it is true, blame others as well as Lund. Mason, his boss, was also an engineer. He should not have advised Lund to take off his engineering hat. He set a bad example for Lund. We can also blame the people in the home office of Morton Thiokol for pressuring the space people in Utah to keep NASA's launch schedule. Such pressure over two years undoubtedly changed the priorities of people working on the Shuttle Program. Safety came to seem less important.

We can also blame NASA for hinting that it would go to another supplier if Thiokol once again forced a delay in the launch. NASA too helped to reduce the importance of safety in the Shuttle Program. We can even blame Congress for

cutting NASA funds year after year without cutting its mission accordingly and the public for acquiescing.

One characteristic of engineering disasters is that many people are to blame. But, our concern tonight is not blame but prevention. Knowing who is to blame simply helps to define the problem. Consider Lund. By all accounts, he was no fool, monster, or maniac. He did not want to wreck the Space Program, kill seven astronauts, or end his career in disgrace. We often think of ethics and self-interest as opposed. But here they were not opposed. Lund's longterm interests, those of Morton Thiokol, and those of NASA would have been better served had Lund kept his engineering hat on and refused to permit the launch.

This is not simply an observation made possible by hindsight. Everyone knew the Shuttle Program required safety to succeed. Its decision procedures had been designed to assure that safety. That was why NASA would not launch without the permission of Thiokol's vice president for engineering. The procedure had been designed to assure that an engineer's permission would be necessary to launch. So, Mason's advice in effect undercut NASA's safety procedures. How could Lund have been persuaded to take Mason's advice? Why did Lund take off his engineering hat and put on a manager's hat instead? What might an engineering society do to reduce the likelihood that managers in similar circumstances will do as Lund did?

We can, I think, dismiss certain explanations of why Lund did what he did even though they seem to be the ones that come to mind first. We cannot explain what Lund did as a result of ordinary carelessness or incompetence. Too much time went into the decision for it to have been simply careless. Too many experienced people concurred in it for it to have been simply incompetent. Something more interesting seems to have been involved.

I don't think that something is ordinary selfishness or weakness of will. Mason's advice does not sound like an appeal to self-interest or an attempt to seduce Lund into a decision against his better nature. Indeed, "Take off your engineering hat and put on your management hat" at least sounds like an attempt to get Lund to make the right decision, right according to management standards even if not right according to engineering standards. When Lund decided to do as Mason advised, he might well have thought of himself as resisting the temptation to think like a mere engineer. And, of course, Lund was not a mere engineer. He was a manager as well.

But (we might say) if Lund thought he was resisting temptation, he was just kidding himself. Perhaps. But we have good reason not to explain what Lund did as a consequence of mere self-deception. Deceiving oneself is something one does, not simply something that happens to one. For me to deceive myself, I must--at the very least--refuse to think about a question in the way I believe most likely to give the right answer. Self-deception is a kind of flight from reality. Whatever is wrong with putting on "a management hat", thinking like a manager is not a flight from reality. Thinking like a manager is as much a species of rational thought as thinking like an engineer is. Hence, talk of self-deception seems out of place here.

Yet, I must admit that, except for its rationality, Lund's shift from thinking like an engineer to thinking like a manager seems to differ very little from the familiar phenomenon we call self-deception. But because it does differ, we need a special name for the phenomenon Lund's decision actually represents. I propose to call the phenomenon "microscopic vision". Let me now explain what I take microscopic vision to be.

Roger Boisjoly, one of the staff engineers who objected to the launch until he was told to stop, has pointed out that the managers at Morton Thiokol formed a cohesive team. Like other companies, Morton Thiokol worked to create that cohesion. There were, for example, what Boisjoly mocked as "charm schools", retreats at which the managers were taught how to behave like managers as well as how to manage. Though Mason and Lund remained engineers, they must also have learned to see the world as managers do. Mason's plea to "put on your management hat" certainly sounds like someone urging a certain perspective he thinks both honorable and appropriate.

That managers should have a special perspective on decisions is neither surprising nor necessarily bad. Every profession does, as do most other occupational groups. We know at least roughly what someone would mean by a "lawyer's hat", an "accountant's hat", a "business hat". We joke about professional myopia--for example, the surgeon who thinks the operation a success even though the patient died. We also joke about the different personalities of different professions. Real estate appraisers, for example, explain the difference between themselves and accountants in this way, "A real estate appraiser is just an accountant with less personality." But the fact behind the jokes is clear enough.

Though we joke about professional myopia, the different ways professions have of thinking and seeing are not forms of blindness. If they were, we would have much less use for professionals. A professional must learn to screen out certain facts if he is not to be overwhelmed by the wealth of new facts professional knowledge opens to him. Professional education gives a professional something analogous to what we get by looking through a microscope. A microscope helps us to see a few things better than we could

otherwise. But it does that in part by excluding everything else from our field of vision. Because our field of vision is limited, magnification without exclusion would leave us with a world too large to see. Magnification requires exclusion.

Our field of consciousness is also limited. We cannot think about everything at once. We must select. We gain power over the world by learning to think about it a little at a time in ways that have proved useful. To think like an engineer, for example, means trying to think of a situation in terms of flow charts, measurable quantities, conversion tables, and so on. To think like a lawyer is, in contrast, to think of the situation in terms of properties like rights, breaches of duty, and proximate cause.

We might then picture professional education as so many lessons in how to tag certain information in certain useful ways and the resulting microscopic vision as in part at least a certain habit of tagging. Different professions will tag information in different ways. Certain kinds of consideration will simply not occur to a person while he is thinking in the way his profession does. The information will lack the proper tag to be recalled. The professional will know it in some sense. (It will be inscribed in his memory bank.) But he will not recall it, or if he does, will bracket it as irrelevant, since the tag determines relevance.

I should, perhaps, say that I do not intend what I say about the professional's microscopic vision to be a defense of a "narrowly technical" education for any profession. What I want to do is bring out a fact so obvious that it is often overlooked. Whatever reforms we make in professional education, we are not going to substitute some sort of global vision for microscopic vision. Ordinary people already have global vision and even the professional has it

when she looks up from her microscope. Professionals are useful, if they are, only insofar as they see something ordinary people don't see and they can't see that while seeing what ordinary people do see. Reform in professional education must therefore mean substituting an emphasis on certain features of a situation for emphasis on certain other features. Times change and what makes a certain profession useful can change too. What we call "narrowly technical" education is usually the teaching of a form of microscopic vision which has begun to lose its usefulness. Too much of importance is now being left out.

The professional's microscopic vision thus differs from self-deception in at least two ways. First, while self-deception seems in general to be irrational, the professional's perspective is generally rational (that is, useful for the purpose for which it is typically used). Second, while self-deception seems to involve a psychological mechanism the function of which is to conceal the truth, the professional's microscopic vision requires only a psychological mechanism that seeks one sort of truth at the expense of others. The professional need not know what he is missing or even suspect that he is missing something important. To be a professional is to miss certain facts others see in order to see what is most likely to matter in the situation.

Let us now return to Lund the night he approved the Challenger's last launch. We might explain what happened in this way. Lund responded to Mason's advice by thinking through the launch the way a manager would. Certain facts an engineer would consider paramount, especially the risk to the astronauts, were simply weighed against other considerations. Managers are taught to think no consideration can automatically be decisive. Managers are taught to think in terms of trade-offs. Other facts an

engineer might not consider at all--for example, the importance of maintaining good relations with NASA--were given substantial weight, since managers are taught to give substantial weight to the effect their decisions have on relations with important customers.

So, Lund need not have been a fool, monster, or maniac to approve the launch if he thought about it in the way managers ordinarily do. The decision might well have been the best decision from the ordinary manager's perspective. Nor need he have been a fool, monster, or maniac to have adopted the ordinary manager's perspective. That perspective is not inherently imprudent, immoral, or irrational. Lund had no reason to reject that perspective out of hand. But, once he had been trained to adopt it, he would--tired, pressured, and excited--have had to be an extraordinary person to make this management decision differently from the way he had made the others. Indeed, Lund still claims that NASA left him no real choice but to approve the launch.

Nonetheless, Lund's decision was wrong and, presumably, in retrospect, even Mason would have preferred that Lund had not made it. How could it have been prevented? Thanks to a substantial grant from the Hitachi Foundation, IIT's Center for the Study of Ethics in the Professions is now engaged in a two year project to provide at least a partial answer to that question, an answer any organization could implement. Since the project has only begun, I can't tell you how it will come out--whether, that is, we will suggest certain changes in the way large organizations make decisions involving safety, or instead suggest special training to make engineers more assertive in dealing with managers, or special training to make managers aware of the professional ethics of engineers, or perhaps some combination of these or other approaches. Still, I think it's not too early to

suggest what you can do to help prevent large disasters like the Challenger as well as some of the little ones that survive only in the anecdotes of engineers.

What I have described as microscopic vision is a normal part of human life. Every environment teaches those working in it to focus on certain aspects at the expense of others. What was wrong with Lund's decision was not that it resulted from the microscopic vision he developed as a manager, but that his management training developed in him the wrong microscopic vision. He came to see his job from the perspective of a manager who was not an engineer. The job required a manager who was also an engineer. What Lund needed was training that would help him integrate his perspective as manager with that of engineer. An engineering society like yours is in a good position to provide such training.

Your society devotes much effort to the continuing education of its members. A small but significant part of that effort goes into ethics education. That is why I am here tonight. If, as I have claimed, the Challenger disaster is much like many other engineering failure both large and small, the IEEE can make a significant contribution to better engineering by doing something not so different from what it has been doing all along.

At least part of the problem at Morton Thiokol was the "management charm courses". They undoubtedly included nothing about engineering ethics. Indeed, they probably included asides depreciating the plodding way engineers have of getting things done, their tendency to overdesign and overspend, their disinterest in what the market wants, and so on. Such asides are only human. They express in negative form the pride managers feel in being managers. You as engineers can understand that. You have your own asides to express pride in not being managers. Still,

while such asides are only human, they would nonetheless be dangerous at a company like Morton Thiokol--just as they would be at Ford, Goodrich, Douglas-McDonald, BART, Three Mile Island, or any other company whose modes of manufacture or products pose serious threats to life, health, or property.

If at least part of the problem at Morton Thiokol was management training, part of the solution might have been programs helping managers to understand the limits of their perspective (though, of course, you would not want to describe the program in just that way). If a company does not have such a program--and few do--local engineering societies should. Such a program need not make managers uncomfortable. A local professional society might simply hold roundtable discussions, inviting managers and engineers to discuss how to resolve certain hypothetical problems not too different from those that actually arise in their work. Such discussions have an advantage over the discussions that go on in real life. There is time for thought, for sober reconsideration, without the blinding pressures of actual decision. That advantage is not bought at the cost of irrelevance.

Such discussions can develop between engineers and managers a shared perspective now missing. Such a perspective would assure engineers that raising an ethical issue with management would not be pointless and help managers appreciate what the engineers are saying. Such discussions would provide a vocabulary, now missing from most organizations in which engineers work, that would allow ethical matters to be discussed on with the same precision that ordinary technical matters are. Think, for example, of how I could now tell you just by saying, "This is a Challenger situation".

I make this suggestion to illustrate what you can do. It is, I think, a surprisingly modest suggestion--so modest in fact that I wonder why it was not adopted long ago by at least one professional association. After all, many of the managers who should participate in such discussions are already members of the appropriate professional association.

What I find most remarkable in the engineering scandals I have studied is how seldom professional societies receive any mention (aside from their contribution to technical matters). The IEEE's defense of whistleblowers in the BART case is, I think, the sole example of a professional society working directly to help prevent an engineering disaster; and the IEEE came on stage only when BART trains were already running and the protesting engineers had been fired--when, that is, most of the damage had already been done and could be undone only with great effort.

You know the saying, "An ounce of prevention is worth a pound of cure." That is all I'm suggesting: an ounce of prevention. Can you see any reason not to do as I suggest?

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