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Ethical Dilemmas in Modern Engineering

ROSEMARY CHALK

The editors of the trade journal *Chemical Engineering* recently conducted a reader survey on engineering ethics.[1] They presented a set of nine hypothetical cases illustrating some ethical dilemmas that arise in the practice of engineering. These cases included situations in which an engineer became aware of illegal dumping of chemical wastes by his employer, or was asked to "fudge" data in performance tests for a new product. The cases were accompanied by a questionnaire in which readers were asked to indicate an appropriate course of action for an "ethical" engineer to take in each case.

The response to the survey was overwhelming, with more than 4300 readers returning the questionnaire. Perhaps the most interesting result of the survey was that the Code of Ethics of the American Institute of Chemical Engineers was almost universally *ignored* by the respondents in determining solutions to the problems. Fewer than a half-dozen respondents even mentioned a code of ethics at all. The readers tried instead to resolve each problem on a very individual and personal level, and the result was a wide diversity of opinion in some cases as to what was the "right" solution to a given problem. In commenting on the results of the survey, the editors of *Chemical Engineering* concluded that there is a real need for the engineering profession to make its codes of ethics relevant to situations encountered by engineers in real life, and to support the ethical conduct of its members, so that individual engineers don't feel that they must grapple with these dilemmas on a solitary and isolated basis. It is in this context of focusing professional society resources on individual problems that I want to talk about engineering ethics this evening.

Rosemary Chalk is staff officer of the Committee on Scientific Freedom and Responsibility of the American Association for the Advancement of Science. This article is adapted from a talk delivered at a meeting of the IEEE CSIT Washington Area Working group on October, 29, 1980 in Washington D.C. The author gratefully acknowledges the assistance of Frank Kotasek in preparing the adaptation.

Ethical Dilemmas

The "rights" and "wrongs" of ethical dilemmas in engineering practice are not sharply divided. True dilemmas, by definition, often involve a balancing of rights and duties, weighing values that may be ambiguously understood or unevenly shared by members of the profession. For example, what is the appropriate balance between an engineer's responsibility to an employer and an engineer's moral or statutory responsibilities to other parties?

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Letters

To the Editor:

These comments are addressed to the proposal to form an "IEEE Society on Social Implications of Technology" and to upgrade "Technology and Society" to an IEEE magazine.

This proposal lends further support to the trend in recent decades towards "The Slow Death of a Free Profession," as identified in my paper under that title and reviewed in *IEEE Spectrum* of July 1971. (pp. 74–75).

It is reassuring to find that at the July 18 meeting of the Technical Activities Board every Society President who spoke (perhaps 6 to 8) opposed the proposal.

Perhaps there might be some justification if our Society were known as the Institute of Electrical and Electronics *Technicians.* There might then be a segment of members who recognized their social and ethical responsibilities to human society and who saw the need for a stronger movement towards implementing these responsibilities. However, our Society is composed of "*Engineers.*" This means that every man who practices the art of engineering is, by definition, "a professional man of integrity carrying high responsibility with independence of choice in applying science for the benefit of mankind."

Unfortunately, the American public, from its daily journalism, reads only about "scientists" and "scientific ventures;" the words "engineers" and "engineering responsibility" are no longer part of the American vocabulary. This is symptomatic of "The Slow Death of a Free Profession." At the same time this helps to identify the kind of challenge resting on every member of IEEE in terms of his duties to serve human society.

Perhaps the time has arrived for re-organizing the Committee on Social Implications of Technology into an Advisory Committee on Engineering Responsibilities to Society, and thereby better serve *all* IEEE members.

Adolph J. Ackerman
Consulting Engineer

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Safety Engineering and the Value of Life

T. W. LOCKHART

It has been argued that any realistic approach to safety engineering must countenance setting a monetary value on human life. This is taken to be a consequence of the fact that most practical engineering designs involve tradeoffs between safety considerations and costs. Usually either it is impossible to produce a design that carries no risk to human life or the costs of implementing such a design would be prohibitive. The engineer often must decide what risks are acceptable. But to say that certain risks to human life are too expensive to reduce is to imply that the value of human life itself is not infinite, for if it were, the costs of preserving it could never be too great. However, if the value of human life is not infinite then it is finite and, at least in principle, it is possible to assign a dollars-and-cents figure to it.

This argument, and others similar to it, have found currency among many of those charged with making decisions about safety. If a monetary value can be assigned to human life, then the task of deciding how safe the design should be is greatly simplified. Since human life has a monetary value, the preserving of a human life is an economic benefit, just as the costs of safety are economic costs. Since, in the final analysis, the benefits and costs of safety improvements are economic in character, both may be weighed in the balance with other economic benefits and costs. The optimum design will be that which is expected to maximize the margin by which benefits exceed costs.

It is therefore of practical importance to determine what monetary value should be assigned to human life, and this is the chore that a number of analysts have undertaken. However, views differ greatly on how one even approaches such a task and this has led to widely varying results. Part of the difficulty is the necessity of dealing with vexing conceptual issues: For example, are all human lives equally valuable? Are not some lives of greater quality than others? If so, does the phrase "the value of human life" refer to an average value of human lives or to some component possessed by all persons? Is there a difference between the value of a person's life to the person himself and its value to others—his family, friends, society? Is there a value of human life *per se*? Which notion is the relevant one in safety considerations? Could several of them be relevant? And in different ways?

These difficulties cast doubt, perhaps, on the entire project of estimating *the* value of human life. At least, a more precise statement of the problem is needed. If we agree that when a person dies something of value is lost that is not merely its utility for society, we have reason to believe that there is an intrinsic value of human life that generally makes it worth preserving. This factor would have to be taken into account in decisions about public safety. It is also this concept of the intrinsic value of human life that is especially interesting and problematic philosophically. This is so in part because there is an honored tradition in moral philosophy, associated primarily with Immanuel Kant, according to which human beings have a worth that is not commensurable with that of mere objects. According to this view, because of this incommensurability we must recognize and respect the liberty and dignity of each person and refrain from treating him merely as a means to some end. Human beings may not be used in order to achieve some higher good, for there is no higher good. Let us call this view the Incommensurability Principle.

The Incommensurability Principle has had a powerful appeal for many. This has been true mainly because it has been felt that unless it, or something like it, is accepted it is not possible to account for such fundamental human rights as the right not to be killed, the right not to have one's liberty abridged without just cause, and the right to be treated fairly and honestly. The Incommensurability Principle is clearly incompatible with an attempt to place a monetary value on human life or to justify actions on the basis of such a valuation. There is thus further reason for doubting the wisdom of any such attempt.

Is it possible to reconcile the Incommensurability Principle with the commonsense view that considerations of safety must be weighed against economic costs? The answer is in the afirmative only if the argument presented at the beginning is faulty. That argument asserted that to accept the weighing of safety against costs amounts to accepting in principle the assigning of a monetary value to human life. The question thus becomes—Is it possible to deny that safety considerations always dominate economic considerations without placing a monetary value on human life in the process? It has seemed to many that it is not possible to do so—that the weighing of safety against costs in a particular instance would automatically contain an implicit monetary valuation of human life. I shall argue that this is highly questionable, since the implications of a particular tradeoff between safety and costs for the value of human life are at best extremely problematic. I shall also briefly examine some of the methods that have been proposed for assigning a monetary value to human life.

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Some have recommended using the size of court awards in cases involving loss of life as a basis for appraisal.[1] It has been claimed that over time such awards eventually reflect the public's perception of the value of life as judges adjust the size of those awards in response to public pressure. Even if this is so, this method is reliable only if we assume that the public collectively is endowed with insights that we may be reluctant to attribute to any of its members. Furthermore, at least in some instances, judgements are clearly intended to be punitive—to provide incentives against future negligence rather than to exact payment for damages. Here the Incommensurability Principle could be considered to be at work: something of immeasurable value—a human life—has been lost; the best that can be done is to deter acts of negligence. Whether this is always, or even usually, the judge's purpose is perhaps questionable. However, it seems not unreasonable to ask for explanations of the sizes of such awards if they are claimed to constitute just compensation for the loss of human life, especially in view of the diversity of the amounts awarded. If so, to use the size of the awards as a basis for the valuation of human life is to put the cart before the horse. A further complication would be the need to distinguish the portion of such an award that is intended to reflect the extrinsic value of a particular human life—i.e., the person's economic productivity, value as a companion, parent, etc.

Some authors have questioned our abiliy to appraise human life in any direct way and have recommended oblique approaches. One suggestion is that we examine our own willingness to pay for reductions in the risk of death. If we would spend x dollars to lower the probability of death by Δp then, it is argued, we should be willing to spend $x/\Delta p$ dollars to lower that probability by one hundred percent—i.e., in order to preserve a human life (possibly our own). If we make the plausible assumption that the intrinsic value of a human life is the amount we should be willing to spend to preserve it, then all that we need to do is to determine the ratio $x/\Delta p$.[2] The problem with this approach is that there is no guarantee that the ratio is constant. It is much more likely that the relationship between x and Δp is nonlinear and depends on the "initial value" of p, the probability that death will occur if no additional money is spent on risk reduction. For example, if p is already relatively low, it may be felt that no risk reduction is needed and people may be willing to spend relatively little for further reductions. However, if the situation is considered dangerous and immediately so, then people may be willing to spend relatively large amounts to reduce the risk of death to an "acceptable" level.

One author has argued that since most actions that are taken in the interest of public safety can be expected to bring about only a relatively small reduction in the risk of death for each individual, the value of saving a life can, on the average, be thought of as the "marginal value of a decrease in risk" (of death)—rougly, the ratio $x/\Delta p$ for a very small risk reduction.[3] Since this would vary, not only from person to person, but also, in view of the preceding arguments, with respect to the "current" levels of risk, even the average value of life would not be constant. This is so because the ratio of maximum voluntary expenditures for risk reduction to the size of the reduction may vary. For this reason this approach, considered as a method for appraising human life, is highly counterintuitive. In fact, the underlying analysis conceives the value of human life to be dependent on the "current" levels of risk of death and on the material wealth of the individual. We are inclined, however, to view human life as having a fixed value rooted somehow in human nature. Any variation in this value should occur only because of differences among human beings, their characteristics and merits, and not because of temporal changes in the precariousness of human existence or the material standard of living. I am inclined, therefore, to say that this notion of a marginal value of a risk reduction is not a concept of the value of human life at all, but rather a premature attempt to connect safety and economic considerations with such a valuation.

There is a more fundamental reason to question any approach based on the public's willingness to spend money in order to reduce risks. It is extremely problematic how one is to assess that willingness. For example, people may actually spend far less for safety improvements than they claim they are, or would be, willing to spend. Therefore, may an investigator depend on (carefully worded) questionnaires to determine what sacrifices people would be willing to make in order to increase their safety, or is it necessary to analyze their actions with respect to risk reduction? If the latter, must it be established that in taking those actions people are well-informed about the levels of risk involved? More importantly, should it not be determined that people's views about risk reduction are rational? Can it simply be *assumed* that they are, especially in view of the vast differences of opinion about the acceptability of risk that studies reveal?[4] Can we be confident that a public in which nine out of ten persons consider it too inconvenient to use their automobile seat belts have rational attitudes about risk reduction? This point is crucial if we are to base safety design decisions on our assessed value of human life. For if those opinions are irrational it is difficult to see how they can lend rational support to those decisions. On the other hand, in view of the disagreements and uncertainties that exist about how safe designed products should be, any judgment about the acceptability of risk will be controversial. To adopt an approach to the valuation of human life that requires the prior resolution of those controversies is to render that valuation inoperative in their resolution.

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It is apparent, I think, that whatever the public's attitudes about the costs of risk reduction, the implications for the valuation of human life are problematic. This conclusion casts doubt on the heretofore plausible supposition that the weighing of safety against costs implies the existence of a monetary value of human life. Thus our the acceptability of risks can be established only on the basis of a cost-benefit analysis, where the costs are the economic costs of reducing the risk of death and the benefits are the human lives saved as a result of that reduction. We need make no such assumption.

But what are the alternatives? If we accept the Incommensurability Principle, how can we ever say that further risk reductions are "too expensive?" I believe that part of the answer is that we raise the quality of life by accepting certain risks (where "quality of life" may be thought of as the value of human experiences and is not the same as the (intrinsic) value of human life). We increase our quality of life, for example, by accepting the risks inherent in air transportation just as we do so in accepting those associated with driving our cars or walking across the street. We would consider it "too expensive" to eliminate those risks by foregoing those activities. Economic costs often mean reductions in the quality of life resulting from the loss of opportunities for investment and purchase or leisure. A totally safe automobile, if it were possible to build it, would be prohibitively expensive—prohibitively, not because no one could afford it, but because owning it would generally require such large expenditures as to deprive one of other things that "make life worth living." (This illustration should not be taken as an endorsement of existing safety standards for the American automobile.) The point is that public safety considerations must be weighed against quality of life considerations in decisions that affect both. The (intrinsic) value of human life, while perhaps not expressible in dollars and cents, may be commensurable with the quality of human life. The illusion of monetary commensurability occurs because economic factors obviously affect the quality of life, although they do

To say that some safety improvements may be rejected as "too expensive" of course does not explain how to distinguish them from those that should be implemented. The central issue thus remains unresolved: how do we decide how safe a designed product or system should be? I have suggested that part of the answer is that it should be safe to the point where further risk reductions would unduly diminish the quality of life. Obviously, the next question is—how does one determine, in specific instances, when this point is reached?—and this is an extremely difficult if not intractable problem. Ultimately each person may have to weigh the value of life against its quality for himself, and there is certainly no guarantee that his intuitions will match those of others. Perhaps, however, our analysis does support the principle that we should forego available safety improvements only when they would require substantial sacrifices in the quality of our lives. There is reason to suspect that such a principle would require altering the ways in which safety decisions are usually made.

Notes

1. See, for example, C. Abraham and J. Thedie, "Le Prix d'Une Vie Humaine dans les Decisions Economiques," *Revue Francaise de Recherche Operationelle* (1960).
2. See, for example, G. Fromm, "Civil Aviation Expenditures," *Measuring Benefits of Government Investments,* ed. R. Dorfman (Washington: Brookings, 1965).
3. See M. W. Jones-Lee, *The Value of Life* (Chicago: University of Chicago Press, 1976). chapter 5.
4. See, for example, Jones-Lee, chapters 6 and 7.

The Value of Human Lifetime—and its Application to Environmental and Energy Policy

GERALD RABOW

Policy alternatives in many areas, and particularly in environmental and energy policy, can have an effect on the length of human life. For example, it has been demonstrated that air pollution increases human mortality and hence shortens human life.[1,2] One approach to making policy decisions is a cost-benefit analysis, in which the value of human lifetime increments should be an important consideration.

Techniques of modeling policy alternatives are currently under development. For example, Brookhaven National Laboratory is developing models to include environmental effects and other externalities in the comparison between solar energy and other energy sources.[3] Since solar energy is generally environmentally more benign than other forms of energy, the proper valuation of health and lifetime differences between solar and other forms of energy could be important in making proper decisions on the relative development of these energy sources. Unfortunately, the value of human lifetime appears to be greatly understated in most analyses. This could lead to excessive use of high polluting energy sources instead of low pollution alternatives such as energy conservation and solar energy. It is the purpose of this paper to advocate a more appropriate method for valuing human lifetime than is generally used at present.

It is also hoped that arguments that it is not at all appropriate to set a value on human lifetime can be countered through the process of valuing lifetime correctly. In this paper, the emphasis is on the value of a person's time, which is generally recognized as an economic commodity, rather than a more nebulous "value or life."

The conventional approach to valuing human lifetime is given by Cooper and Rice.[4] It consists of a present worth evaluation of earnings for the remainder of the lifetime of the population of interest, or of the differences of this present worth for the alternatives to be compared, using a net (i.e., adjusted for changes in productivity) discount rate of the order of four percent to six percent per year for the present value of future earnings. As a change from earlier papers, the value of the work of "housewives" was obtained from estimates "of the cost of replacing the housewife's duties with person-hours from the labor force to do the same work." Using life expectancy, labor force participation, and earnings data, Cooper-Rice have prepared tables of present values of lifetime earnings, discounted at four percent and six percent, by age, sex, and race, 1972. As an example, some of the entries of their table is reproduced below.

"Present" (1972) Value of Lifetime Earnings

Age	4% Discount		6% Discount	
	Men	Women	Men	Women
Under 1	$95,965	$58,439	$48,720	$30,976
25-29	220,884	115,647	170,988	90,439
50-54	108,581	53,929	96,158	47,115
85 and over	534	199	519	194

I have two main objections to the above conventional approach of valuing human life. One is that a discount on the present value of future lifetime is not appropriate. The other is that all human lifetime should be valued, not merely that spent in remunerable activities. The stated value of human lifetime greatly increases when these corrections are made.

The case for not applying a discount on future human lifetime can be stated in three ways. One is that human lifetime is the basic value, and all other measures of value should be expressed in terms of it. There is then of course no discount on human lifetime.

The second way is that the normally applied discount on future returns results from the following three factors, none of which applies in the case of future human lifetime. (a) The risk that the anticipated return might not in fact be realized. In the case of future human lifetime, that factor is included in the application of life expectancy to the evaluation of future earnings (or more generally, to the evaluation of any values of future lifetime); including it also in a discount would be double counting. (b) Inflation; any comparison between present and future values should, however, be made in constant units of value and not in inflating currency. (c) The expansion of the economy. However, growth of productivity and other values of human lifetime should on average keep pace with the growth of investments, and there should be no net discount between them. (In a risk-free, noninflationary, nonexpanding economy, there can be no time discounts on the average, nor persistent rate of interest, as otherwise any portion of wealth would increase without limit and eventually exceed the total intial wealth.)

The third way is that if a discount is applied, then the value of future lifetime (in inflating currency) should rise correspondingly, because the risk factor should not be double counted, and because earnings (or more generally, money equivalents of lifetime) should rise due to inflation and productivity increases. However, human lifetime is much more conveniently measured in terms such as per capita GNP (gross national product) than in terms of inflating currency (or even of the ratio of currency to cost of living index). Hereafter, all valuations in this paper are in terms of GNP or per-capita GNP, and all quotations from references have been converted to this measure.

In making the case that *all* human lifetime should be valued, not merely time spent on remunerable activities, it should be understood that what we are considering is the value of lifetime to the individual whose lifetime is at risk, because only in that way will the values of all lifetimes at risk aggregate to their value to society. Since society has the option of spending, on average, more time on work to produce a greater GNP, the fact that it does not choose to do so implies that comparable value is attached to the nonwork time. As a first approximation, then, we can say that all of a person's time should be valued at the rate at which some of it is traded for pay. The value of human lifetime, then, is a multiple of the per-capita GNP produced in that time.

There is the question of what multiple to use. Since somewhat over on third of the U.S. population works at producing the gross product, at which the average worker spends somewhat under half of available time, a multiple of six might be considered. This is an overestimate, since not all of everybody's time at all ages could be efficiently spent participating in producing the GNP. Some experiments could perhaps be run, with various persons at various ages, to determine how much work of various types could be done if all of one's efforts were devoted to that single goal. A multiple of four might meanwhile be a reasonable estimate, meaning that the value of a year of human lifetime is on average four times the per-capita yearly GNP.

It should be noted that some considerations which might complicate lifetime valuations in other situations are not significant in assessing pollution damages. For example, the loss of human lifetime due to pollution is probably widely spread over the affected population, so that particular individuals generally lose only a small portion of their lifetimes. (In contrast, catastrophic accidents, e.g., automobile accident mortality, exact a large lifetime loss each from a small portion of the population, and for them linear lifetime valuation might be less appropriate. Where individuals or classes at excess risk from pollution can be identified, society should take special measures to protect the affected group from the extra losses, and the cost of these measures are an additional pollution cost.) As another example, although different lifetime valuations as a function of age and sex might be troublesome in some contexts, they are probably not important in assessing pollution damages, where the damages are aggregated over the whole population.

In the above valuation of lifetime loss due to pollution, it is assumed that the lost lifetime is a portion of all stages of life, not just a reduction of the final portion of life, which may be of relatively low value because the person may be infirm and incapacitated. As a first approximation, the effect of pollution may be thought of as speeding up the process of deterioration with age. This model also suggests that some of the morbidity costs of pollution are already included in the above mortality assessments. In assessing remaining health costs due to pollution, the morbidity of a person in a polluted environment should be compared to that of an older person in a nonpolluted environment, so that the ages are the same fraction of the life expectancy in their respective polluted and nonpolluted environments.

This paper concludes with a comparison of my estimate of the health costs of air pollution,[2] to those by Lave and Seskin [1] using the Cooper-Rice valuation [4] and highlighted in the Brookhaven National Laboratory Report. [5] My results [2] are that air pollution in the United States caused 17 percent excess mortality (in the years 1949–1960) corresponding to an average lifetime loss of 3.7 percent, which translates to an equivalent money loss of 15 percent of the GNP. The Lave-Seskin results [1,5] are that air pollution (1970) caused nine percent excess mortality corresponding to an average lifetime loss of two percent, which translates to an equivalent health related money loss of two percent of the GNP. The discrepancy factor of 7.5 between the two estimates of monetary loss will be analyzed below. It should be pointed out, however, that this discrepancy factor of 7.5 is an improvement over a factor of 25 by which the 1971 estimate of health related losses due to air pollution by the U.S. Council on Environmental Quality [6] was below the author's mortality loss figure [2].

Of the factor of 7.5, a factor of four is due to differences in valuation of human lifetime. The discrepancy in the mortality valuation (which comes about through differences in treatment of time discount and nonwork-time) is much greater than a factor of four; the health valuation factor comes down to four because the Lave-Seskin figure includes medical expenditures and work loss due to morbidity as well as work loss due to mortality (in about a 2, 1, 2 ratio for those respective items).

The remaining factor 7.5/4 = 1.9 is a difference in the estimate of lifetime loss due to air pollution. My data comes from an air pollution study in the Nashville, Tennessee SMSA (standard metropolitan statistical area) in the period 1949-1960; Lave-Seskin made a regression analysis of available data from many SMSAs for years around 1970. I believe my figure of lifetime loss due to air pollution to be more accurate than the Lave-Seskin figure, because (a) the data I used is less subject to extraneous factors than the Lave-Seskin figure, and (b) I have tried to balance over- and under-estimates of the effects of air pollution on mortality, whereas Lave-Seskin have tried not to over-estimate but have been willing to under-estimate. The elemental pollution areas in the Nashville study census tracts, were much better defined in pollution level and much more homogeneous in all respects than the elemental areas in the Lave-Seskin analysis, which were the SMSAs themselves, whereas the variation in pollution levels of the elemental areas in the two studies was about the same. In addition, census tracts within an SMSA would be much less subject than SMSAs to a number of extraneous factors, such as climate, which might affect mortality and hence reduce the accuracy of the results even after statistical processing.

As techniques improve in the future, the accuracy with which we can relate health effects to environmental causes will doubtlessly improve. A resolution of the imputed cost of health items, and particularly of human lifetime, will be needed as well. It is hoped that this paper contributes to that resolution.

References

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2. G. Rabow, "Estimating Costs of Pollution", *Proceedings of the IEEE SMC Society,* 1973 International Conference on Cybernetics and Society, November 5–7, 1973, Boston, Mass., pp. 65–69.
3. W. Marcuse, "Internalizing the Externalities of Solar Technology: Methodologies for Incorporating Externalities in the Assessment of Policy Options and Technology Assessments of Solar Energy Initiatives and R&D Programs Using Brookhaven Models," Brookhaven National Laboratory, May 1978.
4. B. S. Cooper and D. P. Rice, "The Economic Cost of Illness Revisted," *Social Security Bulletin,* vol. 39, February 1976, pp. 21–36.
5. W. Marcuse, op. cit., pp. 26–28.
6. "Environmental Quality", the second annual report of the U.S. Council on Environmental Quality, August 1971, pp. 104–107.

CSIT Meeting Schedule

The next two meetings are tentatively set as follows:

Wednesday, April 8, 1981. 11:00 AM,
Sheraton Centre Hotel, New York, NY

Saturday, June 6, 1981. 10:15 AM,
Columbia University, New York, NY

Anyone wishing to attend a meeting should call Jeff Bogumil to confirm the dates.

Chalk, continued from page 1

One case which illustrates this dilemma involves a health physicist who was a radiation safety officer at a state hospital in Missouri.[2] In the course of his duties, he found out that a patient had undergone radiation treatment for a cancer and that, when she was released from the hospital, part of the radioactive material that she had been treated with had not been removed. The health physicist discovered this after the patient had been readmitted to the hospital, claiming severe abdominal pain, when the surgeons had examined her and had found that some of the radioactive pellets had been left inside the patient. (The surgeons also found what was called "surgical debris," including a suture needle and other material.) The saftey officer immediately filed a report with the Nuclear Regulatory Commission, as he was required by law to do, indicating that the hospital had violated NRC regulations in the handling of radioactive material.

The hospital administration subsequently told the safety officer that he should have checked with them before filing the report. He replied that he had a responsibility to report directly to the NRC any time that he discovered a violation, because other parties might be exposed to the radiation (in this case, the woman's family had indeed been exposed), and there might be a need for some kind of emergency action which might be slowed down by his going through a bureaucratic review process. Shortly thereafter, the hospital administration reorganized the hospital's radiation safety department in such a way as to eliminate the safety officer's job. However, he became aware that he was protected under legislation which said that any employee who experiences reprisals for carrying out an NRC regulation has a right of appeal to the US Labor Department. He filed an appeal. After a year of investigation and hearings, the Secretary of Labor issued an order upholding the physicist's action and ordering his reinstatement. The State of Missouri is still protesting the Secretary's order, however, creating a second year of delay. So this case also illustrates the practical consequences of ethical dilemmas—the lack of support for engineers and scientists who choose to act in the public's interest—that need attention from the professional societies.

Professional Society Ethical Concerns

The American Association for the Advancement of Science is a loosely knit federation of organizations. In addition to an individual membership of 130,000 scientists and engineers, AAAS has almost 300 professional societies—including the IEEE—as affiliate members. Part of my role at the Association is to examine how this affiliate network can respond to concerns related to science and ethics, particularly those issues that raise important principles of scientific freedom and responsibility.

The Association's charge to the AAAS Committee on Scientific Freedom and Responsibility is to urge attention to professional ethics concerns in science and technology, and to urge the affiliates to assist those scientists and engineers who experience difficulties as a result of having taken a position which they believe is mandated by their professional responsibilities.

One of the first actions taken by the AAAS Committee was to invite readers of *Science* who had ethical concerns to come forward and describe their experiences and to suggest what roles they would like to see professional societies exercise in response to these concerns. We received a large number of responses covering a broad spectrum of ethical concerns, ranging from private interests such as plagiarism or promotion criteria to more public issues such as concerns about possible risk resulting from scientific research or technical products or services. The Committee believed that it should initially respond to ethical concerns involving public issue as a matter of first priority.

We found that the available resources within the professional societies to assist members in difficulty are very limited at present, but that interest in developing new approaches to ethical concerns is increasingly on the rise. For example, if an individual is in litigation with an employer because he has been fired after releasing data which the company wished to withhold from public disclosure, it's very difficult for a professional society to jump into the litigation and play an effective role. Most societies are not equipped at present to defend their members in court. However, many societies are using these cases to educate members to the problems and pitfalls that may accompany actions related to ethical concerns. Such cases also alert many within the profession to the need for stronger legal protections for concerned employees.

There are many cases where an individual may be in the beginning stages of a potential conflict with an employer, in which he says, "There's something going on here that's not what I think is in the best interest of the public. It may represent a danger or a potential risk. And I would like an opportunity to talk with some of my fellow professionals outside the company, who don't have any direct investment in the project itself, to see what they think and to see if I'm justified in raising some of these concerns." At this point I think the professional societies have resources available to put a concerned individual into contact with two or three other members on a confidential basis to explore what factors should be taken into consideration in making a judgement about identifying risk. Difficulties will be encountered—particularly if a case involves confidential information or trade-secret information—but it's the kind of situation where it's important for the profession to provide support and to reaffirm their tradition that professional judgments require open dialogue and exchange of views among colleagues that are not hampered by private interests.

As evidenced by the response to the *Chemical Engineering* survey, there is a tremendous amount of interest in engineering ethics at present. This interest is prompted in part by a search for clear-cut solutions to the knotty value judgments that must be made by individuals and by a pluralistic society in using science and technology to build society became increasingly sensitized to an awareness that science and technology could be used both for good and for evil, and that technology may have unintended side effects detrimental to individuals who are not directly served by—or who do not participate in the decisions to use—a particular technology. A number of highly-publicized cases involving toxic pollution and environmental waste raised many questions for citizens who had not previously been concerned about the long-range impacts of science and technology. Housewives, clergy, blue-collar workers, and many others asked whether the price of compensating for the health risks of Love Canal was worth the benefits produced by the chemicals stored there. And society in general began to ask: "How do we make our views known to the people who are designing science and technology so that our concerns will be kept in mind when decisions are being made in determining how much safety or risk is being assumed in the design of a product? Who protects the public interests of society?"

In response these questions, the professions are traditionally assumed to be the guardians of the public interest. As independent professionals, we share a commitment to public service beyond private or personal gain. We also have private responsibilities to our clients and to our employers, but in many professions the commitment to public service is held to be paramount to other loyalties. Accordingly, the professions have a responsibility to demonstrate to the public how these public service ideals are addressed in terms of (a) the training of new members of the profession, (b) the correction of abuses when they do occur, and (c) the formulation of new rules or principles affecting professional work.

For this reason, the codes of ethics of the engineering societies have come under public scrutiny in recent years to determine whether the principles and rules included in the codes address the public's common good beyond the private interests of the profession itself.

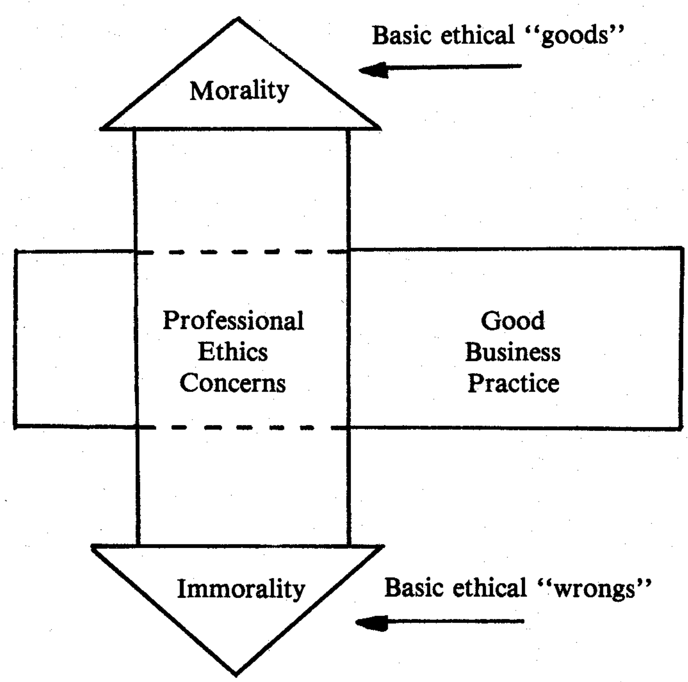
The Central Issues in Engineering Ethics

I mentioned earlier that the current interest in engineering ethics is stimulated by a search for clear-cut solutions to value judgements. This search is often an elusive one, producing many more questions than answers. But in searching for the basic moral principles which lie beneath ethical dilemmas in enginnering, we learn something about the kinds of goals that we strive towards as a society. These goals may be contradictory at times. The experience of looking for ethical principles—even though it may not provide exact answers—may thus transform the engineering profession into one in which technical decisions more directly reflect the values of our society as a whole rather than those of the more narrowly constituted profession. The search for moral principles has fundamental implications for our concept of the profession as a whole.

One part of this new introspection is a national project, directed by Robert Baum of Rensselaer Polytechnic Institute, that paired philosophers with engineers to explore how the existing codes of ethics of the engineering professions might be improved.[3] The project conducted an intense review of the basic moral principles that are imbedded in these codes, and the philospher–engineer teams explored ways in which the codes might be revised to reflect the changing times and the changing public expectations of the engineering profession.

Another project, conducted by the Hastings Center in New York, reviewed the state of ethics educatonal programs in the professional schools across the country. As part of this project, the following issues were identified as ones of central concern in the engineering ethics field today: advertising of engineering services; competitive price bidding; the accreditation of engineering curricula; engineering licensing and registration; affirmative action policies in engineering; age discrimination in engineering; product liability and quality control responsibilities; conflicts of interest; patent rights; trade secrecy policies; engineering employment contracts; problems of engineers employed in foreign countries; formulation and enforcement of codes of ethics; the setting of fee schedules; risk assessment; whistleblowing; bribery and kickbacks; criticism of other engineers' work; informed consent on engineering projects; professional autonomy and employed engineers' technical dissent in organizations; pro bono activities for engineers; individual responsibilities on large-scale projects; and unions and professionalism.[4]

It's difficult to know where to begin in addressing this range of issues. But one distinction that might be useful to those of us who are new to the field of moral philosophy is to use a road map identifying the points of morality that we wish to strive toward and the points of immorality that we wish to avoid. A simplistic view of such a map would look like this:



The diagram represents various sets of issues that involve moral values. The two triangles at the upper and lower parts of the diagram include those values in which there is consensus in religious, moral, or political philosophy as to what are basic ethical "goods" or "wrongs" for an individual or a society. The upper triangle would include, for example, a respect for life, compassion, honesty, as well as the rights to work, to education, to security. The lower triangle would include those values that represent a violation of these "goods"—for example, the destruction of life, greed, deception, as well as unemployment, discrimination, and disorder. The area covered by "professional ethics concerns" between the points of morality or immorality represents a region of values that are not in themselves ethical goods or wrongs. This area may have many values in conflict: for example a potential threat to human life caused by a product which creates jobs for many people.

Overlapping the professional ethics middle ground is a yardstick which I term "good business practice." This yardstick is the visible set of rules or guidelines which result from the resolution of professional ethics dilemmas. It is basically a product of consensus and as such it may represent a set of trade-offs among ethical "goods" and "wrongs." A single ethics question might encompass both moral issues and issues of the good-business-practice variety, in which preestablished rules or guidelines are examined in the light of changing values or changing consensus. The "good business" rule itself, however, may not explicitly address a particular value.

In looking at engineering ethics issues, we discover that a specific action may lean toward the moral or immoral triangle depending on the social context in which that action is viewed. Boundaries shift with time as society changes. Something that has been accepted by the profession over the years as simply a good business practice may suddenly be found to have moral implications that were not considered important when the profession first established the practice.

For example, many professions established a ban on advertising early in their existence on the basis of what they believed to be in the best interest of society—namely, to protect an uninformed public against charlatans who might offer lower rates, but who would not provide a quality professional service at those rates. As times changed, however, society has placed more value on the consumer's right to be informed. The advertisng ban began to raise some basic moral questions about the right of individuals to decide for themselves what is in their best economic interest: does the individual want a group—namely, that group representing the profession—to stand between him and the professional with whom he does business? What actions are really in the best interests of society if the members of the society feel that they are informed enough to make decisions about these matters? Who should represent society's interests when these decisions are being made?

This trend toward increased public participation and government intervention in matters affecting the professions is now being extended to professional accreditation, educational curricula, and other areas where policies adopted in accordance with standards of good business practice or professional etiquette may not have taken account of some of the basic moral values that are becoming important to society today.

In addition to issues imbedded in "good business" concerns, another set of ethical issues related to science and technology are emerging in the context of military applications of professional knowledge. There are very few written examples of scientists or engineers addressing the ethical principles which guide their actions or decisions in developing new weapons. But I've recently seen an excellent discussion by Freeman Dyson, a physicist at Princeton, who included a chapter titled "The Ethics of Defense" in his book *Disturbing the Universe.* Dyson wrote in particular about his dilemma resulting from an invitation to participate in developing the electronic battlefield project in Vietnam:

> The most ambitious attempt by civilian scientists to intervene in the Vietnam war on a technical level was a project called the Barrier. The idea of the Barrier was to stop enemy soldiers from walking into South Vietnam by means of an elaborate system of electronic burglar alarms and minefields dropped by airplanes along the frontiers. Secretary of Defense McNamara was enthusiastic about the Barrier, believing that it would be a substitute for the costly and politically unpopular use of American ground troops in search-and-destroy operations. The professional soldiers were less enthusiastic. They did not believe it would work. I was invited to join the Barrier project and considered with some care the ethical questions that it raised. According to my general principle of preferring defensive strategies, the Barrier was theoretically a good idea. It is morally better to defend a fixed frontier against infiltrators than to ravage and batter a whole country. But in this case, if one believed that the war was wrong from the beginning, a shift to a defensive strategy would not make it right. I refused to have anything to do with the Barrier, on the grounds that the ends it hoped to achieve were illusory. But I do not condemn my friends who worked on it in good conscience, believing that it would save many lives and mitigate the effects of the war on the civilian population of Vietnam. Their efforts were in vain, for the Barrier was never installed. If it had been installed, it would not have changed the course of history.
>
> I believe that the Barrier would have been not only effective but morally good, if there had existed inside it a government and a people with the will and the competence to operate the system themselves. As a part of an indigenous effort of a country to defend itself, the Barrier would have made sense. What made no sense was for American technicians and air crews to operate a sophisticated defense system around a territory that had no political cohesion and no capable military forces of its own. It is unfortunate that the concept of the Barrier grew out of a hopeless attempt to save the American intervention in Vietnam from inexorable defeat. The association with Vietnam gave a bad name to a good idea. (5)

Dyson lays out some of the basic principles that he personally gave weight to in making what for him must have been a very difficult decision about whether or not to become involved in this particular project. This type of discussion explicates the values and moral principles on which a person bases his decisions, and it is sorely lacking in the professions today. I hope that your CSIT group will begin to fill this gap by providing some discussion of what you, as engineers, see as the basic social concerns that shape your professional work: i.e., what are the considerations that you give weight to in deciding, for example, how much emphasis to give to a safety factor in designing a piece of equipment? When you begin these kinds of discussions, you're going to have to go beyond the engineering community to get some ideas and perspectives on what it is that society is giving weight to. There's a need to begin to think systematically about these values, rather than to assume that everyone knows what the right thing is and what the wrong this is. We must develop ways to glean out concepts of right and wrong in order to identify the values that shape those concepts.

Value Conflicts in Science and Technology

It's very difficult to deal with these morality–immorality issues without lapsing into ideological discussions. It's much easier to stay in the area of good-business-practice types of issues, which can identify clear-cut rules without tying them to specific moral goals. (e.g., "It's appropriate to advertise" or "It's not appropriate to advertise.") Once you enter the arena of values in conflict, ethical questions cannot be resolved with simple rules. We need the kind of questioning, the kind of critiquing that Dyson has gone through in laying out the values that need to be weighed in making an ethical judgment. The fact that these value con flicts are so difficult to resolve may explain why the ethics activities of the professional societies have focused instead on the good-business-practice kinds of issues. The problem with this narrow focus is that it draws attention away from the basic value conflicts that shape the whole future development of science and technology. If your group is going to get involved in engineering ethics activities, I hope you will try to keep the focus in the morality–immorality area and not get trapped in the area of solely critiquing good-business-practice-type issues.

One of the most important value conflicts that I see occurring today in science and technology is balancing the needs of a society for effective communication with the rights of an individual to privacy and confidentiality. There has always been a historic tension—particularly in democratic societies—between individual rights and the common good, and it is now appearing in the development of information technology. One of the major challenges facing the professions is the preservation of the rights of indvidual choice. Yet the profession also has a vested interest in ensuring that the technology is developed in a way that serves the collective interests of society.

It's very important that engineers be aware of and acknowledge the basic values that guide their technical choices. Otherwise we have a situation which I call *ethical drift,* in which a common response is, "I'm designing something that is value-free; it can be used for either good or evil. There's a particular need that I'm responding to, and there really are no broader ethical issues associated with it." This is a very narrow—and dangerous—perspective for a professional to have. There's a real need for the engineer to ask: "What values are imbedded in the private demands that I'm responding to? What public goods do they address?" This is not to say that engineers should become philosophers. But they need to recognize the value implications of their work. Ethical drift avoids these questions; it attempts to "resolve" them by simply not thinking about them.

Conclusion

In conclusion, I will suggest some specific activities through which professional groups like CSIT can contribute to the work that is going on in engineering ethics.

First of all, there's a real need for engineers to clarify, by discussions among themselves, some of the basic values that are seen as being important in engineering work today: What are those values? What considerations shape the way in which engineers do their work? What are some of the areas of value conflict—areas in which there is disagreement about priorities in an engineering project? How are these value conflicts resolved?

Once some basic values have been identified there's a need to lay out some of the fundamental principles that surfaces in the work of engineers today. From the collective experience of its members, a group like CSIT could construct some hypothetical or actual cases that illustrate the ethical dilemmas encountered in the electrical engineering profession in modern times.

Then there's a need to involve students in these discussions. Many students are seeking ways in which to integrate, in their future career, their concerns about environmental quality and other societal problems with their technical expertise. Engineering ethics courses are appearing at many universities, and it would be productive to have a regular forum for an exchange of ideas between students taking the ethics courses and engineers with real work experience.

It's important that links be established with other professional groups. Once a group such as yours has established its own objectives and identified some of the key moral values to be emphasized, contacts should be made with similar groups, not only within the IEEE, but within other engineering societies as well. Bridges can then be built between the engineering profession and other areas of the sciences—including the social sciences—to see how other groups grapple with the issues of concern to you. For example, the American Psychological Association has examined the issue of information technology and privacy, and its implications for individual rights; their conclusions might be of interest. The humanities are one field that will increase in importance as we learn that the existing kind of science and technology is really shaped by what society expects that specific science and technology to do—what the qualities of life are to which society gives importance. The humanities can provide us with some perspective on the qualities of a "good life."

Aside from professional societies of national scope, there are many local groups with similar interests with whom liaison can be established. In the Washington area, for example, The University of Maryland has a Center on Philosophy and Public Policy that studies areas related to science and technology. The Kennedy Institute of Georgetown University is examining the moral implications of scientific and technical decisions in the biomedical field. There are many other groups—civic, religious, and public-interest groups—now addressing science and technology as part of their concerns.

Finally, in the Washington area, where government policy itself raises issues of concern to the engineering profession, there is an opportunity to interact with some of the people making policy decisions. For examples, we have invited representatives from the Labor and the Commerce Departments to our committee meetings at AAAS to discuss their policies which affect issues related to scientific freedom and responsiblity. We're involved in a dialogue to help shape some of the policies of these departments in ways that would benefit scientists and engineers who raise ethics concerns. Many other government agencies are also looking for assistance and discussion on such issues.

In becoming actively involved in engineering ethics, an engineering group such as CSIT is part of a much larger fabric that extends beyond the group and beyond the specific professional society. Because of the particular knowledge and experience of each group, it is in a position to make an important contribution to this effort and to assist in transforming the profession to take account of the values important to our late 20th century world. It's an exciting opportunity.

Recommended Reading

General Ethics and Engineering

Ian G. Barbour. *Technology, Environment, and Human Values.* (New York: Praeger, 1980). Paperback.

Philip L. Bereano. *Technology as a Social and Political Phenomenon.* (New York: John Wiley & Sons, 1976).

Robert J. Baum and Albert Flores. *Ethical Problems in Engineering.* (Troy, NY: RPI Studies in the Human Dimensions of Science and Technology, 1978). Paperback.

Harold Fruchtbaum (ed.) *The Social Responsibility of Engineers.* Proceedings of a conference sponsored by the New York Academy of Sciences. Annals of the New York Academy, Vol. 196, Article 10, pp. 409–473. Febraury 28, 1973.

Robert F. Ladenson et al. *A Selected Annotated Bibliography of Professional Ethics and Social Responsibility in Engineering.* (Chicago, IL: Center for the Study of Ethics in the Professions, Illinois Institute of Technology, 1980). Paperback.

Edwin Layton. *The Revolt of the Engineers.* (Cleveland: Case Western Reserve Press, 1971). This is out of print—try your library.

Specific Ethics Cases

The BART Case: see Robert M. Anderson *et al. Divided Loyalties.* (West Lafayette, IN: Purdue University Series in Science, Technology and Human Values, 1980). Paperback.

Goodyear Brake Case: see U.S. Congress, Joint Economic Committee, Subcommittee on Economy in Government *Air Force A7D Brake Problem.* Record of hearings on August 13, 1969. (Washington, D.C.: Government Printing Office, 1969).

Dames & Moore Case: see articles by Robert McLaughlin in *New Engineer,* June 1976 and August/September 1978.

Hypothetical Cases

National Society of Professional Engineers. *Opinions of the Board of Ethical Review.* Vols. I–IV. (Washington, DC: NSPE).

References

1. Roy V. Hughson and Philip M. Kohn. "Ethics." Two articles in *Chemical Engineering.* May 5 and September 22, 1980.
2. Details of this case are drawn from private correspondence and articles in *Science* (March 7, 1980, p. 1057), the *Newsletter* of the Health Physics Society (May 1980, p. 1, 13), and the *Columbian Missourian* (December 11-12, 1980).
3. The product of one such team effort is described in "Proposed: A Single Code of Ethics for all Engineers" by Andrew Oldenquist and Edward E. Slowter, *Professional Engineer,* May 1979, pp. 8–11.
4. Robert J. Baum. *Ethics and Engineering Curricula,* Monograph VII of the Teaching of Ethics Project (Hastings-on-Hudson, NY: The Hasting Center, 1980).
5. Freeman Dyson. Disturbing the Universe, pp. 150–151 (New York: Harper and Row, 1979).

News, Notes, and Comments

Society for Social Implications of Technology: Executive Committee Approves Status

At its January 12 meeting, the IEEE Executive Committee approved the formation of a Society on the Social Implications of Technology (SSIT), subject to several conditions. These are: (a) that a constitution satisfactory to IEEE's main boards be submitted for approval within six months, (b) that the field of interest statement and operating procedures of SSIT be checked to ensure against conflicts with the roles of other IEEE entities, and (c) that the history of the societal aspects of electrotechnology be added to the field of interest statement. None of these conditions are expected to pose any significant problems, since a draft constitution has already been developed by an AdHoc committee of TAB, the history of technology would fit well into the field of the new Society, and there do not appear to be any conflicts with the activities of other IEEE entities.

The matter was discussed at the 1/17/81 meeting of CSIT, and a subcommittee was appointed to revise the constitution as appropriate. (The committee consists of R. J. Bogumil, F. Kotasek, S. H. Unger, and W. H. Underwood.) It is anticipated that a final version of the proposed constitution will be ready prior to the end of February.

Before reaching the Executive Committee, the SSIT petition, which by then had well over 800 signatures, was presented again to TAB at its 12/4/80 meeting. Pursuant to TAB action at its previous meeting, the proposed constitution referred to above was integrated into the proposal. The adhoc committee that drafted it was composed primarily of individuals representing the views of those who were most skeptical of the SSIT concept. In line with a proposal made by then President Leo Young, a key feature of the constitution is that the seven TAB Directors will each appoint a member of the Society's AdCom, which also is to include nine people elected by the members of the Society.

After considerable discussion, TAB recommended approval of the proposal by a vote of 16 to 15. There were a number of reasons why the vote to approve was so close. One was that a number of SSIT supporters (including President-elect Dick Damon) were unable to attend the meeting due to a conflicting meeting. But a more important reason was that a number of Society AdComs has instructed their TAB representatives to oppose the SSIT proposal without having had the opportunity to consider the new factor introduced by the newly-proposed constitution. Although some opposition may have remained even if the AdComs involved had been able to act on the basis of more complete information, it is probable that the opposition would have been substantially dissipated had they been able to do so.

It is hoped that final action to launch SSIT will be complete in time to enroll members for 1982. Current T & S subscribers will be invited to become charter members. Their support of the petition for the formation of the new society was a major factor in the success of the effort. Steps are now under way to gain formal approvals allowing T & S to attain magazine status concurrently with the birth of SSIT.

Stephen H. Unger

News from Switzerland

The Working Group for Society and Technology of the Swiss Section of the IEEE held its annual open meeting on 10. December 1980 at the Swiss Federal Institute of Technology in Zurich.

As in the past, two main areas of interest were discussed: energy and communication.

The format for these annual meetings has members of the working groups present background material and the results of the groups' own deliberations followed by the presentation of a guest lecturer.

In the area of energy, group members reported on the World Energy Conference held in Munich last fall and on a concept for energy self-sufficiency for Switzerland. The guest lecturer was Dr. Hans Luzius Schmid, scientific advisor to the Swiss Federal Department for Energy, who spoke on the outcome of the recently finished, Government-initiated study of an energy strategy for Switzerland. There is substantial debate concerning the need for more nuclear power plants as advocated in this study vs. conservation measures.

In the area of communication, group members reported on recent developments: first on digital terrestrial communication technology and then on satellite communication technology. The guest lecturer was Franz A. Zolch, from the staff of the Swiss Federal Commission working on an overall communication media plan for Switzerland. In addition to the legislative basis for such a plan, some of the problems characteristic to Europe were discussed. Examples are satellite broadcasting from one country into surrounding countries and rights issues caused by the rebroadcasting of foreign programs by cable TV networks.

The goals of self education and of generally increasing the awareness of the social aspects of energy and communication seemed to have been well met.

Harry Rudin
IEEE Swiss Section
Working Group for Technology & Society

The Social Implications of Technology
or
The Engineer's Trilemma

ROBERT C. WINTON

"There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things."

Machiavelli (1469–1527)

The Engineer's Trilemma

As the debate on the social implications of technology (SIT) grows in volume, scope, and often in inaccuracy, one concerned voice is not heard. Engineers maintain their deafening silence, while at the same time seeking status and recognition as a concerned profession. The public, who see engineers as the source of the technological revolution, must be puzzled by their evident lack of interest shown in the social implications of the revolution engineers themselves are creating.

The effects of technology and its implications for society are now a live issue in the United Kingdom, and are generating widespread debate. Although this article draws on UK experience, its contents are relevant to the SIT debate which is, or will be, taking place in other countries as well. Joining in these debates will give engineers a fine opportunity to raise their status. The best way for engineers to do this is to communicate directly with the public on matters concerning engineers' work, in terms which the public can understand.

A possible immediate reaction might be, "Think about and talk about social implications—what me? I have no education, training, nor experience in social problems. Leave it to the experts." However, the truth is that in forecasting social implications there are no experts; the views of social scientists often conflict. On the other hand the engineer is knowledgeable on many aspects—what has and what has not been achieved to date; the speed and nature of future development and its cost; the application of new discoveries. The engineer also has a great deal of background and experience in education and training and, finally, the engineer is a citizen. This then is the engineer's SIT trilemma: how to discharge his responsibilities as technical expert, as educator and trainer, and as concerned citizen. And these are not three separated areas; the engineer will frequently find his responsibility spilling from one area into another, and will even occasionally be in doubt in which function his responsibility lies.

To join the SIT debate requires the engineer to keep himself informed on, and thinking about, all three aspects of this trilemma, which lie not only in those areas in which he has some special knowledge, but also in areas where he is, like everyone else, no more than a citizen. It will greatly help IEEE members to keep themselves informed on SIT if the steps being taken to form an IEEE Society on Social Implications of Technology are successful.

The author is a former Chairman of the UK and Republic of Ireland Section of IEEE, and is currently Secretary/Treasurer of Region 8.

The Art of Social Problems

The engineer who is concerned with social problems is entering a quite new and challenging field. Gone are the precise laws which govern engineering and which can be relied on to forecast results; gone is the knowledge that most of these results will be true anywhere in the world; gone is the ability to make assumptions, knowing how they will affect the accuracy of the results; gone is the relevance of experience in one set of circumstances to a different set of circumstances; gone is the ability to make precise measurements. Dealing with individuals and predicting their behavior is an art involving many unpredictable and uncontrollable factors, factors which differ tremendously from one country to another and even between one part of a country and another part. This is one of the major reasons engineers rarely discuss social problems and is the chief barrier they must break through to join the SIT debate. The purpose of this article is to pose some of the social problems resulting from technology, in order to encourage engineers to think about the issues and formulate possible solutions.

As engineers we have a great deal of catching up to do before we can join the SIT debate effectively. We must learn how to make ourselves heard by the public; we must learn how to make ourselves understood by the public; we must define our social responsibilities; and we must learn how to challenge the fallacies presented by other debaters. Equally as important as getting ourselves heard by the public is getting ourselves heard in those centres where the power lies, especially in government and on the boards of companies. Engineers must attempt to provide these centres with accurate and up-to-date information, and the best way of ensuring this is for engineers themselves to become members of these power centres. Some progress in these directions has been made in the USA; engineers in many other countries have further to go.

Getting Heard

How do we go about getting ourselves heard by the public? In today's world there is only one way to do this effectively, and that is through the mass media. Engineers must learn how to join in televised debates, how to be interviewed, how to get their opinions presented through the press. And I mean "learn"—to put your point of view effectively via the mass media requires training by those who know how to do it, and one of the best ways of increasing the status of engineers would be for every undergraduate to be given this training and encouraged to use it in the right circumstances.

The first step is to make the public aware that engineers are concerned about SIT and that they have considerable knowledge and experience which will benefit the SIT debate. A widespread misunderstanding which engineers must do their best to clear up quickly is that although engineers are responsible for developing new technology, they are not responsible for how it is applied. Application is determined largely by government policy, by commerical considerations, and by public demand.

Double-Speak

A most disturbing aspect of the SIT debate is the general ignorance about technical matters shown by those who control the applications of engineers' work, and who are responsible for causing and dealing with the social results. Not only the public, but politicians, civil servants, industrialists, and those working for the mass media, often show little understanding of the technicialities they are dealing with. This is a gap which engineers can fill, but since all these people will not study the technical side of engineering, engineers must study SIT. Like many other subjects, SIT has generated double-speak which must be challenged and exposed, and which must teach us to analyse what so-called experts say. Often heard, for instance, is the statement that new technology will create new jobs as well as abolish existing jobs. This is a numbers game which says that if X new jobs are created and Y abolished there will be a net gain in jobs of X minus Y. This game is based on the fallacy that everyone who loses a job will take over one of the jobs which has been created; it ignores differences in skill, education, training, and experience between the old and new jobs; it ignores the fact that many people do not wish to move from where they live, and the difficulties and delays often encountered if they do wish the move; it ignores the resistance of those who have spent a long time in one job changing to another job; it ignores the fact that those who lose their jobs are usually the older people who find it more difficult to absorb change than the younger.

We are told that the social structure survived the Industrial Revolution and, therefore, we shall survive the technology revolution. The first fallacy here is that we have not yet survived the Industrial Revolution; it produced many still unresolved problems, such as the gap which frequenctly divides management and trade unions, national and international economies which governments appear increasingly unable to control, and the energy crisis. Again, the new technology revolution is so different from the Industrial Revolution that there is really no analogy; the speed of change is now much greater, so that no one dies in the world they were born into; the effects of new technology penetrate far more lives, and penetrate them far more deeply, than did the effects of the Industrial Revolution; national economic systems are now much more interdependent, much less stable, and much more sensitive to any distrubance. Any adverse social effects of the new technology are being imposed on the considerable amount of social unrest which already exists.

The effects of SIT on employment has attracted more attention than its effects in any other areas, but here again we have a form of double-speak. Those who are unemployed need work and it is a fallacy to pass off their position as an increase in leisure or as a kind of affluent redundacy. We speak of natural wastage or attrition, meaning no one is dismissed, merely not replaced upon leaving employment. So no one gets hurt; no one, that is, except the individual who would have stepped into the job if it had still existed and who remains unemployed instead.

Yet another fallacy is that every new idea will be immediately applied and its social implications quickly felt. Forecasts of the rate at which change will be introduced are made by specialists who speak about the "inexorable advance" of some new technique or new system because they see only the commercial pressures building up to transfer new devices into the hands of users. It is the user who decides how quickly anything comes into use; those who ignore this find either that there is virtually no market or that after new equipment is purchased it lies unused. For instance, teleconferencing, a telephone service which enables a group of separated people to have a communal discussion over their telephones, has never been a great success in the UK because participants find unacceptable the absence of togetherness, of visual contact, and of nonverbal communication. Teachers' resistance to completely new teaching methods was the major factor which killed the introduction of teaching machines in the 1950's and 1960's. I believe that working with robots, the paperless office, working from home, and working with an "ultra-intelligent machine" are examples of other developments which will likewise not be accepted as soon as they become technical and economic realities. Another popular fallacy is that equipments go wrong but human operators never make mistakes, and that if a computer is in control of a system it is invariably the fault of the computer if things go wrong. If people realized that it is almost always a human fault somewhat along the line, and did not allow human error to hide behind computers, we would all be better served. Another widespread fallacy is that 100 percent realiability can be designed in; there is little understanding that reliability can never be based on more than a probability.

On these and on many other technical misunderstandings the engineer is the expert, and can establish his expertise and his concern with SIT by the educating the public to a correct understanding of reality.

Change

The only true generalization I know is that generalizations are never true. The category "people" does not refer to a homogeneous group, but a collection of individuals who will react to change in different ways. The difference in reaction to change between the old and the younger has already been referred to. Change has three basic components—type, volume, and speed of change—and each of these is significant in making a change acceptable and unacceptable.

For instance, much of today's unrest originates in the boredom of workers who are tied to repetitive tasks carried out by a machine at a pace which they cannot control. Data processing systems, for instance, can create frustration. By making it more difficult to obtain information (a not infrequent result of installing a DP system), people find it more difficult to carry out their work; another result is that people who formerly had the satisfaction of working in a group now work in unhappy isolation; in addition the equipment may not react to controls in the way the operator expects. From the engineer's point of view all this adds a new dimension to the man/machine interface—a social dimension, a need to design "user friendly" equipment. "People acceptability" should become a major deign consideration.

The volume of change to be introduced at one time is important because many changes introduced in parallel over a long period may be as unacceptable as a few changes introduced over a short period. It is the product of volume of change multiplied by the rate of introduction which is a more significant factor than either component taken separately.

When considering the type of change it is important whether the change is a continuation of existing methods by new means, or whether it introduces something new. The first will usually be more acceptable than the second. For instance, in domestic equipment the introduction of electronics in place of electro-mechanics make little difference to the person pressing the botton of, say, a washing machine. But changing the button and indicator interface to two-way person/machine speech would be far less acceptable, at least initially.

Education and Training

One of the few aspects of SIT on which there is general agreement is the need for initial education, continuing education, training, and retraining to play an increasingly significant role. In the technical education and training area engineers have the specialist background to play an important part, not only in devising syllabuses to meet industry's needs but also in the task of defining those needs. Defining the needs for continuing education, training, and retraining is not too difficult because such courses are short and industry's needs do not change much during such short periods. But for initial education the task is much more difficult because there may be a gap of four to six years between establishing the syllabus and the time when the first students complete the program, which poses the impossible problem of devising a syllabus which will meet industry's demands for "oven ready" graduates but with a long half-life.

The ability of people in the work-force to accept change is a key element in industrial and commercial success. Consequently a new educational element will be required—the concept of educating people to accept change. We must make students more aware of the implications of the half-life period of what they are taught at college; that during their career they will be faced with changing their jobs, moving home, acquiring new skills, undertaking continuing education and retraining; that they must not only learn what is new but also unlearn what is out-of-date. This view of work must be taught to some extent at all levels, from the shop floor worker to the manager. And, as a corollary, there will also have to be education of employers to accept that their staff and work-force must be given opportunities for continuing education and retraining, and that in assessing an individual's potential for employment or promotion they may have to assess a additional factor—"retrainability"—since an ability to benefit from continuing education and retraining will become essential for a wide spectrum of workers.

Opinions are divided on whether the new technology will throw people out of work. In the UK the majority opinion is that the introduction of new technology will leave less work to be done by people, which will lead to higher unemployment, longer holidays, earlier retirement, and shorter working hours. In whatever way these elements are mixed, we shall be faced with more time away from paid work, and one of the additional tasks of education will be to teach how this time can be usefully and interestingly used, and avoid it producing frustration and boredom which in turn produce social problems. During the 1990's we shall have to find outlets for human energy which is no longer channelled into paid employment.

The engineer is fitted to take a leading part in these processes of education and training for change. In areas where he has specialized knowledge he can clearly take a leading role; in areas outside his specialization he can still contribute because he has first hand knowledge and experience of the education and training process.

The corollary of having more time away from paid work is education in the concept that paid work is not the most important of life's activities, and that everyone does not have a right to paid work. Of course this concept makes no sense unless the unemployed, and those with more time away from paid work, somehow receive an income adequate to meet at least life's basic needs, and unless such a society can be operated without serious side effects such as an unacceptable rise in taxation and in manufacturing costs. These are major, basic problems posed by SIT.

Unemployment

The SIT debate is giving more attention to the effect of new technology on employment than to any other single aspect. It is an aspect which will continue to attract great attention, and it is an aspect of a special importance to engineers because it concerns them in all three components of their trilemma.

Opinion is deeply divided over the effect which new technology will have on the numbers in employment, although many people have accepted that refusal to come to terms with the new technology will make it impossible to unemployment and the fall in living standards the results of non-acceptance must be worse than acceptance.

After a two-year study Arthur D. Little, management consultant, quoted in the British journal *Electronics Weekly* for March 28, 1979, forecast that by 1987 microelectronics will provide a net increase of one million jobs in the UK, France, the Federal Republic of Germany, and the U.S. American and Japanese opinion believes on the whole that unemployment fears are exaggerated. Wilfrid J. Corrigan, Chairman of the Fairchild Camera and Instrument Corporation, is quoted in *Electronics Weekly* for November 15, 1978, as saying that the suggestion that microprocessors will put people out of work is "a load of British bull----," and a study group set up by the British Department of Employment uses less colorful language to report that "few companies state the microelectronics applications, whether in products or processes, are likely to lead to redundancies. Most companies take the view that any necessary reduction in manpower can almost certainly be achieved by natural wastage." (The Manpower Implications of Microelectronic Technology—Jonathon Sleigh, Brian Boatwright, Peter Irwin, Roger Stanyon, Her Majesty's Stationery Office, page 93.)

On the other hand many trade union leaders believe that the new technology will cut jobs drastically and Prof. Tom Stonier of Bradford University, England, stated on the BBC World Service Program "*The Microfuture*" in March, 1979, that in 30 years' time all our material needs can be satisfied by one-tenth of the present labor force.

There are a number of points to remember when sifting these conflicting viewpoints on the effect of SIT on unemployment. Firstly, no one knows exactly what form the new technology will take, how quickly new developments will spread into production, what new pro ducts and services will arise, and what the rate of marketing will be. Secondly, all these uncertainties will be superimposed on the existing uncertainties and problems of national economies. Thirdly, we shall mislead ourselves by using the word "unemployment" in a generalized way. SIT-induced unemployment will be more severe among some groups of workers than among others; we must look not only at the forecast numbers in unemployment but also examine whether there will be a redistribution of skills which will lead to an increase in both unemployment and ing "structural unemployment;" apart from the effect on the total number of people employed there may be an effect on the number employed among a specific group of workers whose skills are no longer required, or SIT may appear in the form of changed ratios of male/female or part-time/full time jobs, and in the regional allocation of jobs.

Conclusion

This article has touched on a number of controversial points which I believe are relevant to the great SIT debate. But the major message is that each and every engineer should be prepared to join the debate and to face the trilemma of how to do so as technical expert, as educator and trainer, and as concerned citizen. Engineers will not be able to take part without adequate reading and discussion of all aspects and arguments of the debate in order to form intelligent and reasoned views. Taking part in the debate will establish their concern and status as professional engineers and concerned citizens.

Some further reading:

The Third Wave—Alvin Toffler (Collins)

Managing the Development of Microprocessor-based Systems-Eddie Bleasdale and John Walker (Bleasdale Computer Systems)

The Viewdate Revolution—Sam Fedida and Rex Malik (Associated Business Press)

The Future with Microelectronics—Ian Barron and Ray Curnow (Francis Pinter)

The Mighty Micro—Christopher Evans (Gollancz)

The Collapse of Work—Clive Jenkins and Barry Sherman (Eyre Methuen)

The Manpower Implications of Microelectronic Technology—Jonathon Sleigh et al. (Her Majesty's Stationery Office)

The Impact of Microelectronics on the UK: A Suggested Classification and Illustrative Case Studies—M. McLean and H. Rush (Occasional Paper Series Number 7, Science Policty Research Unit (SPRU) University of Sussex, June 1978)

Book Reviews

Electric Automobiles—Energy, Enivornmental, and Economic Prospects for the Future. William Hamilton, McGraw-Hill Book Company, 1980. 425 pp., illus. $24.50. *Reviewed by John E. LaGraff, Associate Professor of Mechanical & Aerospace Engineering, Syracuse University, Syracuse NY.*

This recent release offers, perhaps for the first time under a single cover, a comprehensive analysis of the environmental, economic and social constraints controlling the potential role that electric vehicles (EV's) may play in the future transporation picture of the United States. At least it is as comprehensive as one can get with future projections of past trends especially in the notoriously risky business of energy-use and supply projections. The book is the result of a two-and-one-half year study funded by the U.S. Department of Energy and its predecessor (USERDA) under the direction of the author. At least seven other technical staff people are acknowledged by the author to have contributed significantly to the material presented. The comprehensive approach to modeling EV cycle costs, energy use, utility impacts, market penetration and environmental impacts certainly reflects the major effort of a large group. Although much new material was generated in the course of this study, especially in the modeling projections, the book is at least as valuable as a consolidated summary of the vast quantity of existing literature spread throughout the libraries of the world. While most of the detailed analysis of future transporation requirements and energy/fuel availability are specific for the United States market, many of the results could be easily interpreted or adjusted for other advanced industrial nations. This is especially true if some adjustments are made for utility fuel mixes, load factors, and of course a different set of constraints on the policy options.

The author assiduously attempts to avoid taking on an advocacy role for electric vehicles. In this he, for the most part, succeeds. So much so, in fact, that advocates may be disappointed. Projections to the year 2000 of the major trends that will determine EV impact are made in comparison to reasonable projections of gasoline-vehicle performance. Thus, projected improvements in gasoline-vehicle fuel economy and emission levels would lessen the impact of EVs considerably in these important areas. The major conclusions of this book are presented separately in terms of (1) primarily economic grounds, and (2) "societal" considerations. Thus, an individual "free market" decision based on capital and operating costs and vehicle performance will limit the market penetration considerably in the near term considered in this book. It will only be with some market adjustments through legislated approaches that the market for EVs will be enhanced to the point of having significant impact. Although there will be a measurable beneficial societal impact in the areas of urban air pollution and urban noise, the impact on energy use (or specifically petroleum use) can be important enough to make the role of EVs in a future transportation mix worth encouraging (e.g., by the year 2000 with 60% market penetration, a reduction of 83% petroleum use for cars is possible). Overall energy use would be improved only if the primary source of the energy was coal for both electricity and gasoline (synfuels). This is due, of course, to the significant inefficiencies of the synfuel approach and not to the overall energy efficiency of EVs. The impact on petroleum can be major, however, if the EV recharging is done from coal and nuclear based power. Obviously this is an important societal-public policy question and cannot be made on simple economic grounds.

The above conclusions are, where possible, quantified and the public policy questions offered only after a very thorough analysis of each of the major factors (and some minor ones, e.g., eliminating lubricating oil dumping and used car body dumping) which can determine the future of EVs. Thus, there is a separate chapter on each of the following areas: future battery technology, future EV configurations and performance, EV operating conveniences and costs (market), energy-use impact, petroleum use, urban air quality, urban noise, materials availability, and industrial economic impact. Each chapter can stand as a separate technical report complete with a full reference listing. Although many of the cited references are from difficult-to-find documents, a useful service is provided by reprinting much data from these widely scattered sources in one text. The author deserves much credit for this effort alone. In addition, each chapter contains much in the way of new analysis using well-documented projection models and often posing important new questions which should be considered by policy makers.

Also, each chapter is a useful point of departure for anyone interested ininitiating research in some aspect of electric vehicle design. In fact, even planning groups such as transporation planners or urban planners will find much of the material of great interest in their work quite apart from the EV analysis.

There are always many uncertainties in talking about the future. This book acknowleges that there are areas where their projection can be seriously disrupted. Some of these uncertainties are identified, others, probably are not. As an example, the availability of excess capacity in electric power generation depends on many factors. Other pressures working to improve utility power factors may remove potentially cheap off-peak power as a recharging source. Some European power companies, it is pointed out, have already essentially leveled their load through residential storage heating applications.

Some of the other uncertainties identified include the availability of off-street parking in the urban areas where EVs have their best cost-benefit potential (e.g., up to 48% of urban cars may be parked on the street). This is important for those considering EVs. Another is the availability of raw materials for some of the proposed battery compositions. We may become dependent on another limited imported raw material in exchange for relief from the OPEC oil dependence. Also, the possibility of surprises in battery technology is recognized. A range of currently attractive technologies is considered in the excellent chapter on batteries, and yet some are left out of the analysis. One type has received much attention in the months following the release of the book (zinc chlorine) but received little attention in the book.

In summary, this book represents an excellent addition to the literature. It brings together in a single work the efforts of many workers and offers a sufficiently comprehensive treatment of the subject to be of value to research workers and policy makers alike.

Housing in Third World Countries, Perspectives on Policy and Practice, edited by Hamish S. Murison and John Plea, St. Martin's Press, New York, 1979, 182 pages. *Reviewed by Dipak L. Sengupta, Research Scientist, Electrical and Computer Engineering University of Michigan.*

The book under review is the result of an International Workshop on Housing for Third World Countries held in Australia in June 1978. The stated objectives of the Workshop were "to explore the issues of housing in Third World Countries and to provide a forum for the exchange of ideas on human settlement policies." The workshop participants were people in a position to influence, formulate and implement housing policies in their own countries.

The contents of the book represent the proceedings of the Workshop, and are written by nineteen experts associated with various Australian Universities and other organizations. Since there are no contributions by any of the participants from the Third World, the experts and planners of these countries may consider the opinions ex pressed as foreign having little or no direct application to their problems. In spite of this, it is a valuable book and contains a wealth of information.

The book is divided into two parts: the first part consists of theoretical discussions of the socioeconomic aspects of housing in the Third World, and the second part discusses the practical aspects of housing technology.

The majority of the theoretical papers discuss the ideals and goals for human settlement, as perceived by non-Third World minds using non-Third World values, standards and requirements. Because of this, the present reviewer feels that the Third World may not be fully receptive to the ideas presented. This point is brought out very clearly in Chapter 4 entitled "Housing Deficit in Cities of the Third World: Facts or Fiction?" where the author, Dr. Odongo, questions the fundamental assumptions used by the experts from the industrialized nations in formulating solutions to such problems. Housing being a socioeconomic problem, its solution will depend on, among other factors, the standards guided by local cultural norms which in many cases may be vastly different than those in developed countries. Nevertheless, the planners in the Third World may find the book useful. Although they may not agree with all the conclusions reached, the analytical discussions of various issues given will certainly help them in the formulation of their policy.

The second part of the book discusses at length the technical aspects of housing from the viewpoints of climate, comfort, shelter, energy, manpower and skills during a town's development. There is much information here which would be of practical use during the actual implementation of a town planning.

Overall, the present book should be of interest to those involved in housing in Third World Countries. In particular, persons in the United Nations as well as other industrialized countries who are developing some planning towards providing help and/or advice to the Third World may find it useful. A detailed bibliography given at the end of the book will be of interest to those engaged in urban and town planning not only in the Third World but also in the other two Worlds!

One of the debates going on within the professional communities of engineers and scientists concerns questions of human rights and the responsibilities—both personal and professional—that individuals have to preserve and protect these rights for colleagues of any nationality. Among engineering professional societies, the American Society of Civil Engineers (ASCE) has taken a public position on the matter. The Board of Direction of ASCE adopted the statement reprinted below on April 13, 1980 to explain publicly why ASCE should be a participant in the movement for human rights. Comments of readers are solicited.

ASCE and HUMAN RIGHTS

"A prime responsibility of every Academy is to encourage and defend the scientific life of the country. Despite this fact, scientists of German society, as far as I know, have become silent witnesses to the fact that a considerable part of German scientists, students and teachers have been stripped of the possibility to work and obtain for themselves the means of subsistence. I haven't the slightest desire to belong to any scientific society capable, even under outside pressure, of conducting itself in such a fashion."

Albert Einstein, on resigning from the Bavarian Academy: April 21, 1933

Much has changed since Einstein wrote these words. Germany's National Socialist government has been eradicated and its racial teachings condemned. A body of international human rights law which provides standard frames of reference for a person's economic, social, civil, political, and religious rights has come into being since 1948, to guide the conduct of nations. Today the peoples of the world take notice and react with revulsion when governments tyrannize their citizens.

But much also remains the same: human rights violations still are commonplace occurences throughout the world; governments still imprison their citizens without trial; torture still exists; citizens are still deprived of the right to earn a livelihood for holding unpopular beliefs and persons are still harassed and imprisoned for trying to exercise the basic human rights defined by international law.

The theme in Einstein's statement—that professional organizations must not be silent and acquiescent to human rights violations—is as valid and relevant today as it was in 1933.

The standards and ideals of professional ethical and moral conduct to which an engineer and his professional organization subscribe do not allow ASCE to be a "silent witness" to persecution.

The American Society of Civil Engineers, is committed to the "advancement of the profession of engineering to enhance the welfare of mankind" and has challenged its members to "...advance the integrity, honor and dignity of the engineering profession by using their knowledge and skill for the enhancement of human welfare." These sentiments transcend a narrow interpretation of the engineer as only a technical practitioneer and ASCE as only a technical society. By its own words, ASCE declares itself a professional organization and thus accepts the broad based concerns of all professional organizations.

Human rights is one of these broad based concerns. ASCE has a unique opportunity to demonstrate leadership within the engineering community, by making a meaningful commitment in support of the human rights movement.

What makes the plight of the persecuted engineer so unique, that it is necessary for him or her to receive special support over and above that which others may receive? Actually nothing. The engineer's suffering is no greater nor lesser, at the hands of a tyrannical government, than any other segment of that country's society. But engineers are our own and there exists a special quality of collegiality among engineers of all nations.

Experience has shown that this special quality of collegiality can be more effective in supporting victims of oppression, than the appeals of the broad based human rights organizations. The professional organizations of lawyers, social scientists, physical scientists, and other groups have been effective in assisting their colleagues who were victims of persecution. By becoming involved, ASCE can offer the same kind of valuable peer group support to engineers suffering persecution at the hands of tyrannical and totalitarian governments.

There is a place, a need for, a professional responsibility for ASCE's joining the ranks of other professional organizations in the human rights endeavor.