TECHNOLOGY and SOCIETY

IEEE

CONTRIBUTED PAPERS, REPORTS, REVIEWS, AND CORRESPONDENCE OF THE COMMITTEE ON SOCIAL IMPLICATIONS OF TECHNOLOGY

EDITOR: NORMAN BALABANIAN **VOL. 8, NO. 2, JUNE 1980 (USPS 321-090)**

The Automobile Fuel Economy Standards: Are They Cost-Effective?

Making Sense Out of the Cost Benefit Analysis in the Harbridge House Report, "Energy Conservation and the Passenger Car, An Assessment of Existing Public Policy"

FRANK VON HIPPEL

Considering the world all round,
A thorough study has recently been found:
To save the place
For the human race,
Is not economically sound.

Heinz Kallman, 1978

The September 24, 1979 issue of the *New York Times* carried on the front page of the business section an article by Edwin McDowell entitled "U.S. Fuel Standards Questioned." The story described a study by Harbridge House, "a Boston-based management consulting and research firm." According to McDowell, the Harbridge House analysis

> adds up to a major challenge to the assumptions underlying the Energy Policy and Conservation Act of 1975, which requires auto manufacturers to build car fleets with increasingly higher miles-per-gallon averages. The assumption was that the energy saved in the program would vastly exceed the costs involved. To date, savings do appear to have slightly exceeded costs, but the study finds that the longer-term outlook for savings is grim.
>
> The analysis was funded by the General Motors Corporation on the understanding that the Harbridge House would exercise total control over the content. The technical advisor was David E. Cole, director of the University of Michigan's Center for the Study of Automotive Transportation, and the analysis was reviewed by faculty and staff members from Harvard University, the Brookings Institution, Purdue University, the University of Wisconsin, and the Massachusetts Institute of Technology.

The author is a senior research physicist at the Center for Energy and Environment Studies, Princeton University, NJ.

The Harbridge House report is available for peer review at a price of $50. The purpose of the present critique is to give a brief account of what one reviewer learned from the report about the costs and benefits of the current U.S. program to reduce the thirst of our "gas guzzlers."

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In This Issue

Note on CSIT People

In preceding issues of *Technology & Society,* the Editor has not been sufficiently diligent to ensure that the correct, up-to-date listings of CSIT officers and Chairmen of Working Groups appeared on this page. For this, I offer my apologies. At the March 15 meeting of CSIT, the new officers, including the T&S Editor, were formally reaffirmed. The listings appearing on this page should now be accurate.

Ethics Hot Line Established

The New York Section PAC has established an ethics hot line at (212) 679-0935. IEEE members whose job might be in jeopardy because of their adherence to the IEEE Code of Ethics can call this number and ask for advice. A number of IEEE members who have some experience in dealing with such matters have volunteered to serve as consultants. One of them will return the call and provide advice on a confidential basis. The idea originated with V. Edgerton, Chairman of NY PAC. Funding is provided by USAB and the enterprise has the cooperation of the Member Conduct Committee.

CSIT Meeting Schedule

Tentative dates of the next two meetings of CSIT are as follows:

Saturday, September 13, 1980
Saturday, November 15, 1980.

Meetings are held at Columbia University in New York, 13th floor of the Mudd Building from 10 am to 3 pm. Anyone wishing to attend a meeting should call Steve Unger to confirm the dates.

People Wanted

A symposium on Alternate Energy Sources to be held on Long Island is being scheduled for the spring of 1981. Anyone interested in participating on the Steering Committee and the Technical Program should please contact:

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as soon as possible.

IEEE TECHNOLOGY AND SOCIETY is published quarterly by the Committee on Social Implications of Technology of The Institute of Electrical and Electronics Engineers, Inc. Headquarters: 345 East 47th Street, New York, NY 10017. Subscription price: $2.00 per year, IEEE members only. Second class postage paid at New York, NY, and at additional mailing offices.

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The Fuel Economy Standards

The U.S. fuel economy standards were mandated by Congress in the Energy Policy and Conservation Act in 1975 when the average fuel economy of the new automobiles sold in the U.S. was still only 14 miles per gallon (mpg). The Act requires that by model year (MY) 1985 the "corporate average fuel economy" (CAFE) of the new automobile sold by each major manufacturer in the U.S. market should be at least 27.5 mpg, as measured on the EPA combined city/highway driving cycle. The Department of Transportation may raise or lower this target on the basis of further information relating to "feasibility" but may not raise it above 27.5 mpg or lower it below 26 mpg without being liable to veto by the House of Representatives or the Senate. Table 1 shows the milestones on the way to the MY 1985 target which have been established by Congress and the Department of Transportation.

TABLE I

Fuel Economy Standards for U.S. Automobiles

Model Year	Corporate Average Fuel Economy (mpg)[a]
1978	18
1979	19
1980	20
1981	22
1982	24
1983	26
1984	27
1985	27.5

[a] The average fuel economy is calculated by first calculating the average fuel *consumption* of the model year fleet (measured in terms of gallons per mile).

The Harbridge House Cost-Benefit Analysis

The *New York Times'* representation of the conclusions of the Harbridge House is accurate. Indeed the first of the eight principal conclusions put forth in the Executive Summary (p. 2) of that report is as follows:

> Congress originally expected the value of the energy conserved through the automotive fuel economy program to vastly exeed the costs involved; it now appears likely that the costs may exceed the savings. (underlining in the original)

The complete backup for this statement in the Executive Summary is as follows:

> The 1974 report to Congress by the U.S. Department of Transportation and U.S. Environmental Protection Agency was primarily responsible for the formulation of the Energy Policy and Conservation Act. This report estimated that in order for the automakers to achieve a 33 per cent gain in the overall fuel economy levels of new cars over a five-year period, an incremental annual investment of approximately $200 million would be required. It is now evident that just the capital investment associated with increasing corporate average fuel economy levels from 19 mpg in model year 1979 to 20 mpg in model year 1980 will be on the order of $2.5 billion to $3.0 billion. During the entire lifetime of these 1980 cars,the fuel saved, based on retail gasoline prices of $1 per gallon, will be worth approximately $3.0 billion.

This discussion contains major conceptual errors. The most serious of which is the implicit assumption that a capital investment in fuel economy improvements must be paid for by the fuel savings in the first year's production of automobiles which are affected by that investment. Below, I will explain this error and will then show that, when it is corrected, the Harbridge House (HH) numbers in fact provide strong support for the fuel economy standards. I will also review the other governmental and industry analyses which bear on the costs and benefits of the fuel economy standards and find that they also support the value of the fuel economy standards.

The Neglected Gasoline Savings

The conceptual error in the HH cost benefit analysis which is the primary focus of this paper is the implicit assumption that the only benefits from investments in improving the fuel economy of a given model year automobile are the resulting lower gasoline consumption by the automobiles produced during that model year. Thus, in the example chosen in the HH report, it was assumed that the investments made in raising corporate average fuel economy (CAFE) from 19 mpg in MY 1979 to 20 mpg in MY 1980 must be paid back by the resulting fuel savings in MY 1980 automobiles.

In fact, however, the tooling bought to increase the fuel economy of a given model year will ordinarily improve the fuel economy of automobiles for a number of years thereafter. This may be seen, for example, in the strategy by which HH expects GM to raise the average fuel economy of an annual output of 400,000 of its intermediate "A-body models" [1] from a value of 15 mpg in MY 1975 to 28 mpg in MY 1985. The type and magnitude of tooling and equipment investments by year are tabulated in Exhibit II-2 of the HH report. That table shows major investments involved in the projected program of fuel-economy improvements in two years only: $600–700M in MY 1978 with a "downsizing" and $750M in MY 1984 (1975 $) associated with a "reconfiguration" from rear-wheel to front-wheel drive. The investments made in these two years account for three quarters of all the investments in fuel economy improvment projected for the ten year period. HH explains that it chose this pattern of investment in order to match the product change cycle of the GM models where a "major vehicle redesign year" is scheduled for each body (pp. II-40, II-41.)

If we assume on the basis of a major vehicle redesign every six years[2], that the average useful life of the tooling is six years, then the investement should be credited with the associated fuel savings for *six model years* of production rather than the single year's savings credited by Harbridge House.

[1]Buick Century and Regal, Chevrolet Malibu and Monte Carlo, Oldsmobile Cutlass Salon and Cutlass Supreme, and Pontiac LeMans and Grand Prix.

[2]According to HH, the spacing of the major redesign years is closer for GM than for other companies.

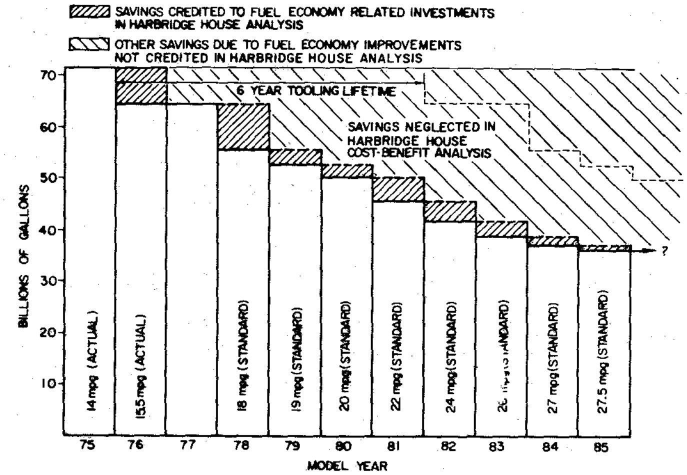

Figure 1

The magnitude of the error made in the Harbridge House cost-benefit analysis can be easily understood from Figure 1. There we show, for a hypothetical production of ten million automobilies per year[3] and an average expected automobile lifetime of 100,000 miles, the number of gallons of gasoline which will be committed for future consumption in each model year–assuming for model years 78 and beyond that the CAFE standards are just met on the road.[4] Harbridge House, by considering only the incremental savings in each model year has in effect credited these investments with saving only the amounts of fuel indicated by the heavily hatched boxes on Figure 1—ignoring the fuel savings in subsequent years. Obviously this is a large error which increases in magnitude the longer the fuel economy standards are in force.

Indeed, it could be easily argued that the fuel savings associated with more than six model years of production should be credited to the investments associated with the incremental fuel improvements. In Figure 1 it will be seen that, once an incremental fuel economy improvement has been made, the associated savings will go on indefinitely. This does not mean that the same tooling will last forever; periodic replacements will be necessary. But the replacement costs should be charged to the fuel economy standards only to the extent that the periodic replacement of tooling for the production of fuel efficient automobiles are inherently more expensive than for the production of gas guzzlers.

Other Conceptual Errors in the Harbridge House Analysis

There are a number of other conceptual errors in the HH report of which I will mention two.

One error is the implicit assumption that the only benefit from the current high level of investment by the auto makers in new tooling will be fuel economy improvements in future automobiles. As the Harbridge House report makes clear (Section IV), the U.S. automobile industry was relatively technologically stagnant prior to being challenged by the fuel economy standards. The major manufacturers had been investing much less in their production facilities per dollar of sales than is the norm in other industries of comparable size. Their rate of investment by this measure was declining, and their production tooling was relatively old.

The automotive fuel economy standards have forced the automobile manufacturers to retool, and they are reinvesting in more modern and productive equipment.[5] The improvement in productivity of this modernization should be credited to the fuel-economy related investments and will reduce the cost increases which would otherwise result from these investments. The Harbridge House report fails to consider this benefit to the auto industry from the fuel-economy program, nor, to my knowledge, does any other cost-benefit assessment of the fuel-economy standards.[6]

Another error in the Harbridge House analysis is its failure to consider changes in the manufacturers' variable cost in addition to the capital costs associated with fuel-economy improvements. Thus, for example, downsizing would reduce the material costs associated with an automobile. An analysis in 1977 by the U.S. Department of Transportation concluded that these savings would dominate the other variable cost changes associated with fuel economy improvements.[7] However, this conclusion

[3]Annual sales in the U.S. of automobiles have been running at a level of ten to eleven million units during the past few years.

[4]That the EPA test overstates average on-road fuel economy is by now well known. In another report [Frank von Hippel and Margaret F. Fels, "The U.S. Gas Guzzler Problem—Time for a Second Look," (Princeton University, Center for Energy and Environmental Studies, Draft Report, Nov. 1979] it is shown, however, that the magnitude of the corrections reported here are changed very little if in-service fuel economies are used instead of EPA test values.

[5]See, e.g., the recent *Automotive News* story on the productivity increases which have occurred at G. M. as a result of the retooling for the front wheel drive X-cars. [Roger Rowand, "G. M. Pursues Efficiencies: X-Cars Provide Opportunities," *Automotive News,* Nov. 26, 1979, p. 8].

[6]This point was made to me by Eugene Goodson (private communication, October 5, 1979).

[7]The Department of Transportation estimated a $200 per automobile savings in materials associated with downsizing. U.S. DOT, National Highway Traffic Safety Administration, *Rulemaking Support Paper Concerning the 1981-1984 Passenger Auto Average Fuel Economy Standards* (1977), p. 7-3.

is somewhat sensitive to the strategy assumed.

Unfortunately, I am unable to quantify the impacts of these last two omissions on the results of the Harbridge House cost-benefit analysis, although HH should be able to do so. I therefore return to the correction of the first error: the neglect of the gasoline savings other than incremental savings between model years. In making this correction, we will consider first the cost-benefit analysis from the point of view of the automobile manufacturer.

Making a Profit Selling "Saved Gasoline"

Industry's goal is to make money, or at least not to lose it. Therefore, to the extent that the fuel economy standards increase manufacturing costs, automobile manufacturers will wish to recoup the investment plus a reasonable profit by increasing the prices of their automobiles. Recouping in six years[8] an investment at an annual rate of return after taxes of 8 percent in constant dollars would require an annual capital charge rate of 25 percent.[9] In other words, to obtain an 8 percent return on its investment after taxes, the industry would have to increase the price of its automobiles in order to recoup 25 percent of its investment during each of the six years of the useful life of that tooling.

Thus, under conditions where a one dollar investment in fuel-economy related tooling would result in a reduction of fuel commitments by one gallon in each of the six subsequent model years, an automobile manufacturer would, in effect, be able to sell future gasoline savings at a "price" of 25 cents per gallon saved and make a reasonable profit. The manufacturer could do this by raising the price of each automobile by 25 cents for every gallon of expected savings over the life of the automobile.

The Harbridge House Cost-Benefit Calculation Corrected

In Appendix A, I present specific calculations of the "prices" of saved gasoline implied by some of the different sets of investment costs for achieving the fuel-economy standards estimated in the Harbridge House report. The results of these calculations are summarized in Table 2. It will be seen there that manufacturers could sell "saved gasoline" at a profit at calculated prices ranging from 20 to 42 cents per gallon. This price is low in comparison with the price of gasoline in the United States in late 1979 (about $1.00 per gallon) and even lower in comparison to the prices of 1980.

TABLE 2

Prices of Saved Gasoline—Based on a Comparison of Fuel Economy Related Investments and Automobile Efficiency Improvements Between Given Model Years

Comparison Years	Price of Saved Gasoline (1979 $/gallon)
MY 79—MY 80	$0.20-0.25
MY 75—MY 85	$0.31
MY 81—MY 85	$0.42

[a] Based on Harbridge House estimates of investment costs, a six year investment depreciation period, and an eight percent real rate of return on investment after taxes. See Appendix A for details.

Other Cost-Benefit Analyses

A number of other cost-benefit analyses of the fuel economy standards have recently been made which give similar results to those which I have obtained from the Harbridge House numbers. These studies focus on the estimated prices increases of MY 1985 automobiles which can be attributed to the costs of fuel-economy related charges. In Table 3, I list these estimated price increases, the associated lifetime fuel savings for the average MY 1985 car, and the price the average new car buyer would be paying for these savings per gallon.[10]

The Value of Future Saved Gasoline

I still have left out one refinement in the cost-benefit analysis which is dear to the heart of economists—the question of the appropriate discount which should be applied to future gasoline savings.

The value of future fuel savings to the new car buyer depends upon the likely future price of gasoline and the "discount rate" used to reduce the value of future savings. The most recent government cost-benefit analyses of the automotive fuel-economy standards assume that the price of gasoline (before taxes) will rise at an average real annual rate of approximately three percent until the year 2000.[11] They also reduce the value of future dollar savings at the ten percent real annual discount rate mandated by the Office of Management and Budget for calculations of the benefits of federal investments (in water projects for example). The difference between the assumed increase of value of gasoline of three percent and ten percent discount rate is an effective discount rate of seven percent. With this effec-

[8] I choose six years because this is a typical length of time between major redesigns. According to the strategy outlines in the Harbridge House report, some relatively inexpensive improvements (e.g. three-speed automatic transmission with lock-up torque converters) would be used for only a year before being superceded by more efficient systems (the four-speed automatic transmission with lock-up torque converter). Offsetting the short useful life of the tooling associated with such improvements, however, would be the greater than six year life of other tooling.

[9] I assume a six year (straight line) depreciation, and a 50 percent combined federal and state corporate income tax rate. An 8 percent rate of return in constant dollars corresponds to a 17 percent annual rate of inflation. The average "real" rate of return on U.S. common stocks over the period 1947-1976 was 7.6 percent, [Roger G. Ibbotson and Rex A. Singnefield, *Stocks, Bonds, Bills and Inflation: The Past (1926-1976) and* The Future (1977-2000), (Financial Analysts Research Foundation, Charlottesville, VA, 1977)].

[10] See Frank von Hippel and Margaret F. Fels, *op. cit.,* for a more detailed review of these cost-benefit estimates.

[11] U.S. Department of Transportation, National Highway Traffic Safety Administration, *Report on Requests by General Motors and Ford to Reduce Fuel Economy Standards for Model Year 1981-85 Passsenger Automobiles* (1979); and Carmen Difiglio *et al.* (DOE), "Cost Effectiveness of the 1985 Autombobile Fuel Economy Standards" (Society of Automotive Engineers Papers #790930, 1979).

TABLE 3
Findings of Other Studies of Costs and Benefits of the Fuel Economy Standards to the Automobile Owner

Analysis (Comparison years)	Average Price Increase of New Domestic Fleet (1978$)	Lifetime Gasoline Savings (gallons)[d] EPA[e]	On-road[f]	Dollars/Gallon (on-road)[g]
DOT (77)[a] (MY 81-85)	206	780	600	0.34
GM (79)[b] (MY 80-85)	510	1360	1020	0.50
DOE (79)[c] (21.3-My 85)	160–460	1060	800	0.20–0.58

[a]U.S. DOT (NHTSA), *Rulemaking Support Paper Concerning the 1981-1984 Average Fuel Economy Standards* (1977), Table 8.2, Case I (No Diesels, No Mix Shifts). We have taken $1(1977) = $1.08(1978).
[b]U.S. DOT (NHTSA), *Report on Requests by General Motors and Ford to Reduce Fuel Economy Standards for Model Year 1981-1985 Passenger Automobiles* (1979), p. 55.
[c]Carmen Difiglio *et al.* (DOE), "Cost Effectiveness of 1985 Automobile Economy Standards," Society of Automotive Engineers (SAE) Paper #790930, 1979, Tables 4 and 7. The baseline MY 85 new fleet average EPA fuel economy in the absence of standards was assumed to be 21.3 mpg.
[d]My calculation, assuming a lifetime expected mileage of 100,000 miles.
[e]Assuming that the EPA combined city/highway test fuel economies are actually achieved on the road.
[f]Adjusting the EPA (X) to on-road estimated fuel economy (Y) using the best fit fuel economy relationship for MY 74–78 automobiles: $Y^{-1} = 0.76\ X^{-1} + 0.024$ mpg [Barry D. McNutt *et al.* (DOE) "Comparison of EPA and In-use Fuel Economy of 1974–1978 Automobiles," (SAE Paper #790932, 1979].
[g]Assuming a zero effective annual discount rate on the value of future saved gasoline. For a 7 percent effective annual rate, these numbers should be multiplied by a factor of 1.29 (see text).

tive discount rate and using the average yearly miles traveled by U.S. automobiles as a function of automobile age, the average value of gasoline saved over the lifetime of an automobile is equivalent to the value of 0.77 gallons at the time of purchase.

The use of the federal discount rate for private investments in automobiles would seem to be inappropriate, however. For the person who can buy a car with cash, the logical discount rate would be the real rate of return which the money could realize after taxes if invested in a large savings account, the stock market, bonds, etc. For the person who must borrow to pay for a car, the corresponding comparison rate would be the real rate of interest paid on the loan after tax deductions. Consumers have loan and investment opportunities in the neighborhood of two to six percent real after after taxes. A discount rate in this range would approximately cancel the three percent annual increase assumed for the price of gasoline giving an effective consumer discount rate of nearly zero.

Starting with the late 1979 price of $1.00 per gallon of gasoline, therefore, the average value to the new car buyer of a gallon of gasoline saved over the lifetime of his car will be approximately $1.00. Even at $0.77 a gallon, corresponding to an effective discount rate of 7 percent, the value of the saved gasoline would be higher than the price ranges for saved gasoline which I have estimated would give the automobile manufacturers a reasonable profit (see Tables 2 and 3). Thus the selling and buying of saved gsaoline would appear to be mutually beneficial to both the manufacturer and the new automobile purchaser and would certainly be in the national interest.

Conclusion

It would appear therefore that the Harbridge House members, when corrected for the most flagrant error, *support* rather than challenge the position that the benefits to the nation from the U.S. fuel economy standards far exceed their costs. Yet the Harbridge House study was promoted in the *New York Times* as a "major challenge" to the federal policy on automotive fuel economy. I would therefore like to close with the following questions:

- How could Harbridge House have put forward such far-reaching conclusions without having a more substantial analysis to back it up?
- How could the elementary errors in analysis which led to the incorrect conclusions concerning the value of the automotive fuel economy standards have escaped all the academic specialists who were listed in the study as having reviewed the draft report and whose involvement "legitimized" the Harbridge House report with the press?[12]
- How can the press protect itself from such "analyses" in the future?

I hope that some of the answers to these questions will be forthcoming.

[12]Subsequent to writing these words, I called up one of these reviewers who told me that he had in fact brought at least some of these errors to the attention of Harbridge House in his review of the report while it was still in draft. I have requested from Harbridge House copies of the reviewers' reports—but so far without success. The misuse of technical experts to "legitimize" rather than to advise is discussed by Joel Primack and Frank von Hippel in *Advice and Dissent: Scientists in the Political Arena* (Basic Books, 1974; New American Library, 1976).

Appendix A: Prices of Saved Gasoline Obtained Using the Harbridge House Estimates of the Costs of Fuel Economy Related Investments

Harbridge House's own calculation of costs and benefits is for a specific model year, MY 1980. In Section IV of the HH report, it is estimated on the basis of public statements by GM and Ford spokesmen that the U.S. auto industry has invested $2.5-3.0 billion in raising the average fuel economy of the U.S. new automobile fleet from 19 to 20 mpg in MY 1980. HH estimates the resulting lifetime savings in MY 1980 automobiles to be three billion gallons. (This is the shaded area over MY 1980 in Figure 1.) The savings are therefore six to seven gallons over six model years per dollar invested which, at 25 percent annual capital charge rate, would allow the automobile manufacturers to sell the saved gasoline savings at an average "price" of 20 to 25 cents per gallon.

The choice of the investment in one specific fuel economy increment as a measure of the cost-benefit balance for the whole fuel economy improvement program appears somewhat arbitrary, however. I have therefore checked the Harbridge House result for MY 1980 against results obtained from comparing the total cost of the projected ten year fuel economy improvement program for GM's A-body cars (as laid out in HH Exhibit II-2) with the fuel savings resulting from the production of vehicles having a fuel economy of 28 mpg instead of 15 mpg at the end of the program. Calculated in this manner, I find a savings averaging approximately five gallons of gasoline over six model years for every dollar invested.[13]. At an annual capital charge rate of 25 percent, the manufacturers would be able to sell this saved gasoline at an average price of 31 cents per gallon, slightly higher than the price obtained for the MY 1980 figures.

The Harbridge House report also claims that future investments in fuel economy will yield much smaller savings per dollar investment than past investments. I have checked this by calculating the savings per projected dollar invested in GM A-body cars during the period MY 1981 through MY 1985 using the HH numbers in Exhibit II-2. I find an average savings over six model years of 3.6 gallons of gasoline per dollar invested.[14] At a 25 percent capital charge rate, the price of these gasoline savings would be 42 cents per gallon.

[13]The investments shown in Exhibit II-2 of the HH report are associated with an increase of the average fuel economy of an annual production of 400,000 automobiles from 15 to 28 mpg. The total investment over ten years is $1.7–1.89 billion. The savings in the lifetime (124,000 miles according to Harbridge House) fuel consumption of 400,000 vehicles as a result of the change in fuel economy from 15 to 28 mpg is 1.5 billion gallons or approximately 0.8 gallons per model year for each dollar invested.

[14]From Exhibit II-2 of the HH Report, it can be seen that HH estimates that it will cost $970–1080 million to raise the average fuel economy of an annual production volume of 400,000 A-body GM automobiles from 21 mpg in MY 1981 to 28 mpg in MY 1985. The savings over the assumed average lifetime of these automobiles associated with an improvement of their average fuel economy from 21 to 28 mpg would be 0.6 billion gallons of gasoline per model year or approximately 0.6 gallons per model year per dollar of investment.

Nuclear Engineers of the 1980s?

LANCE J. HOFFMAN

Those who work in the computer industry will be the nuclear engineers of the 1980s. The loss of credibility and the self-doubt that came to nuclear engineers at Three Mile Island (TMI) will come to us as well.

There are many disquieting similarities between the nuclear reactor emergency at TMI and the problems with which we computer people deal every day.

Unexpected Anomalies. One of the problems at TMI was the appearance of a hydrogen bubble; this problem was "not analyzed heretofore," in the words of Harold Denton of the Nuclear Regulatory Commission. Computer people deal every day with bugs which were "not analyzed heretofore." The fact that our bugs are discovered at or after program execution has affected the records of possibly everyone in a multimillion-person data bank.

Compounding the Problem. At TMI two workers, trying to reroute the plumbing, opened a pipe full of radioactive gas and vented it to the outside. There have been many instances where programmers trying to fix a bug have destroyed information in data files. In one reported case, a company almost went bankrupt: critical information was destroyed first in the master file and then in the backup file. By luck and good fortune, the grandfather file was not destroyed.

Inadequate Instrumentation Systems. Operators at TMI were misled by faulty instrument readings into nonproductive and counterproductive actions. In computer systems, operators and programmers are misled daily by error messages with quality ranging from poorly worded to incomprehensible. These messages lead them into time-wasting searches through large manuals (which themselves are too often incorrect) or through adjacent offices in search of someone with an idea of how to solve the problem.

Inadequate Emergency Plans. The Harrisburg area had an old civil defense plan that included no contingencies for the accident at TMI. Some computer facilities have untested emergency plans; a few facilities actually test these procedures periodically. But the majority of facilities have no written emergency plans.

Regulations Poorly Monitored. Auxiliary feedwater pumps are designed to prevent TMI-type incidents.

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However, three of these pumps in the cooling system had been taken out of service two weeks prior to the event, in violation of federal regulations. This went unnoticed; there were no on-site inspectors. Most federal government computer systems are required to perform regular security and vulnerability audits and risk analyses. However, compliance scrutiny is typically left up to the internal auditors. There is no independent, external review.

Policy Attitudes. There are also similarities between the nuclear industry approach to safety and the computer industry approach to information use. There are numerous reports on the benefits of nuclear technology, but in two decades there have been only a handful of comprehensive reactor safety studies and little work on the radioactive waste disposal problem. Similarly, in the computer industry, we have only minimal work on data accuracy, integrity or social effects. Instead, we tend to emphasize decreasing cost-per-computation.

The nuclear industry has done very little social impact analysis and the computer industry doesn't have a much better record. Work on risk assessment uses checklists, for the most part, although there is some embryonic work using probability theory and fuzzy set theory. Very recently, some halting steps have been taken to perform social impact analysis at the Office of Technology Assessment and at the Social Security Administration. But for the most part, we have been reluctant to take hard looks at these tough problems.

Public Backlash. Permission to truck radioactive wastes from TMI through South Carolina was denied. Pennsylvania refused to allow the nuclear industry to pass on TMI costs to consumers. California denied requests to build Sun Desert I and II nuclear plants because of unsolved waste disposal problems. And these are not isolated incidents. Almost every week one can read of a new delay for some nuclear plant.

There are similar instances of public skepticism regarding once-highly-touted computer innovations. There has been an effective suspension of active development of the FBI's National Crime Information Center. The proposed IRS Tax Administration System has been scrapped.

The public is increasingly leery about the effect of computers on the quality of life. In a recent Harris poll, the public opined that "computers are an actual threat to individual privacy" by a margin of 54% to 31%, a dramatic change from only three years ago. What is perhaps even more surprising is that computer executives felt the same way, 53% to 44%. Only 27% of the public thought that the privacy of personal information in computers was properly safeguarded, while 52% thought it was not. Fully 63% of the public agreed with the statement "If privacy is to be preserved, the rise of computers must be sharply restricted in the future."

The question is not *whether* this public concern will be translated into effective political interest, but *how soon*. It took the TMI accident to get some of the most powerful members of Congress to seriously question the statements of the nuclear industry. It will take a gross data bank abuse—something like the creation of 30 million electronic unpersons for a day or two—to raise the eyebrows of politicians. This abuse will occur, probably within the next five years. We will then have our very own Three Mile Island.

Reforms Needed

What can we do to stave this off, or at least to mitigate its effect?

First, education must be improved to reflect the fact the social, political, economic, and legal circumstances surrounding any system should be understood before it is designed and put into place. The nuclear industry is only now fully realizing this.

We must also improve training for security planning and auditing. There are problems in developing these programs in the university context; there is always the question of whether to put them in computer science, business, law, government, or elsewhere, since the issues are not the sole province of any one discipline. We need increased analysis of the risks and benefits of new systems in general and of systems with widespread effects (such as electronic funds transfer systems, social security, FBI systems, etc.) in particular.

Until we develop societal mechanisms to better control computer systems, we should exercise healthy skepticism about our own work and that of our colleagues. While not everyone will make the same value judgements about the social effects of various systems, it is reasonable to subject new systems to more technological reviews: Do they do what they claim? How problem-prone are they? How cost-effective are they? Do the benefits outweigh the social and technical risk and costs? This is especially important now that low-cost, high-utility microcomputer systems that sit on a desk and plug into an ordinary wall socket are here.

If a proposed system cannot provide satisfactory answers to these questions, it should be redesigned or forgotten. Only in this way will we maximize the benefits and minimize the risks that computers bring with them.

Stereotyped Images in the Technology/Society Debate

A Critique of Suran's "Technology in Modern Society"

ROBERT J. WELCHEL

It would seem that the dominant paradigm for social discourse in our age is bifurcation. One takes an issue of some complexity, reduces the rich, amorphous ambiguities of the issue to two antithetical positions, chooses a side, and then comes out swinging. A recent example of this genre of thought is Mr. Jerome Suran's essay "Technology in Modern Society"[1].

It is interesting to study the underlying structure of the introductory paragraph of this essay. Mr. Suran's first step is to enlist the full technological community in support of his theses. He does this by citing an anti-technology quote which questions the wisdom of developing nuclear power plants. The conclusion of his quotation from the *New Yorker* article is: "The Faustian proposal that experts make to us is to let them lay their fallible hands on eternity, and it is unacceptable." Mr. Suran's first sentence following this quote creates his constituency: "If you are wondering about who this journalist was talking about, he is talking about those of *us* in technology" (emphasis added). He does qualify this statement somewhat by admitting that the *New Yorker* quote applies particularly to those technologists associated with the development of nuclear power. However, the tenor of the remainder of the essay clearly shows that Mr. Suran assumes a camaraderie amongst the fraternity of technologists so strong that this distinction is hardly worthy of mention.

After creating a sense of 'we-ness' encompassing the entire technological community, Mr. Suran next creates a worthy opposition. This 'other-than-we' is the group of "...our nontechnical associates afraid of those things that we do." Mr. Suran takes care to establish the opposition's credentials: "These are not kooks. They are not all crackpots." Not only do these statements indicate that the opposition is seriously composed, they also indicate the broad-minded attitude Mr. Suran brings to the debate.

Mr. Suran then issues his call to arms which he further amplifies at the essay's conclusion: "We (i.e., we technologists) must recognize that we have a role of education to play in society." The implication being, of course, that if our opposition knew what we know, then they would throw away their weapons and embrace our conclusions gladly.

What exactly has Mr. Suran accomplished in this first paragraph of his essay? First, as stated perviously, he has taken a complex issue, the social impact of technology, and implicitly reduced it to only two positions: one either favors technology or one opposes technology. Next he either presumes, assumes, or strive to create the impression that all persons who practice technology are, *ipso facto,* on his side, i.e., technologists favor technology. Last, it is clear that Mr. Suran's token acknowledgement of the sincerity and seriousness of the opposition will never extend so far as to admit that they are ever correct in any of their assertions. The immediate result is that one's hope for a meaningful discourse on "Technology in Modern Society" are crushed at the outset. What one has here is a paean of technology reminiscent of nineteenth century pseudophilosophical tracts in favor of progress.

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Mr. Suran carries his romance with bifurcation a step further when he broaches the subject of ethics. He first tentatively separates professional responsibility from social responsibility, then more boldly establishes two opposed ethical realms:

> When we talk about our responsibility to society, let us remember first that we have a responsibility to the practice of our profession. I would like to put that responsibility in terms of the ethics of engineering as opposed to the broader ethics of mankind with which we are usually concerned.[1]

The first sentence reverses the commonly established priority of social responsibility over professional responsibility; the second sets the ethics of engineering in opposition to the "broader ethics of mankind." Needless to say, this is a rather potent pair of sentences and concepts.

In defense of Mr. Suran on these points, one could argue that certain crucial words in the quote are ambiguous, and that I have misconstrued his meaning. Thus, his "first" might mean first in time only rather than first in priority. Further, his "opposed to" may merely mean in contrast to, i.e., he may only be delimiting the ethics of engineering as a subset of the broader ethics of engineering as a subset of the broader ethics of mankind rather than setting it in oppositon to his more general ethical realm.

From the quote alone, this more charitable interpretation is certainly a possibility; however, in the remainder of the paper, Mr. Suran chooses examples where he does in fact put his "ethics of engineering" in opposition to the "broader ethics of mankind" (presumably, the ethics of "our nontechnical associates afraid of those things that we do"). Although Mr. Suran may not have consciously wished to establish the interpretation that I give his quote, I contend that this interpretation is presupposed for the remainder of the essay.

What constitutes Mr. Suran's "ethics of engineering"? He lists for principal constiuents: the ethics of experiment, the ethics of uncertainty, the ethic of trade-off, and the ethic of measurements. Although not comprehensive, this is certainly a goodly collection of engineering principles, and Mr. Suran's discussion of them is creditable so long as he remains in the realm of engineering. Even his contention—really the main thesis of his essay—that engineers need to educate outsiders about these four "ethics" is certainly valid. The lack of understanding by the rest of society about the *modus operandi* of engineering is certainly a major contributor to the difficulties associated with the interaction between society and technology.

Another major factor in the society/technology imbroglio, which contributes to the weakness of Mr. Suran's essay at this point, is a lack of understanding (or acceptance) by many pro-technology spokesmen of the *modus operandi* of the rest of society. Are we faced here with a true bifurcation? I think not. This appears to be simply a mutual misunderstanding which it is to be hoped, is a temporary aberration that time and effort will heal. Although Mr. Suran's essay had the potential for contributing to the healing of this rift, he falls short of realizing this goal since he suffers from this very aberration.

The underlying common element of experiment, measurement, uncertainty, and trade-off is quantification, which is certainly at the heart of engineering practice. But by converting engineering principles into engineering ethics (with corresponding moral connotations), and then setting these "ethics of engineering" against and above the "broader ethics of mankind," Mr. Suran gives the impression that he is trying to reduce ethical decisions to the process of addition and subtraction. The question of how to factor quantitative information into a value judgement is formidable, and I feel Mr. Suran's approach is too simplistic to be fruitful. His discussion of value and price becomes facile and flippant. He begins with Oscar Wilde's famous remark: What do you call a man who knows the price of everything and the value of nothing? Answer: a cynic. Mr. Suran next generates his own question: What do you call a man who knows the value of everything but the price of nothing? Answer: a hyprocrite. Perhaps one should carry this process a step further and ask: What do you call a person who says that everything has a price but no value? Answer: an engineer. I would hope not.

Mr. Suran's final and most ludicrous tirade is reserved for the environmental movement. In order to counter "....the romance of nature that the world seems to be undergoing these days," Mr. Suran proposes another call to action: "I think that it is time for technologists and engineers in particular to stand up and tell it like it is about Mother Nature." Well, how is it with Mother Nature?

> The combination of an earthquake and a flood that struck the Indian tidal basin in November of 1977 killed 20,000 people from just one tidal wave. *That is what nature is,* and it is time to set the record straight. [1] (Emphasis added).

This quote contains such distortion and hyperbole that it is difficult to believe that even Mr. Suran wrote it. The complement to this line of reasoning is: On August 6, 1945, the *Enola Gay* dropped an atomic bomb on Hiroshima and killed 75,000 people. That is what technology is, and it is time to set the record straight.

Lest one believe that I am unfairly and selectively quoting Mr. Suran on this topic, be assured that there is only one sentence in the essay which mentions a positive value of nature, and this reference is immediately blunted by turning to nature's more primitive aspect: "When we talk about the great beauty of nature let us not forget earthquakes."

Mr. Suran concludes his essay by proposing an educational program in the "ethics of engineering" for the rest of society, including a "Fellow in the media" program for placing engineers on the staffs of newspapers, news magazines, and television networks. Their duty would be to promulgate the "true ethics" i.e., Mr. Suran's four "ethics of engineering."

II

O.K., where's the problem? This not a 'get Suran' essay, although it might appear to be that. What I protest is the reductionist approach to complex problems exemplified by Mr. Suran's essay. Not only does this methology not contribute to the solution, it actively exacerbates the problem itself. The problem has been politicized rather than intellectualized.

Our society does frequently seem divided into two warring camps of pro- and anti-technology forces. The artificiality of this construct may be hinted at by the fact that often individuals are themselves similarly split. Thus, an engineer designing missile guidance systems may commute twenty miles to his ten acre plot of land where he chops wood to heat his hand-hewn log home. Engineers do belong to the Sierra Club, just as anti-nuke protesters drive automobiles to their rallies. The problem caused by the reductionist treatment of the technology/society issue is that these actions are artificially forced to seem contradictory and inconsistent. The dielectic of interaction between society and technology is truncated; the intellectual process stagnates at the thesis/antithesis level rather than proceeding to a synthesis. An individual is reduced to a role (I am an engineer; I work to develop new technology, therefore I must be pro-technology) rather than being allowed to exhibit the full complexity of human existence.

One will never solve the technology/society problem precisely because it is not a problem in the engineering sense of that word. It is an organic social issue which calls for contemplation and reconciliation at the individual's level as well as at the social level. Mr. Suran tries to reduce this issue to the equivalent of a low-noise preamplifier design problem; the issue is simply not that clean.

Mr. Suran's treatment of nature glaringly reveals the indequacy of his approach. If man does live in conflict with nature—which he does—then Mr. Suran would have it that one cannot live in harmony with nature. The reductionist thesis/antithesis syndrome prevents Mr. Suran from accepting that contradictory attributes can belong to same entity (this shortcoming is similarly exhibited in his discussion of soft and hard technologies).

By lumping those who have a "romance" with nature into a single pro-nature group, Mr. Suran's inner logic forces him to become anti-nature. He unabashedly opposes those who would strive towards harmony or "balance" with nature: "Modern technology...does not try to strike any balances. It tries to tilt the balance in favor of man. That is the role of technology" [1]. Actually, there is much in the latter portion of this quote that I agree with—not simply as a descriptive statement but as a prescriptive statement as well. My argument is not with the content so much as with the form. Embedded in the context of his essay, these remarks come across as an agressive proclamation that nature is an enemy to be subdued, and, further, that this is all nature is. It is this attitude that I find repulsive.

I feel Mr. Suran could benefit greatly by reading Leo Marx's book, *The Machine in the Garden: Technology and the Pastoral Ideal in America* [2]. Mr. Marx distinguishes between three favorable attitudes toward nature: primitivism, sentimental (or popular) pastoralism, and complex (or imaginative) pastoralism. Primitivism is that attitude exhibited by the person who seeks to escape all tentacles of organized society by striking out into the wilderness and living one-on-one within the primitive, untamed state of nature. The number of persons in our present society who subscribe to this attitude must be truly minuscule; yet many pro-technology statements directed against environmentalists are often addressed toward this attitude.

The pastoral ideal, like primitivism, seems "...to originate in a recoil from the pain and responsibility of life in a complex civilization—the familiar impulse to withdraw from the city, locus of power and politics, into nature" [3]. Unlike the primitivist, however, the pastoralist does not want to escape to the wilderness; he wants to escape to the garden. This distinction is fundamental, and, unfortunately, seems to elude the grasp of many pro-technology spokesmen. A garden is a man-made artifice; it is wild nature subdued, often with the aid of technology. Yet, not only is a garden nature subjugated, it is also a testimonial to nature. A garden represents the sought after Arcadian ideal of harmony between man and nature. The pastoralist faces two enemies, civilization and wilderness.

The distinction between the subclasses of sentimental and complex pastoralism is not as clear-cut as that between primitivism and pastoralism in general, yet this distinction is significant. The meaning of sentimental pastoralism is well conveyed by the phrase itself. It is the popular conception of the word *pastoral* as exemplified by escapist, idyllic, sentimental literary works, those works that contain an abundance of "bucolic cliches" [4]. Fundamentally, it is an idealistic attitude in the pejorative sense of that word. Sentimental pastoralists believe that it is actually possible for an individual to escape the complexities of modern life by retreating to the garden, and, on a grander scale, that society itself can be saved if it would but strive toward the pastoral ideal. Basically, they would like to make the whole world a garden. "It (sentimental pastoralism) says that the dream of pastoral harmony will be easy to realize as soon as the Faustian drive of mankind...has been extirpated" [5]. the condition specified for this "easy" realization of pastoral harmony is, of course, unrealistic: "To fulfill the pastoral hope, in other words, nothing less is required than a reversal of history" [6].

The hollow rhetoric of sentimental pastoralism gets fleshed out through its metamorphosis into complex pastoralism. For Mr. Marx, the complex pastoral attitude is revealed in many of the serious literary works of the nineteenth and twentieth centuries. Complex pastoralism differs from the sentimental variety in that it clearly recognizes and accepts pastoral harmony as an unrealizable ideal; the "middle landscape" between city and wilderness is rejected as even "...a token of a realizable ideal" [7]. In discussing *Walden* as an example of the complex pastoral attitude, Mr. Marx concludes: "In the end Thoreau restores the pastoral hope to its traditional location. He removers it from history, where it is manifestly unrealizable, and relocates it in literature..." [8].

In sentimental pastoralism, nature and man do live in harmony, i.e., nature is always presumed to be in a subdued state; sentimental pastoralists do not allow Mr. Suran's earthquakes to intrude into the garden. In contrast, complex pastoralism is

> ...a view of experience that matches the duality of nature. The possibility of joyous fulfillment exists; the image of green fields is meaningful, but only so far as it is joined to its opposite. In itself the (pastoral) image represents neither a universal condition nor a set of values which can be embodied in social institutions. [9]

Of what value, then, is complex pastoralism? If it removes the pastoral ideal from history (the real world) and places it in literature (where it belongs), what significance does it have for the practice of engineering, the creation of technology? If this discussion of primitivism and pastoralism does only one thing, *viz*., the elimination of the mindless rejection by some technologists of the environmental movement as a bunch of kooks wanting to reject all technology and return to the wilderness (i.e., primitivists), it will have achieved an end well beyond my subdued expectations.

But complex pastoralism has more significance than this. In a sense, it serves the same role for society that myth does. Evidently, a significant segment of our society feels the need to retreat from the many superficialities and banalities that often characterize our comtemporary civilzation. An escape to the pastoral landscape, either figuratively or actually, is one way to get back to the basics that really count: "...it offers the chance of a temporary return to first things. Here, as in a dream, the superfluities and defenses of everyday life are stripped away, and men regain contact with essentials" [10]. In other words, one regains contact with value, as contrasted to Mr. Suran's price.

But given the complex urban structure of our society, can the pastoral ideal be effective even in this function? When many members of our society contact a garden only through its television image, how can the pastoral retreat serve a restorative function? Is not the pastoral image, like myths to the majority of our society, an anachronism?

In one sense, complex pastoralism is a failure, but a much more profound failure than sentimental pastoralism. In reviewing the complex pastoral literature of the past two centuries, Mr. Marx concludes

> ...that an inspiring vision of a humane community has been reduced to a token of individual survival...in the end the American hero is

either dead or totally alienated from society, alone and powerless...The resolution of our pastoral fables are unsatisfactory because the old symbol of reconciliation is obsolete. [11]

Mr. Marx continues with a more positive tone:

But the inability of our writers to create a surrogate for the ideal of the middle landscape can hardly be accounted artistic failure. By incorporating in their work the root conflict of our culture, they have clarified our situation...To change the situation we require new symbols of possibility, and although the creation of those symbols is in some measure the responsibility of society. [12]

These last remarks by Mr. Marx clarify why I consider this digression into pastoralism relevant. The interaction between the machine and the garden is the "root conflict of our culture", a conflict that we as technologists are fundamentally involved in whether we wish it or not. Becoming cognizant of or past, the origins and previous approaches to our difficulties, can only help, not hinder, as we struggle toward "new symbols of possibility." Although the old images of reconciliation may no longer be fruitful, the concept of reconciliation itself must remain central to our pursuit. Incorporating stereotyped images and posturing our responses to "our nontechnical associates afraid of those things that we do" can only intensify the tension between us and them. It seems to me that our society is still at the position where we need to expand the intellectual scope of our awareness of the interaction between society and technology, particularly with regard to the "machine in the garden" conflict; hopefully, this brief excursion into pastoralism has contributed to this goal. To propose a solution based on the "ethics of engineering" to a problem that we have yet to understand seems premature.

References

[1] Jerome J. Suran, "Technology in Modern Society," *IEEE Trans. on Industry Applications,* Vol. IA-15, No. 6, 1979, pp. 586–590. In part I of my essay, everything within double quotation marks ("') has been taken from Mr. Suran's article.

[2] Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America*, Oxford University Press, New York, 1964.

[3] *Ibid*, p. 22.

[4] *Ibid*, p. 275.

[5] *Ibid*, p. 277.

[6] *Ibid*, p. 277.

[7] *Ibid*, p. 282.

[8] *Ibid*, p. 265.

[9] *Ibid*, p. 313.

[10] *Ibid*, p. 69.

[11] *Ibid*, p. 364.

[12] *Ibid*, p. 364–365.

Reviews

Medicine and the Reign of Technology, by Stanley Joel Reiser. Cambridge: Cambridge University Press, 1978, 317 pp. *Reviewed by Thomas P. Bleck, M.D., Departments of Internal Medicine and Neurological Sciences, Rush Medical College, Chicago, IL.*

The appropriate (and inappropriate) application of technology to the practice of medicine has become a subject of increasing interest to physicians, scientists, engineers, and the thinking public in recent years. This area has been a source of both encouragement (because of its potential) and concern (because of its cost). Legislative groups have attempted to control its development and regulate its proliferation. Much of the debate over the issues involved has treated this situation as historically unique; Dr. Reiser's book should therefore be welcomed for exploring the antecedents of our present medical technology.

Medicine and the Reign of Technology can be divided into the three sections. The first six chapters document the evolution of the most instructive examples of medical technology. Dr. Reiser has made extensive use of primary source material in preparing these chapters, and has suceeded splendidly in describing the replacement of each diagnostic paradigm by newer methods as more advanced technology became available. It is difficult now to understand the resistance which, for example, the early users of the stethoscope met from physicians who had been trained prior to its introduction. The chemical analysis of blood was similarly opposed by people who did not understand the importance of disordered regulation in disease.

This first section suffers slightly from the implicit assumption that readers are familiar with the process by which health workers collect and interpret data. Ideally, the investigation of a patient's problems begins by *history taking*, the attempt to the understand the patient's problems (both explicit and unstated) by encouraging the patient to tell his or her own story of the illness. Other parts of the history obtain data about past illnesses, family health, social situation, and habits such as cigarette use. This step also includes a review of frequent or important symptoms which the patient may not have mentioned. The history is followed by a *physical examination*, which allows the practitioner to observe the structure and function of organs which may contribute to the patient's complaints, and to look for derangements which may not yet have caused symptoms. Laboratory and radiologic testing is then employed to assess the validity of diagnostic impressions obtained through the history and physical examination. Many practicioners also obtain a routine series of tests on most new patients, a practice of undecided usefulness.

From the carefully sketched scenario of technologic development presented in the first six chapters, the author attempts to draw conclusions regarding its effects on the practice of medicine, and especially on the relationship of patients and physicians. Titles such as "Medical Specialism and the Centralization of Medical Care," and "Selection and Evaluation of Evidence in Medicine" conthat reliance on diagnostic procedures has contributed to an erosion in "nontechnical" skills, such as history taking and physical examination. This has ostensibly occurred because of the seductive nature of the seemingly objective data obtained by, for example, biochemical and radiologic analysis.

The author makes an important step toward the clarification of this argument by pointing out that these "nontechnical" aspects of diagnosis are not necessarily less reliable tools than methods which generate graphic or numeric answers. It is fortunate that he touches also on attempts to make these skills more uniform and reproducible. However, to conceive of these skills as nontechnical is probably no longer correct. In many medical curricula there is a concerted effort to teach history taking and physical examination in the context of standardized techniques whose reliability can be tested. When the reliability of a given complaint or physical finding is known, its contribution to diagnosis is as important as those of other techniques. The resurgence of interest in the skills of "history and physical" needs to be accompanied by better attempts to convey the limitations of laboratory and radiologic procedures. The extent to which these procedures are overemphasized by practitioners may represent inappropriate trust based on a lack of understanding of the procedures. Unless physicians are taught the limitations inherent in measurement, they may tend to treat this data as more exact than it is.

In his final chapter, Dr. Reiser expresses his opinion that physicians must rebel against a tendency to be bound to techniques which result in increasing alienation between wholeheartedly endorse it. It is important to remember that its purpose is to improve patient care. In pondering the appropriate uses of technology in medical care, this goal must be considered along with the separate issue of cost.

Much discussion of technological advances in medical care has emphasized a purported overreliance on procedures as a cause of the rapid increase in health-related costs. Implicit in this argument is the assumption that the same standard of care could be delivered if the patient's problems were investigated with less reliance on (expensive) technology. I fear that this represents a covert attempt to push the question of who should accept substandard care out of the public arena and onto the shoulders of health practitioners. If health workers can devise ways to reduce costs without adversely affecting patient care, they should be expected to do so as a part of their public responsibility.They should not be placed in the position of having to reserve the highest standard of care for people who are powerful or sophisticated enough to demand it. If cost controls require that care be decreased, then we should all share the burden.

Medicine and the Reign of Technology provides an excellent introduction to the historical interaction of patient care and advances in instrumentation. If the latter parts of the book are read with the issue of the best standard of care kept separate from that of cost, it will provide a thought-provoking view of where we are and where we should be headed. I recommend it to anyone with a personal or professional interest in these issues.

Letters

To the Editor:

I refer to the letter by Carlos M. Varsavsky in the December 1979 issue of *Technology and Society* and applaud his concept of examining the export or transport of hydroelectric energy by means other than the conventional electrical transmission lines. However, I am somewhat alarmed by the lack of definitive statements outlining the sociotechnical difficulties and dangers associated with schemes based on the transmission of very high powers through the atmosphere and near space using microwaves.

The first difficulty is obviously international agreement concerning the allocation of a radio frequency for such a purpose. Naively, one might assume that only one discrete frequency need be allocated for such a purpose, and no interference with telecommunications or radar need result. This assumption would be totally incorrect. Any radio frequency generator at a single frequency produces energy at other frequencies, both incoherent (broad band) and coherent (harmonic and possibly subharmonic, narrow band, plus mixed frequencies due to nonlinear interaction with energy at other radio frequencies). In telecommunications microwave systems, such harmful effects to other systems are contained by geographical separation (for terrestrial beams), by careful attention to minimizing harmonic energy levels at the transmitting antenna, by careful attention to render receiving equipment less susceptible to the effects of off-frequency energy and by careful engineering of beam antennas to reduce side lobes. Energy densities as low as $\mu W/m^2$ (or even in some cases p W/m^2) can be harmful. The energy density (at the space antenna) involved in the scenario outlined by Varsavsky is about 500 W/m^2 level (145dB above the p W/m^2 level).

It is not hard to imagine the reaction of the international authorities concerned (e.g, ITU concerned with the allocation of free-space spectrum usage, a body to whose *mandatory* agreements most of the nations are signatories; and CISPR a body which produces international *recommendatory* documentation directd to the reduction of radio interference). International usage of the radio frequency spectrum is too limited and too valuable a resource to be prejudiced without the most prolonged and careful evaluation.

In addition to international frequency allocation, international allocation of "slots" in the limited area of the geostationary orbit is also practised. Spacing of satellites using powers of a few tens of watts at the same frequency is of the order of a few thousand kilometres. Technical argument as to whether (and by what technical improvements) the existing size of slots would accommodate "birds" using powers of a few kW is not yet entirely settled. At the frequencies in question deficiencies of the size of millimeters in the "perfect" shape of a transmitting antenna cause radiation of appreciable energy outside the main beam. It is hard to see how a near perfect shape for a space antenna could be constructed and then maintained over a reasonable life time even if a frequency-coherent power source of 5000 MW could be achieved. A set of nonfrequency-coherent power sources totaling 5000 MW would produce considerable out-of-band energies both broad-band and spot frequency.

Diffraction of energy at discontinuities in a beam antenna also causes out-of-beam radiation. Discontinuities in the level of energization across the dish would also cause out-of-beam radiation (e.g., the breakdown of one or a number of a set of sources powering a transmitting dish, or "burps" in the smoothness of the level of energization by a beam incident on a passive reflector dish).

A biological hazard exists (particularly to the eyes and the gonads) from the irradiation of living tissue at microwave (i.e., nonionizing) frequencies. National standards for maximum permissible human exposure range from 100 W/m^2 to several orders lower. When or if international agreement is reached, the agreed figure for permissible safe exposure will certainly not exceed the value of 100 W/m^2, except perhaps for very short intervals. I presume Varsavsky's scenario envisaged an earth antenna with power densities in the kW/m^2 range; while not as dangerous as the ionizing radiation in a nuclear reactor chamber, this level would certainly require the whole source to be switched off for maintenance or the provision of robot maintenance technicians.

My purpose in writing down the above thoughts is not to argue that such a power transmission system is impossible. It is certainly possible even with today's technology. Rather, my purpose is to appeal to people who write technological scenarios to avoid, even in the initial stages, economic appraisals which take no account of the cost (in political and social as well as monetary terms) of dealing with foreseeable unwanted by-products of the systems they choose to analyze.

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February 11, 1980

TO THE EDITOR:

The following is addressed to all members of CSIT, as well as to engineers in general.

Do you believe that we as engineers have especially great responsibilities to speak out on governmental policies that involve such matters as job security for ethically or politically active engineers, freedom of engineers to move from one job to another or from one country to another, and the use of high technology for military, political or economic purposes? If your answer is yes, as is mine, then certain political issues on the world stage today become great ethical issues for us. In particular, consider the following two ethical issues:

Ethical Issue No. 1 If a nuclear war devastates our and the Russian civilizations, to what extent are we as engineer responsible?

Ethical Issue No. 2. If a country carries out economic or physical reprisals against politically dissident engineers and scientists, to what extent should IEEE and other organizations of engineers take remedial actions?

The time has come, I believe, when we who are the prime implementers of technology must join with all ethically responsible political forces to bring about (a) a humane use of our technology, leading toward a humane society in which technology plays an important role, and (b) a worldwide political climate in which all engineers and scientists will feel secure in their jobs while acting on ethical principles. From my acquaintance with the IEEE Code of Ethics for Engineers *(IEEE Spectrum*, February 1975, p. 65), I believe the IEEE does not have a clear mandate for advancing the engineering profession in these directions.

I suggest that the IEEE (a) take steps to implement this expanded ethical role of the engineer, and (b) take steps to deal effectively with Ethical Issues 1 and 2.

I'll appreciate receiving the opinions of CSIT members on these questions.

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IEEE Energy Committee Position Statement on Breeder Reactors in the United States

Entity Position Statement; December 17, 1979

The IEEE Energy Committee recommends that an aggressive program on breeder reactor technology be maintained. The IEEE Energy Committee further recommends that the Clinch River Breeder Reactor (CRBR) plant project be continued in order to acquire engineering as well as manufacturing experience and the plant component performance data requisite to developing a U.S. liquid metal fast breeder reactor (LMFBR) technology.

This recommendation does not endorse a commitment to full-scale commercial development of the LMFBR fuel cycle prior to resolving the issues of reprocessing, waste management, safety, and safeguards; nor does it oppose the exploration of alternative fuel cycles or strategies which may offer certain advantages over the LMFBR.

Comment on the Position Statement on Breeder Reactors

IEEE Energy Commitee

The earliest dates by which a first commercial breeder will be needed are variously estimated in the period from the late 1990's to the 2040's. Currently, only the LMFBR is sufficiently advanced technologically to become available for commerical deployment early in this period. Failure to demonstrate that the technology can be dependably applied commercially, if required, would subject the U.S. economy and security to unnecessary risks.

The costs of minimizing these risks are relatively small. A completed demonstration of the technology with the CRBR will provide the minimum assurance that the U.S. has at least one independent electrical energy supply option, i.e., the use of the domestic stocks of fertile uranium-238 remaining from prior U.S. uranium enrichment. Additional breeder concepts should also be developed for possible demonstration and commercial deployment later in this period.

Continuation of the CRBR plant project will help to reassert the intent of the U.S. to be an international leader in the development of peaceful nuclear energy and thus to preserve U.S. influence in world councils concerning the establishment of adequate nuclear safeguards and the minimization of proliferation risks.

Dissenting Opinion on the Position Statement on Breeder Reactors

Dr. David Redfield
RCA Laboratories

The primary need in the breeder reactor program is to provide technological opportunities to extend our usable nuclear fuel resources. There are several ways of meeting this need without making the strong commitment to the plutonium breeder (i.e., the LMFBR) that is represented by the Clinch River Breeder Reactor (CRBR). These alternatives were almost totally ignored at the Energy Committee Seminar and in the recommendation to press ahead with construction of the CRBR. Moreover, the potential hazards of nuclear weapons proliferation and large-scale plutonium commerce have not been adequately considered in the CRBR decision.

The argument given for proceeding immediately with the CRBR is a sense of urgency that is not supported by the facts of the situation. The major declines in projected demand for nuclear power have significantly delayed the time at which the breeder may be needed. In the meantime, a very large breeder development program is continuing, with major component fabrication and testing as well as operating experience on the Fast Flux Test Facility. The CRBR itself has been heavily criticized as being too expensive for a commercial system and far from technical optimization.

In view of the reduced urgency, the hazards of the plutonium breeder, and the inadequacies of the CRBR, the most prudent course is to utilize the alternative means of stretching our nuclear fuel by more efficient use, while developing breeders whose hazards are less severe.

David Redfield is Chairman of CSIT's Working Group on Energy and the Environment, and a member of the IEEE Energy Committee.

News, Notes, and Comments

New Society Formed

The interdisciplinary Society for the Study of Professional Ethics was officially launched by the adoption of by-laws in December 1979, although several professional meetings had previously been held.

Membership is open to practicing professionals, educators in the professions, and interested members of the academic disciplines. The purposes and objectives of SSPE are to provide a forum for the consideration of ethical questions and related conceptual problems associated with professional practice; and to promote a fruitful interdisciplinary and interprofessional dialogue on the nature and value of responsible professional practice.

Volunteers in Technical Assistance

VITA, with headquarters in Mt. Rainier, Maryland, was formed in 1960 with the objective to help improve the living conditions of people in Third World countries without affecting the delicate balance between basic human needs and the availability of resources and trained workers. There are now about 4,000 engineers, educators, business people, and others who volunteer their services to the solution of important problems for individuals and organizations in developing countries who otherwise might not have access to technical information.

The types of projects on which VITA collaborates might be called "appropriate technology," which meets the [illegible], economic, and technical needs of a population without adversely affecting the environment or the culture. Alternative technology is labor intensive, easy to maintain, simple to operate, flexible, and decentralized.

(The preceding information was supplied by the IEEE Technical Activities Board in order to inform IEEE members of this possibility to volunteer time in their areas of expertise.)

Sweden's Nuclear Referendum

In a national referendum on nuclear power held on March 23, 1980, Sweden's voters were given a choice among three proposed nuclear energy policy alternatives. The three alternatives, the percentages of the total vote they received, and the political parties that endorsed them are as follows: (3.3% of the ballots were blank or otherwise invalid.)

Alternative 1 (18.7%, supported by Conservative Party). No new nuclear power plants will be built beyond the current total of twelve (six now operating and six more under construction or awaiting permission to operate). Nuclear power will be phased out as quickly as possible, taking into account the nation's need for jobs, energy, and a decent standard of living. Safety considerations will determine the order in which plants are to be closed down.

Alternative 2 (39.3%, supported by Social Democratic and Liberal Parties). Similar to Alternative 1, except that ownership of all nuclear power plants must be taken over by the state and the communities. (At present, five of the twelve nuclear plants are owned by private industry.) In addition, electrical heating will be banned in all new buildings.

Alternative 3 (38.6%, supported by Center and Communist Parties). All nuclear power plants will be phased out within ten years. In the interim, only the six reactors already on line will be allowed to operate even temporarily, and these only under stricter safety requirements. The mining of uranium and the reprocessing of spent fuel will be banned in Sweden. Export of reactors and of nuclear technology will be banned. [1]

The composite total of 58% in favor of Alternatives 1 and 2 has been generally reported as a "pro-nuclear" vote. Prime Minister Thorbjorn Falldin and his Center Party supported Alternative 3. Although the referendum is not legally binding, all of Sweden's political leaders have said that they would abide by the results.

Sweden's five major political parties are unanimous in advocating a vigorous R&D effort on renewable energy sources and a strong energy conservation program that would achieve zero-energy-growth by 1990. Currently, imported oil provides 72% of Sweden's total energy; hydropower 12%; forest wastes 8%; coal 4%; and nuclear 4%. It is projected that the twelve reactors will supply 12% of Sweden's total energy and 40% of its electrical energy. Sweden's uranium reserves are estimated to be 15% of the worlds's total, although the ore is relatively low-grade.

[1] The three alternative were reported in *Nuclear News*, February 1980, page 49.

Engineering Ethics and the IEEE: An Agenda

Stephen H. Unger

Although the IEEE made significant strides in the ethics area during the seventies, much remains to be done. The following items constitute a partial set of goals and tasks.

Ethics Code

The IEEE Ethics Code was originally promulgated in 1975 [1] as a living document to be modified on the basis of further discussion by the membership. A number of constructive critiques have been made and even published [2,3], but, except for a minor change in the preface, revisions have never been seriously considered.

More recently, proposals have been made to join with other engineering societies to establish a uniform code of engineering ethics [4,5], perhaps via the American Association of Engineering Societies. Both this idea and revisions of the IEEE Code should be seriously considered by an IEEE task force composed of interested and knowledgeable members.

The author is Professor of Computer Science, Columbia University. *This work was supported in part by the National Science Foundation and the National Endowment for the Humanities under Grant No. OSS-7906980.*

Legal Defense Fund

In 1977 an extensive survey of American IEEE members (over 61% of 12,390 receiving the form responded) yielded a 63% "yes" response to the question: "Should IEEE establish a Legal Defense Fund to aid members placed in jeopardy as a consequence of their adherence to the Code of Ethics? (The "no" vote was 25%.) No general IEEE action has been taken to implement this proposal (although IEEE's legal counsel has advised that it could be done within the framework of our charter). The San Francisco Bay Area IEEE Council is in the process of establishing such a fund on a local basis. Clearly this is a matter deserving serious attention on the national (perhaps even transnational) level.

MCC Procedures

Although the IEEE Member Conduct Committee (MCC) has been in operation for several years, its work in enforcing and supporting the Code of Ethics has received minimal publicity. Most significantly, no systematic, routine procedures exist for informing or reminding members of a regualr basis that they can be disciplined by the MCC for unprofessional conduct or that they can appeal to the MCC for support if their careers are placed in jeopardy as a result of their adherence to the Code of Ethics. New members cannot learn of the existence of a

Code of Ethics or the MCC except by word of mouth or from infrequent references in publications.

Clearly this is an unsatisfactory state of affairs, but one which is not very difficult to remedy. A simple approach would be to enclose, with the annual dues notice, a leaflet containing the Code of Ethics, a concise summary of MCC procedures with information as to how to contact MCC and an invitation to send for a copy of the relevant bylaws and procedures. In addition, an annual report of MCC's activities should be published in *Spectrum* and/or the Institute. Full reports on ethics cases should also be published (in the same periodicals) as appropriate (e.g., the Edgerton case).

The time is ripe for a general review of MCC procedures, both internal and external. For example, has adequate support staff been provided? Can effective use be made of volunteer member support, for example, on an ad hoc basis to investigate cases? Is the budget adequate? Regarding external procedures, should the support provisions be extended to nonmembers so as to strengthen the Institute's legal position? Should the enforcement provision be reworded so as to define more precisely what is meant by unprofessional conduct?

Other Means for Ethics Support

The efforts of the MCC to raise ethical standards in engineering may be supplemented through other agencies. Two possibilities are (a) legislation to make it clear that engineers have a right to practice ethically and (b) the adoption, by employers of engineers, of internal procedures that encourage more responsible professional behavior.

The IEEE might develop model legislation related to the first approach that could then be proposed to Congress. A good starting point would be the Amicus Curiae brief filed by IEEE in the BART case [7].

With respect to the organizational rules, we might consider such procedures, as those proposed by the NRC for dealing with differing professional opinions put forward by members of its staff. [8,9]. The IEEE could play a useful role in bringing such ideas to the attention of employers.

Acknowledgement

Discussion and correspondence with Walter L. Elden and James F. Fairman, Jr. contributed to the thoughts expressed above, although they are not necessarily in full agreement with them.

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Misinformation and Democracy

A fundamental prerequisite for an open democratic society is that citizens be adequately informed of the major issues of the day, that they understand the factors that go into making public policy on these issues. Currently, few things are more important than the issues that impinge on energy policy, such as: nuclear reactor economic and safety characteristics, solar energy viability, and automotive fuel economy standards. These, and many others, are the subject of intense research and study by many organizations and agencies. Reports on the results of such research and study—often of massive proportions—are released at an increasing rate. Citizens' views of reality concerning energy issues, their perceptions of the facts impinging on public policy, largely come from press-prepared summaries of the summaries-and-conclusions section of such reports often called executive summaries.

Suppose that the information received by the public is inaccurate. The public will then form erroneous perceptions of reality and acquire a distorted image of the truth. This could have disastrous consequences for public policy. If, on the basis of defective perceptions, the public can be led to accept the development of inappropriate technologies or to acquiesce in the weakening of safety- or health-related safeguards, the result could be nothing short of catastrophic. Furthermore, when such manipulation is eventually perceived by the public, it can lead to cynicism and distrust, attitudes that are unhealthy for democratic values and institutions.

Information received by the public can be inaccurate in several ways:

(a) Popular press reporters might simply have misunderstood the report in question. Although this is a possibility, it is a problem that can be overcome.

(b) Reporters might be misled by the manner in which conclusions are stated in the report. This was the case with the 1968 report of the National Academy of Sciences on SST noise [1] which was stated in such a way as to lead the reader to infer that very little material damage would result from the operation of a fleet of SST planes. This was done by presenting an estimate of extremely small probability of damage to any particular building due to a single sonic boom. But taking into account the number of expected supersonic flights per year, when this small damage is integrated over all expected booms (10^{12} in number), the contrary conclusion results; namely, substantial damage ensues, not negligible. [2] This was also the case with the Reactor Safety Study (the Rasmussen Report). In the executive summary, when plotting the consequences of nuclear accidents and comparing with those of other events, such as meteors falling, the axis is labeled "fatalities". In the body of the report, the same curves are labeled "*early* fatalities". Since the long-term fatalities from a nuclear accident are acknowledged to be many hundreds of times greater than the fatalities occuring in the first days after the accident, a highly misleading impression about total fatalities is created in the executive summary, which is the only part of the report that all but a few experts will read. [3]

(c) The aphorism of the computer world, GIGO (Garbage In, Garbage Out), can be applied. The outcomes from an analysis are crucially dependent on what goes into it: the underlying assumptions (about prices, factors taken into account or neglected conditions of society, etc) and the methodologies used (mathematical methods, discounting rates, surveying techniques, etc). If these are flawed, the results will be flawed. In fact, results can be changed dramatically, even reversed, if the premises on which the study is founded are made more realistic or the methodologies improved. In effect, the press can be made a tool and "used to propagate a specific point of view purporting to be the objective outcome of such a flawed study. The article on automotive fuel-economy standards by Frank von Hippel in this issue deals with such a case.

Another case is the report of the National Academy of Sciences' Committee on Nuclear and Alternative Energy Systems (CONAES). The report was released in January 1980, almost three years after it had been essentially completed and preliminary results released. On the question of solar energy, the "Summary" section of the "Overview" Chapter of the report comes up with the astounding conclusion that not much more than five percent would be contributed by solar energy to energy supply in this century, "unless there is massive government intervention in the market to penalize the use of nonrenewable fuels and subsidize the use of renewable energy sources." And this is what the press dutifully reported to the public since, realistically, the "Overview" was its only source of information on the matter.

But the President's Council on Environmental Quality, having enough resources and time, confronted the bulky main report and learned some very disquieting facts. [4]

1. The CONAES Solar Resources Group's no-more-than-5-percent-by-2000 conclusion was based on several assumptions: (a) real prices for fuels competing with solar energy, coal oil, *will remain constant at 1975 levels for 30 years* (b) there will be no major advances in solar technologies over the same period and (c) there will be no national commitment to accelerate the introduction of such advances. Even if the implausibility of the last two assumptions is neglected, how can anyone possibly justify the no-increase-in-price assumption? In the two years preceding their 1975 base, there had been a *tripling* of oil prices. From 1975 to the date of release of the CONAES report a *further tripling* of oil prices had occurred. If the competence of the CONAES scientists is granted, then it becomes very difficult to understand why they would make such a spherically senseless assumption. ("Spherically" because it is senseless no matter how you look at it.)

2. The CONAES Solar Resources Group analyzed another scenario in the main report, one that resulted in a solar energy contribution of about 20 percent by the end of the century. This scenario is based on an assumed major national commitment to solar use, but the CONAES report concludes that the cost of doing this would average about $100 billion each year over the next 30 years, for a total of *three trillion* dollars, a truly prohibitive amount. According to Gus Speth, Chairman of CEQ, there is "no documentation whatever for this cost estimate in the CONAES report itself." Upon questioning individuals who worked on the study, he was informed that only informal calculations had been made, but none of them had been kept. One of the scientists involved recalled that the cost figure was based on the total capital costs of building all solar equipment needed for the next 30 years, using today's prices. But since the Solar Resources Group itself predicted that what has happened historically to technologies like transistors, computers, and hand calculators would happen also to most solar technologies, namely, a reduction of real costs over the next 30 years, this assumption is not a tenable one.

If the CONAES calculations are repeated, but the cost reductions expected by CONAES itself are incorporated, the result is that the CONAES figure is 250 percent too high, according to Gus Speth. Futhermore, this is a *gross* figure from which would have to be subtracted all the capital costs and the fuel costs of the conventional sources which would no longer have to be provided. Again questions intrude themselves. How is it possible for such eminent scientists, under the *imprimatur* of so prestigious an institution as the National Academy of Sciences, to have made such obviously unreasonable assumptions and carried out such slipshod calculations? One consequence is calculable; Erroneous public perceptions of reality to such an extent that the very basis of democracy, an informed electorate, is subverted.

Such questions, and those asked by Frank von Hippel at the conclusion of his article, deserve answers.

NORMAN BALABANIAN

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TO MAKE TECHNOLOGY BETTER SERVE SOCIETY

The IEEE Committee on Social Implications of Technology (CSIT) has launched a petition drive to convert CSIT to an IEEE Society (see box).

The Committee on Social Implications of Technology was established by the IEEE in 1972. During the eight years of its existence, CSIT has published 29 issues of its quarterly sixteen-page newsletter, *Technology and Society*, which features articles, book reviews, and commentary on such topics as ethics, energy, environmental quality, arms control, information technology, societal systems engineering, consumer product safety, and technology in less-developed countries. (*Technology and Society* has a paid circulation of 2500.) CSIT has organized sessions at IEEE conventions on "Social Implications of Nuclear Power" (Electro '75) and "Solar Energy: A Status Report" (Electro '77). CSIT has given four engineers the Award for Outstanding Service in the Public Interest, consisting of a certificate and $750. CSIT provided the impetus for the IEEE to adopt a Code of Ethics and to set up a Member Conduct Committee that enforces the Code and supports engineers who adhere to the Code.

Nevertheless, CSIT finds that its effectiveness is severely limited by the constraints that are imposed on IEEE Technical Activities Board committees. CSIT believes that, to do the quality work that is needed in this area, it must have access to the full range of activities and communication channels that are available to IEEE groups and societies; most importantly, it must be able to publish a refereed transactions.

Maximizing the benefits and minimizing the harmful effects of technology are important for the well-being of all people, but CSIT feels that these pursuits have a special importance for members of the engineering profession by reason of technical knowledge, ethical responsibility, and economic self-interest. CSIT asks all IEEE members who care about these issues to sign its petition.

PETITION TO FORM AN IEEE SOCIETY ON SOCIAL IMPLICATIONS OF TECHNOLOGY

The undersigned IEEE members hereby petition the Executive Committee of the IEEE to authorize the formation of a Society on Social Implications of Technology. The purposes of the Society are to develop and promote understanding of the interaction between technology and society, to enhance our knowledge of the benefits and detriments of technological options, to support the engineer in the exercise of ethical responsibilities, and to discover and promote means to make technology better serve society. These purposes will be pursued by publishing a transactions, by publishing a newsletter, by holding meetings and conferences, and/or by any other activities appropriate for encouraging analysis, communication, discussion, and action relating to social implications of technology. The interests and activities of the present IEEE Committee on Social Implications of Technology, including publication of Technology and Society, will be assumed by the new Society.

Signature..

Name
(please print)..

IEEE Member Number
(above student grade)...

Please return signed petitions to: Stephen H. Unger, 229 Cambridge Ave., Englewood, N. J. 07631

Send Form 3579 to IEEE, 445 Hoes Lane, Piscataway, N.J. 08854