Irwin D.J. Bross, Ph.D.
Director of Biostatistics
Roswell Park Memorial Institute
666 Elm Street
Buffalo, N.Y. 14263

4

September 5, 1980

Richard H. Vollmer, Director
Three Mile Island Support
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Vollmer:

In conjunction with the hearings of the U.S. Nuclear Regulatory Commission on the newly released draft Programmatic Environmental Statement (DPES), I would like to submit this critique. Using the metatechnological analysis appropriate to EIS, this critique demonstrates that, relative to viable technological alternatives, the proposed plan is the least feasible, the most expensive, and the most dangerous to the public health and safety. It is further pointed out that NUREG-0683 is an incompetent document from an epidemiological and biostatistical standpoint and all the estimates of hazard are so remote from the real risks that it constitutes a dangerous fraud upon the public.

There is a much better way to do the job of disposing of the radioactive wastes at TMI-2 but there is no way to make NRC bureaucrats listen to reason when they are in complete control of the proceedings.

Very sincerely yours,

Irwin D.J. Bross, Ph.D.
Director of Biostatistics

IDJB/mak
Enc.

CRITIQUE OF NUREG-0683 BY DR. IRWIN BROSS

Let us start with the question: What is an appropriate basis for a critique of a Draft Programmatic Environmental Statement (DPES) of any plan for the decontamination and disposal of radioactive wastes resulting from the March 28, 1979 accident at Three Mile Island Nuclear Station, Unit 2 (TMI-2)?

The clear intent of the National Environmental Policy Act was to insure that the public health and safety be protected. When, as here, there are alternative technologies for achieving the same goal, then the DPES should establish that the technology that is proposed minimizes the danger to the public health, is technologically feasible, and cost-effective. Hence, the critique of a DPES lies in the province of what is now being called "metatechnology". For a more complete discussion see my new paper, METATECHNOLOGY: A TECHNOLOGY FOR THE SAFE, EFFECTIVE, AND ECONOMICAL USE OF TECHNOLOGY, which will be published in the new British journal, METAMEDICINE, in February 1981 (see Schedule A). From this standpoint we must consider alternative courses of action (and alternative technologies) for disposal of the radioactive wastes from the accident at TMI-2. Although there are numerous technological alternatives, for present purposes it will suffice to consider only three:

1. Inaction. No other action beyond present maintenance operations for an indefinite period.

2. DPES*. The programmatic plan proposed in NUREG-0683 for a 5 to 7 year clean-up of TMI 2.

3. Entombment. Disposal of the radioactivity wastes by immobilizing them in concrete in the containment of TMI-2.

A metatechnological evaluation involves comparison of the costs and benefits of the alternative technologies and the choice of a disposal technology that will accomplish its purpose with minimum risks to the public health and safety. The key factors in the cost-benefit evaluation here are the following:

What is the extent to which:

(k-1) Humans are directly involved in the disposal operations?

(k-2) Radioactive materials must be transported inside the containment or removed and transported elsewhere?

(k-3) New technologies must be developed to do the job?

As a rule-of-thumb an unfavorable situation with respect to the key factor will at least double the complexities, practical difficulties, and operational costs of the overall project. It will increase risks to workers and the public by a greater amount, roughly a factor of 4.

Since there is consensus that a first alternative, inaction, is not appropriate for TMI-2, only the second and third alternatives will be considered in what follows. However, an official DPES should also evaluate this alternative carefully. The reassurances to the public on TMI-2 suggest that NRC calculations do not show any appreciable risk of meltdown from the present haphazard configuration of the rods and other radioactive material. The only scenarios that could produce such a risk (e.g., earthquake) involve the mobility of the rods and the large amount of radioactive water in the containment. The risks become completely negligible if the water used to mix with the concrete and the radioactive materials are immobilized in this concrete. Hence, it follows that the goal of suitable disposal of the radioactive wastes in TMI-2 can be achieved equally well by the plan proposed in NUREG-0683 or by entombment. Earlier claims of further benefit from NUREG-0683 by reactivating TMI-2 are now recognized as absurd. The cost of meeting NRC exposure levels (5 rem/year) by decontamination of TMI-2 (where levels of 100 rem/hr have been reported) far exceed the costs of building an up-to-date installation *de novo*.

Since the benefits for the alternative technologies are about equal, the metatechnological choice here hinges on the costs, particularly the health costs to workers in the clean-up and to the general public living near TMI-2 or downwind or downstream from the installation. The situation with respect to the key factors can be summarized as follows:

With respect to the transport of radioactive materials, the proposed clean-up plan involves removal of these materials from the containment and transportation to other locations. Again, to implement the plan in DPES* there must be purging of radioactive water into a river system that serves or affects many U.S. cities. With entombment the radioactivity stays inside the containment of TMI-2. Therefore, with respect to the second key factor (k2) there is minimal movement of radioactive materials in the entombment option, but extensive movement of these materials (and possible dissemination into the environment) in DPES*. For this reason alone NUREG-0683 should be rejected as an incompetent document by the basic principles of metatechnology.

With respect to the first key factor (k-1), the extent of involvement of human beings in the processing of radioactive materials, the entombment option has minimal involvement. The processes for dealing with concrete (including the use of cooling pipes and other refinements) represent a well-known technology that can be largely carried out by machinery under remote control. In contrast, DPES* makes extensive use of human workers in an environment contaminated by both low-level and high-level radioactive wastes. The estimates of health effects in NUREG-0683 underestimate the actual hazards by factors of 100 or 1000.

The Mickey Mouse arithmetic used in federal agencies for what are called "radiological assessments" involves too many scientific errors to detail here. I have given detailed examples at a hearing of the Department of Energy on West Valley (Schedule B) which explains why exposures are consistently underestimated by factors between 10 and 100. In addition, the health effects for given exposures are consistently underestimated by a factor of 10 or more. Documentation of the new factual evidence on persons actually exposed to low-level radiation (which shows 10-fold higher health risks) was given in my invited presentation to the American Statistical Association in Houston, Texas, on August 13, 1980 (Schedule C). The net effect is that the estimates in

NUREG-0683 concerning death and disability for workers understate the actual risks by a factor of 100-1000. When such unrealistic estimates are used in a DPES, this represents a reckless endangerment of the public health. There is no question but the DPES* involves extremely serious hazards to the workers that are being deliberately covered up by the Mickey Mouse arithmetic of these "radiological assessments".

The combination of the first two factors, extensive use of humans (k-1) in close proximity to radioactive materials (k-2) create a difficult situation for DPES*. Safe operations would require new technological developments that are beyond the present state of the art. The difficulties in attempting to develop new technological tools on-site and on-the-job pose formidable management problems which compound the difficulties. In my draft EIS for West Valley, I have discussed these management problems at some length (Schedule D). While a clean-up of TMI-2 is simpler than a clean-up at West Valley, the record of management at TMI-2 and past failures with simple tasks is not encouraging. Very serious dangers, both to the workers on the job and to the public, from failures of untested technologies developed on-site and on a crash basis are ignored in NUREG-0683 and elsewhere in DOE-NRC planning. In contrast, entombment minimizes worker involvement and the manipulation of the radioactive wastes. It uses familiar concrete technologies that avoid most (though not all) of the problems that would require new technology. There could be added technical problems in cooling systems that would require some extension of existing technology. However, entombment operations are orders of magnitude simpler and less fussy than the clean-up proposed in DPES*.

From this qualitative analysis (which could be supplemented with quantitative metatechnological analysis), it follows that the entombment option is much more technologically feasible than the plan in NUREG-0683. Again, the rule-of-thumb on costs (and the adverse situation of DPES* on all three key factors) means that DPES* will cost at least 8 times more than entombment. If, with inflation, entombment costs $0.5 billion, then DPES* will cost at least $4.0 billion. These costs will have to be paid by ratepayers and taxpayers of Pennsylvania and other states and perhaps by shareholders of the utility. As noted at the start, <u>the extra money will buy no actual benefits</u>. Both alternative technologies will do the disposal job equally well. Moving humans into the containment of TMI-2 and moving radioactive wastes out of it is costly and this money buys nothing but grief for both workers and the public.

The only explanation offered here for the NRC insistence on DPES* is that bureaucrats follow their own special "logic" where it is easier to endanger the health and safety of thousands of human beings than to bend NRC regulations to deal sensibly with the unprecedented situation at TMI-2. If there are legal problems in entombment, I believe Congress would act to change the laws since this will save billions of dollars and perhaps hundreds of human lives.

Finally, let us come back to the real issue here, the choice of an alternative technology that will minimize the risks to the public health and safety. NUREG-0683 relies on inadequate "radiological assessments" instead of on more realistic "public health assessments". We now have more than 20 years of experience and more than 20 specific instances where both kinds of assessments were made (Schedule C). In each case, the "radiological assessment" predicted that there would be no hazard from the exposure to nuclear or medical radiation. In each case a genuine "public health assessment" found evidence of serious hazard to the persons exposed. NRC "radiological assessments" are fake "science" and do nothing to protect the public health and safety from radiation hazards. I have further discussed the distinction between "radiological" and "public health" assessments in a letter written in conjunction with the Krypton purging (Schedule E).

Any adequate "public health assessment" of the danger to the public health and safety from implementation of the proposal in NUREG-0683 would show that the "radiological assessments" have covered up the grave dangers that would occur. Since there is a cheaper, easier, and safer way to dispose of the radioactive wastes at TMI-2--essentially immobilizing them in an ideal "tomb" (a containment that can never again be used for other purposes)--only idiots would go ahead with the NUREG plan. However, from my personal contacts with the decision-makers involved in this issue, I am confident that the clean-up of TMI-2 will follow the NUREG-0683 plan.

ABOUT DR. BROSS

A complete vita and bibliography for Dr. Bross has been included in previous NRC testimony and will not be repeated here. . is the author of more than 300 publications on biostatistics, epidemiology, and public health research. He is also the author of three books. The first is a recognized classic on statistical decisionmaking (DESIGN FOR DECISION, Macmillan, 1953). His latest text deals with the science and politics of public health decisionmaking (SCIENTIFIC STRATEGIES TO SAVE YOUR LIFE, Dekker, 1981). He has testified on radiation hazards to numerous Congressional and other committees.

On August 13, 1980, he debated the scientific issues before the American Statistical Association meeting in Houston, Texas and routed his two opponents from the federal agencies. His primary interest at present is the protection of the public from the hazards of the technogenic diseases that have become the number one U.S. public health problem. Technogenic diseases are those produced by the misuse or abuse of new technologies. The TMI-2 accident and its mismanaged sequel are a prime example of this growing public health problem.

METATECHNOLOGY: A TECHNOLOGY FOR THE SAFE, EFFECTIVE, AND ECONOMICAL USE OF TECHNOLOGY

Irwin D.J. Bross, Ph.D.

ABSTRACT

Alarmed by Three Mile Island, Love Canal, and other disastrous deployments of new technologies, the public is demanding more voice in the decisionmaking on technology. To make this possible, it is proposed that metatechnology be evolved that will provide a practical technology for the safe, effective, and economical use of technology. A case history of a specific metatechnology is presented. Here the metatechnology enabled a realistic balancing of the benefits of mass screening of women by mammography against the hazards from the x-rays. By showing that the screening of women under 50 was counterproductive, this metatechnology helped to ban such screening in a program involving a quarter of a million women. The strategic mistake in setting up this and other technological programs was that the decisions were made by the technologists. They benefited the technologists but were not beneficial to the women. One of the potentials of metatechnology is that in its fully computerized versions it could be used directly by the public for decisionmaking on the deployment of technologies.

I. INTRODUCTION TO METATECHNOLOGY

In recent years, sophisticated technologies have often been deployed on a large scale with no adequate consideration of the long-term consequences. The current procedures for decisionmaking, whether they are informal (such as a consensus of 'expert opinions' of members of a committee) or more formal (such as cost-benefit analyses), have consistently failed to give realistic appraisals of either the costs or the benefits of new systems. The major factor in these failures is the point of view or perspective of the decisionmakers. Most of the decisionmakers are directly involved with the technology. In this sense, they are 'close' to the action situation. On purely technical issues, this may be advantageous. However, in considering strategic issues in deployment of a technology, this 'closeness' to the action situation can give a very distorted view of it. The decisionmakers are, in fact, a part of the action situation.

The view of an 'insider' is necessarily different from--and often in flat conflict with--the view of an 'outsider'. The members of the public are the 'outsiders'. However, it is *their* costs and benefits, rather than those of the 'insiders', that should be the basis for decisions on deployment. *The long series of fiascos and disasters with sophisticated new technology are often the result of decisionmaking from the wrong perspective*.

The performance of new technological systems has consistently fallen far below the promises or expectations of the technologists who were promoting these systems. At the same time, the costs were grossly underestimated, leading to huge cost overruns and to unanticipated hazardous side effects.

The public has become increasingly disenchanted with sophisticated technologies. We are now reaching the point where public resistance to the deployment of new scientific or medical technology will make it increasingly difficult and costly to carry out such programs--if they can be carried out at all. The public will call for moratoriums on technology (either by law or covert resistance) unless it can be given some credible guarantee that technology will be used sensibly. This is not public 'hysteria'. It is the only defense the public has against the mindless uses of technology that have repeatedly jeopardized the public health and welfare.

In my view, the way to meet these legitimate demands is to develop what I have called 'metatechnology'--a technology for the safe, effective, and economical use of technology. This may be, I believe, the best hope of providing a meaningful guarantee against the abuse of technology. Perhaps the two main distinctions between metatechnology and most existing procedures for balancing costs and benefits are (1) a shift in perspective, and (2) a more realistic characterization of the key factors in an action situation.

The first step in the development of metatechnology is to evolve an effective scientific characterization of the action situation and its components. The technology <u>and</u> the technologists are now considered to be components in the action situation. The view is from outside of the system and the benefits and costs are those involving the public health and welfare.

In contrast to the usual characterizations, the objective is to describe the 'deep structure' of the situation rather than the surface features. This distinction will become clearer when we consider an actual example of metatechnology. The description of the action situation strives to be rigorously scientific. Hence it is expressed in mathematical language and is always validated by stringent testing against real data. For the complex, extensive action situation of actual deployment of technology, this is a difficult task. That this task can be accomplished is best shown by considering a specific example where it was done.

In what follows, the Breast Cancer Detection Demonstration Program (BCDDP) will be used as a continuing example of how metatechnology can be used--and was used--for decisions concerning the deployment of a medical technology. In this instance, the metatechnology helped to stop a dangerous and ineffective x-ray surveillance of 130,000 American women.

II. DEVELOPMENT OF A METATECHNOLOGY

Skepticism with respect to the claims of technology should carry over to the claims of metatechnology. Therefore, it is preferable to deal with actualities rather than maybe's. Let us therefore turn to an actual example of metatechnology applied to a major public health issue.

More than a decade ago, the Biostatistics Department at Roswell Park Memorial Institute for Cancer Research in Buffalo, New York, developed the first comprehensive mathematical model for the growth and spread of a human cancer (Bross et al., 1968b). The cancer was breast cancer. The main reason for the department becoming involved with this particular cancer was that a national collaborative clinical trial of this cancer was centralized in the department (Slack et al., 1969).

A collaborative study had been set up to compare various adjuvants to the standard radical mastectomy in the treatment of breast cancer. The actual comparison of the adjuvant treatments was only of transient interest. Of more enduring interest was the development of a comprehensive mathematical model to describe this data base of over two thousand breast cancer patients (Blumenson et al., 1969). This rigorously-tested model explained the results in the treatment comparisons (Bross et al., 1968a). It was subsequently used to predict the results in the next collaborative study set up by Dr. Bernard Fisher. Before this study began, it was predicted that no significant differences between the various treatments in the new study would be found. The detailed predictions of the results of the new study were published in Cancer (Bross et al., 1971). Five years and many millions of dollars later this prediction was fully confirmed (Bross, 1972).

The distinction between a model that characterizes the 'deep' structure or underlying structure of a scientific situation and one that describes only the surface features is that the deep structure carries over from one study to the next even though the surface features may change. Five years ago, Dr. Blumenson, who had worked with me on the deep model for the dissemination of breast cancer, became interested in a deep model for the screening procedures used in what is called 'secondary prevention' or 'early detection'. The Breast Cancer Detection Demonstration Programs (BCDDP), for instance, attempted to detect breast cancer at a stage when it could still be cured by standard surgery. The idea was to use the new technology of mammography to repeatedly screen a population of women and thus to detect cancer early enough to be controlled by mastectomy. The catch is that x-ray itself produces breast cancer. Therefore, the risks had to be balanced against the benefits.

On this controversial issue, more than a dozen independent calculation of the risks and benefits have been made. Whenever the calculations were done by the American Cancer Society, which was pushing hard for this program, the results were very favorable to the program. Whenever the calculations were made by radiologists (the technologists who deliver the mammography) or by the American College of Radiology (which was also pushing this program), the results were again overwhelmingly favorable. One popular figure which appeared in the <u>New York Times</u> and in Kodak advertisements in <u>Science</u> and the <u>Scientific American</u> gave 125-to-1 as the benefit-to-cost ratio (Bross, 1980a).

On the other hand, whenever the benefit-to-cost ratio was calculated by competent epidemiologists and statisticians who were <u>not</u> involved in the BCDDP operations, the results were entirely different and it was clear that the program was counterproductive. Dr. John Bailar, then editor of the <u>Journal of the National Cancer Institute</u>, was the first to report that the benefit-to-cost ratio was probably close to unity (1-to-1) for the BCDDP (Bailar, 1975). Unfortunately, the public and many professionals are unfamiliar with such ratios. Hence they would not necessarily realize that this ratio meant there was no point to continuing a program that was then costing the National Cancer Institute about $10,000,000 a year.

The benefit-to-cost ratio for the entire program tends to obscure the critical factor of age. Our new metatechnology provided, for the first time, reliable figures on the benefit-to-cost ratio for the subseries of women under 50 in the BCDDP (Bross et al., 1976) as well as for the women over 50. It turned out that the situation for the women under 50 was so adverse that it was unethical to continue this part of the BCDDP operation. This was reported to the Society for Epidemiological Research in the spring of 1976. The metatechnology showed that four or five breast cancers were being produced by the x-ray for each cancer that could possibly be cured by earlier x-ray detection.

III. METATECHNOLOGY IN ACTION

When the arena of action is the real world of the press, the public, and the lobbying of pressure groups, ideals of logical or rational planning for future events are no lo ealistic. In the turbulent tides of public affairs one can at bes ope to stay on top of events like a surf rider. There is no hope of actually controlling the events once many persons and powerful forces are involved. In this instance the metatechnology probably had some impact at critical times and therefore played some part in the eventual decision of the National Cancer Institute to issue a guideline banning the screening of the women under 50. How much influence the metatechnological findings had is impossible to assess. However, this remains one of the few cases where scientific methods of decisionmaking have had any influence on public affairs.

The unfolding chain of events following the Toronto report of our metatechnological findings could hardly have been expected or planned. First the Toronto Globe and Mail gave front page banner headlines to the story and the wire services picked it up. This gave the politically-minded Washington decision-makers a glimpse of what might be in store for the National Cancer Institute and the BCDDP (which up to this point had only received highly favorable publicity). Second, a presentation had been scheduled in the Washington area for the next week (long before the Toronto talk, which was a last-minute addition to the program). Coming off the Toronto furor, this all-day discussion turned out to be more productive than it otherwise would have been. With Dr. Bailar pushing from inside and with our findings generating outside pressure, the NCI was getting nervous. At the time of the meeting the NCI said it had no plans for issuing a guideline banning the screening of the women under 50. Nevertheless, as the pressures mounted in the next three months, the guideline was issued.

Although metatechnology came into the decision, the NCI decision was made by the usual decisionmaking processes, basically a political process. To be realistic about future applications, it is likely that if metatechnology does have a role in shaping the decisions on the deployment of technology it will be as part of a political process rather than as a purely technical instrument.

After the shut-down of the screening of the women under 50 the radiologists continued to make the same absurd calculations of benefits and risks and used these to bitterly denounce 'government interference' (although they were getting the money from the government!). We offered our metatechnology to the NCI as a means of evaluating such factors as the frequency of screening, effect of changes in detection capabilities, effects of the newer lower-dose techniques, and other moot questions in mass screening. The offer was not taken up since the BCDDP radiologists were not interested in a metatechnology that so deflated their hopes and claims.

There is a grim postscript to this story that carries a grim moral as well. Despite what had happened in the United States, the National Cancer Institute of Canada decided in 1979 to go ahead with its controlled experiment on the mass screening of women under 50 by mammography. By this time non-ionizing ultrasound was available as a substitute for ionizing radiation, but the plans had been made for lower-dose mammography. Even with lower x-ray dose, the benefit-to-cost ratio was again adverse and the experiment was unethical.

These points were made again, using our metatechnology for this purpose, to the Toronto Board of Health. Some details will appear in the Canadian Medical Association Journal (Bross, 1980b). However, once the technological juggernauts get rolling, there seems to be no way to stop them. Unfortunately, the women in Canada will be subjected to an iatrogenic epidemic of breast cancer like their American sisters. The grim moral is that when technologists find it profitable to exploit a particular application, neither factual evidence nor realistic cost-benefit analysis is an effective deterrent.

IV. DISCUSSION OF THE PROSPECTS OF METATECHNOLOGY

The twists and turns in the case history of application of metatechnology to the BCDDP evaluation may be unique in some ways but they do not offer grounds for excessive optimism about the future prospects of this or other approaches to safe and effective deployment of technologies. No matter how scientific and comprehensive the analysis may be, those in power will use the results only if it suits their purposes. Hence, the eventual decisions are likely to be made on the basis of the costs and benefits to the decisionmakers rather than to the costs and benefits to the general public.

This is well illustrated by the enormous difference between the 125-to-1 benefit-to-cost ratio calculated by the radiologists and the 1-to-4 ratio in the women under 50 generated by the metatechnology. The 125-to-1 ratio advertised in the scientific journals was a public relations gimmick to try to save the faltering BCDDP program. This kind of rationalization of an existing deployment has been the main use of the risk-benefit analyses that have been developed over the past 15 years. The machinery for making sound decisions on deployment is something completely different from that used to provide 'scientific' windowdressing for decisions that have been made on a political basis. However, the public may have trouble making this distinction.

Even when genuine scientific decision-making is the goal, the nature of these complex action situations impose severe practical limitations on metatechnology. Generally speaking, these problems are too broad and much too complicated for us to achieve anything close to complete specification of the action situation. In practice, then, only the main or key features of the situation can be brought into a practical mathematical model. Some aspects of the situation may be well understood. Some costs and benefits may be easily estimated. However, there will always be other aspects which are not well understood--and some costs and benefits which are hard to estimate.

We have a natural inclination to deal mainly with those areas which can be well characterized and to sweep the other problems under the rug. This is a fatal strategic mistake which metatechnology tries to avoid. The easier areas, for example, will involve short-term costs and benefits. Technologists may have a good picture of the short-term balance, but it is the long-term costs and benefits that usually matter.

A good example of short-term vs. long-term costs is the reprocessing plant at West Valley in Western New York. At a short-term cost of only 8 million dollars, it was possible to start the operations which produced the 600,000 gallons of high-level nuclear wastes now stored in liquid form. The long-term costs of disposing of the wastes are currently estimated at well over a billion dollars. These disposal costs were completely ignored in what has turned out to be a disastrously bad decision for Western New Yorkers.

The perspective of technologists naturally focuses on short-term costs and benefits because these are the ones immediately encountered in start-up and in the early operations. The problem as technologists see it is to "get things going" (and to worry later about where one is actually going).

Another component of the action situation that is relatively easy to quantify (and which has gotten most of the attention in past) is the hardware of the system. At West Valley, as in most sophisticated technological systems, the trouble developed at the human-hardware interface rather than in the hardware itself. The human component in any system is much more difficult to characterize realistically in a mathematical model. The usual reductionist approach that merely conceals the human problems does not lead to a sensible balancing of costs and benefits.

Most of the planning has been done by engineers and physical scientists who are interested in hardware and not in human beings. These scientists may be impressive when they talk hardware at a conference table. However, they have incredibly naive and simplistic views about human beings. They often tend to think of people as somewhat defective computers. For instance, they ignore persons in the lower levels of the organizational tables as unimportant. But these 'low level' people often frustrate 'high level' plans and instructions. These 'low level' people often adopt ingenuous methods to cope with what they perceive as the hostile environment of a technological system. These 'adjustments' to the theoretical system prescribed by management often have profound effects on performance and on the safety and costs of that system.

From the standpoint of someone working inside of the system who is trying to get things moving, all these uncertainties in the action situation are merely obstacles that have to be overcome by hook or crook. Hence, getting the 'right' (i.e., favorable) cost-benefit analysis becomes largely a matter of getting the 'right' analyst. But this is no way to get an objective, scientific, characterization of the action situation. This precludes going deeply enough into the underlying structure to permit the decisions to be made in a sensible way, While the 'right' cost-benefit figures may provide mathematical window-dressing to hold off congressional critics or concerned citizens, this only works when they cannot understand the complications of the 'analysis'. Finally, this is not a way to make decisions that will be advantageous to the health and welfare of the public--a point which has been repeatedly demonstrated by the bad decisions that have been made in the past 10 and 20 years.

The public has made the disastrous strategic mistake of letting technologists make the decisions about the uses of their technology. Superficially this strategy seems sensible. However, an elementary principle of the evaluation of complex systems is that a good evaluation cannot be made <u>within</u> the system--it is necessary to go outside of the system to make the evaluation of performance. There is no individual and there is no discipline in the sciences that has comprehensive expertise in the utilization of technology. Hence, while the point may be concealed by a smokescreen of technical jargon, the public and its representatives are about as well qualified to make these decisions as anyone else.

The public has the advantage that their perspective of benefits and costs is more relevant that that of the technologists, which more than compensates for any lack of technological expertise. This is not really a new idea. The old slogan "War is too important to leave to the generals" reflects the same idea in a non-technological issue.

A fully computerized metatechnology would make this direct participation by the public possible. For instance, it would be feasible to automate the mass screening technology to the point where a woman could use a computer terminal to enter such parameters as her age and could get back estimates of her risks and benefits or benefit-to-risk ratio. She could make a better decision on whether to enter a screening program on the basis of this objective information than on the basis of the subjective claims of a radiologist. The entire process need be no more difficult than the computerized banking which thousands of ordinary citizens carry out every day.

The thought of concerned citizens making the decisions about the deployment of technology may seem horrendous to many engineers, physicians, and scientists, but if suitable metatechnology is available, the decisions would insure safer and more effective deployment than the decisions that are currently based on 'expert opinion'.

Irwin D.J. Bross, Ph.D.
Roswell Park Memorial Institute
666 Elm Street
Buffalo, New York 14263

REFERENCES

Bailar, III, J.C.: 1975, 'Mammography--a contrary view', Proc. Am. Assoc. Cancer Res. 16, 90.

Blumenson, L.E., Bross, I.D.J.: 1969, 'A mathematical analysis of the growth and spread of breast cancer', Journal of Chronic Diseases 21, 95-109.

Bross, I.D.J.: 1972, 'Scientific strategies in human affairs: use of deep mathematical models', Transactions of the New York Academy of Sciences 34, 187199.

Bross, I.D.J.: 1980a, Scientific Strategies To Save Your Life, Marcel Dekker, Inc.

Bross, I.D.J.: 1980b, Letter to the Editor, Canadian Medical Association Journal, July 19, 1980 (in press).

Bross, I.D.J., Blumenson, L.E.: 1968a, 'Statistical testing of a deep mathematical model for human breast cancer', Journal of Chronic Diseases 21, 493-506.

Bross, I.D.J., Blumenson, L.E.: 1971, 'Predictive design of experiments using deep mathematical models', Cancer 28, 1637-1646.

Bross, I.D.J., Blumenson, L.E.: 1976, 'Screening random asymptomatic women under 50 by annual mammographies: does it make sense?', Journal of Surgical Oncology 8, 437-445.

Bross, I.D.J., Blumenson, L.E., Slack, N.H., Priore, R.L.: 1968b, 'A two-disease model for breast cancer', in A.P.M. Forrest and P.B. Kunkler (eds), Prognostic Factors in Breast Cancer, (Proceedings of First Tenovus Symposium Cardiff 12th-14th April 1967), E.S. Livingstone Ltd., Edinburgh and London, pp. 288-300.

Slack, N.H., Bross, I.D.J., Blumenson, L.E.: 1969, 'Therapeutic implications from a mathematical model characterizing the course of breast cancer, Cancer 24, 960-971.

HOW TO LIE WITH MATHEMATICS

Well over a year ago, the Department of Energy (DOE) was given one year, a million dollars, and a Congressional mandate to produce a feasible plan for cleaning up the nuclear wastes stored at West Valley, New York, not far from Buffalo. The end-result is a DOE Final Report which, like most such reports, contains many numbers. Some of these numbers are the estimates of radiation dosage that will be considered here. These numbers were obtained by methods known in the trade as "Mickey Mouse arithmetic". These numbers are windowdressing. They have almost no value for making the decisions on the clean-up of the West Valley wastes--particularly the 600,000 gallons of high-level liquid wastes which constitute a major potential public health problem.

How can the public tell that the numbers in this Final Report are meaningless and useless? Surprisingly enough, the public has only to read (and understand) the Companion Report put out by DOE. To anyone who can read the technical languages, the latter report plainly says that the numbers in the Final Report are worthless. Is such candor in a report from a federal agency incredible? Not really. This is a way that the technologists who do the Mickey Mouse arithmetic can cover themselves against criticism by their peers. At the same time, the public will go on believing that it has received something of value for its million dollars when in fact it has not.

This fool-proof method of having your cake and eating it too is based on a simple fact: The mathematical and technical jargons used in these federal reports are incomprehensible to the public and its representatives. No one who can read these jargons is likely to embarrass his colleagues by translating this jargon into plain English. However, that is precisely what I am going to do here: First of all, I will give a paragraph of the jargon in Section 4.2.2 on Estimation of Radiological Dosages. Then I will explain what it means.

> "The dose estimates presented in this report are for the implementation of the various options. The future population doses which could occur after the various options have been implemented were not addressed. The possibility of exposures from accidents was not considered, nor were risks for the various decommissioning options assessed. An option with a low dose estimate may have a higher potential for accidents, and consequently additional exposure, than one with a higher dose estimate. The doses were calculated simply to scope the choices in a gross way. In order to assess the radiological hazards of the various decommissioning options, a detailed pathway analysis based on a detailed work plan would have to be performed. This type of an analysis was beyond the scope of this report."

Now what is all this about? From a public health standpoint, there are certain concerns about low-dose radiation that are especially important. The whole point of any disposal plan is to prevent future radiation exposures to the general population and to minimize the exposure of workers in the clean-up operations. The future exposures are "not addressed". In general, as long as standard operations are going routinely (as in a smoothly functioning power plant) the radiation exposures to workers or the public are quite low. The risks occur when everything doesn't go smoothly and there are "accidents". However, "exposures from accidents...(were)...not considered".

High risks also come into the picture when, as here, the clean-up requires development of new operations for which there is little or no previous operating experience. There is obviously no scientific way to get accurate estimates of radiological risks when the clean-up methods ("decommissioning options") have not yet been developed or tested. The authors of the cited paragraph complain that they could not do what they consider an appropriate risk analyses ("pathway analyses") because the options lack any "detailed work plan". In order to draw up such a plan (which is what should have been done in a competent Final Report) it is necessary to have operating experience with the processes used. But none of the proposal options have ever been used for anything like the clean-up operations needed at West Valley. No one really knows how they work or even if they would work.

In other words, the report concedes that it did not do the job of assessing radiological hazards that was required by the Congressional mandate. Only the hazards for routine operations have been considered and this omits the more serious hazards. The authors do warn that the numbers are not a reliable guide for decision-making. They point out that if the estimated risk for one option is lower than for another option, this doesn't mean that the actual risks are lower (because "a higher potential for accidents" has been left out of the calculations). What, then, are the numbers good for?

The answer is: "These doses were calculated simply to scope the choices in a gross way". What does this mean? To "scope the choices" means to consider the options only in a vague general way (such as might be called in plain English "talking around the point instead of to the point"). The appearance of words such as "simply" or "gross" in technical jargons is rare. They make this a strong statement which might be freely translated as: "You can talk about these numbers but for heavens sake don't try to use them to make serious decisions". Some of the DOE staffers do realize that the health and safety of most Western New Yorkers would be jeopardized by a bad decision on the clean-up of the high-level wastes.

When Congress gave DOE a mandate to come up with a plan to clean up the nuclear wastes at West Valley, DOE had two choices. It could have tackled the difficult job of producing the "detailed work plans" which are lacking here. Or it could take the easy way out, so often used before, of lying to the public in a mathematical language. DOE chose to produce a Final Report consisting of a set of unevaluated and unevaluatable options. DOE chose to fake it. While technical readers get a warning of this in the Companion Report, the Final Report for public consumption gives these dangerously misleading numbers without any warning.

Irwin D.J. Bross, Ph.D.
Director of Biostatistics
Roswell Park Memorial Institute
December 22, 1978