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June 26, 1979

Mr. Carlton Kammerer
Director
Office of Congressional Affairs
Nuclear Regulatory Commission
1717 H Street, N.W.
Washington, D.C. 20555

Dear Mr. Kammerer:

I have enclosed, for the Commission's review, a copy of a paper, prepared by Mr. I.W. Rozian of the Michigan Universities Consulting Service, regarding the Three MIle Island Incident

In his paper, Mr. Rozian argues that an investigation of the accident, itself, is insufficient because "The same sequence of equipment and operator failures is unlikely to occur again." He states that beyond an investigation of the accident, intensive research is needed on the management of complexity as it relates to the safety and reliability of nuclear power. Your consideration and comments of Mr. Rozian's paper would be appreciated.

Thank you for your attention in this matter.

Sincerely,

Wm Broomfield

William S. Broomfield
Member of Congress

WSB:khn

Enclosure

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MATHEMATICS · SCIENCE · BIONICS · ENGINEERING · BUSINESS · MARKETING · EDUCATION

May 9, 1979

Dear

At the height of the Three Mile Island crisis, I called several friends and acquaintances in the nuclear industry to check the feasibility of some ideas I had about solving the hydrogen bubble problem. The ideas were sound, but I learned that adequate measures were already under way.

Nevertheless, the importance of the nuclear safety question has prompted me to put in writing my suggestions for longer term studies and solutions. I am anxious to be of help through technical advisories to legislators or through committee testimony in my areas of expertise. Also, I would like to encourage further research on the reliable management of complex technology, which is where I think the real problems lie for the nuclear industry and government decision makers.

Sincerely,

Irving W. Rozian, P.E.

President, M.U.C.S.

POOR ORIGINAL

IWR:sdr

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THE THREE MILE ISLAND INCIDENT

A Proposal For

Action

I.W. Rozian, P.E.

Executive Summary

It is necessary to make engineering investigations of what happened at Three Mile Island. However, technical fixes alone will not save the industry. The same sequence of equipment and operator failures is unlikely to occur again. But other accidents of equal or greater severity may occur if we cannot correct deficiencies of managerial practice and policy in the nuclear industry and in government.

At an even more basic level, there is an open question as to how much complexity we can manage reliably within the limitations of human beings and our society. Computers may or may not help.

In my opinion, these technical, institutional, and societal questions can be better resolved, and the results will be more credible to the public, if the make-up of industry and government task teams is broadened to include not only scientists from other disciplines, but managerial and social science specialists as well. Some intensive research is needed on the management of complexity as it relates to the safety and reliability of nuclear power.

Legislators should await the outcome of thorough and objective analysis which will require about one year. It may seem politic to delay or suspend nuclear power development, but there is as yet no functioning alternative to fission energy for making up the short-fall in oil and gas over the next two decades. Therefore, lacking nuclear power, the majority of us will be poorer, and the poor will be without hope. By far the greatest nuclear danger remains the danger of nuclear war over the remaining petroleum resources, if no alternative technology is developed.

In the essay which follows, I have attempted to identify some technical remedies which ought to be evaluated, and studies which should help to resolve questions about human and institutional factors.

April 19, 1979

THE THREE-MILE ISLAND INCIDENT : A PROPOSAL FOR ACTION

By Irving W. Rozian, P.E.

I. Overview

At a superficial level of analysis, the Three Mile Island Incident can be attributed to the failure of a couple of valves and, perhaps, an instrument, compounded by operator error in misunderstanding what was happening in the process. It is certainly necessary to investigate and determine as much as possible about exactly what went wrong with the equipment and the operator's decisions.

The next deeper level of analysis should, and undoubtedly will probe design questions, adequacy of operator training, test and maintenance procedures which may have permitted operation with two emergency core coolant pumps locked out of service, etc.

Still another level of analysis will consider actions of the management of Metropolitan Edison, the Nuclear Regulatory Commission, and the Governor of Pennsylvania in responding to the crisis.

However, the answer needed by other utilities and the nation about the safety and desirability of nuclear fission power will not be provided by these detailed analyses of the incident itself. The exact same sequence of events is unlikely to recur. What is needed is a look at a much broader range of activities than just the engineering design and operation of a pressurized water reactor. The activities to which I refer are in the realm of management practice, human factors engineering, group dynamics of decision making (in normal and crisis atmospheres), public policy, quantitative risk evaluation, conflict resolution, and even cultural anthropology.

Broadly stated, the underlying question is this : Is there a limit to the complexity of systems which can be managed reliably over long periods of time by human beings within existing social structures.

The corollary to this general question is whether the nuclear power industry, with its severe maximum credible accidents and long term waste disposal problems, exceeds the limits of manageability for mere mortals.

A second corollary question which then follows is whether computers can be used to extend the capability of human control, or whether they may worsen the problem.

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II. Specific Studies Needed

A. Computer Control of a Reactor Power Plant

To date, the Nuclear Regulatory Commission (and its predecessor, the Atomic Energy Commission) have not permitted direct computer control of a nuclear reactor. The computers associated with reactors have therefore been used principally in data-logging and process monitoring modes.

Actual control of the process has been accomplished by local loop controllers, motorized valves and switchgear under the over-all control of a human operator. Display of process status to the operator has been through banks of control-room instruments, lights, and alarms. The principal automatic features such as turbine overspeed trips, reactor scram for various conditions, emergency feedwater, pressure relief. etc., are at a localized loop control level, with manual initiate or override available to the operator in most cases.

As a result, the main model of process dynamics and status is a conceptual model in the brain of the chief operator on duty, rather than a mathematical model embodied in computer algorithms. The plus in the current arrangement is that a well-informed human is a more flexible problem solver than a computer because of his superior ability to integrate data about particular situations with his general knowledge, which might not have seemed relevant at the time of computer programing. He can still beat the computer at ad hoc use of inductive reasoning.

The minus is that human memory for numerical detail is limited and, even more important, the physiological process of accommodation tends to tune out of consciousness all elements of the surroundings which are unchanging or seemingly unthreatening. The level of human attention and concern for small abnormal details diminishes with familiarity. The computer can beat the man at unflagging attention and total recall (assuming certain self-checking routines and redundancy). It may be better than he at rapid deductive reasoning leading to corrective action.

A middle ground suggests itself which I believe has not been adequately considered. That is to have the computer set up to be fully capable of automatic control, like an autopilot, but to have it normally off-line, functioning not only to monitor and alarm, but to print or graphically display advisories on emergency action to restore stability.

The pre-programing of the computer should include the results of think-team studies of every conceivable system failure. A formal discipline for these studies has been developed under the name of Failure Mode Effects Analysis.

An extremely important by-product of any planning for full computer control capability is the more thorough analysis of process dynamics which must be made, and the improvement of instrumentation necessary to present the computer with an unambiguous picture of the process status.

B. Improved Operator Training

Conversely, the process model in a computer can be linked to simulation training for the operator. A special form of Link Trainer should be employed to give the illusion of the control room under normal and crisis conditions, as is done with pilots, astronauts, ships' officers, etc. It is highly instructive for a neophyte, or an experienced operator on refresher training, to "crash" the plane a few times when he makes a mistake under stress. Abnormal situations can be simulated which one would not risk trying on an operating reactor.

Although some simulator training is already employed, because of the elaborate nature of a reactor control room, special development may be needed in projection techniques under simulator control. The simulator will need to be supported by a fairly powerful computer or computing center. On the other hand, only one or two simulation centers would be needed to serve many varieties of reactors, since the changes would be mainly in software rather than hardware.

Even if an effective training illusion required a full-scale mock-up of the actual plant control room for each facility, it might be money well spent. The instruments could be real instruments kept as "live" spares for the actual control center.

C. Socio-Dynamic Factors

Special recommendations IIA and B above are efforts at technological "fixes" although they deal with improving the human-factors performance of the operator.

As stated in the Overview, the nuclear industry needs to step back farther and review many of its assumptions. There has been a common sort of tunnel vision at work here. The experts on nuclear energy and power plant design constitute an inbred elite whose cross-associations with other disciplines (particularly the "soft" sciences) may have been limited by the intensive time demands of their own pioneering technical work. However, the management of complexity requires the full panoply of human skills.

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C 1 a. Plant and Utility Management

A review should be made of the type and level of managerial training of nuclear plant personnel and the managerial styles, policies, and practices in effect. What are the typical chains of command for routine and crisis operation? Can a high level of attention to detail, good housekeeping, etc., be maintained? Is there too much pressure put on by top management to stay on line, or to avoid rocking the boat with troublesome questions? Is the pressure even really there, or is it only perceived to be there by lower level supervisors and employees as a result of inhibited vertical communication about employee concerns and true corporate policy?

Were these, perhaps, some of the underlying causes for backup systems being locked out for two weeks after testing, and for maintenance work being done on the condensate return system with the plant running at full power, rather than shut down (according to preliminary reports) ?

Have lines of authority been defined in advance for crisis situations, or are decisions first made in isolation by an operator who cannot get fast consultative support, and then by an overgrown committee whose direction changes each time a higher official shows up? Do public relations considerations outweigh timely and factual notice to public officials and the news media? How much censorship, if any, and by whom, is necessary to avoid unwarranted panic from misinformation?

What were the managerial factors of competence and preparation? The governor of Pennsylvania has recently suggested that the plant management and perhaps higher utility officials should have been examined and licensed by the N.R.C., not just the operators.

There are a number of nuclear reactors, both fixed and mobile, under military or at least Department of Defense control. Are they any better managed, or worse?

1 b. Governmental Management

A similar management review is needed of organization structure, personnel selection, policy, practices, and training within the N.R.C., other U.S. government crisis agencies involved, and the various state governments.

A specific parallel which comes to mind is that of the interaction between an airline pilot and an F.A.A. ground control center.

The pilot has the final authority to make crisis decisions, but he is constantly under guidance and advisories from the ground. Apparently there was no such established hot-line to information center relationship between reactor operators and the N.R.C. Studies are needed on a suitable relationship and the backup structure needed in N.R.C. If N.R.C. personnel happen to be present, or arrive during a crisis, under what conditions should they assume command?

1 c. State Authority and Responsibility

Another area of confusion and lack of advance definition of roles is that of State government authority and responsibility. Disaster control, evacuation, etc., are State level responsibility in most situations, but T.M.I. demonstrated that State level government, even in a well managed state, has insufficient bases of knowledge to make decisions about nuclear reactor mishaps, much less any real and appropriate civil defense preparations. Again, the lines of authority and responsibilities appear largely undefined.

Furthermore, if the potential need for evacuation in the vicinity of nuclear reactors adds substantially to the cost of civil defense or disaster relief, this cost must be factored into any comparison of nuclear power with other alternatives and must be taken into account in site selection decisions. Offsetting the apparent desirability of sites remote from population centers is the loss of potential for "co-generation," i.e., the use of by-product heat for industrial processes or residential space heating. Transmission line losses also limit practical distances to a few hundred miles.

C2. Human Factors

A great many studies have been made of man-machine interactions on a short term basis. An extreme example would be the three-way interaction among a fighter pilot, his plane, and its computer which may be tied into terrain-avoidance radar.

On an intermediate time scale, there is some information available on how operators interact with communications networks and business data systems and how both affect the fortunes of the firm. Surely NORAD and other military systems must have dealt with problems of both flagging alertness and false alarms. Air traffic control systems are replete with similar problems. With the exception of close parallels in the chemical process industry and fossil fuel power generation, I am not sure how completely the nuclear industry has researched other experience in human factors engineering.

There is also a phenomenon which I shall call sub-culture regression. At the beginning of any new high technology enterprise, it is easy to get bright young college graduates and even Ph.D.'s to be operators for a year or two. This has been true of the Space Program and the aviation, computer, and nuclear industries. However, with the exception of airline pilots, who receive excellent salaries, travel, and pretty flight attendants as interest sustainers, it is hard to hold college graduates in routine operating positions. There is a gradual regression of education requirements, and one falls back on technician-level personnel who have been "trained" rather than "educated".

The effects of human factors on realistically maintainable quality control, operator skills, attention levels and crisis handling ability for the long term steady state of the industry must be evaluated more thoroughly.

Moreover, what about the unsteady state? What levels of skill and care would be available during a depression, natural disaster, epidemic, strike, civil insurrection, war, etc.? Although nuclear power is seen as a way to avoid technological decline of western civilization, what happens to our ability to handle operating or decommissioned plants and waste, if such a decline occurs through either mismanagement or by public choice of a simpler and poorer lifestyle?

III. Summary and General Recommendations

Fission nuclear power cannot be casually dismissed from our national economic planning. The only other near-economic alternative to declining petroleum supply is direct or converted use of coal which has its own serious risks to the health of workers and the public, as well as major environmental impacts, including radioactive potassium in fly-ash.

Nuclear fusion is as yet only a principle with no break-even process. It is by no means free of radiation problems. Solar energy, which the public thinks of as free, is the most capital intensive of all major energy sources under consideration. Its technological problems are difficult to solve, not because they are enormously sophisticated, but because they involve basic, almost irreducible costs of supporting structures and land necessary to collect a dilute, intermittent resource.

Therefore, it is essential to the interest of the nation and humanity to review the safety of nuclear power from a viewpoint which is deeply concerned with safety, but also objective, rational, realistic, and constructive.

I believe that it is imperative to the technical success of the nuclear industry and the believability of this round of studies that professionals be brought in from a wider range of disciplines, including the biological and social sciences. There is a critical guidance role to be played by those generalists whose life experiences have taken them into physical science, social science, business, and public affairs. They can serve as coordinators, translators, advisers to decision makers, and educators to the general public. We need credibility and understanding of our conclusions by the public and their elected officials far more than we need any one technical fix.

Further, I urge that research be undertaken immediately on the societal management of complexity with the nuclear industry as the case in point. Funding should come from industry or government or both to one or two institutions, and should have a deadline of approximately one year for preliminary report.

The nuclear issue will be a major factor in the 1980 elections, and the results of unduly prolonged scholarly debate may come in too late to alter the set course of energy policy.

On the other hand, should the conclusion of the various study committees be that we must curtail or abandon nuclear power, that conclusion would have to be supported by the most comprehensive, objective, and exhaustive use of our intellectual resources. The consequences of such a decision may be the end of economic growth for all, and the end of hope for the underprivileged both here and abroad.