WE DID
<u>NOT</u>
ALMOST LOSE DETROIT

A Critique of the John Fuller Book:
"We Almost Lost Detroit"

Detroit
Edison

WE DID NOT ALMOST LOSE DETROIT

(A Critique of _We Almost Lost Detroit_ by John Fuller)

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INTRODUCTION

The Book, We Almost Lost Detroit, by John Fuller has been reviewed by those who participated in the Fermi project. The book treats many of the often discussed legitimate issues of the nuclear power controversy from the point of view of the nuclear critic using the Fermi 1 fast breeder fuel melting incident as a vehicle for such a discussion. The unique aspect of the work is that considerable detail is provided of both a technical and documentary nature tending to add credibility to the views of the author as perceived by the average lay reader. In some quarters the work is being cited as some sort of technical authority. Herein lies the major danger of the book because the treatment of much of the source information is distorted such that the average reader without technical background could easily be misled to agree with the anti-nuclear stance of the author. For this reason, this rebuttal has been prepared to help correct some of the inaccurate impressions that may be conveyed to the average reader.

CRITIQUE OF TECHNIQUE

We Almost Lost Detroit is an interesting combination of historical fact, colorful adjectives, a few mistakes, and extremely carefully chosen excerpts cleverly combined to lead the reader inexorably to the conclusion that nuclear power is too dangerous to be handled by fallible man, and that the government knows this, but is unwilling to admit it.

One very effective device used to draw the readers to such a conclusion is to state a technical fact, but out of context, omitting the precise situation to which it applies and any qualifying remarks, and then to expand the significance of the fact through a carefully controlled scenario. Erroneous impressions are also given through the use of "leading" statements and terms that cannot be explicitly labeled as false, but in the context in which they are rendered leaves the reader little place to go but to the predetermined anti-nuclear conclusions. A mood of impending disaster is created by the simple use of well chosen modifiers and phrases sprinkled throughout the book.

This assessment is derived chiefly from a review of the portions of the book that deal with the Fermi 1 fast breeder reactor project and with the various reactor safety studies sponsored by the Atomic Energy Commission. It is in these areas that there is considerable local experience and/or documentation to draw upon. For this reason the major portion of the rebuttal discussion that follows will deal with these two subject areas.

THREE MAJOR THEMES

It is felt that a direct rebuttal to specific passages including callouts to appropriate references is the most fair and the most effective way to attempt to correct the misleading impressions that are conveyed. However, some background information is first given to help counter three of the major themes or impressions conveyed throughout the book. These impressions may be stated as follows:

- We almost lost Detroit as a result of the Fermi 1 fuel melting incident of October 5, 1966.
- Any mistake in nuclear power plant design, construction, or operation will most likely lead to disaster.
- The government performed a reactor safety study hoping to show that the risk to the public is low, but when the risk turned out to be high, they suppressed the study.

We Did Not Almost Lose Detroit

Fuller cites the results of a University of Michigan study[1] contracted for by the designers of Fermi 1, that shows the rather severe public consequences that would result from an assumed release of fission products from Fermi 1, as some sort of measure of the public threat that existed as a result of the Fermi 1 fuel melting incident. However, the significance of the Fermi 1 fuel melting incident with regard to public safety is best understood by comparing the extent of the actual accident both with the hypothetical accident that was used by the designers as the basis for containment design, and with the assumptions used in the University of Michigan study.

The Fermi 1 containment system was designed to accommodate the effects of an energy release that would result from a secondary criticality accident involving an assumed collapse of half of the total reactor core into the other half.[2] The October 5 melting incident caused by coolant blockage of two of the 103 fuel subassemblies that comprised the core resulted in the melting of about half of the fuel in the two affected subassemblies, or only about 1% of the fuel in the core.[3] Thus, the event was well within the safety envelope used as the design basis for the containment.

Now, note that the severe public consequences calculated in the University of Michigan study assumed all of the fission products normally contained in over 4,000 pounds of highly burned up reactor fuel were arbitrarily released to the atmosphere as if the reactor vessel, primary shield tank, and containment building did not even exist (see also comments on page 20). Compare these conditions to the actual fuel melting incident that involved some 40 pounds of low fission product content fuel* that melted and slumped several inches within the affected subassemblies with all containment barriers remaining intact and producing no radiation excesses to anybody.

Nevertheless, this real accident was significant. There was uncertainty in the degree of melting and core geometry dictating a cautious approach to preclude additional damage to the plant and to permit an accurate diagnosis of the cause of the accident. Future designs should and will be improved to minimize the probability of a similar occurrence and further reduce the public risk should it occur. But the difference between what actually happened on October 5, 1966, at the Fermi 1 plant and what was arbitrarily assumed in the University of Michigan study is enormous!

Any Mistake Will Not Produce Disaster

Fuller uses the Fermi 1 project and related fuel melting incident as well as several other reactor accidents as vehicles to convey the theme that any mistake in reactor design or operation will most likely lead to disaster. This contention is contradicted by Fuller himself by spending

*The actual Fermi 1 fission product activity on October 5, 1966 was several thousand times lower than the activity assumed in the University of Michigan study.

considerable time describing various Fermi 1 defects and by alluding to numerous "abnormal occurrences" among nuclear power plants (p. 229, Fuller). While most such occurrences are trivial, they are documented, they do result from some kind of mistake, and yet there has been no resulting public radiation injury, much less a disaster.

This should be no surprise. While great care is exercised in the design, construction, and operation of nuclear power plants, infallibility is recognized to be impossible and is not required. Thus, enormous safety margins are built into a nuclear plant.

A simple example - there must be an off-site supply of electricity to assure operation of important reactor systems. It is recognized that this source could be lost so a second off-site electrical source is provided, which is physically located a prescribed minimum distance from the first to reduce the chance that a single event would render both sources useless. Nevertheless, this event is deemed credible, and an on-site diesel generator is provided as backup, which is designed to provide the required electric power even in the middle of an earthquake at least as severe as any ever recorded in the area. Finally, it is recognized that there is a finite chance that such a diesel generator may be inoperable when required, so an independent second diesel generator is provided also designed for earthquake operation. This is but a single example of a myriad of design and operational features to provide a principle of defense in depth that can accommodate rather significant "mistakes," should they occur, without public harm. This philosophy of design and operation is set forth in some detail in the Code of Federal Regulations[4] and is further delineated by a series of Regulatory Guides that provide descriptions of acceptable procedures for carrying out the intent of the federal regulations.

Application of this defense in depth philosophy to individual nuclear power plants is achieved through regulatory procedures expedited by the federal government's Nuclear Regulatory Commission (NRC). First of all, an extensive licensing procedure is applied to every proposed plant. A preliminary environmental report and safety report is required before a construction permit is issued. While termed preliminary, these multi-volume documents provide a detailed description of the ability of the plant to conform to federal safety and environmental specifications.

Only after a significant session of additional questions and answers, public hearings, and a review by the Advisory Committee on Reactor Safeguards, a construction permit is issued. This procedure takes about two years. A similar procedure is again applied to obtain an operating permit with the reports containing more finalized data. Because of the attention to detail and the extensive review given to licensing reports, a single copy of all such licensing documents and associated correspondence for a single plant would produce a stack of paper 12 feet high.

Enforcement is accomplished by a program of auditing, inspection, and reporting. For example, there is a regulatory guide that summarizes reporting requirements for persons subject to NRC regulations; 110 different reports are listed.[5] A quality assurance program used in design and construction by the power plant owners, as well as the reactor vendor, and a program for plant operation is described in some detail in the safety analysis report.[6] These programs must satisfy the NRC. Inspections are made by safety personnel administratively independent of the operation they are inspecting and by the NRC. During the construction phase the NRC inspects a reactor some 25 to 30 times followed by 10 to 12 inspections during testing and about four per year during operation.[7] NRC inspections are both of the announced and unannounced variety with items of non-complianc their significance, and description of corrective actions becoming a matter of public record.

Finally, neither safety criteria nor design is stagnant. From the very beginning of the nuclear program there has been an on-going program of research and development in nuclear safety. Such work is currently sponsored chiefly by the Energy Research and Development Administration (ERDA) and the NRC of the federal government, by the electric utility companies, and by many of the vendors associated with the supply of nuclear components. The scope of their work includes not only items related to potential nuclear power plant accidents, but to all major segments of the nuclear industry that have any potential for public risk. The goals of such programs are to more accurately assess the safety margins now existing and to reduce public risk where appropriate through improved design and construction.

Federal Government Believes Reactors to be Safe and Does Inform Public

Fuller devotes almost three chapters to a description of the attempts of the AEC to update an earlier reactor safety study normally labeled WASH-740.[8] The thrust of Fuller's story in these chapters is that the AEC hoped that the additional safeguards provided on the newer reactors would lead to reduced calculated consequences of accidents, were terribly surprised and disappointed when the results turned out worse than the earlier study, and therefore, suppressed the new report. While there are some elements of fact provided in the Fuller presentation in these chapters, the conclusions drawn as to the significance of the various reactor safety studies with regard to public risk are grossly misleading. Specific passages from the book in this subject area are rebutted in some detail in the following section. However, due to the complexity of the issue, it is felt instructive to provide a short overview and history of the safety studies in question. Direct quotes from the safety reports in question are utilized where practical to help give an accurate portrayal of their content.

WASH-740 Does Not Provide Accident Probabilities:

The earliest study reported was a safety study performed by Brookhaven National Laboratory for the AEC. The results were published in March 1957 in a formal report titled, "Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants," WASH-740.

The report considered a range of reactor accidents, the worst being an arbitrarily assumed cold release to the atmosphere of half of the fission product inventory produced from 180 days of operation at full power following a 24-hour holdup period. Further a pessimistic temperature inversion is assumed to occur. Thus, no mechanism is given to explain how such a release would occur and no credit is taken for engineered safeguards designed to reduce the probability nor magnitude of fission produce release if such an accident did occur. While the report also treats less severe accidents, it is the consequences of this maximum postulated event that are most often quoted from WASH-740, i.e., 3,400 killed and 43,000 injured.[8]

While such limit calculations are informative, they do not in themselves measure public risk since there is no determination of accident probability. Contrary to its title, there was no serious attempt in WASH-740 at the difficult task of trying to quantify probability of occurrence for such accidents. While several approaches one might use for such a task were discussed, the conclusion was, "none of these approaches is satisfactory."[a] Thus, the report in no way calculates public risk from a nuclear accident since knowledge of accident probability as well as accident consequences, are required for determination of risk.

The situation is not unlike recognition that the crash of a large jet into a crowded stadium is theoretically possible and would produce horrible consequences possibly killing tens of thousands of people, but the probability is sufficiently low that the resulting risk is deemed acceptable, and we continue to have jet airline flights during football games.

WASH-740 Update Does Not Provide Accident Probabilities:

Some seven years later in May 1964, the Joint Committee on Atomic Energy (JCAE) requested that the AEC consider whether any experience or developments, since issuance of the WASH-740 in 1957, would require any modifications in the basic assumptions or procedures in that study to alter the judgments made on accident probability or the calculated consequences of upper limit accidents. The request was in anticipation of hearings that were to be held on the extension of the act that provides federal insurance against the consequences of nuclear-related accidents

[a]The nearest thing to a statement of accident probability was a statement of the range of estimates produced by the "best judgment of the most knowledgeable experts;" these "estimates for the likelihood of accidents which would release major amounts of fission products outside the containment (the major release accident) ranged from one chance in 100,000 to one in a billion per year for each reactor."[8]

(Price Anderson Act). The study was to be directed by the AEC and performed chiefly by Brookhaven National Laboratory, similar to the approach used for the original WASH-740 study. On July 21, 1964, a target date for completion of October 31, 1964 was given by the director, Dr. Clifford Beck.[9,10]

There were indeed reasons to ask for a re-evaluation of the earlier work since the design of nuclear power plants had significantly changed since the time of the earlier study. Reactors were larger, fuel burnup was greater, and there was improvement in engineered safeguards. While the effects of safeguards had not been included in the earlier study, evidence suggests that some of the people involved with the new study were hopeful at the outset that the effects of such safeguards together with a meaningful evaluation of accident probability could now be taken into account. For example, from the meeting minutes of an early meeting of the AEC Ad Hoc Committee on revision of WASH-740 are the statements:[11]

- "There was general agreement that a thorough revision of WASH-740 would be useful, even if the major dimensions of the problem, i.e., estimates of probability and consequences of major accidents, are not greatly different from those given in WASH-740. The basis for this view was that the knowledge and experience that has since accumulated would enable a revised report to be considerably more factual and realistic."
- "Mr. Staebler was strongly of the opinion that the report could and should include a technical treatment of probability of occurrence of the most improbable accidents."

Considerable discussion was held as to how to accomplish the very difficult task of assessing the effects of engineered safeguards and of determining accident probability. Meanwhile, Brookhaven National Laboratory proceeded with the collection and treatment of the necessary data to determine the maximum consequences of an accident; note, however, the ground rules for this part of the task.

"...it was made clear in the assignment of the present task that questions of probability and, thus even reductions in probability were not to be considered. Therefore, we have as in 1957 assumed that all safeguards, such as emergency core cooling, fission product retention devices, containment, etc., fail to perform their intended functions."[12]

Thus, the arbitrary approach in defining the accident as used in WASH-740 was again invoked but with some variations. The current study treated a reactor with a fission product inventory some ten times larger than used in the earlier study as a result of higher operating power levels and greater fuel burnup. The worst case placed the reactor in the center of a metropolitan area, contrary to existing site guidelines, assumed breakage of a major coolant pipe, concurrent failure of all safeguards systems such as emergency core cooling and spray systems, failure of the containment building through postulation of an existing hole the size of a door, no credit for plate-out of fission products on available surfaces, the worst weather conditions, and that all affected personnel are out of doors and take no protective action.[13] While other accident models were also considered with lesser consequences, they are seldom mentioned, and it is this worst accident with the assumptions stated that lead to the 27,000 fatalities cited by Fuller(p. 139, Fuller). Even though some improvements were made in the analytical treatment relative to the earlier WASH-740 work, "they have had little effect on the size of these estimates!"

"...because reactors now being contemplated are several times larger than those in prospect in 1957, and fuel cycles are longer, it is an inescapable conclusion that, assuming the same kind of hypothetical accidents as those considered in the 1957 study, the theoretically calculated damages would not be less, and under some circumstances would be substantially more, than the consequences reported in the earlier study."[14]

Thus, without a meaningful consideration of probabilities of accidents and of malfunctioning of safeguards, little information was being added by the new study. In the words of two AEC committemen, "...since they were leaving out statistics, the same result would be reached as in WASH-740, and, if so, there was no point to the study."[15]

The formal treatment of accident probabilities was never seriously undertaken by Brookhaven in the short period of time that was available to produce the update. Some simplistic calculations based on reactor operating experience were performed. But with only some 1,500 reactor years of experience such determinations were essentially meaningless since they could only give an upper limit to accident probability which "does not say how low this probability is...which is the question of real importance."[16]

The only serious attempt at calculating such accident probabilities during the WASH-740 update effort was by a company called Planning Research Corporation under contract to the AEC. They had just developed a probabilistic methodology for safety analysis of power reactors and suggested to the AEC that it be applied to the revision of WASH-740. The AEC agreed and a small contract of some $10,000 was written to support such an effort.[17] The study took about three months with the final report being issued on March 21, 1965, some five months after the original target date set by the AEC for the entire WASH-740 update.[18]

The primary effort by Planning Research Corporation was to attempt a determination of probabilities for catastrophic reactor accidents by describing the sequence of events required for such an accident, assigning a probability for each of the required events, and then combining such event probabilities to obtain the probability of the accident. However, a major problem was that "since quantitative information is frequently lacking, 'best' engineering estimates and judgments were frequently used" in the model. The Yankee reactor, a PWR served as the primary source of information for light water reactors with BWR effects superimposed where appropriate.[18]

The resulting probability for the most likely catastrophic accident in a light water reactor per year was calculated to be one out of 15,000,000.[18] Interestingly, this value lies in the range obtained from a "best judgment" in WASH-740.[8] Unfortunately, while the value supported the feeling of many scientists, namely that the probability of such accidents was exceedlingly low, the large data and calculational uncertainties in this rather modest effort applied to an enormous problem did not allow the results to be taken with mathematical confidence. No uncertainty analysis had been performed. To empirically check the value through statistics of operating experience would require some 15,000,000 reactor years of operation which obviously was out of the question. There had been only 1,500 reactor years of operation.

As indicated earlier, this small data base of no accident experience was of little value though it was formally treated by Planning Research Corporation to yield the result that with 95% confidence, the probability of occurrence of a catastrophic accident is <u>at most</u> 1/500 during one year of operation.[18] As noted in the Planning Research Corporation final report, the fact that the accident probability value obtained from the "sequence of events" approach first described was much smaller "does not indicate any fundamental disagreement, but merely reflects the fact that much more experience must be collected before a stronger statistical assertion (i.e., one based on simply total plant operating experience) can be made."[18] Fuller has misrepresented this statement several times in public appearances.

Thus, the AEC was faced with the problem of how to report results of a task that was far from complete. No meaningful results on accident probability had been produced; no meaningful assessment of the effects of reactor safeguards had been made. The only information that had been produced was the upper limit consequences for arbitrarily assumed accidents as was done for WASH-740 but for larger reactors. No formal study would have been required to determine that the accident consequences for a reactor containing some ten times the fission product inventory relative to the earlier study would result in some ten times the consequences for similarly postulated accidents. There was considerable internal discussion as to the public impact of formally issuing such results since there was already evidence from the effects of the WASH-740 report that they would be misinterpreted and improperly used. This concern had also been expressed by the Atomic Industrial Forum and Oak Ridge National Laboratory.[20] Thus, succumbing to this concern as well as recognizing that little of technical value had been produced during the WASH-740 update effort, the AEC decided not to write a formal final report containing any of the numerical values that had been produced at various stages of the study. Instead, the conslusions were expressed in the form of a latter dated June 18, 1965 to the JCAE.[10] The two major points of that letter are quoted:

- "A firm basis has been laid for the belief that the likelihood of major accidents is extremely low."
- "...assuming the same kind of hypothetical accidents as those in the 1957 study, the theoretically calculated damages would not be less and under some circumstances would be substantially more than the consequences reported in the earlier study."

While there is ample room for a variety of opinions, there are definitely grounds for some criticism of the AEC on two counts with regard to the WASH-740 update study. The first would be the poor judgment that led them to believe that meaningful reactor accident probability and calculations of safeguards effects could be determined within the budget and schedule provided for the task. The second would be the choice not to prepare and issue a final report that included the major numerical results despite the fact that it would have added little to the original WASH-740 study. The risk of misinterpretation and misapplication should have been accepted.

In any event, the public had become aware that some sort of updating of the 1957 WASH-740 was taking place largely from the speech by the AEC Commissioner, John Palfrey, given in San Francisco in December of 1964.[21] Subsequent inquiries eventually followed by a Freedom of Information suit filed by the Union of Concerned Scientists, led to release of all of the working papers (memoranda, proposed chapter drafts, etc.) related to the WASH-740 update study (there had never been a completed report). All of this material became available to the public through its placement in the USAEC Public Document Room in June of 1973.

Rasmussen Report Demonstrates Probability of Reactor Accident is Very Small:

The previous WASH-740 update experience underlined the great need for a definitive study on the degree of public risk from radiation release that could accompany a nuclear power plant accident that would include a detailed assessment of the probability of accidents, as well as more realistic calculations of accident mechanisms taking into account the detailed design features of the as-built nuclear power plant. Such a study would require a great deal of effort and access to detailed design features of the plants in question. Thus, in the summer of 1972 the AEC commissioned a reactor safety study with the following objectives and expectations:[22]

> "The principal objective of the study is to try to reach some meaningful conclusions about the risks of nuclear accidents using current technology. It is recognized, however, that the present state of knowledge probably will not permit a complete analysis of low-probability accidents in nuclear plants with the precision that would be desirable. Where this is the case, the study will consider the uncertainty in present knowledge and the consequent range in the predictions, as well as delineating outstanding problems. In this way, any uncertainties in the results of this study can be placed in perspective. Thus, although the results of this study of necessity will be imprecise in some aspects, the study nevertheless will provide an important first step in the development of quantitative risk analysis methods."

The study was organized to be independent of the AEC's operating and regulatory organizations. Professor Norman C. Rasmussen of MIT, as Director of the Reactor Safety Study, reported to the Commission. While funds and such other assistance as were needed were provided by the AEC, the study operated under the general charter provided by the Commission, but received no other direction from it. In addition to AEC staff help principally required for their detailed knowledge of reactor plants, the study utilized contributions by some 20 additional contractors and national laboratories. The study is reported in a document titled, "Reactor Safety Study," WASH-1400.[22]

The overall approach represents a significant extension to the direction taken earlier by Planning Research Corporation for the determination of reactor accident probability. Failure probabilities and safeguards systems are specifically related to accident consequences. The probability of occurrence of a given accident sequence (e.g., radiation release as a result of a specific core meltdown accident) is composed of the probability of the initiating event (e.g. break in main coolant line) probability of the failure of safeguard systems (e.g., an emergency core cooling system) included in the sequence, and the containment failure probability under accident conditions. Complex event and fault trees are used to show relationships between component (e.g., a valve) and system failure probabilities as well as interactions between various systems. The probabilities for initiating events and component failures were based on appropriate available failure rate data. Since implementaltion of these methods requires knowledge of the details of plant construction, the study utilized a particular BWR and a particular PWR as typical of each of these classes of plants.

These procedures coupled with consequence models yielded families of curves that related the extent of public harm from a reactor accident in terms of fatalities, injuries, or financial penalty and the probability for that given consequence. This information is then used directly to determine the public accident risk from the operation of a nuclear power plant. The results indicated that such risk for the case of 100 operating nuclear plants was thousands of times lower than the risk caused by other man-made events or from most natural events.[22]

This discussion of the methodology and results is extremely simplified and does not do justice to the detail and extensive analysis of reactor safety accomplished by this study. It should be noted that the study took three years to complete and cost some four million dollars. The final report is contained in eight volumes and includes discussions of the meaning of risk, development of event and fault tree methodology, a description of reactor accident mechanisms, treatment of human error and common mode failures, descriptions of the safety design rationale for nuclear power plants, discussions of calculational uncertainty, and detailed presentations of the results.[22]

WASH-1400 first appeared in draft form in August 1974 when it was given considerable circulation for the purpose of soliciting comments.[23] Many organizations and individuals submitted such comments, though all who were requested to do so did not respond. An important adjunct to the 87 comments that were received was an independent one-year study on reactor safety performed by the Study Group on Light Water Reactor Safety of the American Physical Society.[24] Since they had obtained a preliminary draft of WASH-1400 early in their work, the resulting study in many ways is a critique of WASH-1400 and includes many recommendations for modifications to be made before issuance of the final version. However, it is significant to note that the American Physical Society study concluded that, 'we have not uncovered reasons for substantial short-range concern regarding risk of accidents in light-water reactors."

The final version of WASH-1400 was issued in October 1975 incorporating many of the comments that had been received on the earlier draft. There is a specific Appendix in the final report that specifically addresses the comments received.

The conclusions of WASH-1400 substantiate the feelings expressed in the earlier report on theoretical consequences of major accidents (WASH-740), namely that the probability of such accidents is extremely low leading to a very low public risk.

REBUTTAL OF SPECIFIC PASSAGES

This section contains a number of selected passages directly quoted from We Almost Lost Detroit followed by a rebuttal directed toward the specific passage. While much of the rebuttal is a logical extension of the general discussion presented in the preceding section, additional detail is provided to attempt to better illustrate the flaws in the passages selected. The order of presentation is generally the same as that of the book except where passages on the same subject have been grouped for convenience.

p.1 "The phone call came in sometime in the mid-afternoon of Wednesday, October 5, 1966. The exact time is not recorded, because it was never entered officially on the log of the sheriff of Monroe County. Michigan Sheriff Charles Harrington, known as Bud, a lanky man with a lean, craggy face, received it. An unidentified voice on the other end of the line spoke sharply and briefly, saying it was Detroit Edison calling --- the major utility company in southeastern Michigan. There was something wrong at the new Enrico Fermi Atomic Power Plant, which Detroit Edison operated at Lagoona Beach --- just a handful of miles away from the town of Monroe. The cause of the problem was uncertain, but the caller said that the situation should not be publicized, that no public alert should be given. More information would follow.

p.2 At the same time, some hundred miles away, Captain Buchanan of the Michigan State Police in Lansing was alerted by a similar phone call, again from a Detroit Edison representative."

The opening paragraph sets the tone for much of Fuller's book --- dramatic, tense, whether or not the actual events call for such a portrayal. It may never be known whether or not the alleged phone calls that provide the dramatic opening of the book were actually made. They do not appear in the detailed log of events that was kept at the Fermi-1 plant, nor can they be recalled by any of the plant personnel involved at the time. However, the validity of the telephone calls is not the issue. The important point to make is that there was no reason for anyone to have made them. Neither the plant emergency procedures nor AEC regulations required such notification. Only the reactor building was restricted for a time immediately after the incident. No one left the site because of radiation or a concern that radioactive material might be released. There was no threat of danger that would call for any kind of public notification.

See page 33 for a description of the plant emergency procedures for various classes of reactor accidents.

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p.40-41 "One exterior hazard that still hangs over every nuclear plant is the possibility of heavy modern aircraft falling into it. Because the probabilities would be so small, this factor was generally dismissed. Other considerations were earthquakes and floods which would be equally dangerous."

The vague implication is given that a general decision has been made that the probability of large aircraft falling on nuclear power plants is so low that its consideration is routinely dismissed in nuclear plant design, while a reference to earthquakes and floods says nothing except to point out to the reader that they are "equally dangerous." Current procedure is for every individual nuclear plant site to be examined with regard to the probability of aircraft crashes for a spectrum of plane sizes. Only if this probability for a given size plane is less than one out of 10,000,000 per year are the consequences dismissed.[25] (Earlier limits were placed at one out of 1,000,000 per year.[26]) If the probability of such a crash exceeds one out of 10,000,000 per year, the plant must be designed to limit any radiation release that might result from such a crash to a value less than the limits allowed by federal regulations[4] (10 CFR Part 100).

As an aid in perspective, note that the probability of an aircraft crash into the Hollywood Park race track while occupied is more than 100 times greater than the probability limit cited above for crashes into nuclear sites. If the race track were occupied with 50,000 people, the expected result from an average crash is 5,000 mortalities while a direct hit from one of the larger jets could kill 32,000 people.[27] It is interesting to note that these values exceed most of the various calculated theoretical consequences of a major reactor accident cited by Fuller.

With regard to earthquakes and floods, federal regulations[4] (10 CFR Part 100, Appendix A) require that a nuclear plant withstand the effects of earthquakes and floods of a magnitude at least as great as the largest in recorded history for the given site. In the case of the Fermi site where earthquakes activity has been minimal, the Fermi 1 containment building was designed to withstand an earthquake load caused by a lateral acceleration of 0.1 gravity. For Detroit Edison's Fermi 2 light water reactor now under construction, a more severe earthquake occurring elsewhere in the country was chosen as the design basis for its safety-related equipment and structures.[6] The design basis flood assumes hurricane force winds traveling down the center of Lake Erie at the same time the lake level is assumed at the all time high.[6]

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p.58 "Any fission product inhaled or absorbed by the skin is deadly."

Such a statement that does not define the fission product or specify quantities is meaningless. It would be like saying any carbon monoxide that is inhaled is deadly. Carbon monoxide is certainly considered a rather toxic poison, but everybody anywhere near an operating automobile inhales it. The question is, how much? Many fission products are not even radioactive. Some are quite dangerous, but the quantity must be defined. The federal regulations[4] (10 CFR Part 20) that define maximum permissible radioactive concentrations take cognizance of the particular fission product or other type of radioactive isotope and its individual characteristics.

* * * * *

p.61 "Less than two months later, in July of 1957, the University of Michigan issued its own study on what would happen if the fission products were accidently released from the Fermi reactor. Any hopes that the study would be more encouraging than the infamous WASH-740 report were shattered."

p.62 "In his attempt to evaluate the likely effects of fission products on the surrounding population, several possible conditions were assumed. Critics, however, could not help but focus on the most pessimistic of the situations studied when the report was finally circulated. This involved the release of all the poisonous fission products during a time of temperature inversion, where a warm layer of air would clamp the cooler air to the ground like a lid over a box."

One doesn't accidently release all the fission products from a reactor by something innocuous like turning the wrong valve. The University of Michigan study alluded to here (a study sponsored and published by the designers of Fermi-1) treats as its worst case an arbitrary unexplained release of the entire reactor inventory of fission products as a gas, an assumption even more unrealistic than postulating a major meltdown with failures of safeguards and complete failure of the containment. Even if all safeguards systems failed to function and enormous breaches in the containment somehow occurred, there would still be natural mechanisms to reduce dispersion to the atmosphere such as plate-out of fission products on the many available surfaces. Since the initial assumptions of the worst accident (a 100% fission product release, "without inquiring into the question of how or whether it could occur" and "under the worst possible weather conditions - regardless of its small probability")[1] are even more pessimistic than used in the WASH-740 study, it is doubtful that there were ever any hopes that the calculated consequences of such a postulated accident would be "more encouraging."

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p.63 "LMFBR's are subject to super prompt critical conditions. And as the AEC well knows, this technical terminology translated into layman's language is an atomic bomb."

This statement incorrectly implies that a liquid metal fast breeder reactor (LMFBR) can blow up with the intensity of an atomic bomb. Even the relatively small Hiroshima-type bomb is equivalent in explosive intensity to 20,000 tons of TNT. Contrasted to this, extremely pessimistic assumptions that arbitrarily assumed collapse of one-half of the Fermi 1 core onto the other half led to an energy release only on the order of several hundred pounds of TNT.[2] The containment was designed to limit radioactive release following such a postulated event to below the limits set by federal regulations.

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p.109 "Then meters soared to the lethal dose - 1000 rads."

This statement refers to the radiation meter response upon entering the SL-1 containment following the SL-1 accident at the Idaho Reactor Testing Station and may cause the reader to ask why the man holding the meter did not die. The technical problem with the statement is that a dose rate meter indeed measures dose rate and not total dose. Another source[28] indicates that the dose rate measured upon entering the SL-1 containment building was 500 roentgen per hour, a very high radiation field. However, to receive a total dose of 1000 roentgens (similar to rads), the health physicist would have had to remain in the radiation field for two hours. Such a dose would have indeed been lethal. However, their several minute exposure would have resulted in a dose of about 25 roentgen, the Federal regulation limit for dose to a member of the public under accident conditions.

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p.125 "Only seconds later, an automatic safety disc burst. The sodium rushed out of a faulty relief vent. The moment it hit the air, it flared up violently. Fortunately, the nuclear fuel had not yet been loaded into the reactor, and the sodium was not radioactive. No one was hurt, but the unions protested vigorously that if the fuel <u>had</u> been loaded in the reactor, there would have been a disastrous release of fission products."

In addition to an inaccurate description of the event, this passage implies a gross misunderstanding of a basic feature of the Fermi 1 heat transport system. The sodium that removes heat from the reactor core is not the same sodium that passes through the steam generator to make steam. There are two completely separate coolant systems, the former transferring its heat to the latter through an intermediate heat exchanger.[29] Thus, even if fuel had been loaded into the reactor and the reactor was operating at full power at the time of the sodium reaction cited above, there would be no resulting release of radioactivity since this sodium is not radioactive, never having been in the reactor core. There certainly would be no release of fission products from such an occurrence much less a "disastrous" release.

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p.129 "On the other hand, many improvements in reactor design and safeguards had been made since the 1957 report. Perhaps these new safeguards could present a brighter safety picture for the public."

Such a statement implies that the older 1957 safety report (WASH-740)[8] took into account reactor safeguards then existing, and that perhaps the additional safeguards that accompanied the newer larger plants might result in smaller calculated consequences of postulated accidents. The fact is that the original WASH-740 made no explicit treatment of safeguards, but instead arbitrarily assumed for the accident case most often cited that 50% of all fission products were released from the containment building and subsequently dispersed.[8] No attempt was made to describe how such an accident could occur. If an update of WASH-740 treating larger reactors with greater fission product inventories again made similar arbitrary assumptions, the investigators could never have expected that a "brighter safety picture" could be presented.

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p.134 "...regardless of the one AEC attempt to refer to it as sunshine units."

This statement refers to an alleged attempt by the AEC to refer to radiation as "sunshine units." Whether or not an AEC public relations man*

*See page 58 of Fuller text.

used or promoted such an attempt, the allegation that the AEC officially tried to promote such a term is misleading. It does not seem to appear anywhere in countless AEC, and industry or even layman documents on nuclear energy. I have not been able to find anyone else who even heard of the term.

(Information recently brought to my attention shows the term to be a radiation unit for strontium-90 fallout from weapons testing and was used in Project Sunshine, a classified project begun in 1953.[62,63] Some project reports after the 1954 general declassification still used the term but did not attempt to hide the hazards of fallout.[63-65])

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p.136 "McLaughlin's rough figuring showed that the chances based on experience to date would be three accidents in ten years when the 1,000 planned reactors were built across the country."

p.137 "Dr. Bernard Pasternack, a consulting NYU biostatistician, basically agreed with McLaughlin's estimate, stating that three or more accidents among 1,000 reactors in ten years was virtually a hundred percent certainty."

p.137 "The poisonous fission products released within and on the boundaries of cities was a ticklish subject, because of the high potential of deaths, and destruction to a large population. The tendency of some of the committee was to push this kind of problem under the rug. But Smith disagreed. He told his colleagues this danger should be studied 'owing not only to the fact that this is likely to occur in ten years, but also that many people consider city reactors desirable as an alternative to sulfur dioxide pollution'."

p.140 "He would like to see various types of accidents related to their probabilities so that liability experts could put dollar estimates on them. Dr. Kruper reminded him that this had already been done in the rough figures by Jim McLaughlin, and they were terrifying: three accidents in ten years when 1,000 reactors were completed. Even though these figures were provisional and unscientific they held no promise for more cheerful results when more operating experience was available."

The quotes above show the evolution of (1) admittedly "rough figuring" by Jim McLaughlin that showed that the upper limit to the chances of an accident to be three in ten years for 1,000 reactors, to (2) three or more accidents in ten years was "virtually a hundred percent certainty," to (3) such accidents with a potential of deaths are "likely to occur within ten years," to (4) various types of accidents have now been related to their probabilities and the "results were terrifying."

An entire chain of logic has been built upon one major false assumption which is the original estimate of accident probability by McLaughlin. To systematically determine such a probability at that point in time would have been an enormous task and was never completed as part of the WASH-740 update. (The thrust of the more recent reactor safety study directed by Dr. Rasmussen is the treatment of such reactor accident probability.[30] This study took three years and cost four million dollars, and responsible people still question its adequacy. An early estimate of the Brookhaven cost to update WASH-740 was $120,000).[31]

The basis for McLaughlin's very rough probability estimate comes from assuming "somewhat arbitrarily, our experience to be two serious accidents in 1200 reactor years."[32] The two accidents appear to be based on the SL-1 incident and the accident that occurred in 1958 at the Boris Kidric Nuclear Energy Institute in Yugoslavia. The former was a low power test reactor first operated in 1958[28] and the latter a zero power experimental facility of comparable vintage.[33,34] Neither bear any resemblance to current commercial power reactors and thus can hardly by used to provide meaningful statistics on severe accidents for commercial power reactors. (Pasternak's "agreement" with McLaughlin is based on the same starting assumption[35] i.e., two accidents per 1200 reactor years.) More importantly, as serious as those accidents were, a total of four workman died with five others injured;[28], no member of the public was involved. McLaughlin himself recognized this perspective when he states in the same paper that his probabilities are developed:[32]

> "It should be emphasized that, if this treatment has any validity, we should not use the result in relation to a truly catastrophic accident of the kind WASH-740 would evaluate, but rather a much less severe accident such as those involving SL-1 or the Boris Kidris Institute in Yugoslavia."

Fuller omits this very important qualification when he cites McLaughlin and Pasternak and instead builds upon the almost meaningless statistics described above to conclude that accidents with a "high potential of deaths" would be occurring with "virtually a hundred percent certainty" at a rate of three or more per ten years when 1,000 reactors are built.

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p.148 "Now the figures were coming out so horrendously that the AEC was hoist with its own petart."

p.149 "The one hope that seemed to predominate at the meetings was that if the probability, the odds, the chances - whatever one called it - could be shown to be small, the impact of the numbers on the public mind would not be so great."

p.150 "With considerable hope and interest, the committees awaited the first attempt by Planning Research Corporation to put a definite figure on the odds of a reactor accident."

These passages again infer that the AEC was somehow horribly surprised at the predicted consequences of accidents involving the larger plants when rather arbitrary assumptions were made with regard to fission product releases, and that the probability of accidents had then to be included to soften the impact. An accident analysis that purports to establish risk must from the very outset include probability of the accident. While a determination of the upper limit of consequences is of interest, it is not the risk.

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p.151 "About the only thing that the research group could report with any degree of accuracy was based on the 1,500 reactors years of experience that had been achieved up to 1965. Using a complicated method that assumed that catastrophic accidents would happen according to random tables, the results of the study turned out to be something just short of horrendous.

The report showed:

'We are 95 percent confident'...that the probability of occurrence of a catastrophic accident during a reactor year is less than one in 500'..."

p.152 1 "And when the AEC reached its goal of 1,000 atomic power plants, the possibility would rise to one major holocaust somewhere in the United States <u>every six months</u>."

The progression of logic used here is very similar to that applied to the work of McLaughlin. The research group alluded to above is the Planning

Research Corporation that had been contracted to assess the probability of major reactor accidents.[17] The "complicated method" used to treat the 1500 years of experience that had been achieved up to 1965 was to simply recognize that no catastrophic failures had occurred for 1500 reactor years and thus to set a maximum failure probability based on that experience of no accidents.[36]

A minor refinement was added by assuming that catastrophic failures occur at random over time according to a Poisson process which leads to a failure probability per year (at a 95 percent confidence level) of 3/T where T is the total reactor years of operating experience without failure. For T = 1500, the probability of occurrence of a catastrophic failure becomes at most 1 in 500 during one year of reactor operation.

Thus, the sole data for catastrophic failure probability prediction is the fact that none have occurred to date! However, Fuller then omits the term "at most," extrapolates the predicted expansion of nuclear power plants to 1000, and reaches the conclusion that the possibility of a major holocaust somewhere in the U.S. is once every six months. The extrapolation to 1000 reactors is logical, but as before, the initial premise is false.

This technique is not unlike trying to predict the probability over the next ten years of a Boeing 747 crashing into a football stadium filled with people by observing that there have been no such accidents to date. Assume that the total miles flown thus far by 747's has been ten million. So the best you can do is to deduce that such a crash shouldn't occur more than once out of ten million miles of flight, since you cannot prove one will not crash tomorrow. Then you project into the next ten years accounting for flight expansion plans etc., and suppose you find that 747's are expected to fly some 80 million miles; therefore, the predicted major catastrophic rate becomes eight crashes into football stadiums filled with people over the next ten years. That should certainly be scary enough to immediately cease all Boeing 747 flights during football games unless of course there is a flaw in logic.

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p.152 "In transporting these (irradiated fuel assemblies) for processing the assemblies were packed in containers that could only withstand a fall of 30 feet, a collision of equal impact, or a 30-minute fire at 1400°F. The question was: What about a drop of 35 feet, or a 40-minute fire?"

p.232 "But since the casks were tested only for a thirty foot fall and a thirty minute fire, what might happen in the event of a shock impact or fire beyond those arbitrary limits was too frightening to contemplate. Dr. Marc Ross of the department of physics of the University of Michigan, has concluded that, if fire or impact distorted the shipping cask of a typical fuel shipment, the leakage of cesium from it would be particularly lethal, both directly through breathing it and indirectly through contamination of the food chain."

These similar passages refer to the accident conditions for which shipping packages containing higher levels of radioactivity are designed in order to be licensed and essentially echos the charges made by the Public Interest Group in Michigan (PIRGIM) in their report "Fallout on the Freeway."[37] These accident criteria, however, are not arbitrary, but rather come from detailed studies of the most severe conditions that the radioactive package can be reasonably expected to encounter during an accident so that the probability of significant rupture is extremely low.[38-41] Moreover, recent tests with obsolete casks have shown them to be considerably tougher than required by the criteria, e.g., a 16,000 lb. spent fuel cask was dropped 2,000 feet from a helicopter onto a hardpan desert floor. The cask hit the surface at 250 mph, penetrated about 1.5 feet into the ground, and was essentially undamaged and would not have leaked contents. Incidently, most of the charges contained in "Fallout on the Freeway", including the conclusions of Dr. Ross as to the large effects of cesium in a transportation accident, have been rebutted in detail by the AEC.[42,43] In fact, Dr. Ross has asserted in testimony recently submitted to Michigan's Public Health Committee that, "New research results on the subject have been brought to our attention casting doubt on the possibility of large releases of radio-cesium."[61]

If a cask were to rupture the consequences for the case of high burnup light water reactor fuel could in some cases be described as serious, but hardly catastrophic or "too frightening to contemplate."[40] For the specific case of the low mass low burnup fuel of Fermi-1 that had decayed for more than a year since power operation, consequences of rupture would be very much less than calculated for high burnup light water reactor fuel.[38-40]

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p.166 "Radiation leaks seemed under control..."

This kind of statement is vague and again implies some sort of hidden danger, but without a specific reference has little meaning. Perhaps it refers to the 2 roentgen per hour radiation level opposite a crack between the concrete floor and the poured lead shield around the sodium sample coil that was measured outside the sodium sample station and that was repaired prior to significant power operation.[44] It should be noted that the abstract to the Fermi 1 shield test report states in part:

> "A radiation and shield test program was conducted for the Enrico Fermi fast reactor during the period of August 19, 1963 to October 19, 1966. The results of these tests showed that the Fermi shield system was performing as well as or better than originally designed. All of the shield systems appeared to have been well designed and built, and no unexpected regions of high radiation or streaming were found."[44]

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p.173 "On March 31, 1965 the commission approved a watered-down letter and a watered-down version of the new Brookhaven report to be called an 'unclassified version.' All the terrifying numbers of deaths, injuries, and property damage were missing...All the report amounted to was that the writers had to come to the 'inescapable conclusion' that the theoretically calculated damages would not be less, and under some circumstances would be substantially more, than the consequences reported in the earlier study!"

p.174 "It seemed obvious to some observers that, if the estimated destruction figures had been brighter because of better engineered safeguards, the insurance companies and the utilities would have had confidence to take on the insurance burden.

The implication is again made that there was some hope that the estimated destruction figures would be smaller for the WASH-740 update than for the original WASH-740 report. There could be no reason for such hope since for the update the same type of arbitrary and extremely conservative assumptions were made with regard to the postulated accident with no credit taken for engineered safeguards. Note the assumptions that were made:[11,13]

- A major loss of coolant accident occurred.
- Concurrently, all protection systems and engineered safety features, including ECCS completely failed to function.
- Concurrently, a sufficiently large opening, "the size of a door," existed in the containment vessel to immediately release radioactive materials to the atmosphere and to do so without any deposition or plateout on internal structures.
- No protective measures were taken by individuals in the vicinity of the plant.

Perhaps the best summary can be drawn from the text of a draft document of the WASH-740 update:[45] "Therefore, we have as in 1957 assumed that all safeguards, such as emergency cooling, fission product retention devices, containment, etc. fail to perform their intended functions." Thus, the text from page 174 of Fuller's book is misleading in that the implication is made that the "destruction figures" took account of the effect of engineered safeguards.

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p.183 "Those precautions were necessary as the boiling point of sodium could never be reached without disaster."

This is typical of a series of statements formulated to paint a picture of grave disaster if the slightest slip is made. It certainly is undesirable if bulk boiling of sodium occurs; in fact, that is a limitation sometime used as the basis for criteria for safety system design. But if the term disaster means public or even plant personnel disaster, then the statement simply is not true. The evidence is straightforward; the boiling point of sodium was obviously reached during the fuel melting incident of October 5, 1966, and no one, plant personnel or public, was injured.[3]

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p.183 "But as the control rods slowly withdrew, and the instrument readings reflected this silent power when the huge pumps sent the sodium syrup through the system, vibrations were felt in the floor of the control room that hinted at the reactor's awesome power."

While the description is certainly colorful and consistent with the image of impending disaster the author is trying to create, the vibrations from the primary sodium pumps could not be felt in the control room which is located in a separate building. The source of the term "sodium syrup" would be of interest since the viscosity of hot liquid sodium is about that of water.[46]

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p.183 "Even though it was constantly disclaimed, a nuclear explosion could occur if a fast breeder reactor like Fermi-1 was brought to 'superprompt critical'."

The meaning and purpose of this sentence is not very clear. The potential of an energy release through a nuclear excursion in a fast breeder has been known for some time. Many published non-classified government as well as Atomic Power Development Associates (APDA) reports have treated this subject.[47,48] A significant excursion requires a superprompt critical condition. The area of greater discussion involves the conditions to bring such a condition about. But, in any event, the predicted size of such an explosion in the Fermi-1 reactor based on extremely conservative assumptions as to the course of a secondary critical assembly is of the order of hundred of pounds of TNT.[2] The size of a "small" Hiroshima type atomic bomb is 20,000 <u>tons</u> of TNT.[49]

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p.186 "Hundreds and hundreds of specifications like this had flowed through the process of putting this giant Swiss watch of a reactor together. And through it all, <u>there could be no mistake</u>. What if 0.1 gram of Uranium-236 got thrown out with the packing carton?

Another colorful image to attempt to demonstrate the potential for disaster with the slightest slip. However, there were obviously mistakes made during the construction of Fermi-1. Fuller himself alludes to some of the difficulties with this first-of-a-kind reactor. The reference to 0.1 gram of U-236 being thrown out by mistake is confusing. The only U-236 at the site was microgram quantities in a fission counter. Perhaps U-235, the fissile fuel was the intention. In any case, the effect of throwing out 0.1 gram of either isotope would be inconsequential.

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p.186 "At the same time, it (primary sodium coolant) would convey the heat away from them (fuel pins) as it rushed over to the steam generator building through closed pipes to indirectly create steam. The pipes would be hot enough to boil the water that surrounded them in the heat exchanger, without their sodium contents ever coming directly into fatal contact with the water."

Fatal to whom or what would be the appropriate question here. Leaks in the steam generator that does put sodium and water into contact was a problem that plagued the Fermi-1 project, but it was hardly fatal, or for that matter even injurious, to anybody. Moreover, it should again be noted that the use of intermediate heat exchangers doesn't even place the radioactive sodium of the reactor within the same building as the steam generators and their water.[29]

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p.191 "With many centuries of coal available, why the rush into a catastrophe and disaster that was entirely possible if not probable?"

Bases for such statements assume a constant usage rate of coal at something like the 1972 value. If instead the assumption is made that all electricity is to be produced by coal due to our dwindling supplies of natural gas and oil, the years of reasonably available coal drops to something like 50-100 years. Even this neglects the enormous burden on mining and transportation facilities as well as on the environment were coal to be the sole energy source for production of electricity. If a 1973 Federal Power Commission projected growth rate proved true, such a total coal economy could commit 340 billions tons of coals for plants built through the year 2020. This amount approaches the total U.S. coal reserve.[50]

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p. 192 "Thanks to the Joint Committee of Congress and the taxpayer-financed Price-Anderson Act, there was nothing to worry about now in the way of insurance."

Price Anderson places the financial burden of the consequences of a nuclear accident on the taxpayer only if such an accident actually occurs and exceeds the $125 million dollar coverage afforded now by private insurance. To date not one cent has been required to be paid from such government insurance for a nuclear accident, while some $7 million has been collected in government indemnity fees. Portions of the private insurance premiums have been refunded because of the excellent safety record of nuclear power plants; no such refunds have been made for the Federal government portion of the insurance. Further, the calculated financial risk (consequence X probability of occurrence) as given in the Rasmussen report on reactor safety would lead to calculated lower rates than currently paid the government by utilities for such protection.[51,22] Thus it would appear that the government is not subsidizing the utility industry as some have charged.

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p. 193 "The only thing to do was think positively and pray that nothing would happen -- and to make sure that the Fermi reactor and its crew were infallible."

Infallibility was not required of the Fermi reactor and its crew nor of any other reactor. First of all, the physical phenomena do not demand it and secondly, the defense in depth design concept applied for every nuclear power plant allows much to go wrong before even workers, much less the public, are affected. Fuller himself refers to tabulations of abnormal occurrences in power reactors on page 229 (though hardly secret as Fuller states, since such occurrences are published weekly in Atomic Energy Clearinghouse and various tabulations are available)[52] indicating fallibility as with any technology, but no harmful public consequences resulted.

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p.193 "Since any hot spot in a single subassembly could be a harbinger for disaster, these anomalies were watched and checked very carefully."

While it may be said that a hot spot in a single subassembly could be a harbinger for disaster for a portion of the reactor core, it is extremely difficult to see how it would lead to public disaster since the Fermi-1 containment building was designed to withstand the effects of the energy release resulting from one half of the entire core collapsing into the other half.[2]

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p.197 "This is a Class I emergency. Stand by for further instructions."

p.1 "The phone call came in some time in the mid-afternoon of Wednesday, October 5, 1966."

The reader is very likely to believe that the above announcement of a Class I emergency made at the Fermi plant is the worst that can happen. In reality, a Class I radiation emergency is the least severe of four radiation emergencies defined as part of the Fermi-1 Radiation Emergency Procedures in effect at the time of the fuel melting incident.[53]

- Class I

  Localized Radiation Emergencies, not requiring the implementation of site - wise emergency procedures.

- Class II

  Radiation emergencies limited to the plant site which require movement of personnel to designated on-site shelter areas.

- Class III

  Conditions that may cause persons in the shelter areas to receive whole body radiation exposures in excess of 0.6 rem. usually requiring site evacuation.

- Class IV

  Conditions that may produce to members of the public radiation exposure in excess of 10 rem to the whole body.

Thus, a Class I emergency does not even require that plant personnel go to shelter areas, much less involve the public in any way. Only in a Class IV emergency is it required that public officials be informed. Thus the alleged phone call that provides the dramatic opening for the book was not required.

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p.200 "It (radiation level) had not yet reached intolerable limits outside the containment shell."

The reader could take this statement to mean that the radiation level at some point in time following the Fermi-1 fuel melting incident reached intolerable limits outside the containment shell. This is not true. The offsite doses never even exceeded the limits set for normal operation, much less accident conditions. Even the dose rate <u>inside</u> the containment building could have been tolerated by workmen for periods of hours without exceeding their allotted weekly dose limit.[3,4]

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p.201 "All the rods went down into the core normally except one. It stopped six inches from the full 'down' position. This was no time to take a chance. A second manual scram was activated. The reluctant rod finally closed down fully."

There is a vague inference here that somehow the reactor was not fully shutdown without full insertion of all six safety rods. The Fermi-1 safety system was sufficiently redundant that any one inserted safety rod would have terminated the chain reactor and shut the reactor down.[2] Reactor shutdown following scram initiation was immediately verified by examining the power trace provided by control room instrumentation.[3] Insertion of the last six inches of one safety rod would have made a negligible difference in total negative reactivity provided by the safety rod bank.[54] The event alluded to in the text was the stopping of the number 6 safety rod extension 6 inches short of full down during its fast rundown following scram. While this could have been due to a rod stuck at 6 inches, evidence suggests the rod was full in and extension stoppage was due to a malfunction in the extension drive.

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p.206 "But the first problem would be the one hanging over not only the heads of the crew, but the entire state of Michigan as well."

p.208 "How could they explore a reactor drenched in radioactive poisons without the risk of wiping out Detroit and a big hunk of Michigan with it? Ironically, hardly anyone in Detroit, or the state of Michigan, had any idea of the potential danger they were in."

This is one of a series of quotes that implies grave potential danger to the public as a result of the Fermi-1 fuel melting incident and known only to the reactor "crew." Such danger never existed.[3,55] There was certainly a long period of time before the extent of melting was known, though all evidence suggested it could not be extensive. Even if it had been, and a secondary criticality event occurred, the containment had been constructed to withstand its effects.[2]

Just four days after the incident, on Sunday afternoon, October 9, a group of senior project personnel met in the plant conference room, perhaps 100 feet from reactor core to discuss progress and plan future work. Attending was Walker L. Cisler, President of Power Reactor Development

Company whose birthday had been the day before when he was out of town on business. After the meeting was over, coffee and a birthday cake were produced and all joined in singing "Happy Birthday" to Cisler...strange indeed if the danger were what Fuller portrays!

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p.211 "But the time bomb was still ticking, quietly and relentlessly."

This passage again implies some sort of bomb about to explode instead of a reactor shutdown to a sub-critical state by a margin of about eight dollars negative reactivity following a fuel melting incident involving about one percent of its fuel.[3]

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p.211 "The day of the accident marked the beginning of a warm spell, so any escaping radiation would tend to hang lazily under the nocturnal inversion conditions that existed through each night."

Such statements about the weather have no meaning since no radiation of significance ever escaped.

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p.230 "But the AEC was not about to deal itself such a blow. Not only had it buried the figures of the WASH-740 update, but it had proceeded with the decision to pay out $3 million for a new probability study that might prove more palatable to the public."

p.238 "As I was working on the book, the $3 million Rasmussen study emerged. Suddenly, the public was being reassured. They were told that the chance of 1,000 people being killed by a reactor accident was about one in a million. This was the opposite of what my reporting had uncovered...All of the reservations of the WASH-740 Brookhaven report were bypassed."

The erroneous impression is again conveyed that the WASH-740 update work produced meaningful results on the probability of reactor accidents. This is not true. A three-month $120,000 study simply could not do the job with the sparsity of then available data and techniques.

While the Rasmussen report is not flawless, it represents the only extensive detailed analysis of accident probabilities for explicit reactor designs to date. To completely deny its results because it does not agree with the crude appraisals of accident probability in the WASH-740 update work makes no technical sense whatever.

All of the reservations of the 1957 Brookhaven report were <u>not</u> bypassed. In fact, the accident probability calculated in the Rasmussen report for an accident with consequences comparable to those reported in WASH-740 lies within the range of probabilities offered as judgements in WASH-740.[8,22]

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p.231 "McCarthy and his team were able to avoid what could have been an incredible disaster, by their planning, their expertise, their ingenuity, the low power level...and some luck."

Only planning and expertise as expressed through the design, regulation, and training associated with Fermi-1 as with any nuclear power plant were required to prevent public harm from unplanned incidents. Ingenuity, low power levels, and luck are not requisites to safe operation.

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p.231 "His job was to figure out how to take apart a core full of three and half tons of radioactive uranium (speckled with enough plutonium to cause a decided uneasiness)..."

All the reactor fuel ever used in the core contained about 5 pounds of plutonium, significantly less than produced in typical light water reactors and hardly enough to cause a decided uneasiness. The fuel was removed as in any typical reloading operation and shipped to Savannah River Laboratories for reprocessing, a procedure used for all spent Fermi-l fuel independent of decommissioning.[29,56]

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p.232 "Although the reactor was in the state known as sub-critical, there could be a reactivity accident with little or no warning."

Accidents almost by definition occur without much warning. However, it would have been very difficult to have a reactivity accident in a reactor held subcritical by 7 safety rods when just one was sufficient. Outside the core, fuel assemblies which cannot become critical* singly were handled one at a time and stored in special racks that preclude criticality.

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p.233 "Even the loading of the cut-up fuel assemblies was a precarious process. Each fuel unit was on the verge of becoming critical, even in the cooling water."

Here, a routine procedure is transformed by Fuller into a "precarious" process. The procedure for loading the cut-up fuel assemblies during decommissioning was the same used for shipping any spent fuel assembly off-site following its use in the reactor. The number of assemblies and shipping cask were selected and designed to assure that the configuration would <u>not</u> be critical, <u>even in water</u>.[60*] Fuller's suggestion that water tends to prevent criticality is confusing since a core subassembly in water is closer to criticality than if stored in sodium, air, or most any other material. Since the fuel is shipped as a sub-critical configuration in water, any conceivable accident that could cause the water to be lost would further reduce the potential for criticality.

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*Critical is the term used to describe the condition when a sufficient amount of fissile material is in the proper configuration to produce a chain reaction, thus becoming a source of additional heat and radiation. Criticality is undesirable except in the controlled environment of a reactor core where the heat becomes a useful form of energy.

p.234 "In a shed next to the reactor building, triple decks of shining black steel drums, all marked DANGER: RADIOACTIVE SODIUM, sat in a roped-off area - 30,000 gallons of it that nobody wanted, or was willing to cart away.

The primary sodium has been given to the Project Management Corporation for use in the Clinch River Breeder Reactor Plant. The drums described above are stored in the reactor containment building until needed by the Breeder Reactor Project.[57]

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p.239 "After the Rasmussen report was issued, William Bryan, an aerospace engineer, pointed out in a congressional hearing that the study was an exercise in futility, because it had used analytical methods that had been completely discarded by the aerospace industry as unreliable. Ralph Nader described it in part as 'fiction'."

William Bryan's comments on the inadequacy of the methodology used in the Rasmussen safety study were made prior to issuance of the final report in October 1975. As indicated in previous discussion on the Rasmussen report, the final report addressed all of the major criticisms made on the bases of earlier drafts, and in particular, significant space is devoted to both describing and defending the event tree and fault tree methodology to which Mr. Bryan had referred. Included are letters both from the National Aeronautics and Space Administration and the Systems Reliability Service in England that support the concept of fault tree analysis as used in the Rasmussen study.[22]

Part of the problem is that there had been significant deficiencies in some of the early fault tree methodology sometimes leading to serious underestimation of predicted failure rates. Since the earlier attempts, however, considerable work has been done to improve the methodology to overcome these deficiencies. The Rasmussen study itself "provides a forward step in risk assessment of nuclear power reactors" as judged by the Environmental Protection Agency.[22]

A large effort was devoted to obtaining a good data base of failure rates, including contributions from human error, but nevertheless assessing data uncertainties and carrying them through the entire calculation. A detailed investigation of common mode failures backed up by bounding statistical analyses has also been included. Moreoever, there was sufficient operating data for two systems to provide comparisons between failure rates predicted by the study's technique and actual experience. In these two cases, the predicted and observed failure rates were well within the bounds required for adequate risk assessment.[22]

The value judgment attributed to Ralph Nader without explanation or technical backup is meaningless.

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p.243 "There is enough deuterium -- the basic fuel for fusion reactors -- in the ocean waters to supply the potential demand for energy for more than a trillion years."

p.243 "What has held back the development of fusion power is that no final breakthrough has yet been made in harnessing this source of energy for peacetime use. One major reason for this has been a lack of research funds."

Fusion reactors are a worthy goal for which to strive and one could make a case for larger expenditures in the area of controlled fusion research. In fact, current government plans reflect sizable increases in the fusion budget. However, regardless of the research funds allocated there remains the very real possibility that net power production through controlled fusion will never be achieved, or if so, not for a very long time. Note the comment of Richard Post, long an advocate of fusion research and group leader at the Controlled Fusion Research Division at Livermore Laboratory.

> "Qualitatively, fusion research is in exemplary shape; quantitatively its best efforts still fall far short of achieving proof of scientific feasibility...Controlled-fusion research has come a long way from its starting point...But it would be illusory to think that all of the critical issues facing fusion have now been settled, even in principle."[58]

There is also the likelihood that if a fusion reactor is made to work, it will rely on the deuterium - tritium reaction rather than the more difficult deuterium- deuterium reaction.[58,59] If this is the case, a supply of tritium which does not occur in the ocean's waters, must be made available. Such a supply would most likely come from the use of lithium blankets surrounding the fusion reactor that would produce tritium under neutron bombardment. In such an event, fusion fuel resources would then be tied to lithium reserves; U.S. lithium ore reserves are estimated to be about equal to the world reserve of coal in terms of energy equivalent.[50]

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REVIEWERS' EPILOG

The problem of energy supply in our society is an extremely complicated and broad issue. It involves not only the technique of energy supply, but the choice of options, the resulting risks, and even the degree of need. Given all the technical facts, there is still not a right and a wrong decision to be made at every turn. Often the criteria for decision include, at least implicitly, philosophies of economics, government and perhaps even of life which are not amenable to technical analysis. Hence, judgements and compromise can be expected to play an important role in many of our future decisions on energy issues. However, we still do not have "all the facts," and even those facts that are technically available are known by a very small segment of our society, and usually not by those possessing the greatest political power to effect societal decisions. Thus, accepting the reality of differing philosophies, the development of information through analyses and experiment and the collection and dissemenation of information to all interested and appropriate elements of our society are still prerequisites for making responsible decisions on energy issues.

This job is an extremely difficult one, particularly in the nuclear area due to its technical complexity. It places a tremendous reresponsibility on those in the news media and related fields as well as on the technical experts. Shabby or biased treatment of technical sources in the area of public communication as well as neglect creates a profound disservice to the society. We Almost Lost Detroit presents an interesting paradox in this regard. It purports to correct what the author felt was a neglect of communication of pertinent nuclear information, but the book has so distorted this information that the cause of improved technical communication to the public has been hindered rather than helped.

The rebuttal that has been offered is an attempt to help refocus some of this distortion. Admittedly, a pro-nuclear stance can be identified in the rebuttal material, but there has been a concerted effort to preserve technical accuracy and to provide specific references to the technical source material. The reader is urged, wherever possible, to obtain such material in any area of particular interest rather than to place sole reliance for information on nuclear issues on popular communicators. Unfortunately, the record of the latter to date has been less than satisfactory.

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BIOGRAPHICAL

Eldon L. Alexanderson - Joined Atomic Power Development Associates (APDA) in 1955 and in charge of Reactor and Systems Analysis Section in 1958. Head of Hazards Summary Report preparation group in 1959, and Assistant Plant Superintendent at Fermi-1 during most of its operation. Appointed General Manager of Power Reactor Development Company (PRDC) in 1972 and was responsible for conduct of Fermi-1 decommissioning activities.

Wayne H. Jens - Assistant General Manager of APDA at the time of the Fermi-1 incident and later General Manager. Responsible for coordination of much of the Fermi-1 design and development effort, with initial APDA involvement in 1958 as Assistant Technical Director.

Walter J. McCarthy - Initial association with Fermi-1 Project near its inception as Head of Nuclear and Analytical Division of APDA in 1952. Transferred to PRDC as Assistant to the General Manager in 1962 and later General Manager with overall responsibility for operations, licensing, and financial operations of the Fermi-1 plant through 1968.

Earl M. Page - Reactor physicist employed by APDA and associated with the Fermi-1 project since 1960. Participated in its core design and testing. Immediately following the fuel melting incident, he was involved in diagnostic work to aid in determination of the extent of damage and helped provide concepts for a malfunction detector analyzer which was later added to the instrumentation system. Terminated his APDA involvement as head of the Reactor Analysis Section during decommissioning activities.