

RISK ASSESSMENT IN THE NUCLEAR AGE

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## Risk Assessment In The Nuclear Age

This paper is presented in the spirit of the stated intentions for the Workshop on Comparative Risk Assessment; Woods Hole, Massachusetts; March 31-April 4, 1975. A brief discussion of several topics is provided in the hope of stimulating further consideration in the area of "risk assessment". Included are observations, experiences, clinical impressions, and speculative thoughts reflective of the writer's growing interest in this relatively new field of scientific inquiry. A particular methodology for quantifying the perceived "risk" of various environmental hazards and/or technological advances is proposed. A more detailed and comprehensive approach to many of these issues is the aim of the author after his appointment as Research Scholar with the collaborative International Institute of Applied Systems Analysis-International Atomic Energy Agency Project (Vienna, Austria) in June, 1975.

### The Emergence of a Science of "Risk Assessment"

Perhaps the place to start is the beginning. When was it and under what circumstances did the scientific community begin to concern itself with the question of "risk assessment"? What is first required to deal with such a question is an adequate definition of the term or concept. "Risk assessment" has been variously defined as "...the identification, estimation, and evaluation of the threat potential of environmental hazard." (Kates, 1975) or as stated by Otway (1974) "...measurement of the uncertainty connected with undesirable effects associated with a specific type

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### Aphorisms Appropriate for an Atomic Age

- Bombs or reactors? My mind is pervaded by a vague sense of mystification...over the lack of differentiation between the peaceful and military atom that I have often detected in people's thinking - Laura Fermi
  - A paradox has emerged. Let me put it simply. After a certain point has been passed, the worse things get, the better. The broad effect of the latest development (speaking of thermonuclear warfare) is to spread almost indefinitely, or at least to a great extent, the area of mortal danger ... Then it might well be that, by a process of sublime irony, we shall have reached a stage in this story where safety will be the sturdy child of terror, and survival the twin brother of annihilation. - Winston Churchill
  - ...the new technology resulted in a tremendous growth of culture in its initial stages. But in effecting this advance a social system was created that eventually curbed and contained the technological system in such a way as to bring progress virtually to a stop. - Leslie White
  - What I am suggesting is that our perceptions of Hiroshima are the beginnings of new dimensions of thought about life and death. - Robert Jay Lifton
  - "It is not the convention but the fear  
That has the tendency to disappear" - W.H.Auden
  - Ideas that we are aware of are called conscious. A great deal of what is described as mood comes from ideas that exist and operate beneath the threshold of consciousness. The whole conduct of our lives is constantly influenced by subconscious ideas. - Sigmund Freud
  - Any new interpretation of nature, whether a discovery or a theory, emerges first in the mind of one or a few individuals. It is they who first learn to see science and the world differently. How are they able, what must they do, to convert the entire profession of the relevant professional subgroup to their way of seeing science and the world? - Thomas Kuhn
  - We can demonstrate that there are certain values for human life which are not matters of opinion but which are biologically determined. If we do violence to these inbuilt values, we disorder our lives, as persons, as groups, as nations and as a world of human beings. - Ashley Montagu
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of activity." The impetus for the research and development of this new scientific endeavor seems to have emerged from two different camps. There are those investigators who have been interested primarily in the risks imposed by a wide variety of environmental hazards such as earthquakes, tornadoes, volcanoes, etc. Their work has extended to the measurement of the "real" and "imagined" risks perceived by individuals or populations exposed to such threatening events. Concurrently there has been a rapidly expanding group of scientists who have been concerned primarily with the potentially adverse, undesirable, or destructive effects of our ever-proliferating science and technology. Here the focus has been not so much on the threats of our natural surroundings, but rather on those man-made products which appear as endangering.

With regard to the question posed by the former group of scientists: it is probably the case that since the dawn of humankind Homo sapiens has maintained a wary consciousness of the perils of his environment. It must have been one of those fortunate and yet necessary mechanisms that slowly evolved in our stoop-shouldered, low-browed ancestors that accounted for their eventual survival and our existence. The question of the intrinsic safety of the world around us posed in such queries as: "is the water safe to drink?" is one of universal and probably eternal importance.

It seems though that the major thrust for the intense interest in the concept of the "assessment of risk" has come from those individuals and groups concerned with the dangers that man has brought upon himself. Over the past several decades there has been an emerging awareness of the power, prestige, political-social-psychological impact of the science-technology complex. Science, as a modern-day institution and enterprise, seems to

be providing the Nietzschean Nirvana that everyone had imagined. There has been an unlimited growth into areas only previously envisioned of in science fiction tales. The age of space travel, laser beams, washing machines, genetic manipulation, electric knives, the eradication of the major infectious diseases, the computerization and transistorization of communication- this awesome age is upon us. As noted by John Platt, "...we are on the steeply rising S-curve of change". He estimates that in the past one-thousand years we have increased our speed of communication by a factor of  $10^7$ , the speed of travel by  $10^2$ , and the increase in our populations by  $10^3$ . Clearly, in the magnitude and in the rate of proliferation of this beast called Science, has developed a propensity for complications which only a prescient few envisioned. Many of our inventions and "time-savers", in whose baths we now luxuriate, have out-stripped the social institutions, and moral-ethical systems we need to properly evaluate their place in our lives. Certainly the whole notion of "risk" must arise in this context and it is therefore no great wonder that we find so many now interested in such an examination.

There are two other brief points to be made about the emergence of a science of "risk assessment". The first concerns the gradual change in perspective we seem to be witnessing among scientists themselves as to the potential social, moral, and ethical 'side-effects' of their researchs into these new frontiers. Perhaps what is being experienced is a quasi-revolution of the type described by Thomas Kuhn in The Structure of Scientific Revolutions. A shift in perception or a change in paradigm among the members of the scientific community as to what they conceive as legitimate problems and standards is what constitutes the revolution. There are historians who argue that the history of science records a

continuing in the maturity and refinement of man's conception of the nature of science and its direction. One such development may be the emergence of a science of evaluating the benefits and risks of science itself. Too long this has been the sole purview of the poet, philosopher, and psychologist.

The second point to be made regarding the new science of "risk assessment" comes from the study of man and his civilization. What are the historical precedents for the apparent increase in resistance and opposition to technology evident in today's Western societies? The widespread challenge to innovation observed in out-spoken individuals, interest-groups, and counter-cultural movements surely has been witnessed at other times, in other societies, in other cultures. As Leslie White so clearly develops in his text The Science of Culture: each new Technological Revolution (Agricultural, Industrial, Atomic) has resulted in a tremendous growth of culture in its initial stages. In effecting this advance a social system has been created that has eventually curbed and contained the technological system in such a way as to bring progress virtually to a stop. One thus wonders that the evolution of a concept of "risk assessment" might be such a social-system spin-off. The assessment of the actual and perceived benefits and risks of science thus is interpreted as an expected, culturally determined undertaking. What will be required to investigate such a possibility is an inter-disciplinary, systems-analytic approach that addresses itself to many of the determinants of "risk", i.e. technological, economic, socio-political, environmental, psychological, moral-ethical, etc. Hopefully, collaboration and interchange among those involved in such disciplines will facilitate the process of making rational decisions in the best interest of the community. (Refer to "A Systems Analysis Approach to Nuclear Facility Siting", IIASA/IAEA Research Memorandum RM-74-29)

Alamogordo as Archetype

In keeping with an inter-disciplinary, systems-analysis orientation, another approach to our understanding of "risk" is that provided by the social scientist and the behavioral scientist. Included in this category are the sociologist, social psychologist, psychiatrist, and the psychoanalyst - those interested primarily in the emotional-cognitive determinants of human behavior. It is apparent to those directly involved in observation of individuals and groups, whether in the social laboratory setting or in the private practice of clinical psychiatry, that there is mounting concern about the potential threats of our rapidly proliferating culture. The concept of "risk" on an individual level may apply to a wide variety of personal situations. A change in residence, an occupational promotion, illness, economic recession, the chaotic pace of life may all be viewed as "risks" to our health and well-being. In some instances these changes may be ones prompted by our own, independent decisions. Other changes may be unplanned, fortuitous occurrences ("the slings and arrows of outrageous fortune"). For example, a person's decision to change his job, based on what he perceives as the subsequent benefits and risks, may be a venture which influences his physical and emotional equilibrium. The death of a close relative, an event which is beyond his capacity to prevent, may likewise impose a "risk" to his health and productivity. In either case, there seems to be an increasing awareness of such changes on our lives. Concurrently, there

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has been increasing interest in the potential positive and negative outcomes of our decision-making process. To the behavioral scientist it is a curious note that there is this escalating preoccupation with the notion or concept of "risk" on an intra-psychic, personal, individual level. What arguments might be forwarded to help account for such a ubiquitous social-psychological phenomenon?

Certainly one major determinant to the "risk" perceived by individuals in our current time is related to the effects of the 'technological revolution' of the Nuclear Age. With the introduction of nuclear energy we entered a new era of concern about the power and perils of science. This is not to minimize the obvious impact of previous scientific-technological revolutions on the prevailing life-style and existing social institutions. Rather, as nearly as we can tell, there was a more gradual assimilation of the new technology into the culture in these previous generations. In part because of the sophistication and efficiency of our modern-day communication systems, nearly everyone in the world was made aware of the birth of the Nuclear Age, and rapidly. A new form of energy was heralded in through its military, war-time utilization and we all came to know of it in a rather frightening manner. What was made manifest for the first time, on such a universal scale, was that science was capable of producing a truly ambivalent beast - one whose potential benefits were purported and whose risks were only too evident. Science, the great provider of leisure, pleasure and profound expectations could now be seen as the creator of annihilation. In the event this discussion has become too prosaic, too rhetorical, or too anthropomorphizing of science, please permit a brief digression.

July 16 of this year will mark the thirtieth 'anniversary' of the detonation of the first atomic device at Alamogordo, New Mexico. There was, in the early morning hours, a sudden, blinding flash, a white-out followed by a billowing gray-red-brown, immense mushroom-shaped mass that arose from the dry desert floor. Square miles of particulate matter were hurled into the stratosphere. Then there was a scorching heat, wind against the face, a dull and thunderous roar, a seemingly endless tremor. It was perhaps in this brief moment, acute and awesome as it was, that the potential "risk" of scientific pursuit was fully realized. What had only months before been chalky formulae on dusty blackboards was now a converted reality - an awareness of the potency of man's inquisitiveness, ingenuity, and intellectual fervor. What is advanced as premise is that this singular experience may represent an archetypal, universal symbol for our age and for those to come.

It is indeed unfortunate and yet striking that there should be so little information or research in this area. Despite thirty year's experience with this "primal scene" and all of its ramifications ranging from the destruction of Hiroshima and Nagasaki to above-ground and under-ground testing, the proliferation of nuclear weaponry and rocketry, MIRVs and SALT, etc. the study of its impact on the "Everyman" psychology has been largely neglected. Granting the public reaction to nuclear energy in its early years, the Ban-The-Bomb movement in Britain during the 1950s, isolated incidents of opposition to thermonuclear testing in the Pacific, the general feelings and fears related to the destructive aspects of nuclear technology gradually disappeared from view. It has taken another international crisis for these concerns to surface

once again. As power companies, energy commissions, and federal governments plan for the wide-spread expansion of nuclear power facilities to meet our growing energy demands, the responses to this perceived "risk" on individual, group, and societal levels becomes more apparent. (This problem is of particular interest to the International Institute of Applied Systems Analysis, Energy Group - International Atomic Energy Agency Project). Many of the developers of the peace-time use of nuclear energy have registered "surprise" at the tremendous public outcry to the siting of nuclear power plants (see Haefele, 1974). What is even more surprising however, is that a review of thirty years research and available literature in the social and behavioral sciences fails to uncover more than a few salient studies of the commonly held beliefs, attitudes, fantasies, fears and facts regarding nuclear energy. It is not meant that this issue be made a topic of exaggerated obsession, but rather that the question be raised of whether or not we might gain deeper, richer insights into the whole area of "risk assessment" by examining the perceptions surrounding this particular problem. The opportunity is certainly presenting itself.

Some mention should be made of those seminal works that are available in the scientific literature relating to the social-psychological implications of nuclear energy. In a now classical study of the Hiroshima victims by Robert Jay Lifton, Death in Life, several important metaphysical issues are explored. His interviews of the "hibakusha" (explosion-affected persons), employing what he terms a modified psychoanalytic technique, reveal many of the pervasive effects of this psychohistorical calamity. The obvious initial, traumatic physical sequelae; the later, perhaps more feared "A-Bomb disease" resulting from the invisible radiation; the

intense sense of loss, abandonment, and guilt experienced by the survivors; and maybe most important of all, the profound effect on religious beliefs, social institutions, and the collective psychology. Of particular interest is the point Lifton develops regarding the inability of the survivors to "make sense of" their tragedy. The existing belief systems, social consciousness, and psychological structure were such as to prohibit any assimilation of the experience. The reaction was one of massive apathy, withdrawal, and hopelessness. A later extension of this study is provided by Lifton in History and Human Survival. Here the emphasis is on the ever-extant fear of annihilation and the degree to which it influences the collective, contemporary psyche, particularly the effect on the universal myth of immortality that has been an integral part of man's existence. An amazing insight is gained, too, in the observation that Lifton's original study was undertaken seventeen years after the explosions; up until that time there had been no systematic, scholarly attempts to study the social-psychological effects of the bombing. Most reports had been fragmentary, technically-oriented, by and large inconsequential, and tended to shy away from the human misery and suffering.

Recently, another publication has briefly touched on similar topics. Edwin S. Shneidman in Deaths of Man deals with many of the determinants for the currently popular preoccupation with death and dying. In a chapter entitled "Megadeath: Children of the Nuclear Family", he reports that large numbers of his students at U.C.L.A. and Yale, in a seminar on death and dying, are actively conscious of fantasies and fears they harbor about nuclear annihilation. He feels that their fears should not be dismissed .

as "adolescent nonsense". Studies of such attitudes, values and beliefs should be intensified to help in our understanding of the less visible effects this force may exert on evolving psychological structures, cultural myth-making, philosophical systems, and on our future.

One wonders that the emergence of a concept such as "risk assessment" is but a parallel of the thanatological aura of our times. The pervasive knowledge of potential annihilation, the control of which is in the hands of a few, invisible men, cannot help but have directed our attention to the meaning of our own life and death. The benefit and risk, the good and evil, the positive and negative of a multitude of endeavors is likely to come under closer scrutiny as a result of the Nuclear Age.

#### The Problems of the Measurement of "Risk"

As mentioned previously, the developments in the nuclear, engineering, aero-space, biomedical sciences have greatly out-distanced the capacity of the social and behavioral sciences to determine the full impact of these advances on our lives. As a result, when those in government or those associated with the scientific-technological establishment turn to the behavioral scientist for answers to complex social-psychological questions he is often hard-pressed to provide anything more than an opinion. So too, when those interested in the measurement of "risk" as perceived by individuals or populations, ask the psychologist and psychiatrist for definitive procedures, tests, and methodologies there is often an embarrassing reply, "We have very little to offer." Another obvious problem for the social-behavioral sciences is the inherent imprecision of the "tools" of their trade. The

multiple determinants of human behavior do not lend themselves as easily to the precision, replicability, and reliability of measurement found in mathematics and physics. It is for this reason perhaps that the sociologist and psychologist are viewed askance by their "more scientific" colleagues. The purely humanistic approach needs to be balanced a bit with a chest of "tools" and measuring devices that will lend greater credence to some of the rich, insightful contributions that psychology and psychiatry have to offer.

One of the more reliable methodologies available to the researcher into human attitudes and values is that deriving from the area of psychometrics. The magnitude estimation scale is a method for assigning a magnitude to various items that was originally developed for use in psychophysics - the study of the psychological perception of the quality, quantity, magnitude and intensity of physical phenomenon. This subjective assessment of the observer plotted against the physical dimension being perceived (length of object, intensity of sound, brightness of light, number of objects, etc.) provides a reliable delineation of man's ability to quantify certain of his experiences. This technique was established and refined by S.S. Stevens and his associates in the psychoacoustics laboratory at Harvard.

This process for quantifying human perception has been adapted to study behavioral responses, opinions, values and attitudes. Of particular note is the work of Thomas Holmes, University of Washington Medical Center, Seattle, Washington. His research into the area of life change and illness susceptibility resulted in the development of the Social Readjustment Rating Scale. Here a scale was devised for assessing the perceived

"adjustment" required for a variety of life changes (marriage, death of spouse, change in occupation, parking ticket, etc.). There has now emerged a growing interest by anthropologists, social psychologists, behavioral scientists and physicians in this particular method of measuring attitudes. Many of the completed studies in these disciplines demonstrates a high degree of cross-study, cross-cultural correlation. As envisioned by Otway (1969), this scale and technique are now being adapted to the "assessment of risk". The quantification of the perceived desirability or undesirability of a number of scientific-technological advances has been instituted and further studies are in progress (Fahner, in press). There are likely as yet undiscovered methods for exploring this most relevant and intriguing study of "risk assessment". Hopefully, international seminars and workshops such as that planned for Woods Hole, Mass. will promote a greater understanding of and stimulus for research into these problems.

#### The Risk of Risk Assessment

There are a good many questions which are likely to be avoided and remain unanswered when researchers begin to investigate human values and attitudes. For example, what are the intentions of those interested in "assessing the risk" perceived by individuals and groups? A perhaps remote analogy is drawn from the author's experience. In the practice and process of psychotherapy one encounters the concept of "resistance". This is generally viewed as the patient's unconscious avoidance of unpleasant memories and associations - the perceived "risk" of uncovering the repressed material of his past. In this case the therapist hopes to promote the maturation and emotional well-being of the individual by interpreting the "resistance" in an

empathic, supportive manner. The decision as to whether or not these conflicts will be pursued or that change in behavior is implemented is the decision of the individual first, finally and foremost.

In examining the "risks" that individuals and populations perceive with regard to the products of man's inventive technology we must take care not to undermine critical social-political processes. Often times the scrutiny of the "resistance" posed by special interest groups, revolutionary movements and the like, seems to serve the interests of those favoring the conventional viewpoint. It is important that such questions be closely considered before information would be unknowingly provided to governmental agencies or to the scientific-technological establishment as a means of influencing public opinion or the democratic, decision-making process.

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