TECHNOLOGY AND RESPONSIBILITY

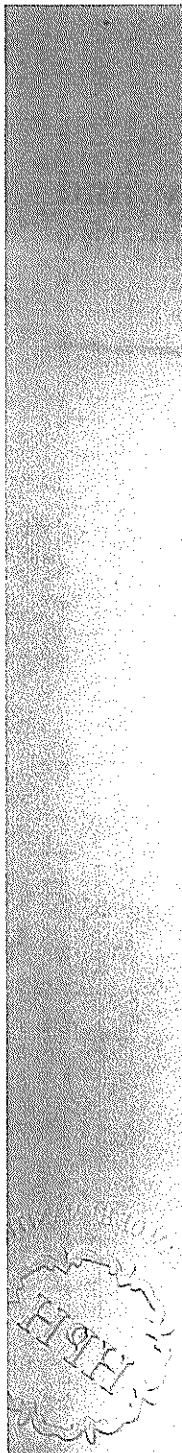
Essays Presented on the Occasion of the Centenary of the College of Engineering and Applied Science

University of Colorado, Boulder

Edited by

Athanasios Moulakis

International Research Center for Energy and Economic Development (ICEED)



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For Clancy Herbst

Foreword

The essays presented in this volume result from a series of lectures and discussions held at the College of Engineering and Applied Science of the University of Colorado. The series was sponsored by the Herbst Program of Humanities with the assistance of the College and of the President's Fund for the Humanities. Cooperation with the International Research Center for Energy and Economic Development made it possible to produce this volume in time to celebrate the College's one hundredth anniversary.

The Herbst Program, founded thanks to a generous donation by Clancy Herbst (C.U., Ch.E. '50), aims to provide engineering students with a coherent grounding in the humanities, primarily by means of text-based discussion classes. It is designed to enlarge the students' cultural horizon, introduce them to different ways of thinking and encourage a flexibility of mind which engineers, like other skilled professionals, require in a rapidly changing technological and social environment.

The "Technology and Responsibility" series is an extension of the core program, addressing issues that arise where society and technology intersect. It brings together speakers with different backgrounds: leaders of industry, academics, figures of public life. Beyond speaking to the students, our discussions also stimulate debate among faculty across various academic disciplines. In our day, when both the hopes and the fears of humanity are intextricably linked with technology, our theme is everyone's concern. Our series—and the volume resulting from it—therefore naturally reaches out to the general public.

In editing this volume, I have sought to maintain the freshness of oral delivery as far as that seemed compatible with clarity and grammar. Deriving texts from transcripts does, however, have an adventurous side. On one occasion, for example, it became necessary to identify what was lurking behind the intriguing pair of Marx and Lenonn. It is my hope that as readers turn these pages, they will not be induced to hum *Das Kapital.*

The oral presentations were followed by lively discussions. The debate among the panelists on the "Ethics of Arms Manufacturing" is included in this volume. It proved impossible, alas, to reproduce the exchanges with the public, which is regrettable since many questions were carried further and the themes presented by the official speakers often subjected to pertinent criticism.

The discussions are included, however, on the tapes that were made of most presentations reproduced in this volume. These tapes are available from the Center for Advanced Training in Engineering and Computer Science (CATECS), Campus Box 435, University of Colorado, Boulder, CO 80309-0435, for whose technical competence and courtesy in providing a suitable auditorium I am very grateful. I thank Richard Seebass, Dean of the College of Engineering and Applied Science, for the moral and material support he provided for our series. I am indebted to a great many other people, but special mention must be made of the patient and diligent work of Solomon Hu. It has been a pleasure to work with Dr. Dorothea El Mallakh and through her with the International Research Center for Energy and Economic Development. I am, of course, particularly grateful to the distinguished contributors to our series and hence to this volume. The Technology and Responsibility series is, however, but one manifestation of the multifaceted Program of Humanities for Engineers envisioned and made possible by Clancy Herbst. This volume is, therefore, his by right.

Athanasios Moulakis

Preface

This volume on *Technology and Responsibility* stems from a series of talks given by a diverse group, principally engineers, on the responsibilities that engineers bear for their technology. These lectures derive from funds provided by Clancy A. Herbst, Jr., a chemical engineering graduate of 1950.

Taken as a whole, I am struck by the unanimity of the views expressed by the speakers despite the varied backgrounds of the contributors.

This volume, among many activities and publications, commemorates the College of Engineering and Applied Science's centennial.

A. R. Seebass
Dean
College of Engineering and Applied Science
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Professional Education and the Examined Life

Harvey Mansfield
Athanasios Moulakis

Harvey Mansfield: *Defining Terms*

My title refers to four terms in the title of this panel, "Professional Education and the Examined Life," and in the title of the series, "Technology and Responsibility." These four items, *professional education*, *examined life*, *technology*, and *responsibility* will be defined as I tell a kind of story.

I begin from the essay, *Two Cultures and the Scientific Revolution*, written about a generation ago in 1959 by C.P. Snow. The two cultures are the culture of science and that of the humanities. Snow was a scientist who became a novelist and thought, therefore, that he knew something about both cultures. He tried to explain what they are, what their differences are, and what is the characteristic conflict between them.

More recently, a colleague of mine at Harvard, the biologist Edward O. Wilson, author of *the* book on ants, asked a question: How can humanists ignore what today's science says about human nature? Humanists are always talking about human nature as if they knew some-

thing about it. But where do they learn of it? From Aristotle, Decartes, Hobbes, Rousseau, and other philosophers, in books written centuries ago. They should instead read more recent science on human nature. If they did, they would find certain natural limits on their utopian schemes.

But another colleague at Harvard, Stephen J. Gould, thinks just the opposite. He believes in the importance of nurture over nature. According to Gould, one cannot describe nature in such a way that it sets bounds to our desires. There are no natural limits to them.

Anyone who listens to both of these famous scientists could easily come away with the suspicion that their opposition is based on politics and not on science. This suspicion has been elaborated in a book you probably know, Thomas Kuhn's *The Structure of Scientific Revolutions.* Kuhn argues that science proceeds almost politically. A ruling scientific theory or paradigm, he says, may be replaced by another paradigm as science progresses. But this replacement does not occur because scientists look at things impartially, as they would if the evidence against the first theory built up gradually to the point where it topples over and is replaced by another, truer theory. No, scientific theories are backed and promoted by their sponsors in an almost political manner. Science proceeds—one can hardly speak of progress—by a series of almost political revolutions as one theory gathers adherents sufficient to overthrow the other. It is not that scientists are persuaded by the evidence to theories that are ever closer to the truth, but rather that they consent to theories which succeed because of the power of their backers.

Kuhn's book is based in turn, whether he knows it or not, on more fundamental thoughts of the German philosopher Friedrich Nietzsche. Nietzsche made a distinction between life and science. A scientist is indeed a human being. But he cannot, as a scientist, explain why one should study science; that justification is pre-scientific. The scientist cannot justify himself as a scientist with science. Anyone who wants to justify science must go outside of science. In fact, Nietzsche continues, science is not only outside life but distinctly hostile to it. Science deadens man; it mortifies every human activity. The fundamental principle of the scientist is scientific objectivity, and what does that mean? It means denying yourself, refusing to believe what you would like to believe and, instead, looking at the facts as they are, objectively. Scientific objectivity always means self-denial, denying one's own life

(and what is more life than one's own life?). Further, Nietzsche concludes, scientific rigor is *rigor mortis*. The life of the scientist, and in this he includes the life of a scholar, is that of an ascetic, a person who denies life.

Life is a whole, whereas science is carved up into parts. The scientist who specializes in one of parts of science might stand up and say: "I am a human being because I'm the world's greatest expert on the brain of a leech!" (Part of the difficulty science has in justifying itself is that all parts of science are equally science, the brain of a leech equal to that of a human being.) But how can you be a human being if that's all you know? Such as person is not a man with a whole life and thus a view of the whole, but rather a specialist with a narrow outlook that leaves him ignorant of, indeed forces him to ignore, the larger questions of meaning that science may touch upon, but never ventures into. But of course the specialization that Nietzsche speaks against is the basis of our present-day professionalization, as well as the basis of the distinction between the two cultures, that of science and that of the humanities. Nietzsche implies, indeed says right out, that science is inhuman; hence, the superiority of the humanist.

The humanist knows the answer to the question: Why science? Why be a scientist? What he knows is more fundamental than, is prior to, what the scientist knows. That is why the humanist of our day typically ignores the results of modern science and does so with good conscience despite the strictures of Edward O. Wilson. Today, when people speak of the *examined life*, what they mean is the life of the humanist. The humanist is superior because he can study the human meaning of scientific discoveries: how do they affect human beings?

For example, look at the problem of technology versus the environment. The cause of the environment is put forward by humanists, those who take up the interest of humans. They say that scientific specialists forget the effect of science on the planet. The planet may be one among the planets of the solar system, or among *n* planets, but this planet is the home of human beings. So the defenders of the earth are humanists (who might include scientists acting as humanists). Here you can see a certain contradiction in environmentalism. Environmentalism is in the first place an accusation against man, against what we are doing with our planet. And yet the environmentalists want to protect the earth, which is the home of man. If man is so bad, why save his home?

Environmentalism both denies man, by accusing him of fouling the planet, and affirms man by daring to defend the home of man, the earth.

The phrase *examined life* has a longer history. It goes back to Socrates and to a statement in Plato's *Apology of Socrates*, in which Socrates says "the unexamined life is not worth living." Not worth living! That sounds like an exaggeration, and perhaps it is. In this dialogue of Plato's, and, indeed, in all Plato's works, nothing is said specifically of what we would call a profession. But in the *Apology*, Socrates tries to find out why people think he is so wise; so he goes and asks three different groups about this difficult point: poets, politicians, and artisans. He discovers that the first two, the poets and politicians, know nothing worth knowing whatsoever. The artisans, however, know something. They know what they do. The shoemaker really knows how to make shoes. It's in the bigger questions, for example regarding the meaning of wearing shoes versus having hoofs, that they fall down.

The Greeks did not have technology, but they did have arts. What are the arts, according to Plato (or the Greeks)? An art is an occupation with limits or bounds; the shoemaker, in making a shoe, knows what pertains to shoemaking and what does not. An art is also rational; if you ask him why he is doing what he is doing, he can give you a reason. And an art is perfect. In principle one could make a perfect shoe, one that would perfectly fit the customer's foot. Being bounded and being perfect within those bounds, the arts do not deal with the whole human being. Then what does? According to Plato, (or again, the Greeks), it is virtue.

Then what is virtue? Virtue is the perfection of the soul. Virtue is composed of virtues, of which Aristotle counted eleven. The virtuous person, he said, is virtuous for the sake of virtue. He is also virtuous for his own sake, not so much to help others, although some virtues involve helping other people, as to help or perfect himself. The virtues, perhaps, have a certain ranking, some of them higher than others. The highest virtue might be the one that combines all the other virtues, magnanimity or justice, according to Aristotle. Virtue, then, is the fulfillment or perfection of all human capacities, and especially the highest.

This picture of virtue and the arts has a certain political consequence, always a matter of interest to a political scientist such as myself and perhaps occasionally to others as well. In general, the political consequence is aristocracy, or politics with a certain aristocratic cast. The

most virtuous, the best, should be on top. The regime of virtue, therefore, is the regime of gentlemen, those called *kaloikagathoi*, the noble and the good. These gentlemen are amateurs. They do not practice the arts because the arts have to do with the satisfaction of needs, which is below the dignity of the noble and the good. But the gentleman is mainly concerned with himself, with being perfect in his gentlemanship (if I may use that expression). Later, professions of a certain kind retain something of this amateur status, the so-called learned professions: religion, medicine, and law. Members of the learned professions, for example, will *accept* money, but they employ secretaries to *ask* for it.

In the seventeenth century, however, occurred the great revolution of modern science, a revolution in thought followed by a revolution in society. The revolution in thought could be quickly characterized as the abolition of the difference between theory and practice, which Aristotle had invented and established. Francis Bacon was the one who said that knowing (theory) is making (practice). According to modern science—and it is just as true today—when you know what a human being is, you can make one, or virtually make one. Knowledge of human nature, of our genes, means knowledge of how they work; hence science gives access to technology. From the beginning, modern science implies the promises of modern technology; and this is very clear in Bacon's writings.

Technology is quite different from the arts in their original, Greek understanding. Technology revolutionizes the arts. Whereas the arts had limited bounds, technology removes them. Shoes become something different: footwear. You conceptualize, or reconceptualize, the problem of clothing so as to inspire new materials, styles, and products. A quill becomes a pen, a pen becomes a typewriter, a typewriter a word processor, and so on. The "and so on" indicates that technology is in a way irrational, since it has no clear end to it. Technology promises an unending progress in which things get better and better, or perhaps merely a process in which they constantly change. There is never a point at which we can say, "that's perfect," or "that's enough."

The unending character of science and technology has an effect on the professions and therefore on society. The learned professions I spoke of were those that had their root in philosophy, in higher knowledge, as opposed to the art of the shoemaker. The shoemaker has knowledge; he knows something useful; but you wouldn't call him

"learned." Now, however, there are new technological professions, and, of course, above all, the profession of engineer. Somehow, too, some of the pre-technological professions remain. There are still shoemakers, but they have become shoe repairers. Barbers are hair stylists but still recognizable as barbers must always have been. In the technical professions there is a distinction between one's professional life and one's ordinary life. In the former, the professional, for example, the engineer, has a very impressive expertise that the ordinary person does not have, but then outside that expert competence he may behave, not exactly as an ordinary person, but often very sensibly. It is typical of the technical professional to make a distinction between his professional and his ordinary life, which are, so to speak, two separate worlds.

There is, however, a danger here in what one might call the technologized professions. There are professionals who carry technology into ordinary life and fail to make a distinction between them. In the social sciences one sees that danger in economists; they are sometimes the kind of person who thinks that economics applies in every department of human life. Rather than remain modest outside their specialty, they think it gives them answers to non-economic questions. They are not so sure, indeed, that there are any non-economic questions. Such people have a narrowness which looks like breadth but isn't; it is just narrowness generalized.

That kind of technologization is bad for citizens. A citizen has to consider a question as a whole and from all its aspects. The political consequence of technology is in general democracy, as opposed to the ancient artist and gentleman, which implies a concern for excellence and virtue. This is so despite the fact that the expertise of the technical professional is much more remote from ordinary wisdom than is the virtue of the gentleman or the knowledge of the artisan. The reason is that technology is concerned with the satisfaction of human needs, not with the promotion of human excellence. Technology does not make us virtuous. It may provide the conditions of virtue, for example longer life freer of disease; but it offers no guide as to what to do with your longer life. Technology lays no requirements, puts no demands on us. It frees us for virtue or for vice, or more likely, for mediocrity.

Technology with its emphasis on human needs is thus not necessarily associated with virtue, or even easily compatible with it. Technology makes for the easy life, and one is almost obliged to make things hard

for oneself by playing games or competing in sports or having a hobby. And yet there is a democratic virtue we all know, the virtue of *responsibility*. What is responsibility? It is not virtue because, in the old sense of perfecting oneself, responsibility is usually or always responsibility for others.

Responsibility is also not the same as duty, because duty usually implies a higher authority, such as God or the Constitution, to whom one has a duty. But responsibility is to other human beings and something horizontal, not vertical, in its profile. Curiously, responsibility as a noun is not so old a term. The first use of it appears to be in politics. One can find it in *The Federalist*, nos. 63 and 70, where the author ("Publius") argues that one great virtue of the Constitution is to produce responsibility in certain offices. What is meant by that? Responsibility is distinct from responsiveness, from doing what the people immediately want. Rather, it is doing what the people would want their official to do if they could do it, or if they knew how to do it. A responsible official acts on behalf of the people by doing what they cannot do for themselves.

From this political usage, the term "responsibility" is carried into the professions, and we have *professional responsibility*. Fulfilling one's professional responsibility means taking charge of a situation in which one has a certain expertise. Being responsible in this way is not the same as acting in one's own interest. The need for responsibility implies that it isn't enough if everybody acts on his own interest, that there is no viable, let alone perfect, system of interests in which each of us has an incentive to do something, and the result is somehow good without anyone's intending to do good. The latter is the view of the ambitious economist that I mentioned above. If there were a perfectly free market in every activity, nobody would ever have to take responsibility because it would always be in the interest of someone to do the right thing.

Responsibility is for a limited task, and it is done for other human beings. But a responsible person often needs to make a claim for the necessary power to do that limited task. In principle this claim could be for unlimited power: "Give me the tools to do the job." This can happen in politics especially, and it represents another danger: that of expansive responsibility. In claiming to be responsible, people can attempt to be responsible for things they can't really be responsible for, while overlooking things which are close at hand. We have heard of the

kind of person who neglects his family out of love for humanity as a whole, preferring his kind to his kindred.

That expansive responsibility takes away responsibility from others, producing an enervating paternalism. You take responsibility for me, but when you do, you take *away* responsibility from me. In our day expansive responsibility in politics leads among other things to the demand for "charisma," the demand that our political leaders should excite and entertain us. I have a certain sympathy for George Bush, our recent uncharasmatic leader who used to speak slightingly of "the vision thing." I too am not so impressed with vision as we understand it, and I think there is a great deal to be said for minding the store, and for taking responsibility for what one can do without making grandiose promises.

Professional responsibility, too, can apply in two directions: responsibility to the task and to the client. These two are often in conflict. Should an architect, for example, make a beautiful building in keeping with his professional wish or should he build it as the client wishes? It seems again that a professional has a responsibility to do something more than merely respond to the client's wishes. But the responsibility will surely vary according to circumstances. Responsibility is never neglectful of circumstances.

Let us now return to the connection between *professional education* and the *examined life*. The examined life is understood today as liberal education. What then is the relationship between professional education and liberal education? To answer this, we need to know what liberal education is. Two things, I think: an acculturation and a challenge. Acculturation makes you into a cultured person, teaching you, or giving you an experience, of what a cultured, civilized person knows. A civilized person in our time and place knows something of Shakespeare or Dante. Books of this sort make a cultured person and broaden your professional education by giving you experience outside it.

Perhaps such broadening is not enough, however, because it is liberal education that is not yet understood as for its own sake. It is valuable, but it is not the real thing as long as it is understood as an adjunct to, or a broadening of, professional education. So the second meaning of liberal education is challenging: are the things we believe really true? In this way liberal education is good for its own sake. Nietzsche, as I said, argued that science is against life. That means he thought human life was a good thing. But Socrates, in Plato's *Apology*, questions that

assumption. He says: prove to me that life is better than death. All of us ordinary non-philosophical human beings presuppose that it is a good thing to be alive. But we don't really know that life is better than death, do we? This is a matter in which we typically claim to know and don't in fact know. Socrates was condemned to death in consequence of his apology; it was a rather imprudent apology, really more of an accusation against the democratic assembly of Athens. Socrates was condemned to death by a democracy. How could a democracy do such a thing? Is democracy really the best form of government if it could do such a thing to the best person living in it? That question forces us to think; it is a challenge to us who live in a democracy.

A false kind of challenge is at large today, called "multiculturalism." Multiculturalism says that each group in the population should be represented in the university curriculum, perhaps even in proportion to its size. To do this would give representation to each group's culture, thus giving representation to what that group already knows of itself — the very opposite of challenging. Liberal education today is often understood as a kind of world history, a museum culture in which we appreciate everything equally. We today have so much taste that we have lost any sense of discrimination. Nietzsche said that modern man is a walking encyclopedia. When we use that phrase it is usually a compliment. But Nietzsche did not intend it as such. He meant someone who knows nothing but dead things belonging to old cultures, and who cannot discriminate. A person who reads the encyclopedia from cover to cover cannot discriminate what is worth knowing from what is not. Multiculturalism aims at making people comfortable with their beliefs and opinions. Liberal education aims at making them uncomfortable. The challenge for the teacher today—it amounts to his professional responsibility—is to make students of all races, all cultures, and both sexes equally uncomfortable.

Athanasios Moulakis: *Return to the Word*

I see Clancy Herbst in the audience and I know that he delights in poetry. I know that he even serenades the regents of this great seat of learning in rhyme. So I will take my cue from that and start with a poem—Tennyson's *Mechanophilus*, written in 1833.

Now first we stand and understand,
  And sunder false from true,
And handle boldly with the hand,
  And see and shape and do.

Dash back that ocean with a pier,
  Strow yonder mountain flat,
A railway there, a tunnel here,
  Mix me this Zone with that!

Now, those must have been the days! One could still tell false from true by handling things. And with the knowledge literally in hand, one could change the face of the earth to serve man's desire. Away with all the old cobwebs, the trappings of the past! Away with all of this!

Away with shadows! render all
  Plain, palpable and bold,
Then give the crude material
  That we may carve and mould.

All other times were but the shade —
  The preface unto this.
Now knowledge comes, a mortal maid,
  Whom we may clasp and kiss.

The past has no meaning, Tennyson seems to say, except as a preparation for our glorious present and our even more glorious future. Who needs to philosophize, that is to say, who needs to yearn or seek for wisdom? Who needs to relate one's imperfect self to some immortal source of meaning when one can possess knowledge and a knowledge that is made of the same clay as oneself? Why try to measure one's simple existence against eternity, when one is certain of endless progress?

Far as the Future vaults her skies,
  From this my vantage ground
To those still-working energies
  I spy nor turn nor bound.

As we surpass our father's skill,
  Our son's will shame our own;
A thousand things are hidden still
  And not a hundred known.

Each generation reaches higher and higher, at every twist of the Tower of Babel. What causes are there then for introspection, for knowing oneself, that is for knowing one's limits when there are no limits; when one's duty is identical with the execution of some appointed task in one's professional expertise; when one's life is a career; when one's very identity is nothing but one's work? Indeed,

Meanwhile, my brothers, work, and wield
  The forces of today,
And plow the Present like a field,
  And garner all you may!

We are perhaps a lot less certain about those things nowadays. Certainly about whether strowing "a mountain flat" is all to the good. But I will leave the environmental considerations to one side. I am much more interested here in what I would call the inner development of this kind of technological impetus. I think it is fair to call it a movement to abstraction, a movement towards abstraction. We have first of all, fewer and fewer occasions to "handle boldly with the hand." It really has become the case that the way we "shape and do" is more and more to do not with handling things, but with manipulating meanings.

This is something which I experience even in conversations in this house—electrical engineers tell me that now they have to teach the subjects from the top down. They cannot find the guy who would unscrew the back of a radio when he was twelve and fiddle around and "get the hang of it," developing an empirical facility which would then be refined into genuine understanding by academic training. No, instead he has to be told, as it were, "from above" what these miniaturized, in a sense intangible things are really all about. The information that is involved has become external to the man. What do we learn? We learn where to "access it." It isn't like the skill of an artisan, like the turn of the hand of a good shoemaker, it isn't like the ear that one develops for music. It is information about which button to push so that the right data base will come on.

The problem is not so much the absence of information in the mind. In some sense one could say that storing information in external devices liberates one to think other thoughts, though it is also possible that it just lets one rust. It is the high degree of abstraction, which poses more serious difficulties. It leads to a collapse of communication despite the

speed—perhaps because of the speed—of transmission. This collapse of communication goes beyond the separation that C.P. Snow indicated when he spoke of the two cultures.

In a sense, the triumphant march of technology has left us strictly speaking speechless. The formally coherent logical space that technology demands rejects the ambiguities of natural language. Natural language is replaced by abstract mathematical notations, which it requires and develops. These mathematical notations are increasingly divorced from everyday experience. This vocabulary, or rather non-vocabulary, acquires a life of its own for which there is no verbal equivalent. You cannot put it into words. If you think about it, this is perhaps already true in some sense even of Euclid. But at least we have some way of picturing classical geometry. We may be unable to quite put it into words, but we can conceive and project the images. Since the powerful symbolic languages were developed by people such as Descartes and Leibniz, a world apart has been created, a world which is, of course, accessible to those who are conversant with its particular notation, but which is incommunicable in everyday language. It is literally unspeakable.

At the same time the more logically unified natural science aims to be, the more splintered become the notational languages of its practitioners. It is not just the split between the two cultures Snow was talking about, but a splintering within science itself.

The split between the layman and the scientist is bad enough. That is the kind of split that Robert Oppenheimer, for example, thought was utterly insuperable. He thought it was impossible to explain the concepts of modern mathematics and physics to the man in the street without distorting them—therefore doing worse than leaving well enough alone. The misunderstandings combined with the illusion of understanding would do more harm. What is needed, he thought is a harsh modesty, an affirmation that the common man cannot understand most things pertaining to science, and that the realities of which even a highly trained intellect has a cognitive grasp are few and far between. In some respects Oppenheimer doubtless had a better understanding of this than Snow who thought that knowing the Second Law of Thermodynamics was equivalent to having read your Shakespeare.

Others have been more optimistic, and perhaps we ought to be too, because, after all, we have to deal with this. There was a recent report

entitled *The Liberal Arts and Science—an Agenda for Action*, produced by the American Association for the Advancement of Science. I underscore that it is for the advancement of *science*. The report says: "Traditional courses often leave the student with incomplete or incorrect knowledge of scientific principles, underdeveloped intellectual skills and little awareness of the influence of science on their lives." What they propose as a remedy amounts in effect, to what I would call, a return to the word—to speech. "Treat education" they say, "in natural science as a liberal art. Integrate it into the general education curriculum. Subject matter must be broad and to encompass aspects of history, philosophy, sociology, and economics of science and technology." Who would have thought that mathematics, that noble edifice of unambiguous clarity and coherence, will be transformed, at least for the great mass of undergraduates, into a Tower of Babel?

We witness the Association for the Advancement of Science pleading for verbal communication. Understanding the principles of science must pass not by entering directly into the uncontaminated sphere of mathematical form or the unimpeded nature of pristine nature, but first by way of a familiarity with the contingent, changeable, messy circumstances of human society; of economics, history, politics, and the rest of it. It would seem that an unimpeded observation of a candid material world, as it used to be, heightened by abstraction and leading to ingenious applications—a manner of thinking to which we owe the spectacular success of technical achievement—is in its purity simply too good to be true. It must, apparently, look back to its human, historical, social conditions of possibility, and can only reveal itself in ordinary language with all the imperfections and with all the ambiguities that that entails.

Whether that can be done in a form integrating all these things into science, I don't know. I don't know what broadening the curriculum can possibly mean, as opposed to rethinking it and restructuring it. Is this going to be history, philosophy, and sociology of science as well as history, philosophy, and sociology? And how seriously can any of these subjects be pursued if all of them need to be pursued?

The problem of communication is also manifest in public life, not just in the field of science and scientific notation. There has been all this exultation of newspapermen about of the importance of communication in liberating the world, how television was instrumental in opening up Eastern Europe, how the many fax machines helped frustrate the

Russian coup and all that. There is, no doubt, a lot of truth to that, but consider the following: In the elections of 1968, from Labor Day to election day, the sound bites accorded by the evening television news to presidential candidates saying something amounted on the average to 42.3 seconds. By 1988 this has been reduced to 9.8 seconds. At the same time the so called "visuals" had augmented by 300 percent.

Articulate, differentiated speech is in retreat everywhere. Beyond that there is a different kind of loss, the loss of a common world of reference. And yet we feel the pressing need for including people excluded from the possibility of getting ahead in life by not sharing in a common manner of speaking.

It is a problem that Hirsch in his book, *Cultural Literacy*, has faced squarely. That is to say, the necessity to participate in what he calls high culture—the functional idiom of American society. I think his is a generous view, because it is motivated above all by a desire not to allow the devil to take the hindmost. That is certainly an entirely laudable thing.

Even this humane, democratic approach of Hirsch's is however ultimately instrumental, rather than what I would call properly liberal or cultural. I quote from him,

> Why is literacy so important in the modern world? Some of the reasons, like the need to fill out forms to get a good job are so obvious that they needn't be discussed. The chief reason is broader. The complex undertakings of modern life depend on the cooperation of many people with different specialties in different places. When communications fail so do the undertakings. That is the moral of the story of the Tower of Babel. The function of cultural literacy is to reflect nationwide communication. Mature literacy alone enables the tower to be built, the project to be well managed and the airplane to fly without crashing.

Well, yes, but surely the Tower of Babel says something about the sin of pride, something about a sense of human finitude, something about the notion that a wise providence may have wanted a world of several peoples of various tongues rather, than a tyrannical unifier running a mono-lingual tribe. Above all, one may ask, what is the Tower of Babel for?

Nobody ever accused President Truman of being a romantic; he was, you might say, a crypto-intellectual. He astonished a journalist one day by fishing into his pocket and coming up with a yellowed, dog-eared

piece of paper, and he read the following from Tennyson's *Locksley Hall*:

> Men my brothers men the workers, ever reaping something new:
> That which they have done but earnest of the things that they shall do.
> For I dipt into the future, far as human eye could see,
> Saw the vision of the world, all the wonder that would be;
> Saw the heavens fill with commerce, argosies of magic sails
> Pilots of the purple twilight dropping down with costly bales;
> Heard the heavens fill with shouting, and there rain'd a ghastly dew
> From the nations' airy navies grappling in the central blue;
> Far along the world-wide whisper of the south-wind rushing warm
> With the standards of the peoples plunging through the thunder-storm
> Till the war-drums throbb'd no longer and the battle flags were furl'd
> In the Parliament of man, the Federation of the world.

Seven days later he dropped the bomb on Hiroshima, and proceeded to San Francisco to found the "Federation of the World." The United Nations is certainly a worthy enterprise, but it can hardly be said to have effectively put an end to further conflict in our own time or indeed for our posterity.

The time has come, I think, to turn inward to strive to know ourselves. That is to say, to know our limitations.[1]

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[1] I have used some of the materials presented here and sought to develop the argument more fully in *Beyond Utility: Liberal Education for a Technological Age* (Columbia, MO: University of Missouri Press, 1993).

2

Engineering Education and Managerial Responsibility

David Clair
R. C. Mercure, Jr.

David Clair: *Leadership—Creating a Foundation for Empowerment*

Simply put, the responsibility of managers/leaders is to empower the people they manage. I could stop there, but it may be worthwhile to hear an actual case in which many of the theoretical concepts of managing and leading were combined and tested in a real organization. What evolved was a foundation built on discrete, yet interlocking components which can be used to enhance employee empowerment, organizational performance, and hence results.

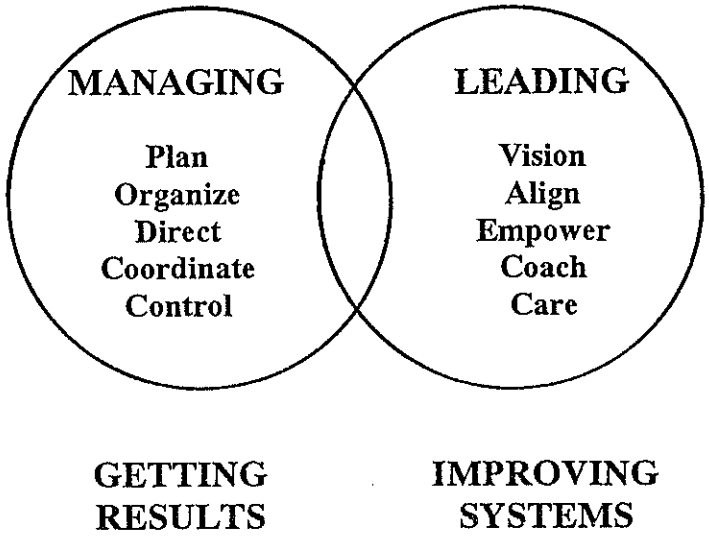
These components can be described in terms of both content and process. They have certainly been used in various forms and many times before. However, they appear particularly effective as a total package or foundation. Building that foundation is time-consuming and often unpredictable, thereby demanding extraordinary patience and persistence by the entire organization and particularly from its leaders. But if those leaders will take the time to build this solid foundation, the benefits will come in terms of employee spirit, motivation, and productivity over the long term.

My confidence in the approach is built on eight years of experience, first as President of EXXONCHEM Europe in Brussels and subsequently as President of EXXON Research and Engineering Company in New Jersey. During my four years at ER&E, this foundation for empowerment took on the current form and structure, therefore, I'll draw heavily on that example.

But, first some definitions. Chart 1 seeks to distinguish between managing and leading. They obviously overlap and both are important. It has often been said that many American companies are overmanaged and underled; because I share that view I will be stressing the very substantial benefits of leading—its impact on people and its focus on improving the many organizational processes and systems which constrain employees from doing their best. There is enormous untapped capability in most organizations, largely due to management impatience and lack of attention to these fundamentals of leading, especially at senior management levels.

Chart 1

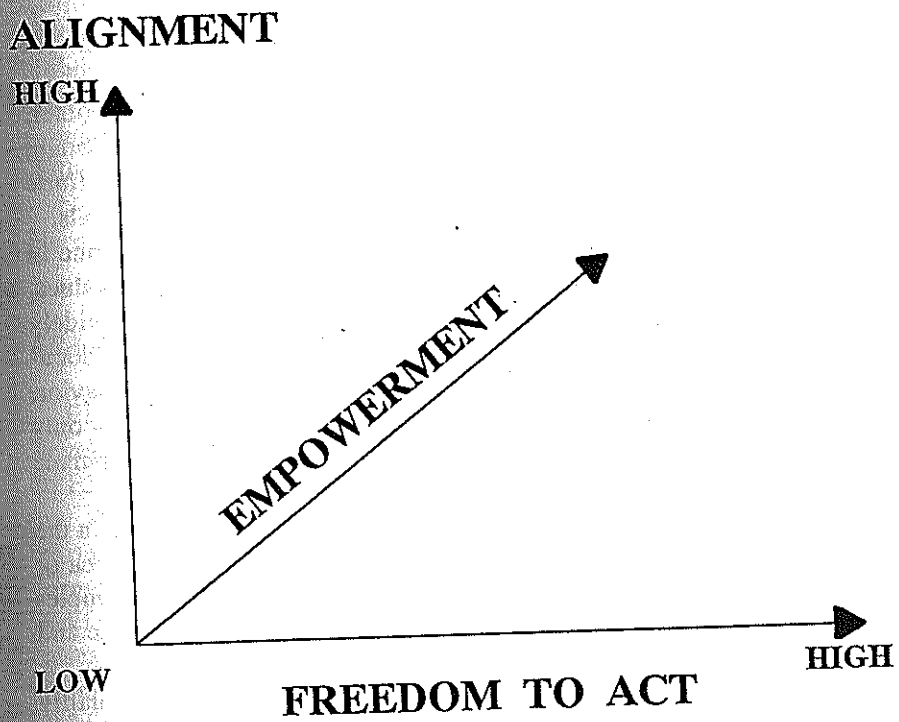
QUALITY MANAGEMENT



Empowerment may also be a misunderstood term, and Chart 2 will clarify my perspective. On the vertical axis is depicted the extent of alignment which has been achieved among individuals in an organization. On the horizontal axis is the extent to which those employees feel they have freedom or even encouragement to act. An organization that is heavy on alignment and weak on freedom to act will tend to be bureaucratic; freedom to act without alignment leads to chaos. What is required is a strong blend of both to fully empower most of the people in the organization. A real case study in how they evolved at ER&E are what I'll be covering today.

Chart 2

WHAT IS EMPOWERMENT?



Foundation Components

What are the components? Chart 3 summarizes the important ones.

Chart 3

A FOUNDATION FOR EMPOWERMENT

- MISSION/VALUES
- GOALS/STRATEGIES
- QUALITY PROCESS
- APPRAISAL/COUNSELING/REWARD
- TRAINING/LEARNING

First, an organization should clarify its overarching mission or purpose. Some would call this a vision of a desired future state. It's also useful for an organization to be clear about its values. These strongly influence how people behave, how they relate to one another, and the overall tone of the work environment. Next are some important goals which an organization wants to accomplish over a more finite period, and the general strategies it should follow to reach those goals.

This sounds simple enough, but recognize that we want everyone in the organization to understand and be committed to the mission, values, goals, and strategies. This requires that they be drafted and widely debated by managers and employees at all levels, and that they be documented, distributed, and reinforced by everyone's actions and behavior. If this is well done, individuals throughout the organization are not only better aligned, but also have the confidence to initiate and pursue actions that will move the company in the agreed direction.

Once understanding and commitment are secured, some people in the organization will know exactly what to do to start moving their area or activity aggressively ahead. But to engage most of the people in implementing the important strategies of the organization, more guidance and structure is needed. That's where the quality process comes into play.

The quality process is known by other labels, such as Total Quality Management or the Quality Improvement Process. It has been given

form and substance by such pioneers as W. Edwards Deming and Joseph Juran. It provides disciplined methods which can help organizations of all types to continuously improve all that they do.

Next on this chart is performance appraisal, counseling, and reward. Individual employee appraisal and feedback as well as the organization's system of reward and recognition must explicitly reinforce the values, desired behaviors, commitment to goals, and implementation of strategies that have been agreed upon and documented. This is particularly important if a major cultural change is desired. My definition of a company's culture is the sum of what employees have been rewarded for over time. It is not what leaders have documented and preached but left unrewarded.

The final item is training, or what I prefer to call continuous learning. This must also be directly related to the organization's mission, values, goals, and strategies and should be focused on the basic skills and knowledge which people need to support and implement them. More specifically, the employee appraisal and feedback process should highlight deficiencies in skills and knowledge which then become priorities for training/learning. Obviously, learning isn't limited to a formal classroom approach. There are many ways to deliver important skills and knowledge to employees.

Now let's get more specific about how this foundation was put in place at EXXON Research and Engineering Company.

ER&E in the Mid-80s

ER&E conducts basic research or science, applied research and development, as well as provides a broad range of engineering services to EXXON affiliates around the world. In the mid-80's, it was viewed by these EXXON customers as technically very skilled but not particularly customer oriented. Its basic research organizations were largely disconnected from their true customers who were the applied R&D units who would eventually apply new science to important research programs and projects. There was generally weak support from the various EXXON business organizations for even the applied R&D work. In addition, falling oil prices had sharply curtailed capital projects throughout EXXON and Engineering's workload had declined

markedly. All this led to five employee separation programs and a halving of the work force over a five-year period. As a result, many employees had become distrustful of EXXON, insecure about their future, but nevertheless confident that, given the chance, they could contribute to EXXON's success.

Directions, A Mission/Values Statement

Clearly, ER&E presented a compelling case for change. The change initiatives started in late '85 with a mission/values statement, eventually titled *Directions*. It set out an overarching mission or goal of "creating opportunity and advantages for EXXON." We could have constrained this mission to producing first class technology for EXXON, but we opted to focus on outcomes rather than output. This forced us into a more interactive role with our customers—users of technology throughout EXXON. We even started thinking of them as partners. *Directions* went on to describe a desirable way of working by developing four basic themes: innovation through partnership; the right technology; the right cost; and success through people. By expanding on each of these themes, *Directions* conveyed not only a desired way of working and a desired future state, but also a set of values which established the tone for ER&E's work environment and relationship among employees at all levels. Chart 4 summarizes the values that can be extracted from *Directions*. Most organizations could agree on a similar list as appropriate and desirable.

Chart 4

VALUES

- •CREATIVITY AND INNOVATION
- •INTEGRITY
- •OPENNESS
- •LEADERSHIP
- •TEAMWORK
- •DIVERSITY
- •WELLNESS (INCLUDING SAFETY)
- •ALIGNMENT WITH COMPANY M, V, G, & S
- •EMPOWERMENT
- •CUSTOMER FOCUS
- •COMPETENCE & EFFECTIVENESS
- •CONTINUOUS IMPROVEMENT

It took about a year to put *Directions* in final form and communicate it to all of ER&E's people. The initial draft was done by the president and then extensively debated and revised with ER&E top management. This process continued in many group and individual discussions with all ER&E department managers and selected business line senior managers (i.e., ER&E's customers). The final product was in the form of this three-color pamphlet to lend a sense of permanence. It was introduced to all employees through 22 departmental meetings (100-120 employees each) where the president and department manager covered its content and rationale, and engaged in open and often heated discussion about a wide range of employee concerns.

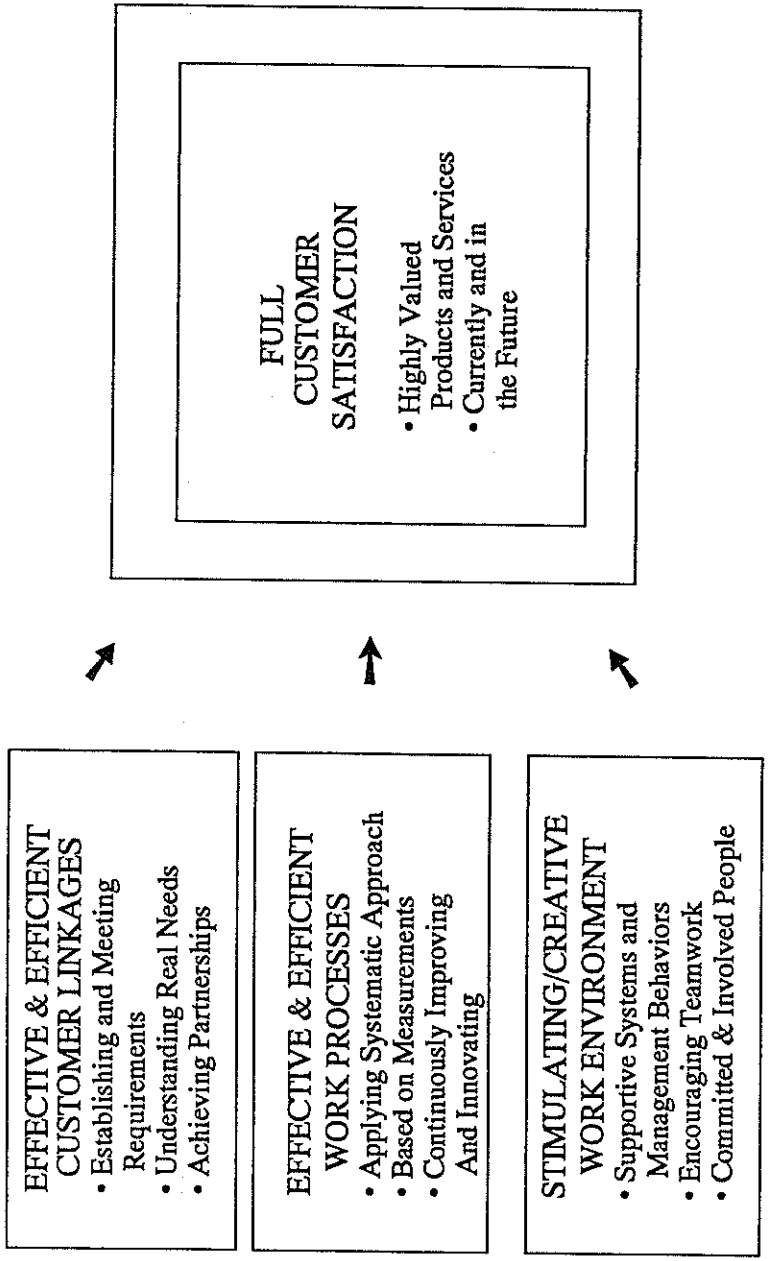
Although many employees viewed *Directions* as just another management flavor of the month, it did have a fairly immediate impact on ER&E's sensitivity to the customer, both internal and external. Most employees could also relate to the implied values and behaviors; accordingly, their practice slowly became more open and obvious. *Directions* also advertised an implementing initiative which was the quality process, an initiative which was to take ER&E's change agenda out of the here today, gone tomorrow category.

The Quality Process

Most companies who try to embrace the quality process as a new way of working and managing learn that there is no tailor made produce suitable for their unique case. ER&E was no exception. After exploring the concepts and offerings of many quality-promoting consultants, and after some poor experience with a consultant or two, ER&E settled down in mid-'87 to develop its own quality process model and quality training strategy and content. This was propelled by the quality manager, a new position reporting to the president, and by a quality council comprised on ER&E's management committee and chaired by the president.

The model which evolved is shown on chart 5. It focuses on creating loyal customers by fully satisfying their needs. This requires (1) establishing partnerships with customers so that we can fully understand, influence, and agree on the requirements to be met; (2) analyzing and continuously improving work processes and systems so

Chart 5
QUALITY: A NEW WAY OF WORKING



they not only meet customer needs but are efficient as well; and (3) creating and sustaining a work environment in which all employees can do their best. When the people are successful, so is the company.

The key to getting this model accepted and put into practice was training. We started with a half-day awareness seminar and then developed a two-day quality team training course, and finally a four-day quality leadership course. The last two delivered modules on such things as negotiation and alignment, innovation and idea growing, simple statistics, measurement/data tools, and team development. All ER&E employees went through the awareness seminar, and most employees have now attended the two-day quality team training. The latter is delivered when a team has formed to work on some problem issue, or opportunity. They then train as a team and return to the workplace to tackle it with quality process tools and techniques fresh in their minds.

Quality leadership training was pitched to highly committed employees who wanted to become quality team facilitators as well as teachers of the various course modules. About 10 percent of the company's employees have gone through that course. We used employees to teach the various modules, and that included managers at all levels—even the president.

While quality process training was the crucial starting point, repeated reinforcing initiatives were required to encourage the application of quality principles and methods to current problems and activities. Slowly, the power of the process became apparent and success built. Customer satisfaction as measured by surveys and questionnaires was improving and, after a couple of years, there were dozens of examples of step improvements in the productivity of systems and individuals. In many cases, quality process analysis and techniques led to the complete redesign of a system or process. The quality process is now firmly established in the language and behavior of ER&E people, but it will be a few more years before it is strongly rooted in the culture.

More Specific Goals and Strategies

As the quality process initiative was moving forward, there were still requests from employees for a more explicit statement of where ER&E

was going over the next five years or so. I resisted these for several months, generally indicating that *Directions* and the tools and techniques of the quality process were sufficient. But, the organization was really sending two messages, one focused and one diffused; both deserved attention. The focused message was that there was still a gap between where the general themes of *Directions* stopped and the specific strategies and plans of the several ER&E departments picked up; a gap that should be filled. The less focused point probably had to do with ownership of *Directions*. The concepts and words were readily accepted by most people, but it was still considered a product of senior management that had been laid on the organization like a stone tablet.

In developing goals and strategies for ER&E, we tried to respond to both of these messages. We started with the same top-down development of the content, but didn't conclude we had a final draft until interactive sessions had included every ER&E supervisor and many senior technical people. Numerous additions, revisions, and refinements came out of these sessions. We then decided to leave the goals and strategies in draft form for one year so that every ER&E organization could review and debate them with their employees and feed back suggested revisions to the president for consideration.

What came back was astonishing. The comments were well-conceived, substantive, and focused. There was considerable agreement, particularly regarding the desire for a much shorter version that would have a longer life. These comments were incorporated, and when the final version was issued after the one-year draft period, many employee groups saw that the management had listened. Not only did we have a better product, we had used a process that maximized employee commitment. It took two years, but it was worth it.

The goals expanded on the mission of creating opportunity and advantage for EXXON. There were four of them, all interrelated:

- A greatly increased pace of innovation. This recognized that ER&E's future lies in innovation, further defined as ideas converted to results. It's everybody's responsibility and it's measurable.

- Lead industry in applying science and technology. This means creative application of both inside and outside technology.

- High bottom line impact. This includes profit, the outcome and the fruit of innovation.

- Successful people, successful organization. Emphasized that enjoyment of job, pride in organization, and motivation all follow from achievement and recognition. In turn, motivation stimulates innovation.

The last goal also became the title of this booklet covering the goals and strategies. Headlines for the ten strategies contained in the booklet are shown on chart 6. Note that establishing a quality culture was positioned as one of the strategies. Most outsiders would consider this group of strategies reasonably obvious in an R&D organization. However, the highly participative approach or process that created them was the key to their aligning impact on the organization.

Chart 6

STRATEGIES

- ENHANCE WORK FORCE MOTIVATION AND ACHIEVEMENT
- ALIGN WITH CURRENT BUSINESS NEEDS
- STIMULATE CONTINUOUS BUSINESS GROWTH
- PREPARE FOR A CHANGING FUTURE
- EXPLOIT BASIC SCIENCE FOR COMPETITIVE ADVANTAGE
- BETTER ASSESS R&D POTENTIAL AND PROGRESS
- EXPAND AND DIVERSITY CONSULTING ACTIVITIES
- MAXIMIZE EFFECTIVENESS OF SUPPORT SYSTEMS & SERVICES
- ESTABLISH A QUALITY CULTURE
- TAKE A BROAD VIEW OF EXCELLENCE

Employee Appraisal, Feedback, Recognition, Reward

Most companies have formal systems for performance appraisal, counseling, rating, ranking and compensation. The key is connecting the performance criteria by which employees will be rated directly to

the mission, values, goals, and strategies of the organization. This means explicitly on rating forms, in feedback and counseling discussions, in business meetings, in award ceremonies, and the many other formal and informal opportunities we all have to reinforce the values and desired behaviors of the organization.

At ER&E, quality process thinking did lead to enhancements in performance appraisal and counseling. We realized that with mission, values, goals, and strategies in place every employee had a fairly clear statement of what the company expected of the employee. And, because of the participative process, most employees could agree that these were reasonable expectations, But, keying off of quality principles, and viewing the employee as a customer, we realized that we didn't have structured way to clarify each individual's expectations of the company.

Ideally, we wanted supervisor and subordinate, and even team members, to discuss their respective individual requirements early in their relationship. To stimulate such a discussion, we suggested a check list of expectation categories (see chart 7).

Chart 7

EMPLOYEES NEEDS/EXPECTATIONS

- JOB SELECTION
- GUIDANCE/DIRECTION
- RESPONSIBILITY
- COACHING
- PRIORITY SETTING
- PROGRESS MONITORING
- FEEDBACK
- SKILLS/KNOWLEDGE
- ADVOCACY/SUPPORT
- TRUST/CONFIDENCE
- SECURITY
- OPENNESS/RECEPTIVITY
- VISIBILITY/RECOGNITION
- CONTROL/INFLUENCE
- ATTACHMENT/INCLUSION
- COMPENSATION
- ADVANCEMENT
- ETC.

We also defined the processes that should be analyzed and improved in employee requirements/expectations weren't being met. We called them relationship processes (see chart 8).

Chart 8

RELATIONSHIP PROCESSES

- EMPLOYEE/WORK MATCHING
- PREPARATION/GUIDANCE/DIRECTION
- MONITORING/FACILITATING/ADDING VALUE
- CONVERTING TO ACHIEVEMENT
- ASSESSMENT AND FEEDBACK
- REWARD AND RECOGNITION

This application of quality process principles to the individual took some training of employee/supervisor pairs. A course was developed which covers the concepts and some of the skills required. Our objective was a disciplined way to enhance open and early communication between supervisors and subordinates at all levels. Because understanding and meeting individual requirements is also the key to managing diversity, this initiative focused on diversity in a way that dampened the "special treatment" connotations that are deplored by most racial or ethnic minority groups.

Training/Continuous Learning

Training in many companies is often ad hoc and disconnected. Once mission, values, goals, and strategies are agreed and documented, a strategy implementation process like quality is underway, and standards for a disciplined performance appraisal and counseling system have been agreed upon, the bases for a well-connected training/learning initiative are in place. At ER&E, we dissected each of these components and compiled lists of the skills and knowledge which employees would likely need to perform according to expectations; and hence to be successful personally and help the company succeed (see chart 9 for skills and chart 10 for knowledge).

Chart 9

SKILLS

- ORAL/WRITTEN COMMUNICATIONS
- INTERPERSONAL COMMUNICATIONS
- SELF-AWARENESS
- LISTENING
- TEAM BUILDING
- IDEA GENERATION/GROWING
- ENTREPRENEURSHIP
- WORK PROCESS IMPROVEMENT
- PLANNING
- DECISION MAKING UNDERSTANDING SPAN
- RISK ANALYSIS
- TECHNOLOGY ADVANCEMENT
- CONSULTING
- NETWORKING
- NEGOTIATING
- POSITIVE INFLUENCING
- MARKETING
- MEASURING CUSTOMER SATISFACTION
- VALUING/MANAGING DIVERSITY
- FEEDBACK/DEVELOPMENT
- MENTORING/COACHING/ FACILITATING/MOTIVATING
- ROLE DEVELOPMENT AND OF CONTROL
- CAREER SELF-MANAGEMENT
- LEARNING

Chart 10

KNOWLEDGE

- WORK UNITS MISSION, GOALS & STRATEGIES
- COMPANY, EXXON, PETROLEUM INDUSTRY
- WHO CUSTOMERS, SUPPLIERS ARE AND THEIR NEEDS AND CAPABILITIES
- CUSTOMER/SUPPLIER WORK FLOW, BUSINESS PLANS
- BUSINESS ETHICS POLICIES
- RESOURCES, CAPABILITIES, BUDGETS, COST, ETC.
- SAFE WORK AND HOME HABITS/ PROCEDURES
- HEALTH AND ENVIRONMENTAL ISSUES/PROCEDURES
- QUALITY PROCESS
- BUSINESS ISSUES OF DIVERSITY
- UNDERSTANDING DIFFERENCES
- PERFORMANCE APPRAISAL AND SALARY SYSTEMS
- LABOR RELATIONS
- COMPUTING SYSTEMS
- JOB INFORMATION/ CLARIFICATION
- WORK PROCEDURES
- PROFESSIONAL INFORMATION IN OWN FIELD
- CAREER OPTIONS
- SUPPORT SYSTEMS/PROGRAMS

We also identified specific delivery vehicles by which these skills and knowledge could be imparted (see chart 11). Then, building on the specific appraisal of each employee, we could construct a multiyear training map which identified the deficient skills and knowledge and the most appropriate delivery vehicle. Chart 12 is a schematic of a training map. With specific dates and learning experiences in the boxes, we can monitor the progress of an employee's training/learning program over time.

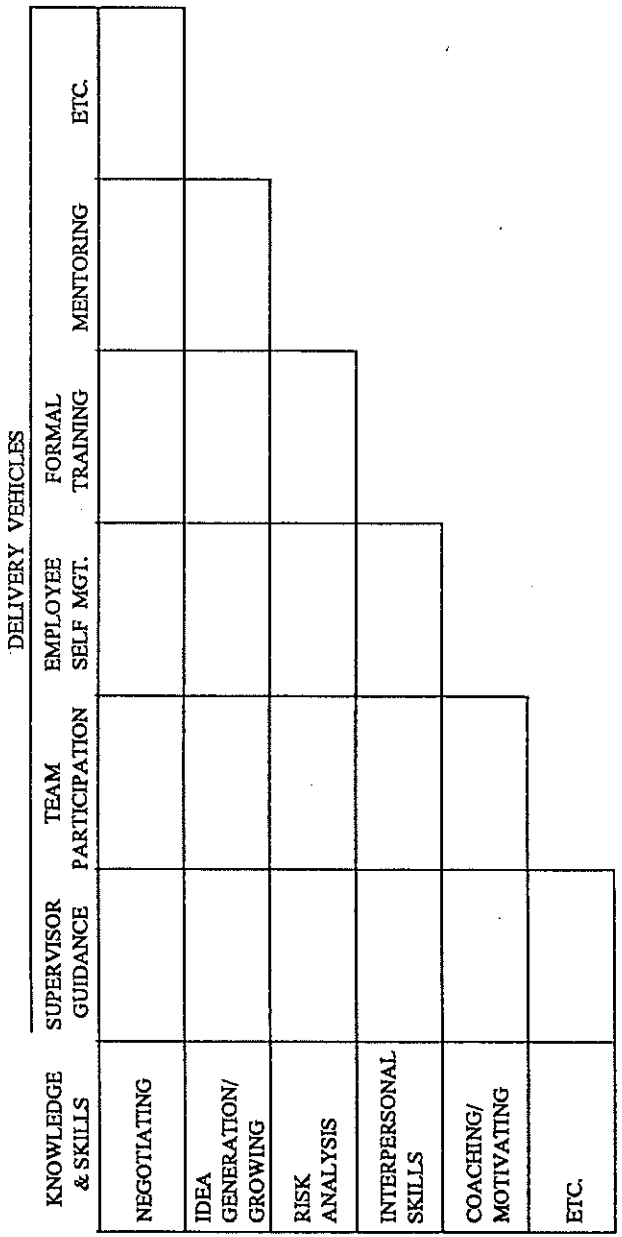
Chart 11

DELIVERY VEHICLES

- HAVING A MENTOR
- BEING A MENTOR
- TEAM PARTICIPATION
- NETWORKS
- PRINTED MATERIALS
- MEETINGS/SYMPOSIUMS
- SUPERVISOR
- PEERS, COLLEAGUES
- EXPERTS
- LEAVE OF ABSENCE
- NEW CHALLENGES
- LITERATURE SEARCHES
- SELF-STUDY
- ONE'S MISTAKES
- SPECIAL, PART-TIME ASSIGNMENTS
- STATE OF UNION MEETINGS, ETC.
- TRAVEL
- TUTORING, TEACHING, CONSULTING
- TV, RADIO, VIDEO, AUDIO
- LECTURES
- INTERVIEWS
- EXPERIMENTS
- DEMONSTRATIONS
- PROGRAMMED INSTRUCTION
- VOLUNTEER ACTIVITIES
- FEEDBACK

Chart 12

INDIVIDUAL LEARNING PLAN



The payoff for all the time and effort invested by ER&E employees on these components, and indeed in a culture of full empowerment, will be a long term and continuing one. But, already the organization's budgets and work force have been increasing since 1986, reversing six years of decline. This is backed up by clear evidence that ER&E's productivity is up, and customers are better served. Employees are more confident and secure and as they accomplish more, morale and motivation have strengthened. But, hopefully, the employees are only a shadow of what they will someday become.

Summary

My experience with two different organizations on both sides of the Atlantic has convinced me that the following are generic keys to full empowerment:

- A participative alignment initiative to agree on the organization's mission, values, goals, and strategies.
- A facilitating structure such as the quality process that encourages and engages most employees in moving the organization in the desired direction.
- Performance appraisal and counseling and rewards that explicitly reinforce agreed values and desired behaviors.
- Individualized training and learning that is tied directly to both employee needs and the mission, values, goals, and strategies of the organization.
- A broad framework of support in all the organization's systems and behaviors.
- A group of managers and employees that relentlessly press toward a culture of full empowerment. And finally,
- A recognition that most organizations have only one chance per decade or generation to put the full foundation in place—so be patient and do it right.

A Postscript

In a major change initiative, it is important to realize there is a "hard" and "soft" side of change. The hard side is the tangible things one wants to initiate and accomplish. The soft side deals with the people and their highly individual reactions to and support for change. As each component of this foundation for empowerment took shape, a skilled organizational effectiveness professional was an indispensable resource to assure enough attention was paid to the soft or human side of change.

Just as critical is the small core of champions that emerge from all levels of the organization. They grasp the concepts and see the benefits early, support and lead initiatives, and take the risk that they might be riding a flashy but fading horse. In the final analysis, the credit for full empowerment belongs to them. They are the real leaders, and every CEO of every organization should be laying awake nights figuring out ways to exploit their capability and power.

R. C. Mercure: *Variation, Values, and Productivity*

As far as I'm concerned, Dave is preaching to the choir. What I'd like to talk about from a perspective of an unfrocked business executive who has some educational responsibilities now, are the implications of what David just walked through to education. I am especially concerned with engineering education, because David was talking about a high class engineering organization—a high class technical organization. I think it is worthwhile for us to reflect on what that really means in terms of educating engineers. But before I do that, I want to say that I think this is a great forum to do it in.

The topic of this series is technology and responsibility. This is an interesting topic to me because I suspect people reading the little brochure announcing this lecture series would say: Ah ha! How does the technologist become more responsible? What do we have to do to get these engineers to be more responsible? I would say to you, that the technologist alone cannot be the responsible party. This business of responsibility and technology is a two-way street. Because it's a two-way street, there are responsibilities on both sides. The sides I'm talking about are the scientists and the engineers on the technically educated

side and then all other people—the lay people, if you want to look at it that way—on the other. I would say that society has a responsibility to educate our lay people to a point where they have some appreciation of what technology is and what it isn't; some appreciation of the limits of technology, and—coming back to what David said—an appreciation for what is now being called variation, as the term is used by Deming. I'd submit to you that most educated lay people do not have the foggiest conception of variation. This is probably one of the most important concepts in our society today. People ought to have some feel for it because we are perpetually faced with catastrophes, which in some sense are the natural outcome of the variation inherent in the system. And yet our legislatures, our lay public, everyone is really looking at these things from the wrong end of the telescope. Any complex society that is dependent on complex technology and complex processes ought to have some feel for what is the expected variation in the performance of these. This very basic understanding is lost in nine-tenths of our population. We must, therefore, educate some of our lay people. This education has to be started in the elementary and high schools and not be left only for the universities, because few of our people ever end up at the universities. Until we do this, we technologists face a losing battle.

On the other side of this street, however, the street we walk on, we have a responsibility as educators and technologists, and that responsibility is not well covered. I think it is probably covered better here at the University of Colorado than at most other places. We're making strides. But we have an obligation as educators of technologists—I use the word technologist so I don't have to fuss with the idea whether you are a scientist or an engineer—we have an obligation, which I think Thanasi tries hard to deliver on, to expose our people to the non-technical aspects of the outside world. This is not a comprehensive list, but I would say some of these non-technical aspects of the outside world would include ethics and morality. Almost every technical question that we see today is somehow contained in the context of ethics and morality. The environmental movement is a good example of this, but I could name a number of others such as the medical profession, the delivery of drugs, etc.

We need to educate our technologists in the social context in which they are going to operate. This is particularly important because we are now in a global economy and the social contexts are different. We can

no longer talk just of the social context of the United States. We have to talk about the social context of our global competitors. It is fascinating, for example, to talk about the social context and the changes it is undergoing in Eastern Europe and the former Soviet Union, and what effect that will have.

Another example of what I think we as educators need to inculcate into our students is the concept of value. Dave touched on this in a number of places. I'm not going to try to define value except to point out that value is not gained necessarily. Too often we confuse value with gain. Or, again, we confuse gain with value added. We need to be able to point out to the technologists that there is a real difference between value and gain. If you take Dave's example—I believe this deeply—that if you have the right set of values, and you can deliver value in your enterprise, gain will occur. Gain will naturally fall out of this, but the reverse is not necessarily true.

This is just a quick overview of some of the things that depend on responsibility, and I suspect that most of you in the audience could say to yourselves: we don't do a very good job of this and in some cases we don't even expose our students to some of these things.

This is important. The subject matter that Dave Clair went over is a "how to do it" case. Here is a recipe, in a sense. But this recipe contains ingredients that are hardly touched upon and I would say touched upon neither in the business schools of the United States nor in the engineering schools. We are now starting to be governed by the imperative of competitiveness, and unless we respond to this imperative we are going to find society is going to figure out different solutions. But we as educators, especially in this country right now, cannot respond to this enormous drive, not only to *remain* competitive, but oftentimes to *become* competitive in a global economy. We mustn't forget, whether we work at a public or at a private institution or at a government laboratory or whatever, that the wherewithal comes from the ability of the United States' private sector to survive. Not only to survive, but also to prosper. Unless we can collectively put together programs that respond to this imperative, our system is going to find other places to accomplish those things. We as educators turn our back on this at our peril. Again something Dave said is very important for the educational system, as well as in technology and government. That is to ask ourselves, do our reward systems really support us in our

endeavors to achieve what this imperative of competitiveness is asking of us? My suspicion is that if you're really honest, you would conclude that they do not. You will see that we need to work on this and I believe that this is going to be very difficult.

Managers in a technologically-based company or enterprise really face two masters. It is rather different than managers in a non-technical enterprise. These two masters, I would submit to you, are first the organization's stakeholder. I use the word stakeholder because it is a broad term in current use. The second master is the technology itself. This is one thing that tends to set aside, or set apart, technologically-based organizations from all others. These organizations have the same types of problems that all other organizations have, the problems Dave addressed eloquently here in terms of motivation, etc. But over and above that, empowerment, all of that alignment that Dave was talking about, is set in a context of technology. In order to be responsible, the managers of these enterprises have to respond to these masters.

The needs and values and expectations of the stakeholders are varied. Again, we as a country are having difficulty understanding how to meet these needs. If you are on a board of directors of a corporation your legal responsibility, the responsibility that you get sued for, if the shareholders decide that you are not doing your job, is strictly to the shareholder. Yet, management's responsibility runs not only to the shareholders, but to a host of other stakeholders. The employees notably, the suppliers, the community in which they operate, the creditors, and the public; a host of different needs, expectations, values, that the manager of a technologically-based company, as well as a non-technical company, has to balance somehow. It has to somehow fit together in our country as in a puzzle. Managers need to balance these and yet return the profit that shareholders expect, whether these shareholders are public or private.

I believe that one of the overpowering responsibilities of management in the modern form of enterprise, especially the public corporation we see in the United States, is to insure the viability and the longevity of the organization. You have no way to sustain the economy, to serve the needs, to support the lives of the employees, unless you can view the enterprise as having a long life. That responsibility is heavy because, in order to do that, the manager has to respond today to very fast changes in the environment. Not only

changes in public tastes, but also very fast changes in legislation. Just think for a moment how quickly our banking system has changed, essentially because of deregulation, or of the vast change the air transportation industry in this country has undergone, because of a relatively simple legislative edict that said that you are not now going to be controlled.

In order to survive in a technically-oriented company, the managers of that organization have to understand that technology and the bounds placed on that enterprise by that technology. I'll give you a couple of examples.

The company I was associated with for a number of years, the Ball Corporation, started out as a glass container company and prospered. Yet, had that corporation not become very knowledgeable in technology based on aluminum and forming aluminum into cans, they would be a far different organization today, because the technology embedded in glass could only go so far. For one thing, glass is not easily recyclable. It's not viewed necessarily by today's public as an environmentally good packaging material. This is a boundary that is placed upon an organization by the technology that it holds. Consequently, I would say that the full sense of managerial responsibility, which means to be socially responsible, to be able to insure the longevity of the organization implies that the manager of a technical enterprise has to understand where that flow is going and how that enterprise can utilize the technologies and how it must obtain new technologies to carry on.

Another thing about that is very important, and again we fail to inculcate this into our students in engineering or science. That is that the misuse of a technology will be discovered sooner or later, and sooner or later will have catastrophic effects upon those who misuse technology. It might take a long time, but sooner or later, if a technology is misused, that will be discovered and you will pay a heavy penalty.

One of Dave Clair's charts focuses on foundations for empowerment.

A FOUNDATION FOR EMPOWERMENT

- MISSION/VALUES
- GOALS/STRATEGIES
- QUALITY PROCESS
- APPRAISAL/COUNSELING/REWARD
- TRAINING/LEARNING

Dave's company was a highly technical company, but I defy you to find anything that has a heavy technology component, except possibly the quality process. Even then, I would argue, this is only a part, but not all of what is involved. All that Dave has talked about in this chart is almost never touched upon in our education. Yet we expect our students to go out of this institution and be able to comprehend something like this and to be able to fit into it. Probably more importantly you'd like those people to be the agents of change that Dave talks about, to be the champions of change, but yet we are not giving them these tools. We're giving them marvelous technical tools, but we are giving them almost no exposure to the things that impact this list. Somehow, again because of this imperative for competitiveness we've talked about, we as educators have got to find time, and the ability to put these sorts of things into our curriculum.

If we don't, we are going to find that the customers are going to go somewhere else. The sort of thing that Dave pointed out is something that is fundamental, and that is going to have to happen to this country, affecting very many different companies. Those that don't, probably will not survive.

Now let me come back to the role of engineering education or technical education. I think first of all the we have to sensitize our students to these kinds of issues, which are not technological issues. You cannot expect the business schools and the arts and science schools to do this for you, because these things are embedded in our business and technical organizations. So we have to be able to help our students understand these issues. I think, if we expect our students to be responsible and develop into responsible individuals, we have to inculcate into them a value system that transcends the values of the technology, because this is what this is all about. It is putting together a new value system in an organization. So, we as educators have a responsibility and a duty to assist by turning out people that are at least exposed to this sort of thing. We are not doing a good job on that.

Let me say one other thing. Dave talked about satisfying the customer. This is the whole thing about quality process. But I will say to you that there is a fallacy contained in this. There is a fallacy of satisfying the customer. That fallacy is this. Ishakowa who is a well known Japanese quality man says, "The customer's king, but sometimes the king is blind." It is the responsibility of management and

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Professional Ethics in Engineering

Clarence A. Herbst
Dr. Albert Knott

Clarence A. Herbst

Good afternoon. The talk today is supposed to be about professional ethics in engineering. How I was selected to perform at this podium, I haven't the slightest idea. So I started off by looking in the dictionary for the definition of several of the words in the title. I found a definition of engineering that satisfied me and was simple enough for my mind, and that is "*the work performed by engineers.*" That goes everywhere from changing diapers to building bridges—I would assume. For the purpose of my talk that definition will fit that whole category very nicely.

"*Ethics*" is the rules of standards that govern the right and good conduct of the members of a profession. So the good and right conduct of engineers is what I plan to make a few comments about today.

Now my approach is that you and I probably spend too much of our

time in the technical side of engineering—at least until we go out and get a job. This limits our experiences and our knowledge and puts us at a great disadvantage when problems come up other than technical problems. I need your involvement to make this afternoon a little fun. I would like each one of you to take out a piece of paper and a pencil and make three columns. The first column on your left can be used to state the problems, and then I'm going to give you two potential solutions to those problems. Then I would like to have you choose a solution. The one that you think is right.

What I'm going to do is present you with real problems from life that you will be facing as you progress through your business career. These problems will be dumped on your desk—literally as you progress through your business career, and hopefully rise to the top. Someday you might even be president of a company, and have to make decisions right away on a set of facts that are given to you. So in this little experiment this afternoon, consider yourself the president of a company. Somebody walks in and dumps a problem, and you are asked to make a choice. There will be a fast pace here this afternoon because time is limited. There won't be any discussion period during the formal part of this presentation. There really are no specific answers to these problems.

The first problem. Remember that you are the president of the company and this is what's happened to you. You use asbestos or some other carcinogen in the manufacturing of your product. This problem can be defined asbestos in your left hand column. You *know and believe* that the health risks are greatly exaggerated. That the health risks are controllable. The product is very useful technically. It is economical when you compare it to substitutes that you might have to use. Your foreign competition uses it and ships products into this country with asbestos in it. OSHA's tests for asbestos are absolutely ridiculous and unworkable. The alternatives to asbestos are dangerous also. You believe that smoking is much more dangerous in the work place than the asbestos you use. And the Canadian asbestos miners and workers have a known health risk level exactly even with the rest of the Canadian population.

These are your two choices with the known facts I have just given you. Choice number one, continue using asbestos, stay competitive, dispute the media, take them on tooth and nail, and fight OSHA tooth and nail. Your other choice is to abandon asbestos, pay the short term cost of doing so, reduce your profits, and put out of work the asbestos workers and companies that have been supplying you for years. Those are your two choices.

My comments on choice one is that by following choice one you'll feel good initially, you will lose eventually, law suits will follow, you and your company will go bankrupt, and your wife and children will become upset. That's the first problem.

The second problem is a completely different situation. You have lots of smoking in your factory or the use of drugs or alcohol. Let's start off with smoking. You know and believe that smoking is dangerous to people's health, that secondary smoke is dangerous, that the health costs are going up at three times the inflation rate, and you personally now are a non smoker. Now you have two choices of what to do in the work place. Choice number one. Stop hiring smokers. Put in a smoker-enders program. Put in a wellness program. Don't allow any smoking anywhere on your property. Give a medical exam to all of your employees. Offer a reward for those people who quit smoking. Now remember that you are stepping on some people's toes as far as freedom of choice ethically, but you are going to save money in the long term. Now that might or might not be ethical, but you are going to do that—you hope. Choice number two, ignore the problem completely and go on with your work. That is the problem and your two choices. Comments about choice number one. You are going to have a group of very angry employees. You are going to spend lots of money on your medical cost on your wellness program trying to improve your employees health. And you will probably miss hiring some good person you might want who happens to admit that he is a smoker, and that might even be your brother-in-law. That's the second problem.

Problem number three. A good customer of yours has a problem in his product or process. The problem is real and it is a big problem. You or one of your employees know the solution. However, the president of the other company was the man who invented the product that's going to crash, and he doesn't like people stepping on his toes. You have two choices. Choice number one. Tell the customer diplomatically that the problem is coming and gain or lose depending on the man's personal whim. Choice number two. Stay silent, prepare for the crash, and exploit it your best advantage. That's problem number three and your

and you know it. A supplier wants to bribe you to spec his material.

Here are your choices for any one of these cases. Choice number one: Don't participate in any of these nasties and also don't snitch on anyone. Don't be a stool pigeon, and try and convert the world to your American's somewhat ethical ways of doing business. Choice number two, is also don't participate, but snitch if you think it is right to do so. There is even a third choice available to you but I won't even suggest it here.

Next problem, number seven, is a lawsuit. You will have many lawsuits pending against your company. They include sex, religious and age discrimination and worker's compensation and product liability problems. I know this problem quite well. I've had them all. You believe that you are innocent of all charges. You have good, but expensive, legal council. You have either deep or shallow pockets.

Now for your two choices. Choice number one, fight tooth and nail. Never, ever, settle and don't ever give up. Choice number two, settle and minimize your overall total costs. Those are your two choices. My comment on number one, lawyers will get rich by reallocating the assets of the country from one person to another. You will spend all of your vacation time fighting all these cases. You will prove to your adversary that it is worthwhile suing someone frivolously. You will waste time and your business will suffer or die. Comment on number two, by settling you are perpetuating a bad system. Is that ethical? You will feel awful every time you settle. Not about giving up the money, you just feel awful, and you will eventually pass the cost of the whole experience on to your consumer.

Now this last problem might get a little controversial. This one is called sex discrimination. You are hiring in your factory. You have both women and men doing a specific job in the factory now. A hundred of each, let's say. The wage is eight dollars an hour in today's world. You know that there are qualified men and women for this job, but you also know that there is sex discrimination in the work-place and that women somehow truly get paid less for doing the same job some places. They seem to be happier at eight dollars an hour than a man at eight dollars an hour in the same job. Yet both have the same educational background. What I'm trying to get at is that in most cases the man in the job wants or expects a higher rate of pay for his efforts. Somehow he believes he has more value than this job can provide. His

ego is hurt. I believe this and you're supposed to believe this because this is the situation.

Here are your two choices. Hire both sexes and switch the wage system to a pay by merit only rather than having it capped at eight dollars an hour for this specific job. Choice number two is to hire only women when possible, but don't tell anybody why, because you are really getting, or your experience tells you that you are getting a better overall employee at eight dollars an hour if that employee is female. I think we should move on.

Summing Up

Now look at your lists, please. Look at how many number one choices you picked versus number twos. Did these problems come too rapidly for you? Just wait a few years until you're the president of a company. If you have too many number ones, may I suggest being a preacher rather than going into business. You are dealing in a world economy and each country is different, and each economic zone has different rules and ethical and moral standards and values, and this creates a big problem for American industry.

I'm going to change tack for just a minute, because I would like you to think about these problems again but in a slightly different way. I'm going to bring into your thought process Mortimer Adler's and Aristotle's definition of moral virtue and ethical conduct. The definition is "*desiring and doing the right thing, but for the right reason.*" Did you choose option one or option two for the right reason in each problem? If it was for the wrong reason, you don't get any points. It is not simply doing good to and for others, and it is not acting righteously and meeting your social obligation that gets you points, according to Aristotle. Now that brings us back to where we are and where I started. I went to the library and bought Aristotle's book. I suggest you do too. There are lots of them there. I also suggest that you read Mortimer Adler's new book *Desires Right and Wrong: The Ethics of Enough*, I plan to send copies of both of these books to Mr. Keating, Mr. Milken, and Mr. Boesky, and a few more of those men to see whether they think that they have enough. Now this whole tirade on ethics and problems that I have presented here is meant to create a demand for and be a plug for the humanities for engineers program. I wish this program was

available in the Engineering School when I went to school here. Maybe then I would have handled some of these problems better than I did.

Dr. Albert Knott

My background is in failure analysis and forensic engineering. My company specializes in the analysis of building collapses and machine failures. Basically, why did the building fail, or why did the machine fail? We also do a lot of vehicular accident reconstruction. We are often asked to go into court and present the results of an analysis. I want to give you some examples of situations we have run across, and some of the ethics questions that have come up.

The Automobile Accident

A client asked us to analyze an automobile accident. This client was an attorney. The attorney's client was an elderly gentleman, 75 years old—he was as nice as the day is long. He drove into an intersection and turned left. There was an oncoming car and an ensuing wreck. In the process of doing the analysis, we found that the oncoming car was speeding. So the attorney asked us to tell the truth: answer the following question. "Had the oncoming car not been speeding, would my client have cleared the intersection and there would have been no accident?"

The answer was yes, that's true. At the point where the left turning person could have seen the oncoming car if you choose that as the starting point for the analysis, and had that car not been speeding, this fellow could have turned left and cleared the intersection before the other car arrived.

I suggested that also you can say that had this man not turned left, then there would have been no accident. He would have stopped, and the speeding car would have passed on through. Therefore, the cause of the accident was the left turn.

The attorney suggested that I might want to get paid. He was not paying me to answer two questions. He was paying me to answer one. Let the other side answer the other question.

What do you do? What do you write in your report? From a practical standpoint you have to reach decisions, and for this particular one I said, "I will write the answer to that one question. But if the other attorney has enough sense to ask me the opposing question, I will not only answer that, but I will also discuss why I was asked to limit my review in the first place." They settled out of court.

Ethics

I define ethics as "for the greater good." That's a simplified definition of the many that you run across. That to me is realistic from where I'm coming from right now. We all learned our ethics when we were kids. Our mothers spanked us regularly. We weren't allowed to beat on our younger brothers—we weren't allowed to lie, but at the same time my dad drove faster than the speed limit.

This didn't happen to me, but it happened to a friend of mine. His folks took him to a movie when he was twelve and told the folks at the movie house that in fact he was eleven. Therefore he got in at a lower price. Those parents gave their boy a lesson in ethics. It stuck in his mind because he was proud of being twelve.

The Floor Tile

I have a case back east in which the floor tile is coming up from the floor. This is in a large mall. In terms of size, if you had a corridor fifteen feet wide, it would be three miles long. There is that much tile coming up. The insurance policy says, "We do not reimburse you for negligence, but we will reimburse you for the consequences of negligence." For example, if a pipe breaks in your basement, the insurance company will not come out and fix the pipe. The pipe was negligently installed. But they will replace the rug that was ruined. The pipe caused the problem, and your argument on the pipe is with the contractor who did a poor job of installing it. The insurance company does not insure the contractor. It does not insure you against his negligence. But it will pay for the consequences of his negligence, the loss of the rug.

Here are a series of true statements about the tile in the mall: (1) the

have a basement. So he got into the crawl space and started digging out the soil. He shaved the soil vertically downward alongside the existing foundations another four feet on down into the ground. These walls started sloughing in, all except this one. I was asked by the insurance company to go out and look at it.

This wall was about to come down. Next door was a wide lawn area. If the wall fell in that direction it wouldn't reach the house next door, but there could be kids in the area. So I went over to the owner next door and said, "This wall can fall down at any time. I want to recommend to the owner that he brace it with struts that go out back into your yard so that if the wall falls, it will kick the other direction. May I do it?" This guy said, "No." I said, "There is no way to brace it from the other side. If it does come down, it might kill some children." His answer was, "To hell with the children. I have a three-foot fence. They're not supposed to be in my yard. I keep them out."

So I called the owner and said, "This wall can come down anytime. It can fall and hurt somebody." He said, "Well, I'll take a look at it on Saturday." This was Tuesday. What do you do?

So one way to ask the ethics question is: if worse came to worst and the news media found out about it, what position would I like to be? If children were actually killed and I, as a knowledgeable engineer, had not done everything in my power to keep those kids from getting killed, I would be hung out to dry.

Well, I called the city. Oddly enough, the city had already come out and looked at it, and had gone back to their desks. I called the city and used the words "imminent danger of collapse." This tends to make city officials belch out from behind their desks and do something about it. They immediately red-tagged the building and the owner had it torn down by that evening. Then he said, "I want to rebuild this building." The city said, "Oh no, this building was built on a twenty-five foot lot. We have an ordinance now that says you can't build buildings on twenty-five foot lots. You could have repaired it, but you can't build a new one." He called me up and offered to sue.

A Mathematical Approach

There is an interesting mathematical approach which I have used. It

doesn't give me answers, but it sure gets me into raising questions abou them. If you have an ethical question, you can identify the players Usually it will involve the public or some subset of the public. We'r talking about "for the greater good." One player will be your clien Your client wants you to come up with a solution that is to his greate good. You are one of the major players. You are in business and thes ethical questions directly affect you. You can lose your job. If you'r the president of the company, you can lose your company. But as junior engineer, you can lose your job as well.

You can identify the players, then you can identify the alternativ actions you can take: Either I can do this, or I can do that. On the wal collapse case I could have called up the insurance company and said "You guys have an exposure. If this thing falls down, someone migh get killed. Therefore you better do something about it." Then hang u the phone, and I would be safe. That was one of my options. So yo look at the various options you have.

You identify their advantages and disadvantages. Make a list o them. Then go through the list and put weight to each of the advantage or disadvantages. Weight may be dollars gained or lost. It might b prestige gained or lost.

Next, you don't know whether a particular result is going to occur. I you make this particular decision, you don't know for sure whether th advantages or the disadvantages are going to occur. So you try to esti mate what is the probability of this occurring? If you take the weigh times the probability, you get the expected value. If I might lose hundred thousand dollars, but I only have a fifty-fifty chance of goin that way, then the expected value of that decision is fifty thousan dollars.

You add up all the advantages and disadvantages. You add up al these expected values, and you come up with a decision that represent the greatest value for all of the players. That decision represents "th greater good."

There are some people who are actually trying to quantify ethica decisions in this fashion, and it's kind of fun to do. What it really doe is it gets you deeply involved in the consequences of a decision. Who' going to get hurt and who's going to benefit. And it allows you t recognize those players for who they are. That is a form of ethical deci sion exploration.

Asking the Question

One of the things I have noticed is that 99 percent of the engineers I know think that they are ethical. Probably 99 percent think that they are *above average* in being ethical. What I have found in my own experience and in working with my employees is that most engineers don't ask the question: "Is it ethical?" They make decisions based on their own personal philosophy. My mother spanked me when I lied, therefore I don't lie to my clients. But when it gets into tough decision making in ethics, a lot of engineers don't ask the question: "Is my action ethical?"

For example, there is a public debate on pesticides. Let's say I am a specialist in pesticides and I know that pesticides, if properly applied, are safe. Can I, as a knowledgeable person in pesticides, ethically remain silent? There are many engineering decisions like the Twin Forks dam. If I know that the city and the state will be better off with more water for the following thirty-seven reasons, and they are all very good sound engineering reasons, is it ethical for me to stay quiet? That's a question that the engineers typically don't ask themselves, because typically engineers don't get involved in trying to answer those questions.

Engineers are typically introverted problem solvers. They love to sit at their desks and do great things there. They don't like to get up on a soap box and join the public conversation. Yet they are often knowledgeable in just what the conversation is all about. They don't ask the question, "is it ethical to remain silent?"

Personal Bias

One of the dominant considerations in ethical decision making is personal bias. If my daughter were killed by a drunk driver, I would probably hate drunk drivers. I would have an unreasoning hatred for them. On the other hand, if I, through my own drinking, had killed somebody else's daughter, my concerns for drunk drivers would be a deep concern for their health, but not a hatred against them. All I've changed in this example was bias. Bias is really and truly with us all. Most people think that they are not biased. Well, you can be biased

towards being honest. You can be biased towards doing a good job on an exam, or be biased towards mathematics. Bias isn't necessarily bad.

We are very definitely biased to save our own skins. There were two guys in a fox hole. One was digging a slit trench radially outward. "If a shell comes in to this foxhole," he said, "I'm going to dive into that trench." He was biased into thinking that he was safer that way. The other guy laughed at him and said, "If a shell hits this foxhole, it is going to go right up that trench." He was biased the other way. Then one day a shell came in close. This fellow leaped into his trench and lit on top of the unbeliever. When it really got down to his own hide, he was very biased in favor of saving it.

Closure

What I would like to leave with you is that we need to recognize the tremendous cacophony of questions that are flowing over our heads everyday. We need to ask the ethical questions or ask the question, "Is it ethical to do that?" You will find, that if you open your eyes and become insightful, that there are a heck of a lot more questions in ethics than we realize. We need to learn to recognize them. Once we do recognize them, then we can ask the questions: Is it honest, is it fair, how does it make me feel? We can weigh the solutions to them once we recognize them.

Certainly, we need to go beyond where we were as children. Go beyond our normal reaction to situations. It is great that we are exploring ethics here today and that all of you are no longer children, so you've gotten beyond that stage. But become more insightful and seek these questions. Look beyond yourselves and recognize your own biases in their solutions.

4

Technology and Environmental Responsibility

William Parzybok
David Roe

William Parzybok

It is a pleasure to have this opportunity to share some thoughts with you today. Hopefully, we will have some stimulating and provocative discussions about a subject that I think all of us are interested in, or we would not be here. What I would like to do is to make six points in order to illustrate what I think are the major issues and some of the themes of things that are being done in private enterprise. The company I am with, is a publicly held company. We employ 2,200 people, most of them in Washington state. We have a major commitment for being a responsible corporate citizen and I would like to share with you some of the things that we think are important along this line.

The first point I would like to make here is what I call sustainable future. I think as a society—frankly as a human race on this planet—we need to figure out a way to have a healthy environment and a healthy economy at the same time. I think, by the way, that each impacts the

other tremendously. Economic health is essential to the environment. The reason for that is that we need to find the funds to clean up previous sins and messes. We need research into new methods and new materials to replace things that we currently use, which are harmful, like CFCs. We need funds from economic health to train people, for better education, better recycling. Economic health is important here. Most of you probably have heard of Mazlow's hierarchy of needs. It is a very simple concept that says there is a hierarchy of your needs and your basic needs are for things like food, shelter, and clothing. The highest one on the list is self-actualization. The whole theory is that once you are well-fed, clothed, and have shelter, then you move up to other things that become important to you. But if something happens, you will fall back down the list. Most of you think that it is important to have an intellectually stimulating discussion this afternoon, but if you all were about to starve to death out there, you are not be really interested in this kind of a discussion.

I guess I have been struck over the years with people who have a certain attitude. Driving between here and the Wyoming border one time I saw a pick-up truck that said, "If you are hungry and out of work, eat an environmentalist." That troubled me because it said to me that somebody operating on a lower level of Mazlow's hierarchy will be less sympathetic to these environmental issues. As the Brazilian farmers who say, "It is really nice for all you folks in the U.S. to have your kids going to school. I am cutting down a forest here so that I can raise some cattle. We'll have that meat so I can get the money so I can sometime in my lifetime or my children's lifetime approach some level of standard of living that you all enjoy."

So I believe that if you have economic disaster you will have environmental disaster. I think Eastern Europe is probably the most vivid example today of this situation. Germany is finding out what a big mess that is. I think environmental health is essential for economic health, maybe not on the very shortest term, because some will cut corners if allowed to on the short term. But on the long term, if you destroy the quality of life, you have hurt a lot of things, particularly businesses that employ what I call knowledge workers, which are a growing proportion of employers in industries in this country: electronics, computers, business, and so forth. You simply do not have to locate your factories near an ore body, or port, airport, railroad. Hewlett

Packard, John Fluke, or IBM, locate their facilities where people want to live. They look for good quality of life. The quality of life encompasses many things of course, but if that is deteriorated, you cannot attract the people you need.

I know that when I lived here in Colorado, we would fly people in to interview in February and March. What you did not want to have to do was drive back into Denver in the late afternoon to see what a mess that was. That was a quality of life issue and it is important. I think if you have an unhealthy environment also, you will have higher costs. Health insurance costs are terrible for U.S. businesses. Our costs for providing health insurance for our employees is growing much faster than our sales. How we pay for this is a struggle for us. Some of these health problems that our employees and that other citizens of this country have are going to be paid by somebody. So there is a real cost for having an unhealthy environment. So my point here is that as a society and as a world society we really need to find ways to have both a healthy economy and a healthy environment. I do not see how either one of them could be given total priority over the other and expect things to work.

The second point is what I call sound science. Over half of the people in this country believe that astrology is a science. That is troubling for anybody who has a scientific or engineering background. There is a science and a pseudoscience. In the case of sound science, we need to really make sure that we improve our skills in terms of risk assessment. We need to be putting our limited resources, both dollars and people's time, on those things that have the biggest risk and the biggest potential payoff. I am not an expert on asbestos. Maybe my colleague on the panel here is. I remember reading an article in *Science Magazine* that says that if you took the money that was spent to tear asbestos out of schools and office buildings in this country and all the workers who were exposed to that asbestos in that process, and you spent that money in a different way, either to educate people or to look for alternatives you might have had a much better deal. But there was a kind of "ready-fire-aim" mentality. Like I said I'm no expert on asbestos, but there was a public scare about asbestos; asbestos workers were affected, and tremendous funds were spent.

I think we need to figure out how to get people to respect science. We can avoid some costly mistakes because we don't have unlimited

resources, and we don't have unlimited time. We need to really be sure that we are doing the right things. I heard the other day somebody closer to this made the following comment, that apparently now the EPA is reconsidering Times Beach and they feel like they may have made a mistake in evicting people from Times Beach. I don't know who's right on that, but this idea of a "ready-fire-aim" mentality is damaging to this whole cause.

Just for fun we brought a little quiz. We just thought it would be interesting to get the sense of the audience here today on what you think are the greatest risks to you and your children. What I'd like to suggest here is that what you have in front of you is a list of 10 things that potentially could threaten your lifestyle or life. This may not be an exhaustive list and you may be tempted to add others. What I'd like you to do is read them over and restrict yourself to only three. You don't have to rate them. Just pick the three that you most worry about for yourself and your children. I know that some of you don't have children, but some of you will. Why don't you pick the three you most worry about. We're going to collect these and show you the results near the end of the program.

I presume that most or many of you are engineers and that you are or will be designing new products and new processes. There are some new concepts that are becoming very important these days that people designing the new products and processes need to understand. One is called the total product life cycle. It starts with the raw material used to build or realize the product. Those get translated into parts or some intermediate phase of their construction through some sort of a process. It gets packaged into something that is shipped or delivered to the customer. It is used somehow by somebody and at some work point in its life it is disposed of. Today engineers have to be careful in thinking about every step of that process. It used to be that you only thought about one or two of those steps. In other words you used to have to make a product that cost a certain amount and did certain things and hoped everybody bought it. Now you have to be careful about what's going to be the eventual disposal of that product.

A real theme is pollution prevention rather than the "out of the pipe" syndrome. Before we put in any kind of process or part we ask ourselves do we really have to do it? Is there a better way to do that? And is there perhaps a way that is more environmentally sound? Recycling in industry can be very expensive. We for example take the residual sludge that comes out after you make a printed circuit board. There is a lot of copper in that process and we collect that sludge and put it in barrels and ship them to Idaho to a copper smelter where they are turned back to copper. That's a very expensive process. We do the same thing with solvents that are reprocessed and with other things. If we could figure out a way to avoid even generating that waste in the first place, we could avoid some cost in there. So we have engineers that are looking at doing that. I believe as engineers you need to think the whole concept of product life cycle from cradle to grave. Packaging of products; paper, plastic, styrofoam popcorn and things like that is terrible problem for landfills.

One of the major themes of industry today is total quality management or total quality control. It's a technique of setting goals, figuring out how you're going to measure whether or not you are achieving your goals, making changes and attempting to have continuous improvement with the aim being perfect quality. These concepts apply very well to environmental issues in an industrial environment. What kinds of things are we generating? First of all do we know what is happening to it? Where is it going to? What are we doing to reduce it? What goals have we set? It is important to use those kinds of business techniques on these issues here.

Education—I guess it probably goes without saying that people who are more educated about whatever subject whether it would be science or democracy, tend to make better decisions both for themselves and for society. People need help in being better consumers. I think most people want to be better consumers and would like some help. Bill Riley who is the administrator of the EPA has launched a campaign to try to get some government standard definitions of what do we mean by recyclable or biodegradable. What is the time it takes to degrade before it is biodegradable? Set some standards and help people be able to make those kinds of choices. Help people learn to change their lifestyles.

In the Seattle area just about everybody recycles. One of the big problems they have is that they need to teach people the fact that if you throw a bottle in with your aluminum cans you could ruin a whole batch of aluminum. It doesn't take very much. One piece of yellow paper will ruin an entire batch of white office paper being recycled. Did you

know that? These are things that knowledge and education can really help people understand.

We recycle where I work and a few people have been anxious to know what can be reused if we are recycling things. We try not to generate waste in the first place by getting rid of plastic and paper in cafeterias, for example. Let me ask you. When you go to King Soopers, they ask you whether you want paper or plastic, right? I've read interesting articles by some credible people that make strong arguments on both sides of that issue. Frankly I don't know. I tend to take the paper because I think that we can regrow some trees, but I'm not really comfortable with that. Bring your own is a much better way to go.

My fifth point—a level playing field. I think this is a really important point for our government both local and national: To try to create an environment where I'm responsible for running a company and I'm responsible for paychecks of 2,200 people and their families. I'm really careful about doing those things which put me in a non-competitive position. Most of my competitors are in the Far East. Most of them are in Taiwan. How many of you have ever been to Taipeh? Unfortunately I don't recommend it. One of the things that bothers me is that I have competitors over there that dump toxic wastes into their rivers. The lead levels in their children are incredibly high. Infertility rate in Taipeh is something like 70 percent of all child-bearing women because of poisons of industrial waste. Lead, cadmium, and mercury are toxic chemicals used to fabricate products cheaper than I can fabricate them in Everett, Washington.

If I lose a sale because I'm not price-competitive and I throw somebody out of work at my company because my competitor is doing what he is doing in the Far East I feel really bad about that problem because I don't think it is right to throw heavy metals in the river. We don't do that. But I also feel bad about throwing people out of work. My competitors think that they are making a short-term gain in their cost and they probably are, on a short-term basis. I don't think it's right in the long term. I'd rather do what I'm doing, but you can see the problem I have in a business when there is that kind of international un-level playing field.

The same is true in a lot of other things. Fortunately in this country we have in many ways gotten some more level playing fields so that people do have to play by the rules—at least in one country. There are

international initiatives for example the CFC's. Try to get some international agreements on reduction and elimination of some of these things. But you can see how important it is to a business that is trying to meet the needs of several different constituents.

Let me summarize and wrap up here with three nagging concerns. The first is world population growth. This has been a taboo subject for environmental people for some time. It is beginning to re-emerge as something we ought to think about. Do you all realize that only 5 percent of the world's population lives in this country? Recent estimates are that the world population will cross through 10 billion by the end of this century.

The thing I worry about is that this many people consume a tremendous amount of resources. What are we going to do about that? By the way, most of that population growth is not going to occur in this country where we like to believe that we are a little more educated and a little more enlightened. You know where that population growth will occur and you know what the urgencies of those people are. So there is a world-wide problem and not just a U.S. problem.

Second, I believe that as a nation we are leaving two incredible debts to our children. One we can measure is called the federal debt. Who's going to pay that back and when? How much are we going to spend on the interest on that debt? We at least can measure that. The other debt we are leaving is what it's going to cost to clean up Rocky Flats and Hanford and all the other DOE places. There have been wild estimates. We're talking about a tremendous amount of money and somebody is going to have to come up with those dollars to do that job. Probably politicians will push this out into the future onto future generations, so I'm concerned about that.

The other thing that sort of goes on human nature which I presume will be a subject of further discussion in some of your other sessions here. But it is the whole idea of getting people to accept short term pain or inconvenience for some really substantial long term gains. Getting people to drive less. Getting people to sort their trash. Getting people to generate less waste. Simple things like that. Getting them to become better informed consumers. They've done a lot of studies which show that people claim to be environmentally conscious but when they go to the store they will buy based on price. In other words they are forgoing any short term pain because it is cheaper and that feels better today. So

maybe it is human nature and maybe that cattle farmer in Brazil is really worrying about short term gain trying to feed his family, but burning down all the rain forest is not the long term gain.

That concludes my remarks. Unfortunately, business is often stereotyped as somehow anti-environment. We are not. Primarily because, in my business at least we want a very good environment, we are trying to attract the best brains because that's the raw material for the business I'm in. So we'd like a nicer environment. We think that there's a lot more that can be done.

David Roe

Well there is a lot to agree with in what Bill said and I will spend some time agreeing with it, but I should start by admitting my reluctance to have Thanasi introduce me as being from Yale Law School. It is bad enough that I'm from California and that I'm a lawyer and I don't even know how to tie a respectable neck tie. The idea that I'm from a place that produced at least one person who's lied to a hundred million people is kind of nerve-racking. I don't know which one it is, but it's somebody and we've all seen him on television. So this is your official warning, so watch out. What you see may trick you.

Technology and environmental responsibility, when you hear that or any sort of set of words like that it's almost impossible not to hear technology versus responsibility. In a way that's what Bill was responding to in saying: Wait a minute; it's more complicated than that. But the assumption in most people's minds, most journalist's minds, most ordinary reader's minds, is that these two things are in some way opposite—that somehow technology is the enemy of environmental protection.

Technology is things like electricity, things that increase our convenience, our ease. Increase the capability of people to do things. Since it is things like electricity, that means things like nuclear power plants or coal plants. It means things like styrofoam clam shells that your burger from the fast food chain comes in. It means the 727 that I flew here on this morning. That's technology.

Environmentalists are against all of those things. Again that's the assumption. They're all the same: we need to use less or do less or

grow less or enjoy less. You recognize this description; you've heard various versions of it from a lot of people. The description is very simple; it's a seesaw. Environment is on one side, the economy is on the other. The only way you can help one is to hurt the other. Either way you can't win. The man most responsible for popularizing the seesaw notion the one who got this across to more people than anyone else is Ronald Reagan. He ran for president on it. He convinced a lot of people that it was true. James Watt was not anti-environmental, he was pro-economic. He was in favor of economic growth. Ronald Reagan was not anti-environmental, he was in favor of the economy. So reluctantly he had to be a little harder on the other end of the seesaw. It was the only way to do it.

Now things have turned around a little since Ronald Reagan left office. The environmentalists have won a few I suppose, but the idea of the seesaw is still very strong. If the environmental side—if the environment—wins in some fashion, it must have been at the expense of the economy. It must mean we're growing less fast, responding less quickly, being less competitive internationally, some form of that. If the greens are winning then it is the triumph of the greens over the greenbacks in some way. That's conventional wisdom. Life, of course, is more complicated than that, but let's see how far we can go.

I've got three questions that I thought I'd play with. The first one is: why is this man smiling? Now I should have brought the full-color version. It is about a year and a half old. This is the cover of *Fortune* magazine. The guy on the cover is the chief executive officer of the largest public utility in the country. The largest privately owned—stockholder owned. Pacific Gas and Electric, which happens to be the one that runs the lights in my house in Northern California. In his pose he's got a walking stick and a kind of a bright red anorack that he borrowed from the photographer. He's beaming. The caption says, "The environment—business joins the new crusade."

The second question is: why can't you get a hamburger in a styrofoam clam shell anymore at McDonald's—because you can't, but why not?

The third question I have is why did one of your senators in this state, Senator Tim Wirth, a Democrat, join forces three years ago with a Republican senator from Pennsylvania and make a whole set of suggestions about environmental policy and technology, which was endorsed

by people as far to the left of the political spectrum as Tom Wicker in the *New York Times*, and as far right as the editorial page of the *Wall Street Journal*?

Let me start with the first one. PG&E is the biggest utility in the country. Fifteen years ago, this company was planning to build ten of the biggest power plants that you could build, either coal or nuclear, and have them all finished by the end of this decade. Either that or have the lights go out in more than half of California. We're talking the late '70s. And that's exactly what the company thought and what the government officials that regulate that company thought: it was build or die. And a small environmental group, even smaller than it is now—the one that I work for—a couple of guys with a very primitive computer and a few witnesses who claimed to be technical experts, said: there is a completely different way to cope with this problem. There is a completely different way to build ten nuclear power plants' worth of new electricity. And its name is—and then it got kind of complicated because its name seemed to be lots of little things all decked together: some conservation over here and some co-generation over there, a little wind, a little solar. A kind of a hodgepodge of different stuff and the only thing you knew about that stuff is that no utility had ever made a large investment in it. Much of it was sort of modern, "new wave" soft stuff. To make it worse these same environmentalists, including me—I was the lawyer for this—said: You'll also save money; it'll be cheaper for you. So of course we had a bitter fight for about six years. Lots and lots of cross examination and briefs and documents and computer runs. The company spent about 2 million dollars to fight off this little threat—which was flattery of a kind. We sure weren't spending that kind of money. We got briefs that said things like "it takes a tremendous amount of gall for this little organization to claim that it knows more about running public utilities than we do because we are the public utility." Then slowly the company started to shift. And in effect, gracefully and slowly, in the years between then and now, the company has done exactly what was on that odd, weird, radical-sounding little prescription that you couldn't quite understand, dating from the late '70s and coming from this small environmental group. So, in what became a very large struggle, this very large company lost. If you're thinking in terms of winning and losing, the environmentalists turned out to be right. In some astonishing degree they were probably very lucky. The

environmentalists turned out to be right about *both* the technological availability of all these alternatives *and* the fact that they were cheaper. In fact they turned out to be so right that this company and all the other companies in California now lease the computer model that the Environmental Defense Fund built to analyze all this stuff to do their in-house analysis.

So the question is: why is this guy smiling? The answer, of course, is that it turned out to be very good business. His company's stock is doing better than other utilities', he's got less worries about the future, and of course he's got a reputation as a pro-environmental major utility, which is not a field in which the industry is normally thought of as being a leader. Plus, he didn't have to buy the jacket.

Now McDonald's. You all know what I'm talking about: The styrofoam clam shell that's got the two pieces that hook together.

You don't think of McDonald's primarily as an educational institution. They sell food. But there are 22 million people a week who go into McDonald's. Roughly speaking a tenth of the country is in McDonald's every week. What they do gives a lot of people their sense of what's doable, at least in the food and food-handling business, and what's appropriate and how society should work.

They sell fast food, they sell convenient food, they sell good food and they're a symbol of the throw away society because, as you know, you go in and buy a burger and you also buy lots of other stuff that never makes it out the door because it goes into the trash can.

About a year ago the Environmental Defense Fund set up a joint project with McDonald's—voluntary on both sides, no money changing hands on either side—but to put our technical experts together with their technical experts to see if maybe there were ways to have less garbage, less solid waste as a part of the business of running the most successful fast food company in the world. We got that started and we were busily working away. McDonald's was sensitive about the styrofoam clam shell so they figured out a way to manufacture it without CFC's and they were just about to announce having done that and they were going to reaffirm a marketing strategy to use the styrofoam clam shell, but because we had a relationship with them we found out about it and the head of our organization called up the head of McDonald's and got through and said, "You know, this could be a very serious mistake. We should work hard in the next week on showing you what the alter-

natives are." And to their great credit one week later the president of McDonald's was on national television and announced that they were getting rid of the styrofoam clam shell.

He did it not because he was knuckling under to pressure, but because he and his technical people became convinced that in fact you could serve burgers and wrap them and retain their heat with packaging that would be about 90 percent less solid waste. Not perfect, not free, not zero, but about a 90 percent reduction from the styrofoam clam shell. And so he jumped out and said, "That's what we are doing," and they got a lot of credit for doing that.

As part of the study, when the rest of the study came out a few weeks later, and McDonald's discovered that there were techniques which would allow it to reduce 80 percent of its total solid waste from all of its operations—not just the selling part, not just the food serving part, but also manufacturing and ordering things—that was very good news too. That's 80 percent of the total garbage impact of one of the companies which is seen by the public as being a symbol of a throw away society, the essence of garbage creation in the service of speed, convenience and pleasure.

To give you an example of how large this company is, they cut down the weight of their drinking straws 20 percent and eliminated a million pounds of solid waste a year from that alone. Again why can't you get the styrofoam clam shell at McDonald's? Good business, very good business for this company.

The third question I asked was sort of more political and more complicated. Your Senator Tim Wirth and the late Senator Jack Heinz of Pennsylvania did a project called Project 88 which got a fair amount of press play, which was a set of recommendations about ways to approach environmental issues. Essentially what was displayed was a faith that there are lots of good approaches across the full range of environmental issues—not just little anecdotes or little spots here and there—ways to get at these problems, ways that were good for both the environment and the economy; ways that haven't been tried just because people haven't been thinking about them, because people were still stuck on the seesaw. They still couldn't figure just how to get that end of the seesaw up without getting this end down. Project 88 got a great deal of positive play because a lot of people would like to see that kind of thing be the case. One of the people to whom that project was

addressed was a guy named George Bush. He in fact put into his Clean Air Act proposal a goal of getting rid of ten million tons of sulphur. That's a little less than half of the total sulphur emissions that cause acid rain. The country totals about 22 million tons. He proposed to eliminate ten million tons and put a cap on sulphur emissions, with a fairly sophisticated economic trading scheme for how to sort out who should make the cuts and how you'd basically pass out the ability to release the rest of the sulfur into the air.

The basic idea was to get the smartest people, who can do it the most quickly, to do the most and then reward them, pay them by having the people who are slower or dumber or more locked into an inflexible technology be able to purchase that creativity in the form of tradable emissions permits. I know that this is a little complicated: tradable emissions permits capped at a level slightly higher than half what's coming out of the smoke stacks now. Squeezed down, but instead of squeezing down by telling you and you to go to zero and everybody else the same level or to tell all of you to come down 42 percent, the total's going to come down this much, but we're going to let the intelligence and creativity of the market figure out how to get it done. We're going to reward the people who are quickest and most economic and can go down the most and have some reductions left over to trade. And that is now law. That in fact is why the administration had a proposal on clean air in the acid rain context, and why it passed the Congress. We're going to start seeing that work very shortly.

If it had not been for that proposal the cost estimates for cutting that amount of sulfur were approximately $1.3 billion higher than the cost of doing it this way. And it was because the President and his advisors were convinced that you could do it in fact much more cheaply than people thought: That you could halve the sulphur emissions in the United States at a much lower price tag—and that therefore he was willing to put his administration behind it and make it happen.

My favorite article describing this whole set of proposals was in *The Economist.* The headline on the article was "The Greening of the Invisible Hand"—a very nice turn of phrase. That's what's really going on, in a sense: introducing environmental concepts into very standard economic approaches. There are some people in the environmental movement, some of my colleagues who don't trust this stuff, who think economics is a dirty word. Economics is the other side's game, so they

think it's not the "greening of the invisible hand," but the "invisible handling of the greens."

There is beginning to be a consensus that there's a real upside here. Why did Tim Wirth and Jack Heinz and a bunch of other people do this? Not only good business, but also good politics. Because it is solution oriented. It's freeing up a system to be able to search for solutions instead of classifying problems.

All three of these examples—our friend in the red anorack, the McDonald's clam shell, and the strange bedfellows political marriage—in all three of these it's very clear that technology is not the problem. The problem is the assumption that technology cuts only one way, and also the decisions as to where technology is going to be applied. Is it going to be applied on fluidized bed combustion of coal or is it going to be applied on getting insulation in people's attics? I oversimplify, but that's a very real issue and that's a very real issue that was faced by this company over ten years ago. Is it going to apply to making better styrofoam or is it going to apply to laminating some paper in a way that increases both its heat retention and its disposeability? It's the definition of the problem. It's the marching orders to the engineers, to the technical experts, as to what they are supposed to be doing. That is where the problem is. By and large engineers and other technical experts don't make those decisions. They're made by the major players in our economy. They're made by the CEO's, a very enlightened form of which we have right here. They're made by marketing people. They're made by congressmen, the President, governors, executive agencies. And all of those in government, as much as in business, are capable of missing the issue and missing the point by asking the wrong question.

So the key, in effect, is to try to set the incentives in this system to reward going in the direction we want to go. We all want to go in the direction of things that are *both* good for the environment *and* good for continued economic growth and competitiveness. We have a situation, we have a mind set, we have a seesaw notion, which does not reward trying to find those things. But there are ways to do that. One of them was in fact this early case, where the reward was simple. The reward was money. Public utilities make their money not from you and me, but from government agencies who tell them how much they can charge you and me. So if you can convince the government agency to reset the

pricing structure, you can do anything. There was a very straightforward case of changing the incentives for a large company because in effect it had only one customer in response terms.

The economic approach, the "greening of the invisible hand," is really a way of mobilizing technological and entrepreneurial resources in favor of finding ways to do both of these things. Instead of saying "we don't trust trying to protect the environment" or "we want to hold back," or "we want to hire our lawyers, we want to fend off the government," instead of all that, creating a sense of "we'll race you there." We'll try to get there faster because the winner actually profits. One example of that is when Starkist went to dolphin-free tuna. They were planning to advertise that as a great advance and they could barely do it because the other tuna companies made the conversion in about a week. Now it is hard to find a can of tuna that doesn't say "dolphin-free" on it.

When I got off the freeway coming in here I thought it would be fun to bring you a styrofoam clam shell so I stopped at one of McDonald's competitors and I was very pleased to be told, "we don't have those. We don't have any styrofoam at all." So the competition is following McDonald's lead also. They are starting to race each other toward things that are both good for business and for the environment. So that I think is very good news, even though it's only early returns.

As far as where technology fits in this, the metaphor that comes to mind is a little bit like the people in the time of Copernicus and Galileo and Kepler. Then the debate, of course, was whether the earth goes around the sun, or vice versa. Astronomers were the first scientists, as I'm sure you know. I don't know if any of you have seen the absolutely technologically wonderful diagrams that were made of the solar system to try to defend the Ptolemaic universe: The universe in which the sun went around the earth and all the rest of the planets went around the earth. As observations got finer and finer it became necessary to construct more and more elaborate epicycles. The diagrams toward the end of the period of what the paths of all of the heavenly bodies were so that you could go around the earth were technological marvels. They were superb technological achievements. Of course, they were wrong, but they weren't wrong in terms of what the technologists of the day were instructed to do. They had really figured out a way to make the premise true. Of course, they had been asked the wrong question.

Today with the environment and the economy and technology, I think we are very largely in the same place. The Ronald Reagan notion, the seesaw notion, the idea that we have to scratch at the margin to find ways to keep the system as we know it going and protect the environment is as conceptually wrong as the notion that the sun goes around the earth. Once we all see that, much stronger advances will be made very quickly and they'll be made by some of the people in this room.

5

The Ethics of Arms Manufacture

Peter B. Teets
Sanford Lakoff
Richard Devon

Peter B. Teets

Good afternoon, ladies and gentlemen. It is a pleasure and really an honor for me to be here today to speak to you on the subject of the ethics of arms manufacture.

You know, it is a wonderful and a precious privilege to live in a place that not only allows, but encourages its citizens to engage in open dialogue on any and all important topics, like the one we will be discussing today. I congratulate and welcome those of you in the audience. Like you, I am here today to learn and to expand my horizons and through the remarks of the other panelists and our distinguished moderator, I hope to learn a lot. I hope to contribute also by giving you some insight into how I have formed my views on this important topic of the ethics of arms manufacture.

As we begin these next couple of hours, where we fully expect to hear different perspectives, I think it is appropriate to start with a couple of points that we might all agree on. The first of these has to be pride in our great nation and the institutions and values that we hold as American people. We all believe in freedom and equality and the right to

have and express our own individual thoughts. It is just exactly what we are doing here today. I think it is appropriate to recognize that this type of forum would not be possible in many parts of the world. We live in a world where ethnic and religious conflict abound and economic and geographic strife lead to daily bloodshed. Although our method of popular consent and majority rule, applied to political disagreement and conflict resolution may not be perfect, we do not resort to open warfare to solve our internal disputes. In fact, our meeting today is an important part of our political process. We are going to rationally and calmly discuss potentially controversial issues in a free and open environment. We need to be aware that our system of government and the combined determination and will of all generations of Americans create this climate and that it is a very precious thing not shared by many that we must cherish and preserve.

A second area where I am sure that we can find wide agreement is that none of us wants a war that would threaten to destroy our way of life. Since we are discussing state of the art technology we can especially underline that none of us wants a nuclear war. Clearly the destruction caused by such a conflict would forever alter the world as we know it. So what we must do is determine the best way to prevent such an event from occurring. This, I believe, drives our ethical determination of how best to use our technology.

As you already know, I am the president of Martin Marietta Astronautics Group in Denver, and a significant part of our business is in providing goods and services to the United States Department of Defense. Martin Marietta does, in fact, manufacture arms. The fact that we provide hardware for the Department of Defense is a source of great pride for all of us at Martin Marietta. We take very seriously, the stewardship of taxpayer dollars and earnestly try to provide the very best of all possible products and services on every contract that we work.

We apply research to meet the societal objective of national security and defense of the United States. We believe that this is ethically and morally the right thing to do. And our business responds to a nationwide popular mandate. The constitution charges us to provide for the common defense. The continued leadership of a series of elected presidents backed by the continued support and direction of the congress, with their close annual scrutiny, reflects that this is the collective will of the American people.

We are proud of Martin Marietta's role in national defense and believe that the best way to maintain peace is through a strong military that will deter any potential aggressor. At the same time, we support our national leaders as they pursue significant, equitable, and verifiable reductions in force levels through arms control agreements and look for other ways to ensure our shores are never threatened.

Political freedom and prosperity flourish best in a secure and peaceful environment. And we are committed to doing our part to maintain this environment for ourselves and for future generations. Over the past forty years, we have learned that the best way to avoid war is through credible deterrence. We have had to deploy modern nuclear weapons to keep from having to use them to protect our vital national security interests. We must be prepared to wage war so effectively that no opponent can rationally conclude that he stands to gain by initiating war, especially nuclear war.

Now, for a little more detail on why I believe that the participation in the defense industry is both ethical and moral. As with any matter of conscience, this is a deeply personal issue and one that all of our engineers and researchers—not only at our company, but in the defense industry as a whole—must come to grips with. All I can offer are my own views and tell you what has influenced me in the choices I have made.

First, it is my strong belief that there is no more honorable profession than the defense of this nation and its constitution. After all, we are a nation created of the people, by the people, and for the people—and security in my opinion, is the greatest social service that the United States government can provide for its people. The defense industry in this country in general, but Martin Marietta in particular, is a vitally important element of our nation's defense posture, and as I have mentioned, I am proud to be associated with this effort.

This pride of course flows from and depends upon our organization believing in and following all laws and regulations established by the United States government. I am proud to be a supplier of arms for the United States, but I can tell you, we will not sell arms simply to the highest bidder. All of our foreign sales, and we do engage in foreign military sales, are carefully controlled, and we are in complete compliance with regulations established by the departments of State and Defense. We intend to keep it exactly that way. In other words, I am

basing my case for the ethics of arms manufacture on direct linkage to United States national security interests. Furthermore, if we are going to arm our troops and send them into battle, then I believe we must provide them with the best equipment and supplies that we can. To do less would be immoral.

Take the Persian Gulf conflict that has happened in the last year as an example. It is clear that the United States defense technology saved thousands of American lives in that conflict. And I must say that Martin Marietta products were used extensively and performed very, very well. An example is the Patriot missile. You saw on nightly television a few months ago, SCUDs raining in regularly on Tel Aviv or Saudi Arabia. Those SCUDs were intercepted effectively by Patriot missiles assembled by Martin Marietta in Orlando. Similarly, the screens that you saw on television, the night vision systems from our F-16 and F-15E fighters were built by Martin Marietta. Those night vision systems allowed our forces to fight at night very effectively. Similarly the night vision systems of the Apache helicopters were built by Martin Marietta. The point is that this modern technology, high technology defense equipment indeed saved thousands of American lives in the Gulf.

There are a number of other issues that touch this subject of the ethics of arms manufacture. I would like to just comment very briefly on a few of these, then during our question and answer period I will have an opportunity, I hope, to engage in more discussion. The first one I thought I would talk about is the very special case of nuclear arms. The fact is that nuclear weapons are weapons of mass destruction and so in some ways there is a special ethical and moral consideration that should be laid against those arms. Yes, Martin Marietta builds Intercontinental Ballistic Missiles, so in that sense we are in the nuclear arms business. The fact is though, I believe that nuclear weapons since World War II, have been developed and deployed strictly as a matter of deterrent force. We have deployed those nuclear weapons because we wanted to avoid having to use them and deter any aggressor from using nuclear weapons against us.

Another argument that one occasionally comes into contact with is that spending on defense diverts resources that would otherwise productively be used in the private economy. While I think there is some truth in that argument, I will go back to the constitution which

establishes one of the primary functions of our government to provide for the common defense. And then I will quickly add also, that a lot of the research and development technology that has been developed under defense contracting has indeed had spin-offs into the private economy. Perhaps the best example is the telecommunications business, whose infrastructure really was spawned by defense technology.

There have been a number of widespread press reports about abuses in the defense industry and I would be remiss if I did not say a few words about that. The fact is that the defense industry is a highly regulated business. There are literally thousands of rules and regulations that apply to defense procurement. I believe that our defense industry has really focused on trying to train employees and educating employees on the subject of high ethical standards and professional conduct within our industry. It is true we are highly audited as well. And so there have been some individuals working in the defense industry, and it is a big industry, that have in essence been guilty of unethical conduct. But I can assure you that Martin Marietta, as a corporation, and the defense industry in general is dedicated to education and training of our employees to conduct themselves with the highest of ethical standards.

I would close these informal remarks by saying that I think it is accurate to say that as the result of hard work and the dedication of many hundreds of thousands of people, both in the military service and in our defense industry, coupled with the investment of our nation in a strong defense and deterrent force, that collective effort has allowed an entire continent to be set free. The events that have transpired here in the last few months are remarkable. I believe they were enabled by our strong peace through strength defense posture. I have enjoyed giving you these remarks and I look forward to more comment later.

Sanford Lakoff

Being here reminds me of the time when I was a graduate student at Harvard and we had a visit from a then-candidate for president, Adlai Stevenson, who had just been to MIT. He said, "I was at MIT where I tried to humanize the scientists; now that I am at Harvard I will try to simonize the humanists." I would very much like to respond to some of the things Peter said, but I think what I will do is stick to my text so far

as I can and then save some comments for the subsequent discussion.

I want to divide my remarks into three parts, as Caesar divided Gaul: First, some reflections on engineering as a profession; second, what is happening to the weapons business now that the Cold War is virtually over; third, how ethical considerations bear on the decisions you will have to make in your career.

To discuss engineering as a profession we need to begin by recognizing that all of us are identified to a considerable extent by our jobs. We are what we do. When people think about anyone, they often think about what he or she does for a living—so and so is a lawyer, a business man, a professional athlete. If you get through this place in one piece you will be known for the rest of your lives as engineers. In addition, you may have a double life as a business man or teacher or some other capacity.

Except for some light hearted ribbing, as in the movie, *The Revenge of the Nerds*, engineering has always been a very prestigious activity in this country, more so than in Europe. There, until recently, it was looked down upon because it was a form of applied science and therefore less prestigious than pure science, which was thought inferior to the humanities. In this country, the humanities were weak, even in the universities, and pure science came into its own only when Einstein and other European refugees, in effect, brought it here with them. Well before then, we had a very proud tradition in engineering shaped by the Yankee tinkerers, by certified engineers like Franklin, Rittenhouse, Whitney, Fulton, Morse, Edison, Roebling, Amman (who designed our bridges in the east), the Wright brothers, Ford, Langley, and Steinmetz. Then, increasingly our focus in engineering was less those on individuals and more on groups of people like those who invented the transistor at Bell Labs, like the others at IBM, Texas Instruments, Eastman Kodak, and the defense and aerospace companies, in the "skunk works" as they call it at Lockheed, Boeing, Rockwell, TRW, and Martin Marietta.

Looking back on how prominent engineers have been in our society, it is not surprising that social theorists (mainly Thorstein Veblen and Howard Scott) earlier in this century should have predicted the rise of technocracy. They supposed that engineers would become a new ruling class, maybe of the kind that Aldous Huxley imagined in *Brave New World*, where our Lord was going to be replaced by our Ford, and the

slogan would be "Ford is in his flivver—all's right with the world." That prophecy began to recede once the first engineer was actually elected president of this country. Everyone of course knows who the first engineer President was, Herbert Hoover. After that experience we decided it really did not make that much of a difference. We had another engineer—I guess you could call him that—in Jimmy Carter, who was a nuclear engineer. Again he did not do quite well enough to have either party require an engineering degree for candidates for the presidency. For the most part, political science majors who go on to become the lawyers still run the country with the occasional advice and consent of engineers. (Now you know why we are in such trouble.)

Institutionally too, this country has had a strong commitment to engineering almost from the start. West Point was created as a school for army engineers. MIT was founded as an engineering school, not as a science school. All the land grant colleges were founded to "promote animal husbandry and the mechanical arts" in the words of the Morrill act.

The reason, I suppose, for this strong engineering tradition is that this country has always been very pragmatic. Even though our humanistic intellectuals have tried to persuade us of the superiority of things of the spirit to machines, we have not really believed them. For example, Ralph Waldo Emerson was probably the greatest American philosopher of the 19th century, and maybe of all time. When he was told that Morse made it possible for people in Maine to communicate with people in Texas by telegraphy, he asked the inevitable, dumb humanities question—"What would people in Maine have to say to people in Texas?" If it had been up to him, they would never have strung all that wire and left us with all those unsightly poles to ruin the landscape.

In 1900, our leading intellectual was Henry Adams and he was so impressed by a row of dynamos at an exhibit in Washington, that like a true intellectual, he sat down to brood in his study and wrote an essay about the conflict between "the dynamo and the virgin." By the virgin what he really had in mind was the faith in the supernatural that had led to such great works of art. He was contrasting the works of art he had seen in Europe with this exhibit of dynamos that seemed to him typical of America. He reflected that perhaps the soulless American technological dynamo would win out over the European quest for transcendence.

Because there are dynamos, there are engineers. As of 1988, there were 3,074,500 engineers in this country, according to the data.[1] Of that number, 2.84 million were employed; the rest apparently married money. That is twice as many as there were in 1978. The number would have leveled off, except that many foreign students came to study engineering here and have stayed on. The three largest categories, incidentally, are mechanical, electrical or electronic, then, of course, comes "other." Just about 80 percent (2.84 million) were employed in business and industry; 118,000 were in educational institutions, and others in government labs. The good news for you as you worry about finding a job when you leave is that from 1976 to 1986 the employment of scientists and engineers in industry increased by 8 percent per year, in spite of recession. The bad news is that some of that employment was provided by the defense industries which experienced a boom from the last years of the Carter Administration, through the Reagan Administration, and are now about to experience a bust. I do not have a breakdown of the number of engineers employed in defense work. The big eight defense contractors (Boeing, General Dynamics, Lockheed, McDonnell Douglas, Rockwell, and United Technologies), however, employ some 700,000 people alone. Not all of them engineers, not all of them do defense work. But unless there is a shift to civil development and production as defense spending declines, there could be fewer opportunities for engineers overall than there have been in recent years.

Some companies are likely to feel the defense cutbacks more than others. General Dynamics does 77 percent of its business with the Department of Defense, Martin Marietta 57 percent, GE on the other hand does only 11 percent, and Boeing 15 percent.[2] So companies like GE and Boeing are diversified enough to weather the cutbacks without feeling too much of a pinch. Still, in absolute terms, the largest

[1]U.S. Congress, Office of Technology Assessment, *Redesigning Defense* (Washington, D.C.: Government Printing Office, 1991) and National Science Foundation (NSF), *Science and Engineering Indicators 1987* (Washington, D.C.: NSF).

[2]Percentage of business under Department of Defense contract for other firms was McDonnell Douglas (62 percent), Grumman (64 percent), United Technologies (18 percent), Rockwell (16 percent), and Westinghouse (13 percent).

contractors are all vulnerable. GE, for example, does $5.87 billion in prime defense contracts, or did in 1989, the third largest amount after McDonnell Douglas, almost $9 billion, and General Dynamics, $7.28 billion.[3]

Now, that gets me to the second part of my remarks which might be called "Whatever happened to the defense budget?" From 1950 on the defense budget rose because we opted for a strategy designed to contain the Soviet threat. An awful lot of jobs, of course, are tied to defense spending, and as the Soviet threat diminishes, there will be a tendency, which is already under way, to cut back the defense budget. From a recent peak of 6.4 percent of the gross national product (GNP) in 1985, it is due to fall to 3.8 percent by 1996 and all of this is before President Bush's recent announcement of unilateral cuts and some negotiated cuts with the Soviets.[4] That is leading people in Congress to feel that the budget ought to be cut even more. Procurement will fall almost 50 percent, and if you look at specific areas, shipbuilding 26 percent, aviation 23 percent, research and development 23 percent, and so on. (See charts 1, 2, and 3.) That may not all happen because, for one thing, a lot of congressmen are reluctant to close defense facilities, because entire communities are affected by them. In view of the unemployment we already have, there is bound to be particular reluctance on this.

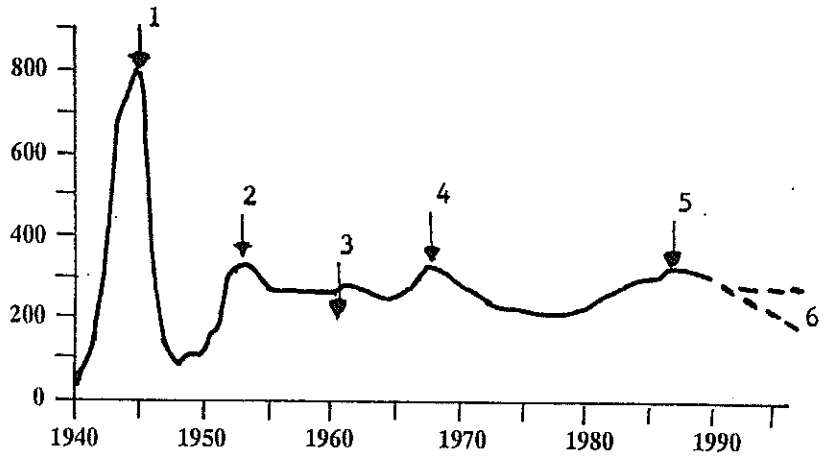
Even so, many of you will be tempted to take jobs in the defense sector and the question before you is, can you do that and still hang on to your soul? This brings me to the third and final part of my remarks, the question of ethics and arms manufacture. As you are probably aware, the word "ethics" is one of many we owe to the ancient Greeks.

[3]The remaining top 10 defense contractors in 1989 by value were United Technologies ($3.54 billion), General Motors ($3.38 billion), Martin Marietta ($3.35 billion), Raytheon ($3.29 billion), Boeing ($3.11 billion), Lockheed ($2.56 billion), and GTE, Grumman ($2.35 billion).

[4]Projected declines in the U.S. defense budget, from a recent peak of 6.4 percent of GNP in 1985 to 3.8 percent by 1996, will be reflected in procurement over the same periods falling almost 50 percent, from $123.9 billion to $64.3 billion (in 1992 dollars). Between 1990 and 1993 budget authority will decline in aviation by 23 percent, shipbuilding 26 percent, weapons and tracked vehicles 77 percent, for research and development by 23 percent. The latest total allocation for defense is $330 billion, due to decline in real terms by 22 percent in 1995. Estimated base closing or realigning of 145 facilities will save $700 million annually.

Chart 1

U.S. DEFENSE SPENDING, 1940-1996
(in billion constant 1990 dollars)



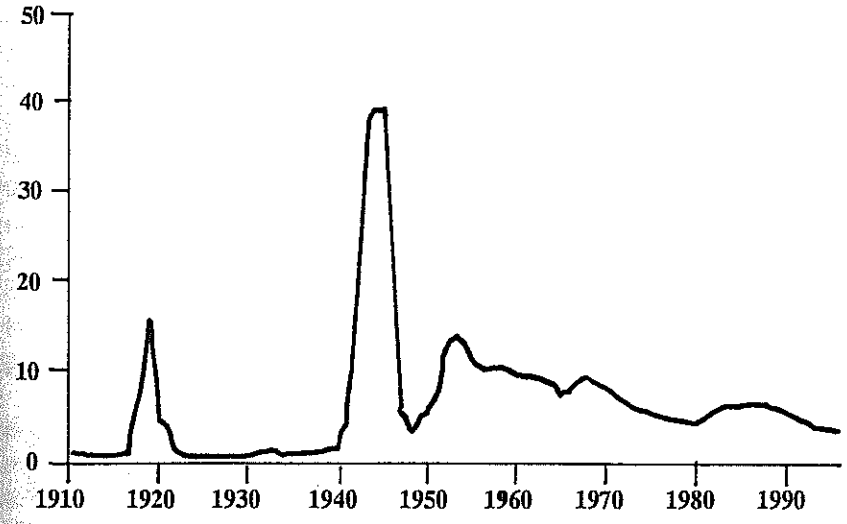
1=World War II **2=Korean War** **3=Cold War Minimum/ Post-War Minimum**
4=Vietnam War **5="Reagan" Buildup**
6=Range of Proposals

Sources: *Budget of the United States Government Fiscal Year 1992* (Washington, D.C.: Government Printing Office, 1991); Stephen A. Cain, *Analysis of the FY 1992-93 Defense Budget Request* (Washington, D.C.: Defense Budget Project, 1991); William W. Kaufmann, *Glasnost, Perestroika, and U.S. Defense Spending* (Washington, D.C.: The Brookings Institution, 1990).

It comes from the word "ethos" which means character or spirit. Naturally the first philosopher to deal with the subject was a Greek philosopher, in this case Aristotle, in his book *The Nicomachean Ethics* named after his father. In this work he sets out to answer the question that is one of the most profound of all philosophic inquiries, certainly the one that concerns us most as individuals, which is simply what it means to live a good life.

Chart 2

U.S. DEFENSE SPENDING AS A SHARE OF GROSS NATIONAL PRODUCT, 1910-1996
(in percent)

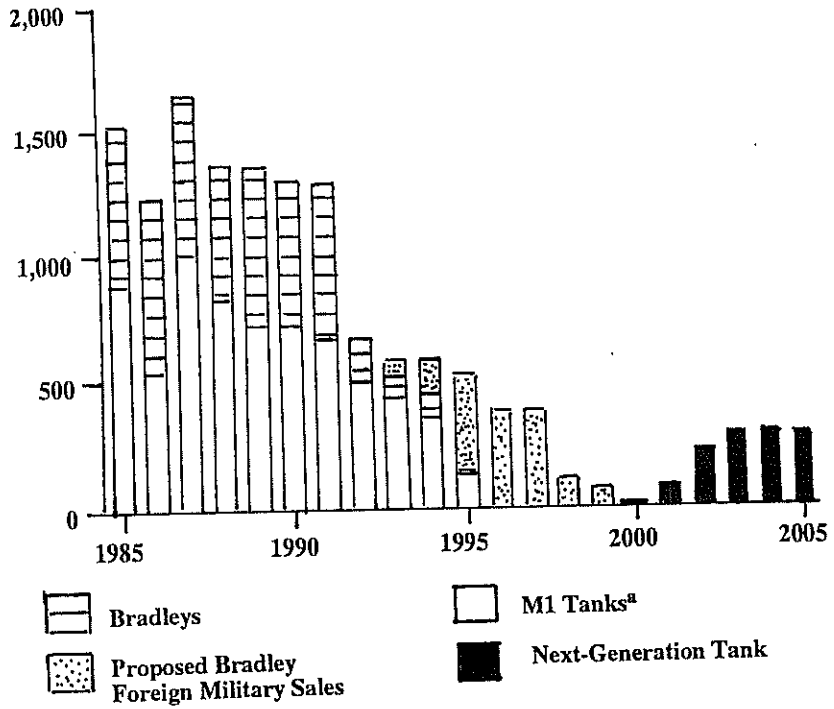


Sources: *Budget of the United States Government Fiscal Year 1992* (Washington, D.C.: Government Printing Office, 1991), part 7, historical tables, table 3.1, and Stephen A. Cain, *Analysis of the FY 1992-93 Defense Budget Request* (Washington, D.C.: Defense Budget Project, 1991), table 15.

The conclusion that he came to is that leading a good life means being happy, but that happiness has to be understood not just in terms of pleasure, but in terms of what is right or just. In order to think about what is just, we have to ask ourselves not simply what is good for us, but what is good for our friends, our society, for the world at large, and life in general. The Greeks were of course preoccupied with the life of the polis. They saw nature as an often violent force. In our day we live in a very interdependent world and we have to be even concerned about what happens to the environment.

Chart 3

U.S. ARMORED VEHICLE PRODUCTION PROJECTED THROUGH 2005



[a]M1 tank figures include proposed foreign military sales to Saudi Arabia and Egypt, with Egyptian coproduction.

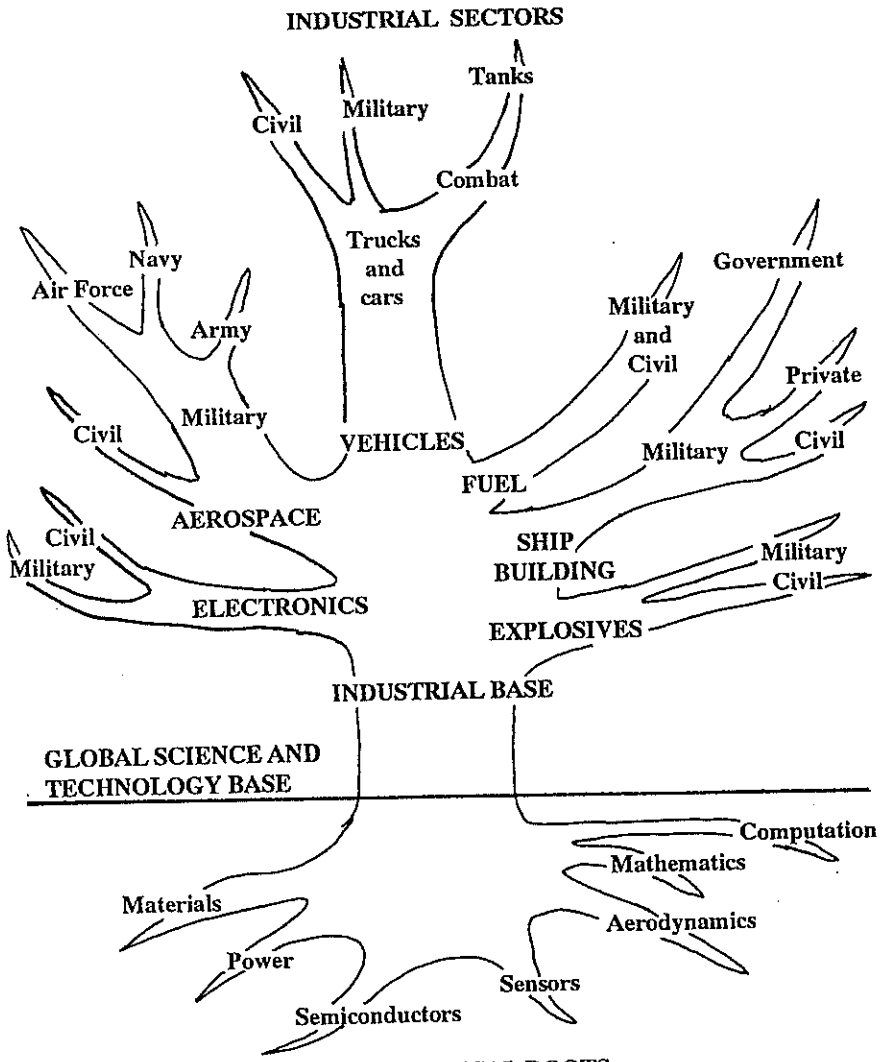
So ethics, then as now, has to do with the personal choices we must make for the sake not just of personal pleasure, but for the sake of living justly. A pacifist would say that if you asked the question of whether arms manufacture contributes to anything good, the answer is obvious—war is not healthy for children and other living things, as the peace movement slogan had it years ago. Weapons are developed to kill, and we would be better off without them. So it follows that it is not ethical to manufacture arms. Stop the manufacture and the arms race, and we all live happily ever after. If we don't develop new weapons, other countries won't either.

The reason that few people are pacifists is not that most of us are immoral, but that the pacifist answer would doom the innocent and encourage the aggressive. If we had followed this advice 50 years ago, Hitler and Imperial Japan would have conquered the world by force of arms. Britain was saved from invasion not just by the valor of the RAF pilots, but also by the radar they got in the nick of time from engineers like Robert Watson-Watt. Had Hitler gotten the atomic bomb first, as the scientists feared, the world order we would have now would be rather different from the one President Bush anticipates. Like it or not, Japan surrendered only after the atomic bomb was used in Hiroshima and Nagasaki. Those bombs may have saved even more lives than they took by making an invasion of the Japanese home islands unnecessary, painful as it is to acknowledge that.

That does not mean that those who designed and built these bombs did not experience moral qualms. Before the atomic bomb was used, many of its creators tried to persuade the government not to use it. But the idea of staging a demonstration on some uninhabited area was found to be impractical. Afterward, Robert Oppenheimer said, "We scientists have tasted sin." He proved reluctant to work on the H-bomb because of moral doubts. His security clearance was removed and he was accused—unjustly—of treason. After that experience, some physicists refused to do war work of any kind and the situation only got better because an arrangement was created whereby they could provide policy advice to the President and Congress so they could take part in the process of decision making.

At first, when the Second World War ended, there was a temptation to close the labs and get back to business as usual. Then came the Cold War, so instead of dismantling our military procurement system we revved it up again under Truman. But note that President Eisenhower in his farewell address warned us about the dangers we were running. He said that we were risking having a military-industrial complex become too powerful and a government be run by a scientific-technical elite. Chart 4 indicates the intertwining of the military and civilian industries from the technological roots.

Chart 4
RELATIONSHIPS AMONG DEFENSE SECTORS AND THE BROADER NATIONAL INDUSTRIAL BASE



Source: U.S. Congress, Office of Technology Assessment, 1991.

Why did President Eisenhower warn about that? Well, for one thing, the problem in our society is that economic resources are often used to influence policy. Defense firms spend a lot of money on lobbying and advertising to win contracts. Not only that, but there is a revolving door phenomenon. In the 1950s more than 1,000 retired military personnel were hired by defense contractors. In the 1960s that went up to 2,000. The number is even higher in the decades since despite laws to prevent it. Consider the scandals. Boeing admitted getting missile information from a Boeing employee who worked in the Pentagon. GE, General Dynamics, virtually all the military contractors have now been found guilty of similar corrupt practices. And now Martin Marietta stands accused by former assistant Secretary of the Navy Paisley. How many congressmen have been bought and sold by defense contractors in their political action committee? What does it do to our representative system when congressmen become dependent for reelection on the contracts they get from defense contractors for their districts. Congressman Mendel Rivers got so many defense facilities for his district in South Carolina that it was said that if he got one more, his district would sink. In the 1970s, when the President and the Secretary of Defense wanted to cut the B-1 bomber program, Rockwell urged its 115,000 employees and shareholders to write their congressman. They rallied 3,000 subcontractors in 48 states. They spent $1.35 million for lobbying and we got a plane that some of its critics call the "flying Edsel" and it certainly does not make sense that we also have the B-2. Certain regions of the country have become heavily dependent on military spending.

On top of that, the politicians get to feel that there is a technological fix; you do not have to worry about negotiations and arms control. SDI was a classic example of the fallacy of the last move—the belief that you can make one more advance and that will end the arms race. All that happens every time one of those moves is made is that the other side is forced to make a counter move and things get worse and worse and more and more nuclear weapons pile up. There is an arms bazaar in the world. It is all very well to say we do not sell weapons to bad guys, but somebody does. The Chinese, the North Koreans, and everybody else are still pumping arms into Iraq, Syria, and Iran. Now we are about to learn that virtually every company in peace-loving Switzerland probably helped Iraq to get nuclear weapons.

So, those are very serious problems and they come from the fact for whatever the good reasons we do get overly committed to the weapons industry. Does that mean we should not do it? I am afraid not. The truth is that western Europe and Japan would not be as stable and as prosperous as they are if we had not provided them with a nuclear and strategic shield. Very likely the Russians would not have come to the decision they have come to, to abandon their command economy, if we had not forced them to recognize they could not have both guns and butter. And it is certainly correct to say that the weapons we had in Desert Storm saved an awful lot of lives. There is no doubt about that. The world remains anarchic. So I do not think there is anything inherently immoral about producing weapons.

I do think, however, there are dangers. The historian Paul Kennedy has warned us we're in danger of repeating the British folly of what he calls "imperial overstretch," biting off more responsibilities than we can chew. The other thing is that we live in a much more competitive world than we did at the start of the Cold War. If you look at the patent picture, our rivals who spend much less than we do on defense are just tromping all over us in electronics and a lot of other areas. There are reasons why we as a country have to think seriously about redeploying our technical resources. I think Gore Vidal had it right when he said the United States and the U.S.S.R. have one thing in common: no foreigner will buy a car made by either of us.

We need a strong defense, but we do not need a frantic quest for ever more exotic high-tech weaponry. I therefore hope that as you make your choice of a career, as you face ethical dilemmas in deciding to promote some new military technology, you will bear in mind your responsibilities as a citizen and not as just somebody who loves to take apart old machinery and put it together as something new, whatever use it has. I do not think you will be doing anything immoral if you work for a defense company, but if you are to behave ethically, you have to behave as a citizen of your country and of the world. That means taking other concerns into account. It may mean becoming a whistle-blower when you find they are not using the right O-rings. It may mean that you should hold back before you promote a new technology you know is not really necessary and that will only perpetuate the arms race. And it may mean too, that you encourage your company to diversify so that it does not have a vested interest in perpetuating military competition.

Richard Devon

For several decades, I have been opposed to militarism. I haven't been opposed to being in the military or building defense weapons but opposed to the degree to which we do those things in this country. And I have had a rather marginal point of view. That is not to say that I have not always been right, it was just that not that many agreed with me. I feel a little odd now because I think my conclusions are probably becoming mainstream America's. However, both of the previous speakers still have made me feel as though I have somebody with whom to debate. So I will cling to my old positions for awhile before I search some new marginal ground.

The other comment I would like to open with is that I am not particularly interested in discussing the morality of individual engineers, I would sharply dissuade you from whistle-blowing. Be very careful. You will sacrifice your career; you will sacrifice your friends, and possibly your marriage too, and you will find it very hard to get other work. Unless you pursue it through the Federal False Claims Act as amended in 1986 which allows you to blow the whistle on companies that are defrauding the federal government. That is about the only support for whistle-blowing there is and I would encourage you to do it only if you could use it.

My view of ethics has more to do with social ethics than individual ethics. There is as far as I am concerned no such thing as engineering ethics. It would have to be something more than the collective sum of moralities of individual engineers. I would encourage you to be as moral as you wish to in your private lives, I am not suggesting that is unimportant. I am interested rather in the way in which we get a better society through technology and the role that policy plays, institutions play, organizations play, and rewards and punishments play in the systems we set up to do that. With respect to the lives of engineers, the metaphor that will govern what I have to say could be expressed in terms of fences and gardens. I think that we have a neglected garden and a very large and sophisticated and unnecessary fence, for the sort of rabbits that are outside of the fence. That will be my basic metaphor.

I will also suggest that although in this country we argue that we cannot have industrial policies because this is a free market economy, lots of capitalist countries do have industrial policies. Furthermore, we

have an industrial policy. We put roughly one-third of all scientists and engineers to work for defense. We have been putting two-thirds of all federal R&D into defense. This happened in the 1980s in a time when the economic competitiveness of the United States was and continues to be in decline, and we were putting nothing into R&D for manufacturing which is one of the places in which we have been suffering a great deal.

There are many costs for deploying our resources this way, with this type of industrial policy. Defense products are unusual in the fact that we are lucky if we do not use them. There was a wonderful photograph of some people working, young men who had been on duty in an MX silo. As I was looking at the photograph of them, I thought that every day they really did not have anything to do. I am glad. There was no further impact on the economy. If, on the other hand, as an engineer you go out and design a bridge, and that bridge is maintained—which it is not always in this country, we have tens of thousands of bridges in a poor state of repair—you have a bridge, people travel to and fro over that bridge, regardless of the jobs that were created when you first built the bridge. But now the bridge is there. People are going to work, they are going to shop, they are going to study to develop the human capital of the country. This type of thing has a knock on effect on economic activity. You do generate jobs when you spend money in defense. You generate more jobs, perhaps not always for engineers, because defense spending is very labor-intensive for engineers and scientists, but you generate more jobs when you spend it in the civilian sector. There is a rough negative correlation between the level of defense spending and the economy, if you look at Japan, North America, and Western Europe. The level of defense funding is inversely proportional to economic growth.

We have in this country a failing infrastructure in many ways: Transportation, water, sewer waste, education. You read the reports daily in the paper through the eighties. There is a lot of work there for people to be doing other than defense. Furthermore, we have been spending so highly on defense that there is a question of resource deployment that we cannot any longer afford to do. Let me just show you one of the things that happened, maybe we could focus on this. Federal receipts went down in the 1980s when we cut taxes and pumped a lot more money into the economy. This was at the same time we were engaging in a defense build-up, but we did not pay for it. Hence, the deficit and

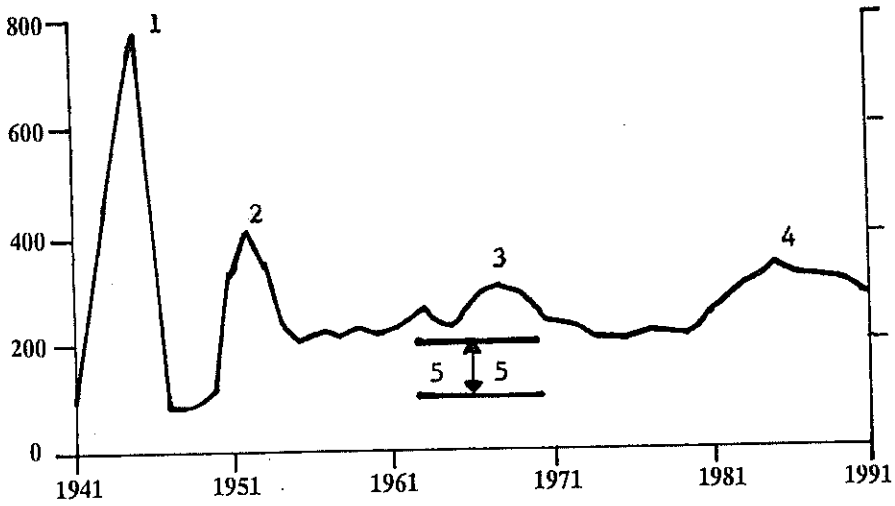
the tripling of the national debt. Already the interest payments on the national debt have gone from something like 6-7 percent of the annual federal budget to something like 15-16 percent. These figures are tough to get right because people keep moving things on or off the federal budget. For example, they are trying to get Social Security on to the federal budget because it generates a surplus and that surplus helps to reduce the deficit. However, the deficit seems intent on growing faster than the social security surplus.

Since we have other places to spend our money, like putting it into the civilian economy, rebuilding our infrastructure, and encouraging civilian industry, we would really need to have a very good reason to be spending as much as we are on defense. Let us have a look at what we are spending on defense (chart 5). This information is from Commander Ronald Fraser of the Center for Defense Information. Fraser's idea was that if you use a constant dollar analysis like this, you can see there is a peak for World War II (the just war), a peak for Korea, a sort of a bump for Vietnam, some other bumps and then another really big bump which goes higher than Vietnam, even though there was no war. The Cold War spending base looks from this analysis as though it is somewhere between $100-200 billion a year in 1990 dollars. That is roughly your spending base. So why did we engage in this increase in military expenditures during the eighties and beginning in the seventies under Carter? Where did this bump come from?

What was argued was that there was a Soviet threat. This included things like George Bush as head of CIA putting out what was called Team-B analyses of the Soviet threat in 1975 or 1976. Team-A was not good enough, that was the straightforward CIA analysis, so we went out and got the most conservative people in the country, put them on Team-B and then used their views. We were not suffering from a Soviet threat in the late 1970s: their economy was collapsing, their economic life stagnating. In 1982 for example, McNamara said that the Soviets were in a weaker position than they were 14 or 15 years earlier. Spending by the U.S. and its allies just prior to the build-up was significantly more than that of the Soviet bloc. In fact, it has always been higher, although the figures are a bit tough because it is difficult to translate numbers referring to the Soviet economy into our free market terms. The Soviet bloc had 69 divisions in 1970, but it was down to 46 by 1980. Our spending in real terms, from 1975 to 1980 went up by ten percent. We

Chart 5

DEFENSE SPENDING/BUDGET AUTHORITY, 1941-1991
(in billion 1990 dollars)



1=World War II **2=Korea** **3=Vietnam**
4=Military Dividend **5=Cold War Spending Base**

Source: Commander Ronald Fraser, Center for Defense Information

had one-third more strategic nuclear warheads than the Soviets, and we had a submarine fleet with 2,700 nuclear weapons off the coast of the Soviet Union. Every Trident submarine could hit every city in the Soviet Union with a nuclear weapon. That is in addition to everything else we had. We were not exactly in any state of great peril, and incidentally when we talk about defending this country, I point out every year in the 1980s, we spent $160-170 billion to defend countries in Europe and another $30-40 billion to defend countries in Asia, and another $20-40 billion to protect U.S. access to the Persian Gulf oil. This is not exactly defending our borders.

I would like to comment on the question of a peace dividend. Obviously, I think you have to get rid of the military dividend before you can have a peace dividend. During World War II, we had 30 percent of the GNP diverted to the military, and it dropped immediately after the war. If we get back to the curve of the graph, you see how steep the postwar drop in military expenditures is after World War II, it is pretty steep after Korea, it gets a little flatter after Vietnam, it is getting very flat now. And incidentally, Weinberger in the mid-1980s was predicting that we would be spending close to $500 billion a year on defense. One of the things that went wrong with defense during the eighties was that they engaged in far more programs than they could afford, and as they cut back, they were stretching programs. Consequently, unit costs went very high and nothing is a better example of this than the B-2 stealth bomber. It was originally designed to operate in the late stages of a holocaust, to flutter over a dead and dying world looking for any sign of life not yet extinguished. This thing is subsonic, it cannot defend itself, it is detectable, and it costs close to a billion dollars per plane. We still have no real function for it. Yet there is still an attempt to defend this weapon.

But this is the sort of thing that many engineers and scientists, particularly aeronautical engineers, physicists, electrical engineers advocate. This is how they spend their lives: Building MX missiles and B-2 weapons and so forth, and doing it at very high incomes, of course. I mean, there is a great deal of vested interest from all the people who are employed by the defense industries. Let me also say that, not only did we have a military dividend, our spending level in constant dollars went up about 50 percent in the eighties above what it was in the seventies, but certain other types of categories went up much higher than that. There was an increase of 112 percent for procurement, 95 percent for military construction, 81 percent for research and development. So a great deal of money went into exactly where the profits were, and profits got very high in the defense industry. They were roughly double what they were in private industry during the 1980s. Obviously you are tending to draw away a lot of your best talent when a lot of the highest paying jobs and the best profits are in defense. This is again, I stress, when our economic competitiveness was going downhill. So we have been paying a high price. Defense profits under Reagan went up about 30 percent at a time when commercial manufacturers profits were

declining to around 10 percent. Many of these contractors are under criminal investigation. By 1990, 25 out of the top 100 had been found guilty of defrauding the government.

We have seen a very high level of defense spending, but there are alternative ways of going about our industrial policy. One would be to have an affordable defense economy and have a spin-on economy. There is a mythical idea that defense spending generates spin-offs for industry and for the economy. There will always be some spin-offs. When you spend $100-150 billion on procurement, you are bound to get some spin-offs. It is almost impossible not to. But it is a very expensive way to get those spin-offs. There are a number of leading policy analysts, like Harvey Brooks who argued that you would be better stimulating a very strong civilian industry and getting your products from there. And maybe you would not have to spend quite so much for your spanners, computer chips, and toilet seats.

The case for economic conversion is a little tricky. This is the idea that we would convert our defense industry into civilian production. It is hard to say that it is necessarily a good policy. Different people have different arguments about it. Politically, we should encourage infrastructure development at a federal level, but mostly you can cut your defense spending. You could cut defense spending by $100 billion a year and it would help balance the budget because we now have a deficit of about $300 billion a year. Incidentally, a large chunk of the deficit is caused by interest payment on debt incurred by the increase in defense spending. So we are really in a trap that past defense spending is limiting our opportunities to spend on the civilian economy. The OMB introduced another sort of trap in the budget agreement last fall which said that any reduction in defense could not transfer into the domestic sector. There are now three separate caps: international, domestic, and military. So if you save money in the military, you cannot have a peace dividend. And that is true until 1994 or until it is revoked by Congress, which some people are thinking of doing.

We also have a great deal of activity going on in what could be called the defense of defense. The first thing is to fight to keep contracts. This is one strategy. Another is to get other federal contracts. Another is diversify, find civilian markets, convert production, or simply go out of business. There is intense lobbying by defense contractors. They have been engaging in very intense lobbying and this is perfectly natural

behavior for them. They are trying to defend what they have. The Department of Defense (DOD) has made a series of proposals to maintain their funding levels. A couple of years ago they made a proposal that they should become an economic policy body, which I think was a faux pas because it drew public attention to the fact that they already were an extremely significant player in our economic policy. Later, DOD suggested taking over environmental research. But earlier, when they were talking about becoming an economic policy body, they had suggested that environmental restrictions were hampering the economy. DOD wants to triple the SDI budget, and the SDI as you probably know is a very hard program to justify technically. Some 90 percent of scientists who have been polled, oppose the idea that it is viable at all. Another plan was for major land acquisitions out in the West. And it is worth noting that DOD is talking about base closings and troop cuts more than they are talking about procurement cuts. I would notice, however, that base closings are not necessarily a bad thing. I think it is the Office of Economic Adjustment in the Department of Defense that reckoned with 97 closed installations; the 93,000 lost civilian jobs had been replaced by more than 150,000 non-military related jobs. And 75 of these bases have industrial facilities, 42 have municipal airports, and over 100,000 students are in educational institutions that have been established there.

I would like to close by commenting that the process is not always rational, that it is not always a collective will that is represented. In the late seventies, when Reagan came into power, he had a plurality in support of a defense buildup. But I think that was generated through the media, and not a rational way. In the mid-1980s that support was gone, but the level of defense spending crept down very slowly. What is worth noting is that although there is a tremendous amount of investment that politicians have in supporting industries and jobs in their various districts, most districts pay more in taxes for defense than they receive in defense spending. Most congressional districts actually are paying more in federal taxes than they receive in federal defense spending. They pay more for defense, and have a net outflow there. And so, politically, there should be a dynamic there to try to bring these expenditures down. I believe, like William Kaufman of the Brookings Institution that the defense spending could very reasonably be brought down to around the $150-160 billion a year level. That would give us

some opportunity to get the deficit under control and also to do some alternative spending which would affect the way that engineers spend their lives in their careers and the types of things that they do.

Discussion

Peter B. Teets

I want to comment briefly on several of the items that both Richard and Sandy talked about and I guess the first thing is that I will pick on Richard's metaphor of the garden, and just say that defense spending in this country in recent years is roughly 5 percent of GNP. So this enormous cost of production, for every 20 carrots grown in that garden we are going to take one carrot and build a fence to protect ourselves. I would come back and say to you that I think that is a pretty reasonable kind of an expenditure, given the process that we go through. I also want to quickly come to this issue of the Soviet Union not being a threat. Do not kid yourselves about the Soviet Union being a threat. It is true that they are in political turmoil. It is true that their private economy has been decimated. It is also true that they have 10,000 very accurate nuclear warheads aimed at this country. Let me just pick up on something that Defense Secretary Cheney used in a speech here about 2 weeks ago. He was talking about his quandary of what he should be proposing now in light of these world events. What should he be proposing for a defense budget? The point that he tried to make was that if you go back to look at what happened in the Persian Gulf War, we used a lot of F-111 bombers, we used a lot of cruise missiles whose technology was developed 15 years ago. The lead time for technology for major weapon systems is approximately, possibly 20 years from the time that the research is initially done on a new weapon system until it is actually deployed and available for our forces. Now, given that kind of a context, secretary Cheney would then ask: Now would you like me to establish our defense budget on August 17, when Gorbachev was in full power and there were the 10,000 nuclear weapons aimed at our country, or should I do that on August 20, when the coup was effective and Gorbachev was locked up somewhere while some other nuts were in charge, or should I wait until the 25th when we think that Gorbachev

is sort of in power? So I guess the point I am trying to make is that our responsible leadership, our government, needs to wrestle through this issue of what is enough defense. We have a method, a technique set up to do exactly that. I admire President Bush for what he said. He announced last Friday evening a dramatic change in our doctrine of defense that we have used for 40 years—successfully, I might add—in deterring any kind of nuclear war. I think we ought to give our leadership in government a chance to respond, and the Congress a chance to respond, and debate what an appropriate level of defense spending should be.

Just two more points and I will give others a chance, but I want to come back on this issue that Richard talked about a little bit, with respect to profits in the defense industry. I could not get straight on 30 percent on defense and 10 percent for everybody else, but I will just cut to a bottom line and you can think about this however you like. If you look at a market valuation of defense contractor profitability, you might look at what defense industry stocks are selling for. One way to value stocks is to look at price to earnings ratios. I am sure many of you have gone through that kind of analysis. You will find the defense industry stocks listed on the New York Stock Exchange, Martin Marietta in particular, selling at about seven times projected 1991 earnings. If you look at the Standard and Poor in Industrial Average, you will find just a tad under 20 to 1 price to earning ratios. So what I am saying is our free market looks at defense stocks as about one-third of the profit potential of commercial business, and this is not something that has changed dramatically over these last few years of Reagan buildup. Defense industry stocks have typically sold at lower price to earnings ratios on a free market enterprise basis than commercial industrial enterprises. The fact is, defense industry stocks by most measures of profitability, like percentages of sales, like return to shareholders in the form of dividends, etc., have not performed as well as normal commercial companies. So I just simply say, this idea of defense contractors having high or exorbitant profits is a lot of baloney.

The last item I want to touch on quickly because I feel so strongly about it, is the business of the Strategic Defense Initiative. For 40 years in the post World War II era when the nuclear build-up was going on our side and the Soviet Union side as well, we and the Soviet Union engaged in this doctrine of mutual assured destruction. Wherein, we

both essentially agreed that neither side would have a defense against ballistic missile attack. Namely, that if anybody started a war, it would be to no avail because the retaliatory force was there to preclude the initiation of the war at all. President Reagan had the idea in mind that this mutual assured destruction, this MAD strategic doctrine was a wrong idea. So he challenged the defense industry and the scientific community in this country: "Isn't there a better way? Couldn't we have a defense against ballistic missile attack? Couldn't we do research and technology development that would give us a shield against that kind of attack." Now, again, you can debate the merit of whether or not it is possible to come up with such a system to provide defense against ballistic missile attack. But I will say in this last year we have all seen on television Patriot missiles knock SCUDS right out of the sky. That is a relatively easy problem, that is a much easier problem than a Mach 19 warhead coming in on an ICBM. That does not mean that research and technology on an advanced strategic defense initiative system will not pay big dividends. President Bush is now strongly supporting the part of the strategic defense initiative called "Global protection against limited strike" and for darn good reason.

ICBMs are proliferating around the world, so are nuclear weapons. You probably heard on the radio today, Iraq was months, certainly less than a year away from having a surface to surface missile and having a nuclear warhead capability. Qaddafi has already made the statement that if he had a nuclear weapon he would point it at NYC and shoot it. I will just say that in today's world because we had adopted the mutual assured destruction philosophy and signed an anti-ballistic missile treaty, we have no defense against ballistic missile attack in this country. There are no Patriots deployed around Boulder, Colorado, and if there were, they would be defenseless against a Mach 19 warhead coming in. I guess I will say that there are a lot of ways of viewing the Strategic Defense Initiative. I view it very, very strongly in support.

This takes me to the last point I want to make, and that has to do with this business of lobbying. Sandy mentioned these tremendous defense contractor lobbying efforts. I want to try and put this in perspective for you. I serve on our Political Action Committee Board. The employees of Martin Marietta on a per year basis contribute about $200,000 to a political action committee which we do indeed use to make contributions to political candidates. On the other hand these same 65,000

employees of Martin Marietta donate over $4 million to United Ways around the country. And I will say that with respect to the donations we make from our political action committee—we are talking about $1,000-$2,000 to a senatorial race, $500-600 dollars in a congressional race—there is only one criterion we use to make those contributions. That is, we would like to have access to the candidate. Why do we want to have access? For $500-600 you cannot possibly buy a vote in Congress. All you can hope to do is have enough access so you can put forth your point of view in the American system way of operating, namely explain to the congressman some of the aspects, be they technical or political, surrounding particular weapons systems involvement. So, with that, I will stop.

Sanford Lakoff

I guess if you sit in the middle you disagree with both sides. The last heartfelt outburst, Peter, made me think of Mr. Keating's remark about why congressmen got money from Savings and Loans companies. Unfortunately we all have to recognize that this is a lousy system and it is corrupting the political process. It is not just the political action committees (PACS), it is also the fact that when industries become such dominant economic forces in their communities, everybody, their trade unions, their representatives are loath to give them up, whether they are bad for the country or not. They just become too vital for some local constituency. If we are talking about ethics today, then we have to start thinking in broader terms. So I disagree on that.

I also disagree with him on the SDI. Let me take a few minutes to say why. It is difficult to confine myself to a few minutes having spent three or four years working on a book on the subject, but at first I want to say that we benefitted enormously in writing that book from the openness of people in industry, the laboratories, the SDI Organization. Congress functioned magnificently. In many ways this was a remarkable tribute to the American system. The tribute was that Reagan did not get away with SDI.

Peter mentioned that Reagan challenged industry to do something they had not been able to do. The truth of the matter is, as he knows,

that the Defense Department was sponsoring all sorts of research on exotic weapons of all sorts. Before SDI was announced we anticipated spending $14 billion, Reagan wanted to raise it to $26 billion. We wound up spending $18 billion in that time frame. Reagan called for a defense that would protect us against nuclear weapons to such an extent that they would become "impotent and obsolete." In other words, a total defense—and that is what knowledgeable people said was an absurd expectation. I am talking about a committee of the American Physic Society, and all sorts of reputable scientists and engineers including many in the laboratories that work on these problems.

What we have now, what President Bush is urging, is not the Reagan SDI, it is SDI 2, or 3, or 4. In other words, GPALS—Global Protection Against Limited Strikes. It might intercept, maybe 10 percent or less of the Soviet missile force. Ask yourself this question, if we put up that shield in space, is that going to be the end of it? Or are not other countries going to undercut that shield? Aren't they going to develop long range bombers to get in under the shield? Aren't they going to think about sending ships loaded with nuclear weapons into our ports? They could even smuggle nuclear weapons in bales of marijuana. So the idea that we are going to somehow defend against Qaddafi by going into space and not even thinking about the rest of the consequences is very dangerous. Senator Nunn is in favor of something else, which is a limited response based on ground-based missiles. Mr. Teets did not mention that we are defenseless by agreement. If we wanted to we could have deployed a hundred ground-based launchers because the ABM Treaty allows us to do that. The Russians did deploy them around Moscow and we can still deploy them around Colorado, or Washington, or any place else.

But let us not kid ourselves, it was not that we "agreed" to get mutual assured destruction. There was no defense against nuclear weapons, and there still is no defense against a massive assault with nuclear weapons. And the more we get involved with the arms bazaar, the more excuses we give to other countries to develop their weapons to sell them to people like Qaddafi. Surely it is time, now that the Cold War is over, to cooperate with the Russians and with our allies in really doing something about nuclear proliferation and about the sale of missile technology so that we do not have to build these defenses that really cannot defend us.

Peter B. Teets

One minor rebuttal, if I may. To get right at the SDI argument, I would say that it is true that serious study, serious analysis, serious technological development would result in a Strategic Defense Initiative that does have multilayers. You will have a layer of ground-based interceptor that Senator Nunn is in favor of, but it will have a space-based layer of defense, something that is currently being developed by Martin Marietta as a matter of fact, called "Brilliant Pebbles."

I maintain that if you just put yourself in the position of the citizens of Tel Aviv and ask yourself how much terror is created when a ballistic missile is aimed at your city and it is coming in, you know it is coming in, you can see it coming in, if you have no defense against it. Sandy's right in that, yes, in the ABM Treaty we had an opportunity to deploy 100 ground-based interceptors. One hundred ground-based interceptors could scarcely defend a Minuteman field in North Dakota, let alone our major population centers. We in this country are defenseless against ballistic missile attack and there is no reason for that to be the case.

Sanford Lakoff

One more small rebuttal. I appreciate his concern for the people of Tel Aviv, I share that concern, but I would urge him to recognize that Brilliant Pebbles will not intercept a single redesigned SCUD missile certainly not a Tomahawk or Cruise Missile that goes in below that Brilliant Pebble shield. They are dunces when it comes to that kind of defense.

Peter B. Teets

That is why you need a multi-layer shield.

Sanford Lakoff

Well, okay.

Richard Devon

I agree with Sanford's observation that offense always overwhelms defense. That is the name of the game in the Arms Race. And with the ABM Treaty in place we had managed to stabilize the arms race on the defense side. If we could develop a workable missile defense system it would be terrifying for the Soviets. It would mean that we could have a first strike and they would have been so weakened that our SDI would have been sufficient to deflect their response. And that is why the Soviets have been so worried about the SDI. And as for the future possible uses of it, I cannot see that at all. As Sanford said, there are so many ways in which you can get a nuclear device across the borders of a country. The only thing to do is to eliminate the production of them. And that would take me back to 1945 when we took the Baruch plan to the UN which said, "Let us not have any nuclear weapons in this world except for the ones that we have." And Gromyko, I believe it was, spoke for the Soviet Union and said, "Let's not anybody have any nuclear weapons," and we said,"no." The arms race began there.

I would also like to comment on the idea of technology saving lives in the Gulf War. It was very pointed: The lives they saved were American lives. Of course, there are also the lives that are taken by the weapons of war, and, in the case of Iraq, most of those lives went to the dumb weapons, the dumb bombs. One of our analysts said, before the war, with 400,000 to 500,000 Iraqis entrenched in Kuwait and nearby, that this will either be the biggest graveyard or the biggest concentration camp in history.

We do not know how many people died there. We do know they were largely the oppressed minorities, the Shiites and the Kurds, who were killed. One analysis based on past wars and the amount of tonnage dropped (which was enormous), has calculated that it was probably over 300,000 Iraqis that died. That was in the Bulletin of Atomic Scientists in May of this year. You can check the analysis and you can argue with them if you wish. So I think we should remember when we develop these weapons. If you do fight a war, what do you gain by fighting it? What did we gain by fighting Iraq and defeating it? I think it was a great military victory, but a political failure. All we did was to reinforce whimsical lines drawn by colonial powers. We did not even liberate the Kurds. We could have done that. We did not defeat

Saddam Hussein. We could have done that. We liberated Kuwait, which is a . . . I do not know . . . most Kuwaitis have not even bothered to go back. They left in their Mercedes and still sit around the coffee houses of Europe and North America. I mean, they do not practice democracy. Maybe it is nice to give them their boundaries back, but let's face it, what we like about the Middle East is not just the oil supply, which we control anyway through the seven sisters big oil corporations, but the supply of oil dollars. Kuwait, for example, earns more money from its investments and they are based in the West—in England actually—than they do from their oil. Japan and West Germany were not very interested in supporting the war, because they do not need that supply of petrol-dollars in their economies. The British and Americans were very keen about it. It was not the oil, it was the money that was the major reason for going in there. Saddam Hussein was probably going to invest in Iraq and other Arab countries, the people of which have not always benefitted from oil revenues. So the causes of war and the costs that maybe other people pay, even if we do not, are, I think, worth bearing in mind.

6

Technology, Responsibility, and Engineering

A. R. Seebass
David Skaggs

A. R. Seebass*

Engineers bear heavy responsibilities and we need to be assured that their professional ethics are beyond reproach. Yet many of us recall one engineer asking another to . . . "take off your engineering hat and put on your management hat . . . " to make a decision. The wrong decision as it turned out.

A recent poll of senior executives (*Engineering Times*) ranked engineers the highest among their professional colleagues in ethics. When asked which profession do you trust the most, engineers were picked 34 percent of the time, CPAs 24 percent, doctors 17 percent, lawyers 8 percent, dentists 7 percent, investment bankers 1 percent. Either they didn't include politicians or the results were thought to be unreportable.

*A portion of the material in this talk derives from the excellent book *Ethics in Engineering*, by Mike W. Martin and Roland Schinzinger (New York: McGraw Hill, 1989). I recommend it to all engineers.

Our accrediting board and our professional societies all have codes of ethics. But we in academe do little to educate our students about ethical issues. Our senior seminar—Management, Ethics and Leadership in the Real World—is a small beginning. It is nevertheless underenrolled and unappreciated by the academic disciplines, despite the singular credentials of its instructors, who are largely captains of small and large industry, and consequently well versed in the ethics of engineering practice.

My colleague here today, David Skaggs, and I both like to blame the Reagan-Bush years for an economic policy that has, according to *U.S. News and World Report*, (March 23, 1992) had the following consequences. Over the 12-year period 1977-1989, real income, that is, income corrected for inflation, rose 8.6 percent. But for the middle fifth in income it went down 5 percent; for the poorest it went down 10 percent. For the top 1 percent it went up 100 percent and for the top 0.2 percent it went up 700 percent. For most of this time, the Democrats were in control of Congress. Congress continues to follow the old advice of Josh Billings: "Live within your income—even if you have to borrow to do it." And they borrow our money excessively.

I would like to talk about three subjects: (1) risk versus benefit; (2) failures of leadership; and (3) the danger of vast projects based on half-vast ideas. I'll then conclude with some comments about two engineers whose ethics distinguished them in public service.

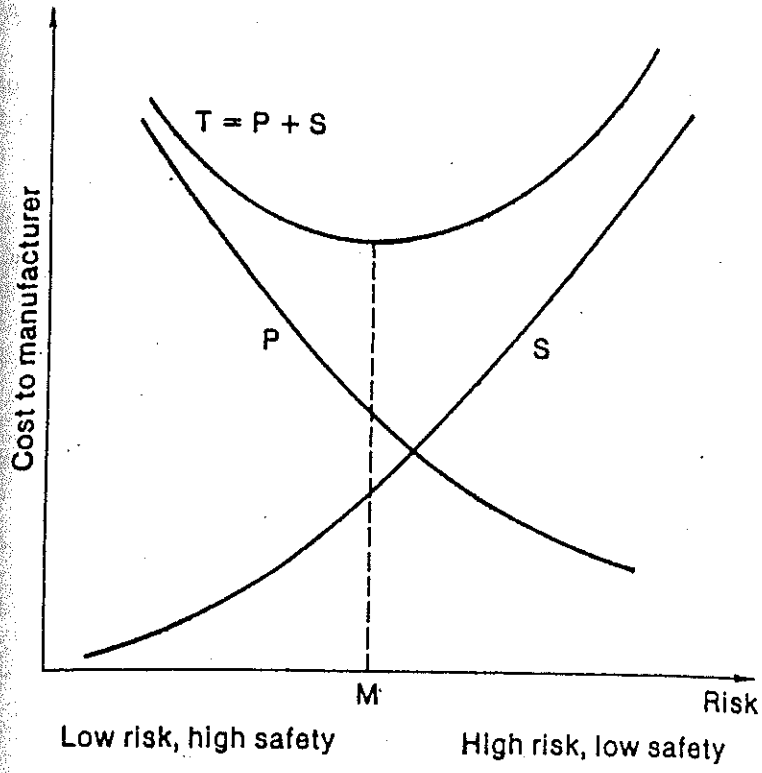
Risk/Benefit Analyses

Most of what we do entails some risk and most engineered products and processes provide a good for others at a varying risk to various individuals. Generally the direct or primary cost (P) of a product or process can be lowered at the expense of an increase in risk to those making it or using the product.

What determines the cost of the risk associated with the product or process? This is now largely determined by the indirect or secondary costs (S). The hard part is to calculate these secondary costs. This is sketched in chart 1 (from *Ethics in Engineering*).

For general aviation aircraft the secondary costs, largely liability costs, are now approximately the same as the product cost, nearly

Chart 1
RISK/BENEFIT ANALYSIS



doubling the price of this class of aircraft. But the fraction of these liability costs that are due to product failure and the fraction due to user error is widely disputed. Based on commercial airlines safety records, where we know far better the number of product failures, one has to presume that this cost is largely a user error cost that our litigious society has built into this product.

What risk we are willing to assume depends largely on whether or not that risk is voluntary or involuntary. In the main, we insist that involuntary risk be less than that of dying from disease, but if our exposure is voluntary we will frequently accept a higher risk.

Chart 2 from Starr[1] and *Ethics in Engineering* greatly underestimates the value of skiing in my view. Still, it tells an important story about our aversion to involuntary risk. This data verifies that we have a poor perception of risk. We worry about some risks inordinately, the Alar scare being one recent example.

The air bags now commonplace in automobiles were invented some 30 years ago. Their technology and costs have hardly changed in the intervening years. Slowly we, represented by our government, are beginning to benefit from them.

Business Week, in a recent cover story (April 6, 1992), noted that economists estimated that doubling the number of graduating engineers would increase the economic growth rate by 0.5 percent per year. Doubling the number of law graduates, they noted, would reduce it 0.3 percent per year. In other words, reducing the number of law graduates to 25 percent of the current level would be as beneficial as doubling the number of engineering graduates. Let's do it.

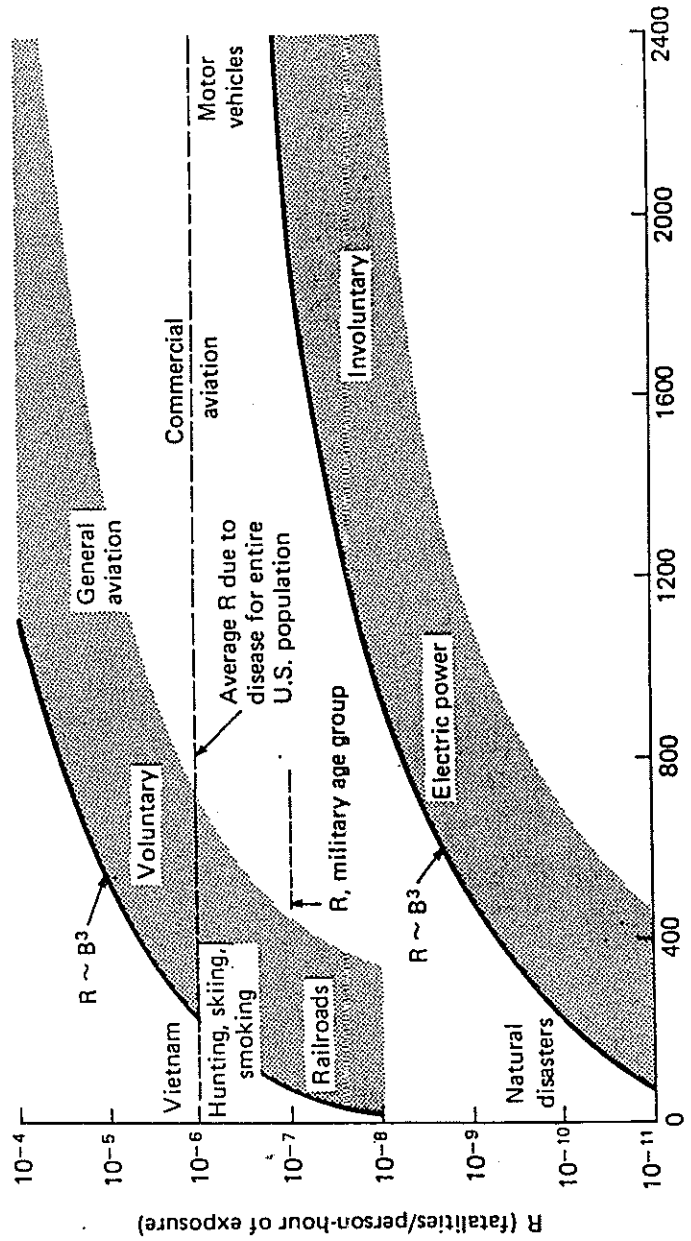
Failures of Leadership

Eighty years ago this month an invincible ship set sail from New York. So invincible was this ship that her life boat capacity was only 25 percent of the passenger and crew capacity of 3,550. Fortunately only 2,227 people were on board the night the Titanic struck an iceberg and sank. Of those, 1,522 people lost their lives while the remaining 705 were saved in the available life boats. This is clearly a failure of leadership; someone in charge decided that the Titanic was unsinkable. It is very unlikely that this was an engineer.

The process for making two frequently used pesticides involves methyl isocyanate. In concentrated gaseous form methyl isocyanate burns any moist part of the body. A complex process, exported to India without the safety procedures used in the U. S., India's insistence that the plant's operators be Indian, and Union Carbide's decision, for financial reasons, to relinquish supervision of safety to inexperienced personnel led, in December 1984 to 3,000 deaths, 10,000 disabled and

[1]Channey Starr, "Social Benefit versus Technological Risk," *Science*, September 19, 1967, pp. 1232-1238.

Chart 2
AVERAGE ANNUAL BENEFIT PER PERSON INVOLVED
(in dollars)



100,000 injured in Bohpal, India. This again was a failure at the very top to insist on safety first, finances second.

On January 27, 1986 one or our alums, Elison Onizuka, was killed when the space shuttle Challenger exploded just a little over a minute into its maiden voyage. NASA and Morton-Thiokol management ignored a unanimous vote of 14 Morton-Thiokol engineers not to launch at the low temperatures present that morning for fear of an O-ring seal failure in the solid rocket boosters. This decision, and an earlier NASA decision to have civilians on the shuttle, cost seven people, including a school teacher, their lives.

A committee on which I served had some years earlier concluded that there was a high probability that one of the first four shuttles would be lost in operations, one of many conclusions that NASA leadership ignored.

Vast Projects

We are suckers for vast projects based on half-vast ideas. The space shuttle is but one example. It was sold on the basis that it would be the only affordable way to get the necessary payloads to orbit. In addition, man was going to be needed in space for important projects. This has of course not been true. We lost our launch capability after the Challenger disaster for two years because it was argued that all payloads must go on the shuttle (to help justify it) and alternate launch capabilities were closed down. That the shuttle is many times more expensive than other launch capabilities is now obvious. But it was always clear that it would be.

The view that NASA would be better if it were bigger, and that what is good for NASA is good for the nation prevailed despite many arguments to the contrary.

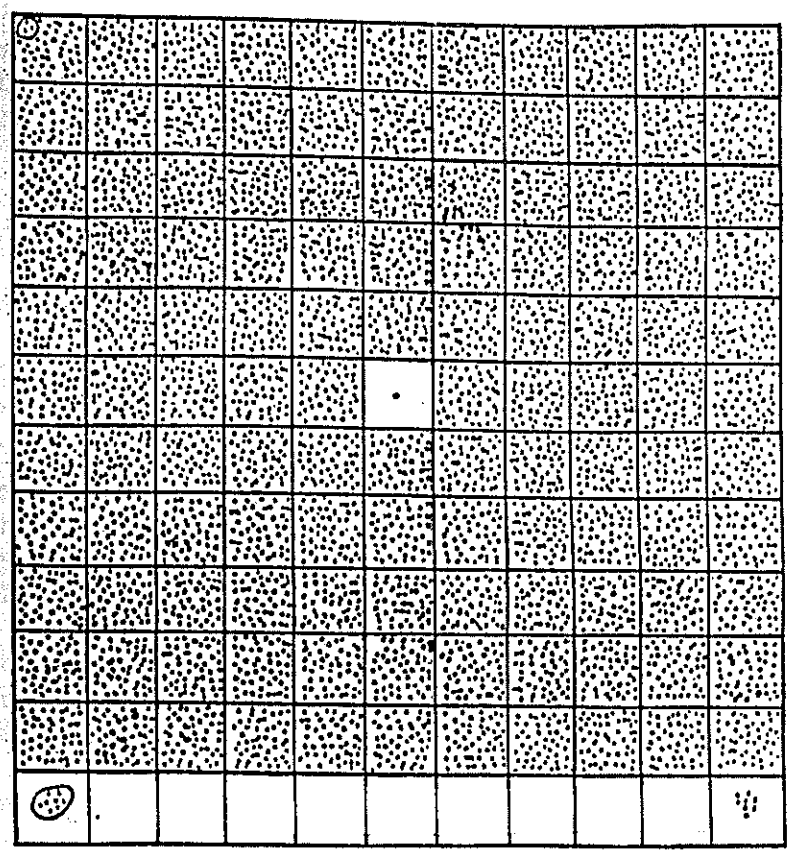
The core SDI concept, a nuclear pumped x-ray laser, and the national aerospace plane are also vast projects based on half-vast ideas.

Perhaps the worst example is the proliferation of nuclear warheads for our long standing defense policy known as mutually assured destruction or MAD.

On chart 3 the one dot in the center represents all the explosive power used in the six years of World War II. The 6,000 other dots

Chart 3

FIREPOWER TO DESTROY THE WORLD . . . PLUS[a]



[a]U.S. Senate staff have reviewed this chart and found it an accurate representation.

Source: Mike W. Martin and Roland Schinzinger, *Ethics in Engineering* (New York: McGraw Hill, 1989), p. 293.

represent the 1990 nuclear arsenal of the U. S. and the then-U.S.S.R. The circle in the upper left represents the capabilities of a single Poseidon class submarine. The United States alone has about 40 Poseidon class submarines. The newer Trident Sub's capabilities are shown in the circle in the lower left, a mere eight World War IIs on a single submarine!

NASA recently raised the specter of an asteroid impact some time in the next 1,000 to 1,000,000 years. Can an asteroid impact be as bad as the 18,000 megaton capability of our the nuclear arsenals? And if it is, the chances of that occurring are probably many times less than the chances of a nuclear war occurring.

We'd better concentrate on the real, current dangers and not be distracted by remote ones.

Distinguished Engineers in Public Service

There is a call for more engineers to participate in public service. I believe this would be very good. A recent example of a highly placed engineer, however, was John Sununu. Arrogant and brilliant they say! Arrogant, perhaps, but his engineering was never brilliant; and he certainly lacked good judgment in other matters as well.

President Jimmy Carter was essentially an engineer. His economic policies may have left something to be desired, but his foreign policy was highly principled and successful. His reputation, badly damaged at the time by the U.S. hostages taken by Iran, continues to gain luster.

The only other engineer to serve as President also had serious economic difficulties as the world entered a depression. But Herbert Hoover, the relief humanitarian, was also highly principled. In his memoirs he writes of engineering (1961):

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

He continues:

> The great liability of the engineer compared to men of other professions is that his works are out in the open where all can see them . . . He cannot bury his mistakes like the doctors. He cannot argue them into thin air . . . He cannot, like the politicians, screen his shortcomings by blaming opponents and hope that people will forget. The engineer simply cannot deny that he did it. If his works do not work he is damned.

Perhaps for this latter reason, and despite the lack of a formal education in ethics, the engineer, when separated from vast projects, remains reliable, trustworthy, and responsible.

David Skaggs

Thank you very much, Dick. I'm glad the survey you cited stopped short of rating politicians.

I have no idea how to work this into my talk, but since Dick has established a precedent for political jokes this afternoon I have to get at least one off my chest. Garrison Keeler on his show reminded us that the source of human intelligence is broccoli. That's it for me.

The topic of technology and political responsibility, believe it or not, is something I spent some time thinking about, even dating back to my undergraduate days where I was allowed for a time to shape a policy or a program of study that was more or less designed to get at the question of science and society. That was in 1962, and those kind of notions were somewhat less en vogue than I think they may be now.

When I got to Congress five years ago, I went after a seat on the science and technology committee for a number of different reasons. This university and its interests were certainly central among them, but it was also a forum in which I thought I could participate in the ongoing public debate about some of the more technical issues that face us as a country and as a planet and where I hoped I would be effective in fostering support for laboratory work across the country, both in the public sector and the private sector, and here at the university which depended on federal funding and was a key ingredient in defining our future. I've worked hard over this period of time, to make sure in

particular that we did what we could to reach into the laboratory and make sure that the activities of research that were funded with public dollars, ended being brought, whenever possible, into practical application to the benefit of society. My position now on the energy and water committee of appropriations is another venue in which to help play some role both in power and in science, cajoling the Congress into addressing this crosscut question of political responsibility and technology.

I recall an event from my brief undergraduate dalliance with a "Science and Society" major. While I was a freshman, C. P. Snow was a visiting scholar at the school I was attending at the time. I thought I might take as a text for this afternoon, or at least set up as a strawman, some observations that Snow made almost 35 years ago in the essay, "The Two Cultures." He observes there that he constantly felt that he was moving among two groups, comparable in intelligence, identical in race, not greatly different in social origin, earning about the same incomes, who had almost ceased to communicate with each other at all, whose intellectual moral and psychological climate had so little in common. People who, going the short distance from Burlington House or South Kensington to Chelsea to meet, might have crossed an ocean. In fact one had traveled much further than across an ocean because, after a few thousand Atlantic miles, one found Greenwich Village talking precisely the same language as Chelsea and both having about as much communication with MIT as if the scientists spoke nothing but Tibetan.

In the late '50s that captured a sense of how poorly we were doing in terms of Western civilization melding technology and political responsibility as one dimension of the humanities.

I want to start with one example from my own experience before getting into the topic which I hope will be useful for discussion later on. That had to do with an incident involving the Rocky Flats plant that cropped up shortly after I first took office in Congress in 1987. Many of you will recall at the time that the Department of Energy had proposed installing what was called the fluidized-bed incinerator, a device used to benignly reduce mixed radioactive toxic wastes into an ash that could be relatively safely disposed of, compared to the problems we were faced with when dealing with those wastes in more conventional ways. That proposal was made public and not surprisingly

the rafters shook with the shouts of the public surrounding the plant to the effect that the idea of burning radicactive waste in an incinerator was an intolerable proposition and was to be opposed at all costs.

Let me revive that memory for those of you for whom it is a memory, and if you weren't around in those days, let me just ask you to think about what I would set up as an instance in which a highly technological proposal became the subject of intense public policy debate, in what we hope remains a functioning democratic society. I want to come back to that in a few minutes.

I think that it is important to start with a couple of definitions. What do we mean by political responsibility? In my mind that has to do with some sense of accountability; a willingness to accept accountability by broadly construed governmental mechanisms—whether it is a legislature or a regulatory official. The same notion extends beyond the governmental players to individuals and firms in their private roles, whether as private citizens or private businesses: accountability, then for actions that have public impacts. I think also that it is important to define technology. To me it means applied science, a practical application of scientific discovery that is made usable through governmental or commercial engineering. To me, it is a complex matter, perhaps inherently elusive for the average educated person and one toward which persons, such as those referred to by Snow, may even have a certain hostility.

All of this, I acknowledge to begin with, commits the sin of oversimplification, of setting up two easy polarities of discussion. I realize the truth is a lot fuzzier, but it helps me get into the subject.

Political responsibility, separate of any overlay of technology, implies a political judgment being made. How are those judgments made, especially in a democracy, which is what is on my mind in dealing with the question of political responsibility and technology in our particular political environment.

Who makes judgments? They are made, first of all, by those engaged in technology. I will not attempt to say very much about that, because I'm not well placed to understand or observe carefully such matters. But I think it is important to identify a couple of components in that category: (1) those who are engaged in doing technology, the talent, i.e., the persons employed in it, the scientists and engineers, and (2) the source of funding, whether it be government, private business,

universities—the talent and the financial resources to put the talent to task. Political judgements about technology are also made by those affected by technological activity, i.e., the people generally, and those of us in politics who are their representatives. I'd like to play out those few different subsets of political judgment makers.

There is the private set of those who are engaged in doing technology, and the public set, those of us who are either in society generally or in a representative capacity in society. Economic models enter into our judgments, depending upon whether we fall on the private or the public side of the fence. I think those of us on the private side, both the talent and those providing the capital employing the talent, have tended to look at technology in terms of internal costs, costs internal to the enterprise. This is true whether it is academic research, commercial research, or government research. It relates to questions of funding, of raw materials, of talent, of labor—basically to all the variables that are used in free market analysis. Those of us who are on the public side of political judgments about technology, those who take political responsibility about technology, tend to apply a different economic model to the task, one that is concerned with external costs—for instance, pollution—social costs and benefits. Instead of free markets—although we don't ignore these—we consider markets that are regulated or taxed when necessary; i.e., markets in which there are efforts to intercede on behalf of something beyond those things identified throughout by internal costs.

Again, carrying out the political economics of those economic models, on the private side we have tended to be concerned primarily with short-term economic growth, with immediate economic advantage, with convenience, with security. On the public side of that paradigm, looking at things involving external costs and social costs, we are more likely to look at long-term growth issues, resource sustainability issues, intergenerational economic implications, as opposed to questions of immediate economic advantage, as opposed to ecological sustainabililty, as opposed to convenience and international security, as opposed to national security. Again, obviously the polarities are not always absolutely valid, but I want to give you a sense of what I'm trying to get at here.

I think that the evolution of our economic and political thinking over the last 20 to 30 years, pushed especially by the environmental

movement, has been to shift our tendency to analyze these questions from that private side of internal costs, from shorter-term thinking to the public side, concerned more with externalities and future implications. In that sense the dialectic that Snow set up 30 plus years ago had started to fade.

Having established that framework, how do those engaged in doing technology see their political responsibility to others? That is, how do they worry about the externalities of their work? The second complementary piece of the issue is the question: How do those of us in the rest of society see our political responsibility toward technology, i.e., our understanding of the internalities of that work and its consequences for a democratic government? I don't know much about the first of those pieces, but let me share with you a few thoughts about the second. How do the rest of us in society deal with technology and what does that mean for our country?

A functioning democracy depends upon informed and thoughtful decisions made by an informed and thoughtful electorate. It follows that if we're going to have a functioning democracy, we need the ability to deal with technological issues. We must have an electorate that is informed and thoughtful about technical matters. That sets up in my mind a further dialectic between technical or technological literacy and technological prejudice. We will need to strive toward technological literacy if we're going to have any hope for a functioning democracy to apply itself to technological issues. My fear and belief is that we are now stuck more often than not in a condition of technological prejudice. To get to literacy we need information. For a population such as ours that means information from the media as opposed to misinformation. We need a level of interest and ability within the population at large to deal with technical information. That requires education. And we need some time for reflection, on all of that which, as an ironic result of an ever-more technological world, seems to be lacking in most of our lives. We also need interest groups that are more interested in rational than in irrational outcomes and political leadership that is willing to insist on a high quality of information and interaction in order to get to politically responsible judgments of technological matters.

That kind of democratically formed judgment or value assessment about technological issues facing our society is what will ultimately inform some kind of operational ethics for us as a people. But given the

tendency we have now to rely on television and market-driven media practices more likely to play on the prejudices than to inform our people, it is particularly hard to be optimistic about a breakthrough from technological prejudice to technological literacy. I am equally cautious about what the next generation holds, given what we know about the quality of our educational system in K through 12 in the areas of mathematics and science.

On the other hand I think that we have recognized that we have a fundamental problem in this area as a society and, certainly, that recognition is the first step toward finding some kind of solution.

I spent too much time on a fairly theoretical argument and I want to go back to that example I cited for you in the very beginning, the fluidized-bed incinerator.

What happened after the public uproar over that proposal by the Department of Energy was that we were able to put together a coalition of local communities surrounding the plant which funded a panel of experts, scientists, engineers, and epidemiologists, who applied both expertise and patience to an analysis of this proposal by the Department of Energy, with the explicit direction to make that analysis accessible to the public, i.e., to the average person in this part of Colorado. What transpired over the period of some weeks and months was a proposal coming out of that expert panel for a technically sound approach for the Department of Energy to test and validate its assumptions about this troubling proposal, and also a shift in the public's attitude toward the proposal from a more irrational to a more rational approach, as we were able to take some of the volatility out of the public debate. It was an interesting example of what can happen when people of good will choose to apply their intelligence to become more technologically literate, and to do it in a way that is available to the public generally through a decent effort by the media to make difficult information understandable, and then use the application of the best spirit of our democracy to try to work its way through to a reasoned technological, politically responsible judgment.

The challenges in areas of very heavy technological involvement that loom ahead of us as a people, as a functioning democracy, are really pretty daunting. Whether it is SDI or whether we are going to spend billions more there of our scarce resources, requires people in public office to be able to make very complicated, technologically and

politically responsible judgments, and to be able to translate that to constituencies so that they understand how their government is operating. This is true whether we are talking about world population explosion and its long-term consequences for the planet, or how we get a democratic society to put aside its technological prejudices and embrace some kind of technological literacy so that we can have democracy that can make meaningful decisions about world population growth, or energy policy, genetic engineering, or whatever. It is startling for someone in public office to see how many of the absolutely central issues facing us as a people and as a planet, come back to a component of technological significance. We are simply going to have to do better at translating to our people and strive to have a people that can understand and engage in meaningful dialogue with elected officials and go through the mechanics of a democratic decision making that will enable us as a democracy to hold true to our ideals of a public shaping of public policy.

I believe that there is a much greater need of cross-cultural sensibility than C. P. Snow suggested over 30 years ago; that science and the humanities are talking to each other more and understanding each other better and that they ultimately see the imperative of technologically sophisticated politics and politically sophisticated technology. We remain a long way, however, from the level of technological literacy that should make us comfortable that our democracy can function well in dealing with those very momentous issues that are just on the horizon. However, as Snow himself observed in the same essay I started out with, there was only one way out of all of this—it is, of course, rethinking our education. I hope we can make some progress on that this afternoon.

7

The Trial of Dr. Oppenheimer Revisited

Sanford Lakoff

I want to take this opportunity to revisit an episode that happened almost four decades ago. I'm going to do it by taking advantage of much that has been written about this case, not just my own work, and I've also taken the opportunity of this invitation to delve into four reels of tape in our library which are the FBI files on this case, which may be in your library as well. I can't really say that they are as fascinating as they are depressing reading—for reasons that I'll get into. Maybe we can take advantage of the benefit of hindsight and greater wisdom which is supposed to come with maturity. This is certainly a case where the meaning of ethical responsibility in science and technology was very much in question. It concerned not just one individual, but the general definition of the roles and responsibilities not just scientists, but of experts more broadly in a country which is highly dependent on experts, but also professes to be a liberal democracy.

What I'm going to do first is look at how the whole affair unrolled. Then say something about how I approached it when I wrote about it. Then I will get into the subject of Oppenheimer as a person, a teacher, a catalyst for the new physics, his role as the director of the Los Alamos Lab, the controversy that developed in the lab over the decision to drop

the bomb, how he emerged as a spokesman and promoter of international control of nuclear weapons, and then the whole business of loyalty and security in the cold war. And why the AEC, the Atomic Energy Commission, reopened the case, then the episode involving a man named Haakon Chevalier, and the question of Oppenheimer's character. Haakon Chevalier was someone who was implicated by Oppenheimer in a possible approach that might have involved espionage, but never really did. We'll take note of the fact that there was some real espionage going on and the FBI never got near those guys. Then we'll look at the controversy over the crash program to develop the "super," the thermonuclear weapon, and what that reveals about the role of morality in the difference of strategy. Then we'll look at what happened afterward, and finally I'll try to draw some lessons.

At the time it all happened J. Robert Oppenheimer was a famous and a highly regarded figure. He had been the director of the Los Alamos Lab which had been created as the nerve center of the Manhattan Project. By the way, the Manhattan Project got its name simply because the whole effort to develop the bomb started in a little office in Manhattan, New York, and for security reasons they gave it a really bland name and called it the Manhattan Engineering District and from then on the whole thing was known as the Manhattan Project. It was at Los Alamos where the bomb was designed and tested. Oppenheimer was appointed director and as we all know it was a highly successful project.

The war ended after two atomic bombs were dropped on Hiroshima and Nagasaki. The scientists and engineers who took part in this project felt they had achieved something really important, but almost as soon as the war ended, remorse began to set in among them. Oppenheimer, at the time, said something rather shaking about it. He said, "In some sense which no vulgarity, no humor, no overstatement can quite extinguish, the physicists have known sin and this is a knowledge they cannot lose." Remorse became coupled with a pragmatic fear that nuclear weapons would threaten the fate of the earth. There was also a terrible feeling on the part of those who understood the awesome power of this weapon, that politicians, the military, and people were treating the bomb in general as just another weapon, just a bigger bomb.

As far as the public was concerned the major feeling was not of one of remorse or of foreboding, but of relief that the war had ended without bringing the casualties that an invasion of the Japanese home islands

was certain to bring. Further, there was a heightened sense of security because the United States enjoyed a monopoly of this new weapon.

As the director of Los Alamos, Oppenheimer personally was showered with praise. The man who was in charge of the entire project was Brigadier General Leslie R. Groves of the Army Corp of Engineers and at Groves' initiative Oppenheimer was awarded the highest decoration the War Department could confer—the Medal for Merit. The citation praised him for exceptionally meritorious conduct in performance for the War Department, involving "great responsibility and scientific distinction."

Not only that, but because of access to positions of power that his new celebrity opened to him, Oppenheimer became a leading spokesman for what came to be called the Atomic Scientist Movement. The movement's aim was to educate people to the new realities the bomb had created. Einstein made a famous observation about these new realities: "The atomic bomb has changed everything about international relations except our way of thinking about it." One rallying cry of the movement was international control of nuclear weapons.

After the war, Congress passed the Atomic Energy Act which created a new agency called the Atomic Energy Commission, and to allow congressional oversight they set up a very special committee known as the Joint Committee on Atomic Energy. Creating a joint committee was a very unusual thing for Congress to do, but was done partly to keep better security. The first director appointed by President Truman was a man named David Lilienthal who had run the Tennessee Valley Authority. Lilienthal immediately sought out Oppenheimer. He and Oppenheimer worked to shape American foreign policy with respect to the bomb. The scientists knew and warned the government that it was only a matter of a few years before the Russians were likely to have a bomb of their own. They had a hard time explaining that once you knew that a bomb could be done and you have the physicist, and access to uranium then it was no secret any more. It was just a matter of figuring out how to do it and getting it done.

What Lilienthal and Oppenheimer agreed was that it was a good time to take advantage of the fact that we had a monopoly to get some kind of international control. They really didn't have a clear idea of how you could separate the dangerous activities of atomic energy and the ones that were not, however, but they thought that should be possible.

They developed a proposal which Oppenheimer wrote, and which became known as the Achenson-Lilienthal report (Achenson was the Secretary of State) and which was presented at the United Nations by Bernard Baruch, who was our ambassador.

You can see from that, Oppenheimer had emerged from the world of the laboratory and was getting into the world of politics and policy making. He also did other things such as making radio broadcasts here and in Europe. He was part of a group of scientists including Leo Szilard who had been instrumental in persuading that government to take this step in the first place.

But in 1954 the news broke that a few months earlier, in December 1953, President Eisenhower had ordered the AEC to erect a "blank wall" between Dr. Oppenheimer and classified information. His security clearance, which was a top-secret clearance (acute clearance, it was called), was suspended and it was to be reviewed in the light of the new executive order that Eisenhower had issued shortly after taking office. This order changed the whole character of the clearance process by making it unnecessary to prove any positive acts of disloyalty or threats to national security. All the agency had to conclude was that someone's employment was "inconsistent with national security." Given that there was this new criterion the AEC could review anybody's old clearance.

The news that a blank wall was to be put between Oppenheimer and security inspired at least one cartoonist, Herblock of the *Washington Post*, to come out with a famous cartoon which showed Oppenheimer trying to put his mind behind a blank wall. Of course he had all the so called secrets of atomic energy in his head, and the whole idea struck people as ridiculous that you would try to put a blank wall between him and security.

The timing seemed very odd. Oppenheimer long ago resigned as director of Los Alamos. He had become director of the Princeton Institute for Advanced Study which is not an institution that does classified research. He was still a consultant to the AEC, and critics of the decision said that if the AEC didn't want his advice it could simply have stopped consulting him. Why was it necessary to withdraw his clearance and subject him to public humiliation?

We learned right away that the reason Eisenhower had acted was that a man named William Liscom Borden, who had been staff director for

the Congressional Joint Committee on Atomic Energy wrote a letter tc the FBI director J. Edgar Hoover in which he charged (a) that Oppenheimer was disloyal, (b) that he was a security risk, and (c) that he was "more probably than not an agent of the Soviet Union." This was a strange letter to send to the FBI because the basis of the first and second charge was all contained in the FBI files that Hoover had been compiling and recycling for years. What was new in the letter was the charge that in addition to the old stories about having had friends who were political leftists, in more recent times he had shown a pattern of behavior that seemed, to Mr. Borden, to indicate that he was disloyal and even an agent of the Soviet Union.

What was the pattern? Well first, he had been promoting international control of atomic energy. Second, he among others on the general advisory committee to the AEC, had objected to the crash program to develop the thermonuclear bomb. In addition Borden said, "He seemed to be opposed to all sorts of things that had to do with developing atomic energy and there were rumors that he had to persuade some of the students and friends not to take part in war research." One other charge was that he had opposed nuclear powered aircraft, which was rather sensible because the shielding necessary to put up a nuclear reactor to power an aircraft was so great that couldn't get the aircraft off the ground, and they were spending good money on this project.

But when you pile up all these things, it seems as though there is this pattern. Now was Borden operating on his own? Well, perhaps but it was also true his views reflected the views of other people—especially people in the Air Force who had it in for Oppenheimer and other scientists like him. Also, some of the members, including the chairman of the Joint Committee on Atomic Energy, were hostile to him. And then there was Edward Teller, who was emerging as the great rival and opponent of Oppenheimer. They had been collaborators on the wartime project and now they were falling out.

FBI director J. Edgar Hoover needed no convincing that Oppenheimer was a bad egg, and he wasted no time forwarding the letter to the Atomic Energy Commission. As it happened, the new director of the Atomic Energy Commission, Admiral Lewis Strauss, was appointed by Eisenhower and he had no great political sympathy with Oppenheimer and people like his predecessor David Lilienthal who was a New Dealer so he sent it on to the White House. The Atomic Energy Com-

mission could have ignored the charges. They were primarily based on pre-war behavior, but why didn't they?

There are several reasons why they did not ignore the charges. (1) The air was rife with concern with subversion and people in the administration were not anxious to be accused of coddling communists. (2) The Soviet Union had finally exploded a nuclear bomb much earlier in 1949, much sooner than most of the politicians predicted, and that frightened people into thinking there was a real need to go further beyond the atomic bomb. (3) The Truman Administration had been embarrassed by the case of Alger Hiss. He was a high official in the State Department, and had been accused of spying and convicted of perjury. As you may have read recently, he feels forty years later that he has been vindicated because a Soviet general had searched the files and found no evidence that he was a spy, but that story is not yet by any means complete. (4) The defection of a Soviet code clerk in Ottawa had revealed a real atomic espionage ring involving a refugee German scientist named Klaus Fuchs, who had been cleared by the British and had been working at Los Alamos. (5) Last but not least Senator Joseph R. McCarthy of Wisconsin was on a rampage aimed at supposedly rooting out alleged communists in government. The Eisenhower Administration had good reason to fear that if no action was taken on Oppenheimer the Borden letter would find its way to McCarthy and he would have a field day with it.

Underlying these particular reasons was an important historical development. The making of the bomb had politicized science and scientists as never before in history. There were some isolated cases involving Galileo and the Doge of Venice and so on, but up until then science and scientists were regarded as politically neutral. And they studiously made an effort to stay out of politics. That was no longer the case. You can see in the opposition between Teller and Oppenheimer not just disagreement about a particular set of weapons, but a disagreement about strategy—a disagreement about policy. The fact is that Oppenheimer had become identified with the Democrats, who were now out of office and the Republicans saw no reason to protect him or his friends. On the contrary they didn't want to be saddled with any risk that they could be accused of harboring subversives. Besides, Oppenheimer as a scientist did not come from a segment of American society that had political clout. The scientists really had no political

clout. If you went after a military man or a minister the governmer would have to be more careful, but scientists were particularl vulnerable and weak.

Now the procedures of the AEC required that consultants were to b notified that their clearance was to be withdrawn and given the chanc to request a hearing. Oppenheimer decided to resign, but to request hearing. He had the hearing and when it was all over the personn security voted two to one to remove his classification. That recommer dation was sustained by the AEC with a vote of four to one. Interes ingly the only dissenting vote was cast by the one scientist on th commission.

The hearing itself was held in secret. Afterward, some of it wa leaked to the press, probably by one of Oppenheimer's lawyers. Th commission decided in 1954 to release the transcripts. It was called, *I the Matter of J. Robert Oppenheimer*. Eventually a playwright used i as a basis of a courtroom drama with exactly that title, *In the Matter c J. Robert Oppenheimer*.

As you can imagine, at that time the press was full of commentary o it and at that time I was a graduate student taking a graduate seminar i public administration at Harvard, and I needed a term paper topic. Th course used the case method. We would look at interesting cases o people, especially professionals, who were in the civil service who go into trouble because they were using professional standards versus civi service which was tied in with special interest groups and the chains o command. You may know the case of Gifford Pinchot who wa appointed by Teddy Roosevelt, and got into trouble with the Interio Secretary. Since we were looking at things like that I thought that th Oppenheimer case would be another instance of this sort, but as I go into it I came to feel, as that playwright did later, that there was a set o issues involved in this that went beyond the public administration text book approach. During the hearings, for example, one of the witnesse called to testify was the physicist I. I. Rabi and he said in his testimon in a security hearing, "This is what novels are about. There is a dramatic moment in the history of the man, what made him act, what h did, and what sort of person he was? That's what you are really doin here. You are writing a man's life."

So I decided to call the term paper "The Trial of J. Rober Oppenheimer," and to write it as a reflective essay on the significanc

of what happened. I took an extension to finish it, handed it in during the next semester with some trepidation because I knew it wasn't an ordinary term paper, and it could have been rejected as inappropriate. The professor turned out to be generous. He called me in and said that he not only liked the paper, but he urged me to submit it in the Bowdoin Prize Competition that Harvard holds every year. I took his advice. I was indeed awarded the prize in the social sciences, and because no prize was awarded that year in the natural sciences the stipend was doubled by vote of the faculty. I was told that it was the only the second time in Harvard history it had happened. Naturally I was overwhelmed and not only that I was temporarily rich. Eight hundred bucks is not a lot of money now, but can you imagine what it was for a graduate student, a poor graduate student in 1955? The book publishers descended upon me and said, "Make it into a book." Well, I tried over the summer and I discovered I had said every last thing I knew about the Oppenheimer case or about science and government or anything in that essay.

Some time later, after I got my doctorate and was appointed to my first teaching job at Harvard, I decided to pursue these questions further, and teamed up with another new instructor to open a new course called, "Science, Technology and Politics." We think it was the first of many undergraduate courses that were taught on the subject.

A couple of years later we put our lectures together and published a book called *Science and the Nation*; which was used as a textbook for a lot of college courses. That book carries an introduction by James R. Killian, who was then the president of MIT. A few years later I edited another book called *Knowledge and Power* which includes the Oppenheimer essay and a number of other studies that were being done around Cambridge at that time.

Now I'm just going to comment briefly on my approach. I decided to call the paper "The Trial of J. Robert Oppenheimer" even though, technically it was a security hearing, and not a trial. One reason is that it had the trappings and the feel of a trial as many commentators noted. For example, Admiral Strauss, the AEC chairman, decided not to use one of the AEC's own attorneys, but to find an outsider. He told director Hoover that he didn't trust the lawyers in the commission because they were holdovers from the Truman administration. The man he picked was a very talented trial lawyer, and just as important, an outspoken political conservative named Roger Robb. Robb chose to

behave not just as a committee council, but as a prosecuting attorney. He went after both Oppenheimer and the witness called on his behalf. He tried to show, using courtroom techniques, that the friendly witnesses to Oppenheimer were contradicting themselves.

Let me give you an example of his style of interrogation. One of the people he interrogated was the distinguished physicist Hans Bethe, who became a colleague of Dean Seebass's at Cornell. When he got him on the stand it was as if he was playing Perry Mason. He asked, "What division at Los Alamos, Dr. Bethe, was Klaus Fuchs in?" (Fuchs had just been found to have been a spy.) "He was in my division. The theoretical division." Bethe answered. "That is all." Robb said triumphantly, leaving the impression that Bethe was an unreliable witness because he associated with a known spy.

Oppenheimer was represented by a defense team who were well known as civil liberties lawyers, but were not as good as trial lawyers. To make matters worse, the hearing wasn't run under the rules of evidence that would have prevailed in a normal trial. In a trial, both sets of lawyers have to be given access to whatever evidence is going to be introduced. That consideration often makes it hard for the government to prosecute cases involving national security, as in the recent Oliver North trial. In the Oppenheimer case, the committee counsel, Robb, was given security clearance so that he could look at any of the FBI and AEC files he wanted to, but Oppenheimer's counsel was denied that clearance. Therefore, they couldn't consult the same body of evidence. Not only that, the witnesses couldn't consult their own files. One of the witnesses called was the former director of the AEC, David Lilienthal. Robb would ask Lilienthal about things that happened ten years earlier. Lilienthal had to rely on his memory. So, inevitably since Robb had the files in front of him, he was able to trip him up and make him seem an unreliable witness. I was struck that it had the trappings of a trial. Not just that, but it struck me as something in the nature of a "great trial." Not just an ordinary trial. A great trial is one in which it isn't just the defendant who's on trial, but society's assumptions of innocence.

Two journalists, Joseph and Stewart Alison, wrote an article in 1954 in Harper's magazine which was headlined "We Accuse," which was a take off on the pamphlet that Emil Zola, the novelist, put out during the Dreyfus trial in France in the 1890s. They were comparing it to that kind of a trial. A historian of science compared it to the trial of Galileo.

In both cases he argued that a scientist was being persecuted for speaking his mind. I, too, had the thought that this really was unusual and might be compared with great trials in American history like the Scopes Trial, but it put me in mind of nothing so much as the first of the great trials, namely the trial of Socrates. I said in the essay that as that trial had been the role of the philosopher in the city in the *polis*, so this trial had been the trial of a scientist in liberal democracy. Socrates with his independence of mind seemed threatening to a polis when it felt menaced by internal and external enemies. Oppenheimer with his scientist's mind, by its nature iconoclastic, irreverent, and so on, also seemed threatening to our society when it felt threatened by communists abroad and at home. There were other things too. Socrates was accused of impiety and teaching young people to be disloyal to the democratic constitution. He was found guilty among other things on the basis of guilt by association because some of his pupils took part in the oligarchical coup known as the tyranny of the thirty. Similar charges were raised against Oppenheimer for keeping people from working on weapons projects.

I want to emphasize that Oppenheimer was accused of being disloyal—even a Soviet spy—because, among other things, he endorsed the proposal, as I mentioned earlier, put forward by the Truman administration, at the U.N. for international control of dangerous atomic energy. J. Edgar Hoover wrote a letter saying, "It appears that the best way of establishing his loyalty is to determine Oppenheimer's present views concerning the international control of atomic energy." The clear implication was that in Hoover's mind anybody who supported any proposal for international control of atomic energy was disloyal. So it wasn't just Oppenheimer, it was Truman, it was Acheson, it was anybody associated with that policy.

Both of these people, Socrates and Oppenheimer, sought vindication even at great cost to themselves. Socrates could have avoided the penalty of death by drinking hemlock if he had agreed to let his friends pay a small fine. Oppenheimer could have avoided public disgrace by simply giving up his security clearance. There is another curious similarity. Socrates began his defense in the apology by noting that the stratagem of his accusers that most amazed him was their warning to the jurors to be on guard and not allow themselves to be deceived by his eloquence. Sure enough, Oppenheimer's accusers painted the same

portrait. He was a Svengali they said, who could charm or hypnotize anybody. "Dr. Oppenheimer," one scientist said, "was certainly one of the most persuasive men that ever lived." "You know he's one of the most amazing people that this country has ever produced in his ability to influence people." "It's just astounding, the influence he has upon a group." "It's an amazing thing." These are just some of the quotations. There were many more like that.

What did Socrates do in response to that stratagem? Well, he came up with his celebrated "profession of ignorance." He said the only thing that makes me different from other people is I know how little I know. Oppenheimer—curiously for someone who is supposed to be brilliant at clarifying ideas—seems to crave the prosecutor's every trap. In the Chevalier episode, Robb went after him, and suggested that he told "a tissue of lies" to the security officers. Oppenheimer didn't say, as Bill Clinton might have, no it's not a tissue of lies, it was just a little misunderstanding here and there. Instead Oppenheimer said, "Yeah, it was a cock and bull story." That of course grabbed everyone's attention. Here's the guy admitting that he told a tissue of lies, invented a cock and bull story. So that blew that whole business out of proportion.

Someone, I said in the essay, had to suggest that Oppenheimer was seducing the young, and someone in fact did say that. The charge was that he poisoned the mind of young physicists so they wouldn't work on atomic weapons.

I was also struck by the differences. Socrates, as a philosopher, was concerned not just with truth, but with goodness or justice. Oppenheimer, as a scientist, was supposed to be concerned only with scientific truth, not with morality, but he was accused of injecting his subjective moral judgements into his scientific advice, as indeed he did in the case of the super. One of the things I found in Oppenheimer's own speeches, which was interesting, was that he himself was a bit conscious of that. Notice what he said: "The study of physics does not make philosopher kings, it hasn't until now made kings, it almost never makes fit philosophers. If the professional pursuit of science makes good scientists, if it makes men with a certain serenity in their lives who yield perhaps a little more slowly than others to the natural corruptions of their time, it's doing a great deal, and all we may rightly ask of it. For if Plato believed that in the study of geometry a man might prepare himself for wisdom and responsibility in the world of man, it was precisely because he

thought so hopefully that the understanding of man could be patterned after the understanding of geometry. If we believe that today it's in a much more recondite sense and a much more cautious one." In other words here he was a scientist and yet he did feel some compulsion to be responsible. He did worry about the morality of what he was doing, but unlike Plato or Socrates for whom knowledge and virtue come together for a scientist it is difficult to bring them together. That struck me as a fascinating difference between this instance and the earlier one.

And then the other thing of course is Athenian democracy was small. Aristotle said that it had to be small so that people would know one another's characters. You couldn't have too big a democracy. What do we have now? It's a large bureaucratic society and as a result you have these rules that are laid down by security officers, and people are sort of like Procrustes fitted into those rules. It struck me as very ironic that Oppenheimer was accused of a breach of security because he didn't want to cause trouble for this friend of his, Haakon Chevalier, because he said, "I know this guy's character and he isn't involved in anything like espionage."

One of the AEC commissioners said, in effect, "Look, this fellow is a scientist but not an expert in the field of morality." And it struck me, what the heck is it to be an expert in the field of morality? In short, I began to wonder what exactly is the role of a scientific advisor when he is asked about decisions that clearly involve major moral questions.

I also felt the effort to intrude into personal life in the name of security was troubling. The FBI files that we now have access to are full of transcripts of telephone conversations between Oppenheimer and his wife about absolutely nothing, but their love for each other, and what their kids are doing, and things like that, but not a thing that has to do with security. The weird thing is that they knew that their phones were tapped. For example, at one time Kitty Oppenheimer say to him, "Well I think the FBI hung up." There was one episode that's reported in the file where Oppenheimer got so exasperated with this gumshoe following him that he turned to him and said, "Why are you following me? Do you think that I'm a subversive?" and the guy said, "Well, that's my job. I'm trying to find out if you are." So Oppenheimer said, "Come with me." And he supposedly took him into the house, got out a piece of paper and wrote, "This certifies that I am member in good standing in the Communist Party. Signed J. Robert Oppenheimer." He said, "Here

take it. You want it? It's yours." The FBI actually made a search of the files to see if they could find that piece of paper. They never did. I think that the story is apocryphal, but it floated around as an example of what was going on.

One other thing that I will mention, that I came to feel in my essay relates to the ambivalence that Oppenheimer felt. It seemed to me that there was a real struggle in his mind over what it meant to be committed to science as a vocation, as a calling. The question really boils down to whether science is just a commitment to solving one challenge after another or whether you are supposed to exercise your own judgement. Are there times when you want to limit what you do as a scientist because you fear the possible consequences of the work? Those questions didn't have to be asked at the time Oppenheimer went to work on the bomb because everybody was afraid about the German scientists were going to make the bomb first, and they all knew that Hitlerism represented evil. But afterwards when Hitlerism had been defeated and the arms race began to seem threatening, it seemed to Oppenheimer and many like him that maybe it was time to limit the pursuit of knowledge.

Finally, at the end of my essay, the man who was at the center of it all became more a symbol than a person. Since then there have been biographies and other accounts that have shed more light on him as a human being. Oppenheimer was six feet tall, weighed 130, he was a chain smoker, and he died of some sort of lung problem plus cancer of the throat. He lived on Martinis and very spicy food. In general he was a fascinating figure. I mean by that that he set a standard for his students. They all became emaciated, put a pipe in their mouths, and poked around with the chalk just the way Oppenheimer did. From childhood on he was a prodigy. He went to Harvard as a sophomore. He didn't bother with freshman year. He took ten courses a term, and it got so exciting for him that when he went to graduate school at Cambridge University in England, he almost had a nervous breakdown. Why? Because he encountered quantum physics, and that was a bit much even for a prodigy like Oppenheimer.

Finally in 1926 he went to the new mecca for physicist, the University of Göettingen. There he became a favorite of Max Born, and he was considered one of the young geniuses. He wrote 16 papers. He came home to take up a joint appointment at Berkeley and Caltech. Some physicists have said that his papers were better at criticizing the

works of others than at advancing their own ideas, but at least one thinks he might have won the Nobel Prize had he lived long enough to see his ideas about distant astrophysical phenomena, such as black holes, vindicated by observation. Clearly he was one of the new generation of physicists who experienced the rise of what was called the new physics, and he was one of the Americans who brought the new physics home to America. The pages of the *Physical Review*, for example, swelled two and a half times over the decade of the 1930s alone. One historian notes that by 1932 the U. S. was already one of the most capable and vigorous branches of the physics community and of course it became even more so.

His friends called him either "Opje"—a Dutch diminutive of little Oppenheimer—or Oppie, and he is often contrasted with another famous, but experimental physicist, Ernest Lawrence of Berkeley, the developer of the cyclotron. They were friends and co-workers, but they fell apart when controversy developed over the super. Oppenheimer was more of a mystical and intellectual figure, more complex than Lawrence. Lawrence was your straightforward middle American. Oppenheimer even studied Sanskrit with a Berkeley colleague in order to read the Indian classics in the original. When the test bomb went off he recalled a line from Bhagavad Gita in which the God Sheva says, "I am become death. The shatterer of worlds." He called the test shot Trinity after a poem of John Donne's.

It is also interesting to note that to Lawrence's great credit, the FBI files revealed that when he was questioned about Oppenheimer's loyalty he did not get into his disagreements with him over policy, but on the contrary, he said Oppenheimer was a grand person in every way. And as to his early involvement with leftist causes, Lawrence said, "Oppenheimer told me that having had the rash, he was now immune."

Oppenheimer was an exceptionally gifted and inspiring teacher. During the fall and winter he taught at Berkeley, then in the Spring he moved south to Caltech. When he moved, his favorite students used to pile into the Chrysler with him, and when he got to Caltech everyone would say, "Here comes the mother hen with her chicks." He had many many virtues as teacher and a person—a very inspiring figure.

He also had the vice that all geniuses have, which was that he was arrogant, and didn't suffer fools. That's one of the reasons that he got in trouble with Admiral Strauss. At a public meeting, Strauss said something about the dangers of exporting radicactive isotopes, and Oppenheimer said, "Oh no, this man doesn't understand. These isotopes are just useful for medical research." He embarrassed Strauss in public and that did not help Oppenheimer.

In his statement to the hearing board, Oppenheimer said that he was so absorbed in physics that he had little notion of what was going on in the world. He had no phone up until about the mid-1930s, no newspapers, no magazines, and that goes along with the popular stereotype that scientists are people with their heads in the clouds. There is a certain truth in this. I have a friend whom you all have heard about in La Jolla called Francis Crick, the discoverer of DNA. He always says that he does not read newspapers or watch television. When I asked him why, he said, "because what really concerns me is what's happening in biology and besides if anything important happens, people like you will sooner or later tell me about it."

Oppenheimer went through a change in the mid-1930s. The Depression convinced him that something was wrong with the capitalist system, and then the rise of fascism in Europe confirmed the judgement, popular among intellectuals, that the choice was among fascism, socialism, and communism. As a result he got very caught up in left-wing political causes. He read Marx's *Das Kapital* and all of the works of Lenin. He attended all the political meetings and rallies, and although he never accepted any political dogma uncritically, there's no question that he was sympathetic to left-wing causes. He made substantial contributions in aid of the Spanish loyalist cause in the Spanish Civil War, and those contributions went through the Communist Party in San Francisco, which happened to be a focal point for a lot of efforts of that sort. And when one newspaper, *The People's World*, came out, they got Oppenheimer to subscribe to it. You can imagine how much attention that got in the FBI files.

Was he ever a dues-paying, card-carrying member of the Communist Party? He said emphatically not. The FBI found one or two people that said he was or might have been, but it was Communist Party policy that if somebody went to work for the government, he dropped out of explicit membership. At one point the effort was made to prove that a Communist Party meeting was held in his home. That was flat out contradicted because Oppenheimer was out of town and he could not have taken part in it.

On the other hand he was close to many people who were Communists. His brother was an admitted party member. His wife had been married to a Communist member, as had his first fiancee. All of that made him very vulnerable on the security question when he took the job at Los Alamos. But you must remember that the Soviet Union was our wartime ally at this point.

Nevertheless General Groves was made fully aware of all this stuff, and he said never mind that; we need him for the war effort, and these things were things he did before, and there is no reason to bar him on that ground.

As director of the laboratory, Oppenheimer was very careful to protect security. Certainly the greatest contribution he made to security was to bring that project to fruition. He was very good at recruiting people and dealing with their frustrations. From its opening in March 1943 Los Alamos absorbed physicists like a sponge. By spring 1945 more than 2,000 technical specialists worked there, including 600 army enlisted men. Many were young; the median age was 27. He ran a tight ship when it came to security. Neils Bohr, a Danish physicist, traveled under the pseudonym Nicholas Baker. The security people insisted on what was called compartmentalization. It was adopted so that nobody knew all that was going on.

To cope with the isolation, with the security restrictions, and with each other, there were occasional pranksters like Richard Feynman, who would enjoy picking the locks of secured safes and putting notes in saying, "Guess who." No wonder General Groves complained, "Here we have assembled the greatest bunch of prima donnas in one place." But you have to bear in mind what these characters accomplished. The Germans gave up on the atomic bomb project because they made some dumb calculations and because the officials were convinced that it couldn't be done in time to affect the war effort. The Japanese came to the same conclusion, except for one determined experimenter, who doggedly persisted with a project using thermal diffusion to produce fissionable uranium, an approach that was used successfully in the U.S. Why did the American effort succeed? Partly because the government put resources behind it, but also because the scientists worked brilliantly and very successfully to do it.

Before the first test shot, on July, 16 1945 at Alamogordo as the war was coming to an end, doubt surfaced about the wisdom of using the

bomb against Japan. The scientists, who by that time didn't have much to do at the Chicago Metallurgic Laboratories, passed a petition around trying to urge the government to think about the post-war consequences and not use the bomb, and instead work towards international control. In the federal government, a committee was established to recommend policy and it came to the fateful conclusion that there was no good technical basis for avoiding military use. Oppenheimer took part in that deliberation. A decision was made to use the bomb. Many of the scientists felt that that was a tragic and unnecessary thing.

Before long the nation's attention was drawn away from WW II to the Cold War and it was then of course that Oppenheimer became a target and the FBI began to circulate its findings about his communist activities in the 1930s. To give you an idea of the climate of fear and security of that time, among the organizations the FBI cited as communist front organizations that Oppenheimer belonged to were the American Civil Liberties Union and the Consumers Union. Those of you might consult Consumer Reports as to what toaster to buy might have been considered out-and-out subversives. Another was the Berkeley Conference for Civic Betterment. (Boy, there's a communist outfit.) And another one, the Association in Support of the Chinese people. These were things he joined quite openly. There was nothing subversive about them. Not only that, but during the war the man who was the chief security investigator was really pleased with Oppenheimer's cooperation, except for the one episode involving Haakon Chevalier where it was said that Oppenheimer had misled the security officers.

Briefly, what happened is that at some point Oppenheimer was pressed to tell the security people anything about contacts that were being made that might have involved espionage. He said that before he left Berkeley for Los Alamos somebody had approached him to see whether it was possible to share what our scientists were doing with the Russians. After all, they were our allies. Oppenheimer said that he immediately rejected that and told the guy that this was treasonous. "Don't even go near this sort of thing." But he didn't want to reveal the name of the guy who told him this. And the guy said that he'd met somebody else in the area named Eltenton who suggested he could transmit the stuff to the Russians. So Oppenheimer said to the security officers, "I'll give you the name of the guy who made that suggestion because he might be genuinely dangerous." So he misled the security

officers because he was afraid they would identify who the guy was. He told them that there were a couple of other episodes when Eltonton approached other people. He said, however, if General Groves orders me to I will tell you the name of the guy that brought the suggestion to me. Groves didn't want to do that for a while so the security officers continued their dance with Oppenheimer. Finally, they got tired of it and they went to Groves and said, "Tell him to tell us." So Groves said tell us and Oppenheimer did. Oppenheimer named Chevalier, a man who teaches romance languages at Berkeley. A very unlikely nuclear physics spy. They investigated Chevalier and found that there was nothing to it. Chevalier had simply made the suggestion in the spirit of wanting to help the Russians, who were beleaguered at the time, and it went nowhere. There was never any espionage, that was it. And it was on that charge that Oppenheimer was finally impeached and convicted for defects of character in misleading the security officers. He did so because he wanted to protect his friend, who by the way, when he told the guy's name and the FBI put the guy's name on the list, the guy was denied a job at the Office of War Information. There were certain penalties associated with that.

It's worth noting that there was real espionage in the Manhattan Project that escaped the FBI's surveillance. They only got wind of it when Fuchs and the Rosenbergs were betrayed, thanks to the defection of that Soviet code clerk. Fuchs told the authorities that the Soviets did have an agent in Berkeley. And only a couple of weeks ago Russian scientists told my colleague Herb York that the KGB was well informed about the progress of the project. We are not sure whether it was because Fuchs told them (he was in a position to know practically everything) or whether it was this agent (as yet unknown) in Berkeley. But it certainly wasn't Oppenheimer or anyone he appointed or anyone he had dealings with who had anything to do with the passing of information. In short, that whole security episode was based on Oppenheimer's associations and this one episode of having, during the war, misled the security officers because he wanted to shield a friend.

What was really going on was this new charge about his behavior post war. In all probability none of this old stuff would have been rehashed if Oppenheimer had not angered Edward Teller and Teller's allies in the Air Force and the Senate by opposing the Crash program in developing the super when the issue was raised in 1949.

Herb York has written a book based on some declassified DOE and DOD files he managed to get, called *The Advisors: Oppenheimer, Teller, and the Super Bomb*. There was no question that this was a set of very serious issues. To give you an idea of what went on, here was the statement that was made by the General Advisory Committee to the Atomic Energy Commission that Oppenheimer chaired. Notice what it said:

> The dangers to mankind in this proposal of a crash program outweigh any military advantage that would come from its development. Its use would involve the decision to slaughter a vast number of civilians. We're alarmed by the possible radioactivity. If the superbomb will work at all, there is no inherent limit to its destructive power. It might become a weapon of genocide. Reasonable people the world over would see it as a threat to the future of the human race. To the argument that the Russians might succeed in developing this weapon, we'd reply that our undertaking it will prove a deterrent to them. Should they use the bomb against us, reprisals by our large stock of atomic bombs would be comparably effective to the use of the super.

In a private letter to Jim Conant, who was the president of Harvard and had been wartime chief scientist, Oppenheimer says,

> What concerns me is really not the technical problem. I'm not sure the miserable thing will work, nor that it can be gotten to the target except by ox cart. It seems likely to me even further to worsen the unbalance of our war plans. What does worry me is that this appears to have caught the imagination of both the congressional and military people. It would be folly to oppose the exploration of this weapon. We always have known that it had to be done, and it does have to be done, though it appears to be singular proof against any form of experimental approach, but that we become committed to it is a way to save the country and peace appears to me full of dangers.

It was because of that ambivalence that the scientists who testified against Oppenheimer, notably Edward Teller, accused him of having dragged his feet and having, in effect, damaged the defense effort of this country. Teller said in the hearings that people at Los Alamos were interested in going ahead with the thermonuclear device because it was generally understood that we were going to do it. It was a "sort of promise in our minds," and notice this, "people were a little bit tired, particularly the younger ones, of going ahead with minor improvements. They wanted to, in a sort of adventurous spirit, go into a new field." In

other words, don't worry about the consequences, don't worry about the morality of the thing, this is something we do. We're scientists, and when they throw a challenge up at us, we get to solve it. Then, "the strongest point, as long as you people go ahead and make minor improvements and work hard at it, you're doing a fine job, but if you succeed in doing a really great piece of progress you are doing something immoral." In other words, there was resentment at the introduction of this issue, and the accusation that those who were going to be working on the bomb were going to be amoral.

What about Oppenheimer himself? Oppenheimer himself was ambivalent, as you can see from that earlier quote, and as you can see even more dramatically from the hearings.

> When you see something that is technically sweet you go ahead and do it and you argue about it only after you have your technical success. That's the way it was with the atomic bomb. I don't think that anybody opposed making it. There were some debates about what to do with it after it was made. I cannot imagine that if we had known in '49 what we got to know by early '51 that the tone of our report, that is on the Crash program, to develop the H-bomb would have been the same. Because in 1949 Teller and Stanislaw Vlam had not yet come up with their technical improvement that made everybody convinced that you could in fact develop the H-bomb.

Finally, it seemed to me in a speech that Oppenheimer made a little later, he made a concession to Teller. He said,

> When a friend tells of a new discovery, we may not understand, we may not be able to listen without jeopardizing the work that is ours, but we cannot find in the Book or canon, and we shouldn't seek grounds for hallowing our ignorance. We may have to leave the room from fatigue or trouble, but that is our weakness and our default.

Herb York was the first director of the Livermore Laboratory, which Teller and the Air Force had built because they needed it. They didn't trust the people at Los Alamos to do it. It was under York's direction that the bomb was actually produced. York nevertheless argues in *The Advisors* that Oppenheimer and the others' advice was good because it would have made sense to get the Russians to agree not to develop the H-bomb. Instead we got into a spiraling arms race, which produced a proliferation of an extraordinary class of dangerous weapons.

In any case, that's what happened, and the result was the Oppenheimer case. Briefly, about the verdict and its aftermath. There was a great shock in the nation, and particularly among the scientists. Some refused to cooperate with the military, but military R and D continued because an awful lot of money went into it. The arms race escalated. We should bear in mind that the failure to draw back from the brink almost led to a major nuclear war during the Cuban Missile Crisis. Secretary McNamara recently said, "We came that close to nuclear war."

On the positive side, one of the things that happened, partly because of the Oppenheimer case, but even more because of the Sputnik Crisis was that the government created an office of science advisors, and along with it an Office of Science and Technology attached to the White House, and even a presidential science committee (now Office of Science and Technology Policy). The first science advisor was Jim Killian, who wrote the introduction to *Science in the Nation.* I say that was positive because scientists were no longer outsiders, but they were expected to be part of the process. They get an opportunity to give their input right into the presidency.

Finally, if I can draw some of the lessons with the benefit of hindsight: the Oppenheimer case arose because the association between knowledge and power or science and government was so new and fragile that no one on either side understood the rules. It arose under the conditions of wartime secrecy and post-war, cold war insecurity. By the time of the most recent debate, the SDI debate three decades later, it surprised no one that scientists should disagree publicly and privately over the wisdom of this particular weapons development. Teller was still in the ring proposing yet another new weapon, the third generation or X-ray laser. Gullible politicians were ready to believe that this breakthrough was around the corner and would make nuclear weapons, as Ronald Reagan said, "impotent and obsolete." Lots of others were arguing on the other side. Their views were also taken seriously, if not in the executive, then in the congress. The debate between Oppenheimer and Teller was not so much a debate over scientific fact as a debate between two strategic policies—the debate between finite deterrence and infinite deterrence. Oppenheimer did not oppose all nuclear development. For example, he favored the development of tactical weapons and wanted to increase the stockpile of atomic bombs. He didn't want to divert the effort into the thermonuclear weapons in part

because he was not convinced the time was right for the Crash program.

In the case of SDI, once again the debate was between those who thought yet another technological breakthrough would make us safe from nuclear attack and those who argue that there can't be a last move in a technological arms race, and that accommodation and containment are better and safer than confrontation.

Scientists and engineers, like other people, are going to disagree when there is uncertainty over technical issues and when people have different strategic and moral views. I think we've learned now that it is a healthy thing to encourage them to disagree. It invigorates the adversary process, it helps to educate us all, it makes our politicians and the public better educated, and makes it possible to come to better decisions.

The second point I would make is that the adoption of the Freedom of Information Act, and the reaction to Watergate and Iran-Contra, suggest that maybe some of the wilder aspects of cold war insecurity may have disappeared along with the cold war. But there is always a danger that if you have a police force like the FBI, the powers are going to be misused. That suggests to me that we still haven't gone far enough in making the FBI and maybe the CIA as accountable as they need to be.

Reading those FBI files is really quite a shock because you realize how intrusive and how dumb the whole enterprise was. It wasn't directed at real espionage, or real problems, but only at loyalty and security, what people read, and that sort of stuff.

Third, scientists will continue to have problems whenever they work on discoveries that have dangerous consequences. In other words, this issue doesn't only affect war research, it concerns possible work on biotechnology, possible work that produces toxic effects, and what have you. They may well have to consider that acting out of conscience can be costly just as it was for Oppenheimer. I hope that we are maturing enough as a society to allow scientists to come forward with their qualms, to express their concerns within industrial structures, within government structures, and for us not to persecute people as we did Oppenheimer who had qualms about what he was doing. I hope also that as you develop careers in this area and do the important work that you will be doing, you may find that his example is an inspiration as I did almost 40 years ago when I needed a term paper topic and discovered a slice of real life.

8

Science, Engineering and Technology

Joseph Bordogna

I'm going to talk personally about what might happen in the 21st century with regard to engineering education, research, and practice, and at the same time share with you the collective thinking of many people. I'm passionate about what I'm going to say—most of which is not new and part of which is intended to be provocative, so we can argue. I'm going to start at the "beginning," in 1776.

Everybody knows that 1776 is the date of the Declaration of Independence, but not many people know about two other striking events that happened that year. The American Society for Promoting and Promulgating Useful Knowledge, which eventually became the American Philosophical Society, was founded in 1776, and Adam Smith's *The Wealth of Nations* was published that year. One reason I bring this up is to note that from the start America seemed focused on useful knowledge. The second reason is to acknowledge that Adam Smith's market economy has won out recently over Marx and Lenin.

Smith suggested several tasks be assigned to government in a market economy. The first is rather obvious. Since government needs money

in order to operate, taxes must be levied. Second, the government should be responsible for educating the work force, because intellectual capital is necessary for productive growth. The third is most interesting because it seems that the notion of "just-in-time" inventory was invented back in 1776. Since commerce can't flow in a market economy unless things can get from place to place, Smith suggested that government build and maintain the infrastructure on which low-inventory factories depend.

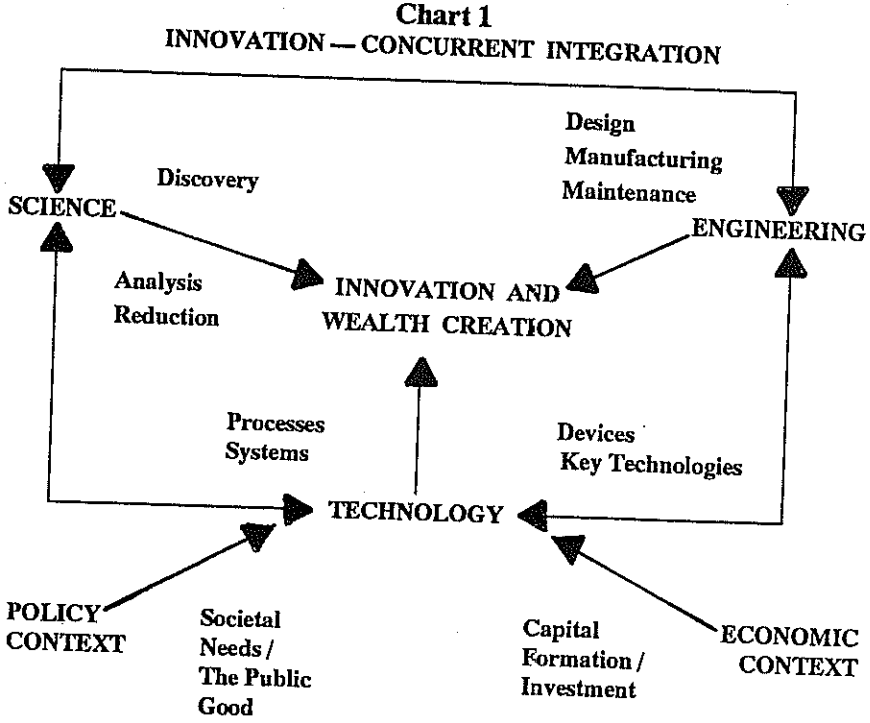
It is irrational to assume that the relationship between scientific knowledge, superior technology, engineering innovation and competitive products is linear. Innovation is not just some new idea, some new technology. From the engineer's point of view, innovation means getting something—a product or a service—out the door and selling it. Innovation also means getting a business started. George Helmeyer recently gave a talk on the liquid crystal he developed at RCA. RCA didn't pursue this invention, and now it is bringing wealth to other nations. Helmeyer emphasized that to innovate means more than to get an idea or even to show how something can be done. You have to create wealth. Accomplishing all that is a complicated but not a linear process, one that I'll return to in a moment.

Another irrational assumption is that investment and discovery alone lead naturally to economic prosperity. Many in the professorate will argue that once we acquire new knowledge, our job is done and that alone will assure the nation economic success 40 years from now. There is much truth in that, but it is not the whole story.

Chart 1 attempts to depict how all these elements interact non-linearly and presents a way of describing concurrent integration. We are used to the word "concurrent" because of concurrent manufacturing, in which design and manufacturing are done together rather than by throwing the design over the transom and hoping a product can be made. But there is more to it: *Everything* must be done concurrently.

What has to be done concurrently in the act of innovating? As we at NSF see it, there are five macro-pieces. The words in large type on the chart indicate the foundation NSF builds on, which is slowly changing. The lower left is the policy context: What is good for the public (which is for the public to decide), and what is needed. NSF was started to promote science *and* to meet national needs. Societal needs and the public good are important when you are using taxpayers' money. Then

Chart 1



there is the economic context (bottom right). If you are stymied for lack of capital and if investment opportunities aren't promising, nothing will happen. The center of the chart is innovation and wealth creation, toward which all the other elements are aiming. Research is a luxury only rich nations can afford. If our $4 trillion debt stays the same or gets worse, research will suffer. For a great deal of basic research, this year's budget is already flat, and not just at NSF.

I want to talk now about how science, engineering, and technology differ. Science is discovery that results from looking deeply into something. The United States excels in academic science, and we must continue to nurture the process of discovery. That excellence alone, however, doesn't seem to be taking us where we have to go as a nation.

Engineering is different than science. I don't mean to say that engineers don't do science; in fact we do a great deal. But engineering science is only one dimension of engineering. Engineering is putting

things together to create something that hasn't existed before. Creating wealth is another dimension of engineering; if you make something that no one buys, no one will reward you for making it. Engineering synthesis and integration are thus becoming very important for all of us at NSF. The aim is to have science and engineering work synergistically.

Technology is neither engineering nor science. It is the stuff you have around: the ideas, the crafts, the pieces of things, the devices. How do you put this all together synergistically as a concurrent integration process?

Two major themes guiding our work at NSF are to improve the quality of life and to invest in people. The chart below allows us to analyze how well off we are today.

The old paradigm corresponds, for example, to the Roman empire, with a large land mass, natural resources, and the will and capacity to conquer the world. The capital is the gold in the ground and the jewels in the crown.

In the last 40 years or so we have seen countries such as Japan—and more recently, other Asian nations—with little land mass and few natural resources growing bigger and bigger GNP's. What countries need today is superior technology: human resources. At the end of World War II, Japan, with nothing left but people, invested in people. Compare that with the political environment in the former Soviet Union today. Societal infrastructure is critical. Our country now needs capital investment—different from crown jewels, but wealth nonetheless.

Determinants of Economic Well-Being

Old Paradigm	New Paradigm
• Land Mass	• Technology
• Natural Resources	• Human Resources
• Population Size	• Stable Political Environment
• Military Power	• Societal Infrastructure
• Available Capital	• Capital Investment

We may look at the situation in this way:

Rapid Technological Change
+
Rapid Political Change
+
Growing Global Competition
+
Information Revolution
↓
Perpetual Innovation
↓
Paradigm Shift in the Way We Do Business

We know how to do what is at the top of the chart better than what is at the bottom. We are good at rapid technological change; it's happening all around us. Though it makes people uncomfortable, perpetual innovation is necessary. It's more than running fast to stay in place: You have to run fast to keep ahead. That means that we have to change the way we do all kinds of things, including education.

In 1944, the Spanish philosopher José Ortega y Gasset wrote in his *Mission of the University*:

> The need to create sound syntheses and systemizations of knowledge . . . will call out a kind of scientific genius which hitherto has existed only as an aberration: the genius for integration. Of necessity this means specialization, as all creative effort does, but this time, the [person] will be specializing in the construction of the whole. The momentum which impels investigation to dissociate indefinitely into particular problems, the pulverization of research, makes necessary a compensative control — as in any healthy organization — which is to be furnished by a force pulling in the opposite direction, constraining centrifugal science into a wholesome organization . . . the selection of professors will depend not on their rank as investigators but on their talent for synthesis.

I bring this text to your attention to stimulate thinking about the nature of integration. Ortega y Gasset was an intellectual giant whose book, *Revolt of the Masses*, is standard reading in philosophy courses. *Mission of the University* has to do with higher education over the last

two millennia. Ortega's argument ran somewhat like this: The intellectual tradition that stemmed from Socrates and the groves of academe led to today's reductionist ivory towers. Our universities, devoted exclusively to analysis, have been digging deep to create knowledge. (Those who do it very well earn Nobel prizes.) Ortega pointed out that something is missing. In 1944, writing about universities, he said that we have to create sound syntheses and systemizations of knowledge.

The kind of scientific genius that had existed hitherto only as an aberration, Ortega called the genius for integration. In this country we respect the genius for reductionism. From K through Ph.D., our students learn how to analyze. How many students in any bachelor's program really learn how to put something together? Most learn only how to take things apart. As Ortega said, the pulverization of research, which impels investigation to disassociate indefinitely into particular problems, makes compensative control necessary. Analysis, done well and deeply on a particular area, can create valuable new knowledge, and I don't want to see our ability to do that lessened. But, something is missing. Ortega, who understood how universities work and knew that to get tenure you had to specialize, proposed a new speciality: a focus on the construction of the whole. His complementary proposal is still considered heresy in universities—to select professors for tenure and promotion not on their rank as investigators but their talent for synthesis.

Many recent reports, put together by knowledgeable people from industry, academe, and the government, convey this message: Discovery is critical, but discovery, rather than being a product of directed government support of a particular discipline, is happening more and more at the interfaces of traditional disciplines. This is really nothing new, but the pace is faster. Rapidly changing technology makes it hard to tell whether science is motivating technology or vice versa. Can any one discipline still expect to go it alone?

What is the engineering task in all this? For engineering science, the task might be to continue to discover knowledge. But the engineering task—for itself and for society—is to integrate knowledge across ever-changing disciplines and apply it to create wealth throughout society.

So what do we do about education? We now emphasize science over practice and engineering, and I do not propose that we de-emphasize science or that we destroy research while we invest in teaching. There

are, however, many opportunities for making connections. We could start by deciding to think holistically.

Components of a Holistic Baccalaureate Education

Vertical (In-depth) Thinking	Lateral (Functional) Thinking
Abstract Learning	Experiential Learning
Reductionism-Fractionization	Integration — Connecting the Parts
Develop Order	Correlate Chaos
Understand Certainty	Handle Ambiguity
Analysis	Synthesis
Research	Design/Process/Manufacture
Solve Problems	Formulate Problems
Develop Ideas	Implement Ideas
Independence	Teamwork
Techno-Scientific Base	Societal Context
Engineering Science	Functional Core of Engineering

The left of the above table shows the things that engineering education does well and the things that most intellectual endeavors are focused on. On the right are the things we pay too little attention to. We reward vertical (in-depth) thinking. Lateral (functional) thinking across a variety of areas lacks an academic niche, and we don't teach it very well. Undergraduates take a course, get an A, go on to the next course. But who connects the courses? As for abstract versus experiential learning, engineering programs begin by teaching abstractions and finish by allowing students to put something together. That's the reverse of the way people learn—by first experiencing, then making sense of the experience. Engineers are thought to work in an orderly way, but out in the world they face open-ended situations which demand they correlate elements of chaos. (Though, as we're starting to discover, there are elements of order in chaos.) As I grow older I am less happy with being defined as a problem-solver just because I am an engineer. So much of my work has consisted of formulating problems, putting them into context—as any professional does before attempting solutions. Both are important. In engineering, we do a good job of teaching our students the techno-scientific base, but we don't really help them put it into the societal context of the world in which they have to work.

What is the functional core of engineering? First, design to meet safety, reliability, and operational and environmental requirements. Second, making things: manufacturing and construction. Third, planning and operating complex systems, needing a proper mix of engineers, technologists, and technicians. Fourth, understanding physical constructs, and the economic, industrial, social, political, and international context in which engineering is practiced. Fifth, intellectual skills for career-long learning, which, as we know, is problematic.

What NSF Can Do?

So what is our new paradigm? In engineering education, we have to pay as much attention to complexity and uncertainty as to simplicity and precision. We have to be flexible as well as efficient.

Reintegration of functions is, I think, a big problem. We have decided that a goal of NSF for engineering is to meld teaching and research; thus, we are developing a number of strands for both.

Before starting, we must take into account that all publicly-funded research is derived from taxpayers' investment. Thus, while the creation of knowledge itself is of great value, NSF's statutes do point to its importance in meeting national needs—to build a productive nation in which things go right for everybody. Our first goal, therefore, is to build engineering capacity to contribute to the nation's security, economic well-being, and quality of life. Our second is to foster excellence, quality, and innovation and do so all the time. The idea is to promote academic leadership, not just research excellence.

Inter-agency and intra-agency initiatives that derive from lists of national critical technologies are controversial. Many believe such a focus mitigates against spontaneity in research, while others enjoy the integrative context that such initiatives foster. Yet the question may be moot as most research programs under way display critical technologies naturally developed in the course of scholarly discussion.

Whatever the impetus, NSF sees discovery as a partner in inter-agency and intra-agency initiatives that invest in technology critical to national well-being. Further, we want to integrate and synergize engineering research and education, and build bridges between academe and industry. The next table shows NSF's engineering organization now.

Directorate for Engineering

Biological and Critical Systems
- Bioengineering & Aiding the Disabled
- Environmental & Ocean Systems
- Earthquake Hazard Mitigation
- Natural & Man-Made Hazard Mitigation

Chemical and Thermal Systems
- Chemical Reaction Processes
- Interfacial, Transport and Separations Processes
- Fluid, Particulate & Hydraulic Systems
- Thermal Systems

Design and Manufacturing Systems
- Operations Research & Production Systems
- Design & Computer-Integrated Engineering
- Manufacturing Processes & Equipment

Electrical and Communications Systems
- Quantum Electronics, Waves and Beams
- Solid-State & Microstructures
- Communications & Computational Systems
- Engineering Systems
- Emerging Technologies Initiation

Engineering Education & Centers
- Engineering Education
- Human Resources Development
- Engineering Research Centers
- Industry/University Cooperative Research Centers

Industrial Innovation Interface
- Small Business Innovation Research
- Management of Technology
- Special Studies and Assessments

Mechanical and Structural Systems
- Dynamic Systems and Control
- Structures, Geomechanics and Building Systems
- Surface Engineering and Tribology
- Mechanics and Materials

One can, of course, question this organizational structure, and we do. For example, is design and manufacturing a discipline? Maybe it is an overarching element, or maybe it should encompass everything.

This structure, however, only hints at NSF's impact on transfer of new knowledge and critical technologies to the industrial marketplace. More revealing is the following table, illustrating that innovation throughout integration has been happening subtly through academic/industrial/governmental partnerships developed over several decades.

Academe/Industry/NSF Partnerships
Innovation Through Integration

Circa 1960s Programs
- Materials Research Laboratories (MRL)
- National Center for Atmospheric Research (NCAR)

Circa 1970s Programs
- Industry/University Cooperative Research Projects (IUC)
- Industry/University Cooperative Research Centers (I/UCRC)
- Small Business Innovation Research (SBIR)
- National Nanofabrication User Facility (NNUF)

Circa 1980s Programs
- Engineering Research Centers (ERC)
- Supercomputer Centers
- Science and Technology Centers (STC)
- Minority Research Centers (MRCES)
- Presidential Young Investigators (PYI)

Circa 1990s Programs
- State/Industry/University Cooperative Research Centers (S/I/UCRC)
- Presidential Faculty Fellows (PFF)
- NSF Young Investigators (NYI)
- Engineering Education Coalitions (EEC)
- Faculty Internships in Industry
- Environmentally Benign Chemical Synthesis and Processing
- Management of Technological Innovation

Thus, connections between academe and industry and NSF have been growing of their own momentum. In the 1970s formal industry/university cooperative research projects arose; there are now over 50 such centers, leveraged 10 to 1 in dollars by industry. The SBIR program, begun at NSF, now stretches across all federal R&D agencies.

Started in the 1980s, there are now 18 ERCs, four supercomputer centers, and 28 science and technology centers. There is a new wrinkle on the IUCRC. Recognizing that innovation happens locally, NSF has synergized state initiatives through the S/IUCRC program to help companies create wealth and jobs.

Finally, I want to make sure you know about FCCSET—the Federal Coordinating Council on Science, Engineering, and Technology. When George Bush's science advisor, Allan Bromley, first came to the White House, he was anxious to learn what was being done in critical R&D areas across the federal government. He reinvigorated the Council, which existed to coordinate federal investment in science, engineering, and technology, and was composed of the heads of those agencies and departments of the Executive Branch which fund or conduct R&D.

Current Projects, Federal Coordinating Council for Science, Engineering and Technology (FCCSET)

- Advanced Materials and Processing Program (AMP)
- Biotechnology Research (BIOTECH)
- Global Change Research
- High Performance Computing and Communications (HPCC)
- Mathematics, Science and Engineering Education
- Advanced Manufacturing Technology

Manufacturing is a crucial FCCSET area. In 1992, U.S. investment was about $1.2 billion in R&D across all the agencies in manufacturing-related activities. The six areas listed in the above chart form the nexus through which investment and basic research may now flow.

Returning to the founding concepts of of our country, I think academe has to make a better case about its value. Our government cannot function without an educated citizenry. In a letter to a friend, James Madison said it well: "What spectacle is more edifying or more seasonable than liberty and learning, each leaning on the other for their mutual and surest comfort."