THE MANAGEMENT OF TECHNOLOGICAL HAZARDS

Preparatory Reading

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Morone, Joseph G. & Woodhouse, Edward J. (1986) Strategies for regulating risky technologies. In *Technology and the future*. Albert H. Teich ed. New York: St. Martin's Press, 1997 (7th Ed.), 132-156.

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Introduction

Many technological operations and products present a hazard to human well being.

Hazard: the probability of an occurrence multiplied by the magnitude of the harm it would cause.

This is, of course, equally true for non-technological activities such as wilderness travel, drinking herbal teas or smoking hemp which may incur the risk of accident or chronic harm.

The particular problems with technological processes and products are:

- they may present greater dangers than those we are accustomed to encounter before the introduction of the technology (technological amplification);
- the state of scientific knowledge about new products (e.g. pharmaceuticals) or processes (e.g. high tension transmission lines for electricity) may be inadequate;
- complex technological systems have innately unpredictable behaviour;[1]
- public perceptions of risk are mental models based on social and cultural factors as much as on the available scientific evidence -- they are social constructs *par excellence*.

Risk: The possibility of suffering death, harm or material loss from some activity or substance.

- learning to mitigate or control the harmful consequences is not amenable to trial-and error.[2].

Dangers

The dangers posed by technological products and processes are of two kinds: catastrophic effects or accidents and chronic effects.

Accidents happen over a very short time span. Chernobyl; Three Mile Island; the foundering of the Ocean Ranger; the escape of dioxins at Seveso, Italy[3]; the Challenger space shuttle; the explosion at Bhopal, are well known accidents. Their immediate causes are usually obvious although their ultimate causes (in company policy, poor standards, lack of training, inadequate supervision and control etc.) are often obscure.

Chronic effects happen over a long time span and their causes are extremely difficult to identify. A combination of laboratory tests on animals and epidemiological studies is required to establish the probability of cause-effect relationships. There are intermediate cases, such as the deformities found in the babies of some women taking thalidomide, where there is a time delay between cause and effect but a fairly obvious correlation is rapidly established.

Risk management

The **management of risk** deals with measures taken to reduce the danger of death or harm. There are three stages to the management process: scientific and technical determinations of toxic hazards and their associated risks, we may call this **risk assessment; communication** of the risk to the public; **regulatory control** and other forms of **management**.

Governments recognize their duty to make regulations, adjust taxes and incur expenditures in such a way as to enhance the health and safety of their citizens. Firms too, to a greater or lesser extent, recognize obligations to stakeholders other than their officers and shareholders.

Policy formation

In arriving at a policy for the management of technological hazards, governments have the choice of several approaches. I shall mention four of them.

The model of bureaucratic politics[4]

In this model, the assessments are treated as tools in the ongoing political process. It is an interest-serving, value-laden activity and the "facts" determined by any of the procedures described later are merely useful to buttress arguments. The facts slide over rather easily into factoids.

Public hearings, consensus conferences and court challenges all have a role to play in this model. Features of these forms of public involvement will be discussed in the context of "arriving at the truth" of the basic data. Very often, questions of policy hinge on questions of truth and the two are intricately mixed. Court challenges may address questions of truth or questions of policy or both simultaneously.

The organizational process model

Ideally, the bureaucracy would have established a set of protocols such as the commensurability proposition discussed later in this chapter and would be guided by these in arriving at decisions. This is the classic bureaucratic solution of rule-based decision making. The legal profession favours this view and in any trials arising out of court challenges it is always more concerned to see that the procedures were followed than to determine whether the best outcome was achieved.

The rational actor model

A technocracy tends to the view that there is single best decision (echoes of the "one best way" in the production field) and that it would be achieved if perfect information were available. Their emphasis is therefore on the specifications of data gathering.

The consensus conference process

This is the most promising development for the future.[5]

In practise, the model of bureaucratic politics dominates our political culture, but elements of both "rational actor" and "organizational process" models are interwoven with it.

Interventionism

There are two ideologically different approaches to policy formation. One emphasizes the importance of individual liberty, and particularly the liberty of firms to pursue their aims without fetters, the other approach emphasizes the aim of societal well-being. One could say that the former is characteristic of the North American economy and the latter of the European Community. The communitarian approach tends to be pro-active and the individualistic approach reactive or even inactive. The proactive approach has the choice of several strategies including: regulation, financial instruments such as Pigovian taxes[6], or subsidy (making the public bear the cost of protecting itself).

From about 1990, the trend to deregulation has intensified the "hands-off" approach. In Alberta, Bill 41 took power for the monitoring and enforcement of regulatory compliance away from the Legislature and concentrated it in the hands of Cabinet ministers. This opens the way for sweetheart deals with business. The Regulatory Reform Initiative (April 1995) proposes to reduce Alberta Environment Protection's administrative workload by exempting several types of industrial projects from the approvals process.[7] Federal Bill C-62 The Regulatory Efficiency Act will enable companies to enter into agreements, similar to contracts, with the Minister of the Environment. Republican legislation in the USA is moving in the same direction.[8]

Clearly, these moves push the process more decidedly than ever into the model of bureaucratic politics.

Problematique

The issue of policy formation is further clouded by the fact that government must respond to public **perception** of danger, regardless of the scientific facts, and **lawyers** have a vested interest in profitable litigation either to deny an existing danger (on behalf of a client firm) or to attribute harm to a product where no causal link has been established (on behalf of a claimant).

Apart from the ideological divide betweeen interventionism and laissez-faire discussed in the previous section, the problems encountered in managing risk include:

- limited funds to be <u>allocated</u> in the most cost-effective way

- lack of scientific knowledge about the consequences of technology and how to arrive at the truth
- lack of agreement on the criteria by which to judge the acceptability of a risk: should we use formal methods like cost/benefit; informal methods like revealed preference; or comparison with some "natural standard".
- strong difference between public perception of risk , the opinion of experts and the actual observed frequency of the adverse events to which we are at risk.
- ideological conflict about the appropriate type of response: e.g. technological fix versus behavioural change
- value, if any, of technological assessments such as Bush's equity analysis?

These problems will now be discussed in more detail.

Allocation of funds

Lip service is usually paid to the **"commensurability presupposition**" which means that we should not spend more money to save a life in one case than in another case of risk. This is claimed to be **rational, responsible and equitable** (fair). What happens when we come to apply it? It follows from the principle that we should prefer policies that save the greatest number of lives for the dollar e.g. we would prefer to protect women from death as a result of cervical cancer at 100 k$ to protecting steelworkers from death at a cost of 5 M$. Yet this is not what is done.

A program in England to deal with small levels of radon in 20 million buildings in Britain costs 80 M$ per estimated life saved.[9] It is doubtful whether the tens of millions of dollars spent removing asbestos from ventilating systems or urea foam insulation from houses has saved any lives.

H.W. Lewis (1990) has calculated that the speed limit imposed in the USA during the oil supply scare saved 2000 lives. But it cost truckers $5 million per life and in his opinion that was not worth it.[10]

These and many other examples in the literature[11] are obviously not economically efficient, choices -- spending money in the most cost effective way. Does that mean, as some have implied, that they are not **rational**?

The argument about **responsibility** is this. Given limited funds, if we spend money in any thing other than the most cost-effective way we are responsible for the lives that might have been saved had the money been spent rationally. Paper companies are being asked to spend $500 million to reduce 2,3,7,8-dioxin levels; yet the high exposures of the past have not caused a single known death. Might it not be a better use of our resources to produce an improved TB vaccine, since drug-resistant TB is now the cause of a rising death toll in Canada. The development of a new drug would probably cost between $10 and 100 million. The Harvard School of Public Health's Center for Risk Analysis estimated that some 60,000 deaths could be averted annually in the United States if the 21.3 G$ spent on the 185 major life preserving programs were reallocated so that more went to the most beneficial measures and less to others.[12]

The **equity** argument stated above[13] is the weakest because it equates degree of protection with amount of money. It also raises ethical problems because it makes the assumption that all lives are equally worth saving; something that society has never accepted. Women and children first -- the breeding stock and Cabinet Ministers go first into the bomb shelters

In practice it is obvious that the decisions are made entirely on the basis of "manufactured consent"[14] about hazards in the news and take little or no cognizance of rationality or responsibility.

Scientific knowledge

Nature of "truth"

Science is a social construct and the "truth" changes as the self-correcting mechanism of scientific enquiry pursues its course over time. It follows that certain widely-held scientific theories may in the course of time be discarded (molecular memory, cold fusion, "deadly dioxins") while others remain the subject of intense controversy (e.g., carcinogenic effects of non-ionizing radiation).

Quantitative analysis

There are several steps in arriving at a scientific estimate of risk. First, the analysis based on the physical sciences establishes the presence and concentration of suspect molecules or physical phenomena such as radiation. "Limits of detectability have been improving by about 1000-fold each decade for the past three decades."[15]

Biological testing or epidemiology

Second, biological testing on animals establishes toxic or carcinogenic properties or epidemiological studies establish a correlation between sickness in the population and the presence of the suspect conditions in the same population (for instance, the frequency of leukemia as a function of time of residence within a certain distance of high voltage electric transmission lines).

Risk calculation

Thirdly, risk calculations are made by experts on the basis of data and experience. Harris emphasizes that "low dose risk assessment is not a science." Winner criticizes the application of statistical standards to questions that have a strong social or moral component. But rather than abandon statistics we could look at the way in which probabilistic methods are used. Before a scientist is willing to assert that there is a danger, he will usually require data that is significant at the 5% level. That is he wants to be able to say that there is only a 1:20 chance that he has sounded a false alarm (technically called a false positive). But perhaps the public would feel much easier if a danger were announced even if the odds were as high as 1:2 (results significant at the 50% level) that this might be a false alarm . Moreover, suppose no toxic effects are found in an experiment that is significant at the 5% level. Although the chances of its being so are only 1:20, the announcement might be a false negative . What is more, the investigator may have missed some danger that she never thought of testing for (another false negative)! Tests do not usually include analyses of the chance of a false negative (statistical power).[16]

Regulators and scientists

What Winner seems to have failed to recognize is that conscientious regulators may take quite a different view of "not being wrong" than scientists. They are more inclined to say "Better safe than sorry". Manufacturers have argued that a chemical should be deemed innocent until proved guilty. But Jellinek, an administrator for pesticides in the EPA, says that doesn't make sense. To give such civil rights to a chemical may be to deny them to its victims. Explicit and adequate protection involves "trading off the chance that the danger was underestimated (false negative) against the chance of an overestimate (false positive)" he says. In other words, while the regulator will agree with his critics that the positive identification of danger might be false; he must insist that there is a chance that another danger was not detected at all.

Common erroneous assumptions include : linearity of response; similarity of response in rats and humans; non-detection equals zero concentration; innocuousness of unmodified plant products.

Many factors contribute to our lack of knowledge.

- **Incomplete data:** Many products are new and their unforeseen effects may be severe.
  Organic chemists have been characterizing toxic chemicals in plant foods for over 100 years but toxicological studies have only been completed for a small percentage of them[17]. Plants develop toxins to protect themselves from insects and other predators. It is only to be expected that many of these compounds will also be toxic to humans.
- **Delayed effects**: This is a major problem. Toxaphene was used until the early 80s in Canada and the United States as a pesticide on more than 250 crops , as a livestock dip to fight scabies, and as a fish toxicant. Scientists eventually discovered that the chemical's toxic effects continued long after application. Years later and thousands of kilometres away, toxaphene was discovered in many parts of the food chain, posing a particular threat to aquatic life. Toxaphene is a complex mixture of chlorinated camphenes or PCCs. It is particularly threatening to the Inuit who eat a lot of fat where the PCCs concentrate[18]. It is still exported to the Third World.

How should we arrive at the truth?

Several methods have been suggested by which an acceptable version of the truth may be found. This is obviously a *logically* prior step to the development of public policy. But in terms of *chronology* it often comes to the fore when public policy is challenged by pressure groups or concerned individuals.

adversarial[19]
consensus-building
mediation or arbitration (like adversarial, this is a legal process)
science court to determine questions of fact followed by decision making[20] .

Adversarial

In our culture in which parliament is dominated by lawyers, the adversarial environment is favoured. The adversarial process has been deplored because it has a built-in delaying system: --the payment of lawyers by the day. Winner fears that opening the door to formal risk assessment will result in interminable delays, that a high premium will be placed on prudence, on a wait and see attitude. Or, as Mazur said, it may deny to society important benefits at least for a while. There is the chance that radical adversarial groups such as Rifkin's group against genetic engineering, could hold things up indefinitely . PCBs and used tyres might continue to be stored dangerously rather than incinerated safely (e.g. in cement kilns).

More significantly, the adversarial approach generally involves two parties of very unequal strength, both in terms of money and of access to information; Friends of the Earth against Du Pont Chemicals for instance. The challenger must be prepared for arguments along the following lines.[21] These are intended to delay, complicate and befuddle.

1. The hazards are not so serious as might appear; at least there has been no demonstration that they will be harmful.
2. Even if there may be some hazard or inconvenience this may be acceptable or tolerable in view of the jobs being created/ protected.
3. We are conducting research to learn more about the potential hazards and R&D to provide a technological fix to eliminate or reduce the hazards.
4. In any case there is no need to worry about the technology until its feasibility has been established; it may never happen.
5. Obviously, the government will not permit the use of the technology until appropriate controls are in place to assure the safety of the public.

Consensus building

There is a growing movement in favour of consensus building. Many municipalities in the United States have adopted this as policy and they communicate by means of a journal. With regards to risk assessment, this has been most successfully implemented in Denmark with what is called 'the consensus conference model.". Full details are given in Richard E. Sclove's "Technology and Democracy" 1995.[22]

Mediation

This shares with the adversarial method the disadvantage of involving lawyers.

Science court

See Mazur (in Teich *op. cit*) for a discussion of this proposal which was first put forward by Professor Arthur Kantrowitz in 1967[23]. It might provide a useful role for the Royal Society of Canada which seems to be searching for one. Shrader-Frechette[24], who comes from the legal side, proposed that a technology tribunal composed of scientists and citizens should identify the significant questions. That done, there would be an adversary proceeding presided over by a panel of impartial scientists or lay people. Finally panel of judges would issue its decision regarding both the scientific and policy factors relevant to the disputed question.

Acceptability of risk[25]

Obviously we have to live with some degree of danger. Anyone who uses a chain saw in the forest knows that. There is a perception, however, that people want a risk-free society[26]. "We have forgotten that much of what we value in our civilization, from innovation to enterprise to love and commitment, is founded on risk."[27] But more than 60% of Canadians polled in a Health Canada survey (1994) expressed the belief that "a risk-free environment is an attainable goal in Canada."[28] Nimby (Not In My Back Yard) has become "Banana" (Build Absolutely Nothing Anywhere Near Anybody). The 1958 Delaney Amendment to the Federal Food, Drug and Cosmetic Act of the US Congress requires reduction of many synthetic additives to a concentration level of zero. This is, of course, nonsense owing to the increasingly sensitive detection limits. There are various ways to determine what is acceptable. I shall mention four.

Cost/benefit analyses.

This methodology, which in the present context concerns the costs versus benefits of risk avoidance, is vulnerable to misapplication through carelessness, naiveté or outright deception.[29]. The findings are no more precise and frequently less so than the assumptions they employ. The procedure usually involves reducing all values to the common denominator of money. The UN's Intergovernmental Panel on Climate Change, in trying to establish the cost of action to halt global warming , concluded that the value of a statistical human life in the AICs was 1.5 M$, whereas it was only 100 k$ in the poorer developing nations. The valuations were based on assessments of a community's willingness and ability to pay to avoid risks of death. The valuation of a statistical life (VOSL) has nothing to do with the moral value of an individual life. It works like this: if 100,000 people are exposed to an increased risk of death of 1 in 100,000 there will be statistically one life lost per annum. If everybody is willing to pay $10 to implement measures to avoid this risk, the implied VOSL is 1 M$. These results were hotly disputed by some social groups[30] and the whole statistical exercise questioned as futile by others. Clive Bates pointed out that the choice of methodology is an ethical and political judgement, not a scientific one. Those outraged by the outcome of the calculations should realise that the inequity lies in the inability to pay for protection, i.e. in poverty -- not in the methodology as such.

The first major problem we encounter is that one social group may reap the benefits and another social group may pay the costs. This is referred to as an "inequitable hazard"..And Winner (114) observes that "Even if one is able to set aside troubling issues about equity and "who pays", risk/benefit calculations offer, by their very nature, additional reasons for being hesitant to propose any practical remedies at all." Since the "costs" become budget items they have to be considered with all the other costs having a claim on our purses. There is the difficulty of pricing human life [see above] and environmental goods. Moreover, they necessarily involve the discounting of future costs and benefits and are thus inequitable toward the future generations. For example the cost of future fatalities is discounted to their present value. If all the radiation-induced deaths from a nuclear power plant were to be added up the totals would be very large - 100 to 800 per plant. So the authors of a 1979 risk benefit study discounted the value of future deaths at 5% with the result that contributions per plant year would be between 0.07 and 0.3 fatality. They call this a "reasonable compromise solution" But "discounted present value represents the value to present people derived from contemplating the welfare of future people. It does not reflect the welfare of future people themselves, or even our estimate of their welfare". The growth of money in the bank becomes the norm against which everything is to be judged.

Then there is the problem of opportunity costs. For instance, if rigorous health standards are imposed in American textile mills how do we assess the social costs of opportunities precluded (for example. the opportunities to produce cheap textiles in the USA and create jobs)?

Risk/benefit studies as generally practised, have strong methodological drawbacks e.g. highly correlated benefits are often aggregated and therefore overweighted.[31] That is to say, all the benefits are added up, regardless of their correlation with each other, and the same with the costs.

For an example from nuclear power: cheap electricity and economic benefit for the country are highly correlated, but cheap electricity and a low accident rate are relatively independent. It is therefore wrong to give all three factors equal weight in the calculations.

The main disadvantage of cost/benefit analyses in comparison to other methods is that they do not have a mechanism for examining alternatives[32] (See Lowrance p.184) That is to say, they are useless in advancing the processes of consensus building and mutual learning in which preferences are open to rational revision. Cost/benefit assumes fixed individual preferences ready made for quantification and imposes in advance a single shared system of conflict resolution, To treat as commensurate the wants belonging to different cultures and contexts of appraisal is often an undemocratic procedure.[33]

Revealed preference

The most common **indirect** method of determining the acceptability of risk is the method of revealed preferences which has its origin in J.S.Mill's utilitarianism. It uses the level of risk that has been tolerated in the past to judge the present acceptability of risk. Some critics (Shrader-Frechette) have challenged the assumption that the past is a good guide to the present.

- The circumstances might have been quite different in the past e.g. the technological possibility of doing otherwise (e.g. use of DDT in wartime).
- There is no reason to suppose that past practice was normative. Indeed, how can we learn if we follow the past?
- Past societies have tolerated a number of activities having very high risks and very low benefits e.g. drinking alcohol, carrying hand-guns, riding motor cycles and smoking tobacco.

The large difference between public perception of risk and that measured by the observed frequency of adverse effects somewhat discredits both this and the next method.

Expressed preference

Expressed preferences are what you get by asking people. Not surprisingly, what you get is a lot of contradictions. A report from MacDonalds[34] says "People may talk healthy but they don't eat healthy".

Natural standards

The fourth commonly used method of risk acceptability assessment is that of Natural Standards. As an example we should accept radiation from appliances if the normal background of radiation is not exceeded (up to 2 mSv/a)[35].

But this assumption can be challenged on the following grounds:

- Nature is hazardous e.g. exposure to naturally occurring radon gas in a granitic region can cause lung cancer; sunlight can cause skin cancer; traditional smoked foods can cause stomach cancer; home childbirth is quite risky.

- The natural standard method ignores the possible synergistic effect of numerous co-produced toxins e.g. in steel making. The cancer mortality rate for Uranium miners who are also smokers is vastly higher than for those who are not.
- Why shouldn't we be cleaner than nature? Why shouldn't we aim to live less hazardous lives?
- On the other hand, why shouldn't we accept a lower standard if we can benefit from tradeoffs.
- There is no historical tolerance for newly synthesized products.
- Neither scientists nor lay people have a good intuitive sense of the frequency (and thus the likelihood) of natural hazards, so the measure is not much good.

Probability threshold

There is a widely adopted principle, called the **probability threshold position**, that society should ignore very small risks. The figure of a chance in a million is often used because it is the chance of dying from a natural hazard in any given year. It is also the case that, with probabilities this low, precise numbers are meaningless.

- We have already discussed Winner's objections to the use of statistical criteria in moral situations.
- A more trenchant criticism is the qualitative difference between a chance in a million that one person will die as a result of a nuclear accident and the same chance that 150 thousand people will die.[36] In a study by Vischof[37] the assessors found that perceived risk was related directly to "**severity of consequences**" even though the probability was known to be small. This folk wisdom is in fact enshrined in the Law of Torts. But the regulatory bodies in the United States at any rate (AEC, NRC) and the courts of law dealing with regulation have consistently taken the position that probability rather than severity of consequence is the determinant of risk
  - Thirdly, we should remember that these calculated risks are always averages and that there will be some groups more at risk than others.

Fatality Interpretation

The meaning of this is that the risk accepted should be inversely proportional to the chance of death ("probability of a fatality"). But the public does not think this way. Starr's Laws of acceptable risk are as follows:

- The public will accept voluntary risks 1000 times more readily than risks imposed involuntarily.
- The statistical rate of death from disease appears to be a psychological benchmark.
- The acceptability of risk appears to be crudely proportional to the third power of real or imagined benefits.

Public perception of hazards, harmful activities, accidents and disasters.

It must be remembered that the politicians respond to the public perception of danger, not to its actual severity in terms of expected fatalities. It is the politician's task to accommodate public perception, to mould it by leadership if possible, but not to ride roughshod over it.

<u>Parties to hazards</u>.
1. First party: operators (includes those in attendance in support roles, like firemen). They are not necessarily victims.
2. Second party victims are those using the system, for instance passengers in a vessel
3. Third party victims are innocent bystanders
4. Fourth party victims are future generations (such as the victims of lead additives to gasoline).

Factor analyses performed by Slovic and colleagues show that people's attitudes cluster around two main factors which he calls "dread" and "unknown risk." Each of the clusters contains several semantic differentials or contrasting adjectival scales listed below.

<u>FACTOR 1 ("DREAD")</u>

Controllable	Uncontrollable
Not dread	Dread
Not global catastrophic	Global catastrophic
Consequences not fatal	Consequences fatal
Equitable	Not equitable
Individual	Catastrophic
Low risk to future generations	High risk to future generations
Easily reduced	Not easily reduced
Risk decreasing	Risk increasing
Voluntary	Involuntary
Does not affect me	Affects me

<u>FACTOR 2 ("RISK")</u>

Not observable	Observable
Unknown to those exposed	Known to those exposed
Effect delayed	Effect immediate
New risk	Old risk
Risks unknown to science	Risks known to science

Peter M. Sandman of Rutgers University has developed a similar theory using the concepts of "outrage" and "hazard".[38] As the importance of such studies becomes more widely appreciated, we may expect a proliferation of nomenclature - the academic version of "product differentiation".

John Luik observes that, "Since risk is at least in part of scientific issue, **scientific illiteracy** counts heavily against sensible risk decisions."[39] "..[T]he media does an extraordinarily poor job of reporting risk in a way that allows citizens to form sensible risk beliefs." Luik criticizes the media for "the risk of the week syndrome", but surely this is part of a much wider discussion on the role of the media in informing the public.

The public may **dread** a technology that has never been associated with any adverse event (defined as an occurrence which produces harm). But adverse events of a magnitude, or in circumstances, that produce **outrage** always increase the dread with which a technology is contemplated. However, the perceived severity of the event in the public mind is influenced by many factors other than the amount of harm suffered. The following seem to be particularly important:

- **Absolute number of fatalities**. This has no direct correlation with the perceived severity of a disaster because concern declines exponentially with ethnic and possibly socio-economic distance.
- **Spatial location**. One aspect of one's attention span. Concern declines exponentially with distance.
- **Time span**
    - Instantaneous i.e., immediately manifested (mine disaster, plane crash). These are considered severe
    - Spread out over time (auto accidents). These are discounted.
    - Delayed (radiation, smoke, erosion of soil). These are ignored.
- **Late revelation** diminishes concern. Windscale [Sellafield] had worse effects than Three Mile Island but was kept secret by British government.
- **Anthropogenic** disasters are always considered more severe than natural disasters. We remember Bhopal but forget the earthquake in Soviet Armenia. The floods that devastated India in the 70s with the loss of 500 000 lives, or those which hit Bangladesh in 1988 are forgotten because people assume they were natural, although in fact they were almost certainly due to forestry operations in the watershed areas.
- **Voluntary/Involuntary**. Death or injury during an activity voluntarily entered into (e.g. racing cars) is less severely rated than one involuntarily suffered (e.g., through a mechanical defect in normal operation).
- **Informed/Not informed**. A more severe view is taken if the victim was not properly informed (e.g. asbestos miners).
- **Media coverage** ("Availability heuristic") The amount of media coverage and ease of remembering is a major factor in assessing severity. Change of name may cause oblivion. Who is aware that "Sellafield" was the site of the "Windscale" reprocessing plant disaster, October 10, 1957[1]; authorities tried to change all references to Three Mile Island to simply "Harrisburg Pa." without success.
- **Stigma**. Many technologies become stigmatized[40]. They are indelibly linked in the public mind with adverse effects and, once stigmatized, contrary scientific evidence is powerless to change the perception. "The impetus for stigmatization is often some critical event, accident, or report of a hazardous condition. This initial event sends a strong signal of abnormal risk. ...The source of the stigma is a hazard with characteristics such as dread consequences and involuntary exposure that typically contribute to high perceptions of risk." Nuclear energy is stigmatized and placed No.1 on the list of hazards prepared by the League of Women Voters, but 20th on a list prepared by a panel of scientific experts.[41] PCBs are stigmatized chemicals in spite of their very widespread use in electrical power transformers (Walter E. Harris considers this attitude quite unjustified on a scientific basis.) In general, all carcinogens are stigmatized and considered "unsafe at any dose" despite the well known toxicological principle that "the dose makes the poison" (Vitamin D is necessary for life but a fatal poison to 50% of test animals receiving 10 mg per kilogram of body mass.)

- **Expert prognosis**. In addition to experience with actual accidents, or adverse effects, the public is influenced by the type of prognosis made by the experts, although their reaction is unpredictable. Factors given weight include:
    - **Expected lethality** i.e. how certain is it that fatalities will result in the event of a mishap? e.g. nuclear winter in case of War. Regardless of expert opinion some will not believe it. Suppose probabilities can be attached, few of the public will understand them. Most of the public believe that probabilities can be refuted by the citation of instances.
    - **Benefit of doubt**. If there is no scientific consensus, even though a large majority of scientists are convinced (e.g. of global warming), the public will tend to an optimistic disbelief.

The problem facing the watchdogs of society is that the greatest dangers that beset us from technology are those with greatly delayed results, about which science does not have all the answers and which will affect fourth party victims. Examples, military technology, the greenhouse effect, chemical agriculture (soil loss). This is no reason not to try to stop lesser accidents.

Conclusions

We must not fall into the trap set by Brer Fox and get drawn in to an endless discussion of the technical details of risk assessment (the "tar baby" of the tale as retold by Winner). We need to step back and consider whether our aims of avoiding unnecessary harm might be achieved by other paths than through regulation of technology.

The effectiveness of the risk management process

There is a great deal of scepticism as to the value of risk assessment, impact assessments and the effectiveness of the management process. Langdon Winner clearly fears that all the activity devoted to calculating how much risk we are willing to accept serves only to divert attention from the dangers which we should avoid. It is agreed that many attempts to manage technology wisely have failed. These have been attributed to: conflict of interest; public anxiety preventing a dispassionate analysis; poor methodology[42]. Two recent examples have been the attempt by Shell to sink the abandoned "Brent Spar"drilling platform in the deep ocean and the delays to the raising of a sunken barge ("Irving Whale") containing PCBs in eastern Canada. In both cases environmental opposition seems to have been misguided; it should have been directed against the technology that gave rise to the problem not to the attempt to deal with it. The "special interest groups" whose business and livelihood are devoted to environmental protection have a vested interest in the magnification of hazard, just as those who stand to profit from it (never referred to as special interest groups) have a vested interest in playing it down. One should not overlook the fact that even if the assessment process is successful, regulatory officials are sooner or later nearly always suborned by the industries they are supposed to regulate.[43]

The Organization for Economic Cooperation and Development (OECD) concluded, in a major report,[44] "It is ...extremely difficult to prove that any analytic assessment has been primarily responsible for influencing a decision." According to a United States National Science Foundation-sponsored study the findings of assessment studies appear to have a greater conceptual than instrumental usefulness -- except in the field of environmental protection, where some practical success is claimed.

The Office of Technology Assessment (OTA) of the US Congress was abolished in 1994, as the Science Council and the Environmental Council of Canada had been abolished in 1992.

William Ruckleshaus, who is generally seen as one of the best administrators of the EPA (Environmental Protection Agency), said, after he had left the agency, "[risk analysis] is a sort of pretence; to avoid paralysis of protective action that would result from waiting for `definitive' data, we assume we have greater knowledge than scientists actually possess and make decisions based on those assumptions" [45]

What seems of central importance is to concentrate effort on (a) getting the scientific facts right in an era of reduced funding for research and (b) concentrating effort on the regulation of "egregious risks"[46] in an era marked by the withdrawal of government from its traditional responsibilities.

Technological fix versus behavioural change

A ideological fault line divides those who would address the problem of risk with a technological fix and those who believe that some form of behavioural change is called for (e.g. speed limits rather than electronic control systems for highways). Our studies of accidents have shown that, in major disasters, both human and technological factors are almost always involved. A purely technological fix is therefore unlikely to be completely effective.

Behavioural change

Social ecologists and those of like mind are convinced that the only secure way to reduce ill-health and accidents due to technology is by adopting a less technically intensive life style. But, because of the non-compatibility of social ideals, all kinds of compromises will be called for. We cannot avoid the increases in technical efficiency required to assure the sustainability of our energy systems; we cannot avoid going for increasingly efficient technical production systems in order to maintain the output of food, goods and services necessary for social justice in a growing population. But we do have to ask, at each step along the way -- do we really need it? And, what will this do for the quality of life of this and future generations?

Values

There is always a value component in a risk determination. The real issue for a democratic society is how to accommodate the values held by a majority of people, whether or not they are scientifically based, within a methodology of risk assessment. The central problem is that the parameters of the same risk assessment could be given varying weights on the basis of alternative ethical criteria. We would expect different criteria to be derived from competing and conflicting (though, of course, infallible!) religious texts; from Kantian rationality with its emphasis on the individual; or from Benthamite utilitarianism with the greatest good for the greatest number as its aim. In other words the problematique of risk and hazard is fundamentally moral and political rather than technical.

End Notes

[1]This follows from complexity theory but see also "Trust me, I'm your software" by Evan I Schwartz in Discovery (May 1996), 79-81.
[2]Internet communication from Dan Yurman, 12 Dec. 1994 (dyurman@igc.apc.org)
[3]A safety valve on a pressure vessel burst and a large amount of herbicide and 2,3,7,8-dioxin was released. Up to 40 000 people were exposed including 730 pregnant women. Chlorachne developed but no excess cases of cancer have been established.
[4]Allison in OECD, 1983.
[5]Sclove, R.E. (1996). Town meetings on technology. *Technology Review*, v.99, no.5 (July), 24-31.
[6]After A.C. Pigou(1920) *The economics of welfare*. London: Macmillan.
[7]Kitagawa, Miles "Facets of deregulation in Alberta." *Environment Network News* (July/August 1995).
[8]An illuminating article by a professional risk assessor is Adam M. Finkel's "Who's exaggerating?". *Discovery*. (May 1996), 48-54.
[9]Stephen J. Wozniak, Handbook of Radon. Abbots Langley:Wozniak, 1992. (*New Scientist* No.1856, p.42.
[10]The data and the question are from Walter E. Harris, Professor Emeritus of chemistry at the University of Alberta (*Low Dose Risk Assessment*. Edmonton: The Author, 1996).
[11]O'Donnell, E.P. & Mauro, J.J. (1979) "A cost-benefit comparison of Nuclear and Non-Nuclear Health and Safety Protective Measures and Regulations." Nuclear Safety 20, 525-40. Cited by Joseph G. Morone and Edward J. Woodhouse in *Averting Catastrophe*. Berkeley CA: University of California Press, 1986.
[12]What it costs to save a life. Globe and Mail July 1994 (Middle Kingdom) A8.
[13]As formulated by Shrader-Frechette
[14]From the title of a book by Noam Chomsky.
[15]Walter E. Harris, Professor Emeritus of chemistry at the University of Alberta (unpublished manuscript, 1996)
[16] S.D.Jellinek "On the inevitability of being wrong.". *Technology Review*, Aug/Sept 1980, p.8-9. Also letter from Paul Muter, Dept. Psychology, U of T. on statistical power.
[17]Ames, Bruce N., 1983. "Dietary carcinogens and anticarcinogens". Science v.221 (23 Sep) p.1256-1264.
[18]Public Works and Government Services Canada RD Bulletin No.227
[19]Shrader-Frechette is the most eloquent supporter of this approach. She is a lawyer.
[20]Mazur
[21]H.P.Green in Hetman, p.354
[22]Not available in University Library. But see his "Technological Politics" in Teich 7th ed.
[23]"Proposal for an Institution for Scientific Judgement", *Science*, 1967. Visit the Science Court Web Site at www.FPLC.edu/SciCt
[24]Shrader-Frechette, K.S. (1985). *Risk analysis and the scientific method*. Dordrecht Holland: Reidel.
[25]RAND Corporation. Issues and Problems in Inferring the :Level of Acceptable Risk (fide Lowrance)
[26]Charles Piller. *The Fail-safe society*.
[27]Luik, John (1996) Risk is a risky business. Globe and Mail 23 April 1996.
[28]Risk-free world.... Globe and Mail 12 April 1995.
[29]Lowrance, op. cit. p.184
[30]New Scientist, 19 Aug. 1995, p.7. (and subsequent correspondence).
[31]Royal Society, 1983, p.131-2
[32]Lowrance, William L. quoted in Teich, 6th ed. p.184.
[33]Letter from Larry Lohrman and Sarah Sexton. New Scientist, 23 October 1993, p.47.
[34]G&M 20May1991
[35]as proposed in the Rasmussen report which was designed to boost support for nuclear power. Note proposal for a quantity of time called the bert New Scientist 1 May 1993 p.49 "Background equivalent radiation time". For example, a chest X-ray would be 4 mo.
[36]Usefulness of frequency vs. consequences lines (Royal Society, 1983, fig.2)

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[37]Reported by Shrader-Frechette, 1985.
[38]Unchecked information from a letter by Geoff Granville, Calgary, in *Pecten* (Shell Canada house magazine) for February 1996.
[39]Luik, John op.cit.
[40]Gregory, Robin, James Fl;ynn and Paul Slovic (1995) Technological Stigma. *American Scientist* v.83, no.3, 220-223.
[41]From "Perception and Real Life" a table provided by the New York Times Service and attributed to Paul Slovic/Decision Research. (Cutting dated 2 February 1994)
[42]Shrader-Frechette, K.S. (1985) *Risk analysis and scientific method*. Dordrecht, Holland,: D. Reidel.
[43]Michael D. Sawyer, a student in the University of Calgary's Faculty of Environmental Design, prepared an impressive paper on this tendency in 1992.
[44]OECD. *Assessing the impacts of technology on society*, 1983. p.57
[45]Hattis, Dale & Kennedy, David. Assessing risks from health hazards: an imperfect science. MIT *Technology Review* (May/Jun 1986) p.60-71.
[46]Morone and Woodhouse 154.