NUREG-0603

COMMENTS ON THE NRC SAFETY RESEARCH PROGRAM BUDGET

July 1979

Advisory Committee on Reactor Safeguards
U. S. Nuclear Regulatory Commission

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Manuscript Completed: July 1979
Date Published: July 1979

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Washington, D.C. 20555

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

July 19, 1979

The Honorable Joseph M. Hendrie
Chairman
U. S. Nuclear Regulatory Commission
Washington, DC

Dear Dr. Hendrie:

The Advisory Committee on Reactor Safeguards (ACRS) is required to submit each year, prior to December 31, a report to the Congress on the NRC Safety Research Program. The Commissioners have suggested that a similar report would be helpful in their consideration of the budget for the Office of Nuclear Regulatory Research (RES) if received at an appropriate time. The attached report has been prepared in response to this suggestion.

This report includes comments on the budget levels and program plans for the supplemental request for FY 1980 to support research related to the accident at Three Mile Island, Unit 2 (TMI) as well as for the FY 1981 Budget. For both budgets, the funding levels considered by the ACRS are the original requests by RES and the Budget Review Group (BRG) markup as of July 10, 1979.

In the attached report the ACRS has given special attention to both the short- and long-term implications of the TMI accident.

The Committee expects to provide its annual report to Congress by the end of this calendar year taking into account the suggestions of H.R. Report 96-194, Part 1.

Sincerely,

Max W. Carbon
Chairman

Attachment:
NUREG-0603, "Comments on the NRC Safety Research Program Budget" - A Report to the NRC from the ACRS

PREFACE

The Advisory Committee on Reactor Safeguards (ACRS) is required to submit each year, prior to December 31, a report to the Congress on the NRC Safety Research Program. The Commissioners have suggested that a similar report would be helpful in their consideration of the budget for the Office of Nuclear Regulatory Research (RES) if received at an appropriate time.

This report has been prepared in response to that suggestion. It includes comments on the budget levels and program plans for the supplemental request for FY 1980 to support research related to the accident at Three Mile Island, Unit 2 (TMI) as well as for the FY 1981 Budget.

For both budgets, the funding levels considered by the ACRS are the original requests by RES and the Budget Review Group (BRG) markup as of July 10, 1979.

In its current review of the NRC research program, the ACRS has given special attention to both the short- and long-term implications of the TMI accident and their significance to research for both the short- and long-term research programs.

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1. IMPLICATIONS OF THE ACCIDENT AT THREE MILE ISLAND, UNIT 2

1.1 Needs for New Directions in Research

One main lesson learned from the TMI accident is that a broader range of safety issues must be considered in planning the research programs of the future. Another lesson learned from TMI is that research must be carried out to provide answers to questions of two kinds:

(a) How to prevent accidents like that at TMI-2; that is, accidents producing severe core damage short of core melting and accompanied by the release of large amounts of radioactive material into the containment?

(b) How to mitigate a TMI-type accident that results in even greater core degradation?

The TMI accident involved multiple "mistakes" and failures not now considered in the licensing procedure, and led to consequences not previously encountered. Much of the activity by the NRC Staff in the wake of TMI, and much of the TMI-related research proposed for FY 1980, relates to preventing "another TMI", chiefly by designing means to prevent the occurrence of similar mistakes or failures.

Once a mistake has been made or a failure has occurred, it is a relatively straightforward engineering task to devise means to prevent it from happening again. It is more difficult to anticipate all, or even most, possible mistakes or failures. This has been attempted in the regulatory process, but the method leans too heavily on the "single failure" concept and design basis accidents.

If means are to be provided to prevent multiple mistakes or failures, attention must be devoted to the sequences and consequences that could result from many different combinations of multiple mistakes or failures, two or three or five, or even six, as necessary to determine the possible interactions and their consequences, and to provide a basis for preventing or greatly reducing the probability of their occurrence. This was attempted in the Reactor Safety Study (WASH-1400) but for only two plants and, as learned from the TMI accident, both the kinds of mistakes and their consequences are dependent on the specific design of the nuclear steam supply system and of the balance of plant.

Although the results of the Reactor Safety Study emphasized the relatively great contribution to risk of transients and small loss-of-coolant accidents (LOCAs), few of the research requests showed a suitable degree of concern about future problems (transients and small LOCAs) as opposed to problems emphasized in the past, such as large LOCAs and ECCS effectiveness.

This situation must be remedied. Many potential accident scenarios must be examined, and multiple mistakes and multiple rather than single failures must be postulated. Such research and its application in the licensing process may provide valuable insight about the problem of how to reduce the probability of TMI-type accidents. Such research need not, and probably should not, lead to new design basis accidents. However, the results obtained should lead to new approaches in the design and licensing of nuclear plants.

The need to consider means to mitigate the consequences of a TMI-type accident presents another challenge to the research program. In this context, a TMI-type accident is considered one that results from a multiplicity of mistakes or failures, at a probability level which has been understated in the past.

If the TMI accident involved the "highly improbable" combination of say five mistakes and/or failures, how improbable must we now consider six mistakes, or another sequence or combination of mistakes leading to significantly greater consequences than resulted at TMI? Within this range of mistakes, it is possible to visualize a sequence leading to core melt rather than the degree of damage experienced at TMI. Although research is needed to learn how to prevent the occurrence of such an accident, as discussed above, research is needed also to understand its consequences and possible means of mitigating them. The fate of a molten core, whether it penetrates the reactor vessel and containment base slab and enters the ground below, and what happens to it and to the radioactivity it contains thereafter, in various geological and hydrological environments, is poorly understood and has been studied only cursorily in comparison with the design basis accidents. Little more is known about the possibility or probability of a steam explosion and its effect on the containment, the last line of defense -- the value of which was demonstrated so clearly at TMI.

Part 2 of this report contains recommendations regarding the FY 1980 Supplemental Budget Request to support, in part, additional research stimulated or required by the TMI accident. Part 3 of this report contains recommendations regarding the FY 1981 Research Budget and research programs. The ACRS recognizes that the NRC research program cannot be redirected overnight, nor should it be redirected completely. Nevertheless, the lesson from TMI is that new directions are required, at least in the areas of reactor safety. Some changes in direction can and should be initiated in FY 1981, only 15 months from now. Other changes can be made in future years, but both the user and requester of research, as well as those who approve, plan, and direct research, must begin now to think about and plan for the research needed to solve future problems before they present themselves.

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1.2 Recommendations for New Directions in Research

In its review of the budget proposals in Parts 2 and 3 of this report, the ACRS has identified a number of areas in which the programs are not yet completely defined in content, but for which the need for research and funding is clear. The following recommendations for new directions in the NRC Safety Research Program are intended to provide guidance to the Commission, to the RES Staff, and to the user offices, that can be utilized in the detailed formulation of research programs for FY 1980, to the extent practicable and for FY 1981, and for the development of requests and plans for FY 1982 and beyond.

The ACRS recognizes that research has already begun in many of these areas, and expects that others will be considered and implemented in a timely fashion. The ACRS believes that this can and should be done without delaying the ongoing budgetary process.

1.2.1 Priorities and Focus

The ACRS believes that the research and regulatory staff of the NRC should, in the reasonably near future, reevaluate the overall priorities, levels of expenditure, and focus of the safety research program. The ongoing program to a large extent reflects priorities that were established several years ago and has been strongly influenced by the single failure concept and research needs arising from detailed studies of design basis accidents. While useful results are being obtained from most ongoing research tasks, it is important that the Staff take a new broad look at the existing and recently proposed levels of support and research directions to evaluate the potential need for major change in emphasis.

The ACRS suggests that the existing structure of the safety research program, which was developed to manage a research program plan established a few years ago, be reviewed to determine whether modifications are appropriate to meet the requirements of the coming years.

Also, the ACRS notes that the focus of the research program has reflected the needs of the NRC regulatory staff as perceived in past years. Here, too, early attention should be given to an evaluation of the priorities of the detailed existing requests as well as requests arising from changed perceptions in safety research priorities.

1.2.2 Anomalous Transients and Small LOCAs

The need for greater emphasis on transients and small LOCAs has been recognized. The ACRS recommended increased effort on transients in its 1977 and 1978 reports to Congress, and emphasized the study of anomalous transients in its Interim Report No. 3 on TMI dated May 16, 1979.

A research program on anomalous transients should have as its focus the need for greater understanding of the probable course of a wide range of possible events leading to severely degraded conditions, in order to provide a better basis for operator training, for improved instrumentation, and for possible on-line computer-diagnostic procedures to aid the operator. Equally, such studies should provide insight into the significance of possible design modifications and into areas of research warranting further study in order to have an appropriate degree of preparedness and background knowledge.

Such a program should receive coordinated guidance by a group including representatives from both licensing and research.

1.2.3 Accident Studies

The NRC should initiate a series of analytical studies to explore the probable course of events and possible potential consequences of a broad spectrum of accidents which go well beyond the current design bases in terms of the damage to the core and the release of radioactivity to the environment via both atmospheric and liquid pathways. In particular, specific studies should be carried out to scope scenarios of serious accidents beginning from the initiating event through to the eventual resting place of a melted core for some of the sequences.

Preliminary guidance for the choice of scenarios to study can be provided by WASH-1400, although the TMI experience showed that many sequences must be considered altered by human intervention at some point. For each scenario, sufficient technical detail should be provided to obtain insight into such matters as the following: to what extent can the probability and consequences of the sequence be quantified; what are the intermediate stages in the sequence, and to what extent may they be affected by human intervention; how serious is the sequence in terms of its effects on human health; where are the trigger points for emergency action, and what are the criteria therefor; etc.?

It is especially important that these studies concern themselves with the identification of significant sequences that have not received sufficient research attention, so that one can develop in advance significant safety procedures, and equipment, and mitigating actions to avoid surprises of the sort that occurred at TMI.

It is expected that such studies would be useful in the specification of instruments to help diagnose and follow the course of an accident, in the identification of new research and development needs, in siting considerations, in modification of containment, etc. An effort on the order of ten man-years is envisioned.

1.2.4 Molten Core Retention

The NRC should undertake a conceptual study to examine the practicality of retaining a molten core within containment or significantly reducing the release of radioactivity via liquid pathways following penetration of the containment foundation, in order to help provide insight into the practicality, benefits and costs of such a safety feature.

1.2.5 Power Burst Facility

The PBF program should be reoriented to emphasize primarily the study of the processes leading to medium and severe core damage in postulated accidents, the possible consequences of considerable molten fuel in the core, and possible measures to mitigate large scale core melt.

1.2.6 Steam Explosions

The ongoing research program on steam explosions should be substantially augmented to gain a better assessment of their potential role in various postulated accident scenarios, as well as possible insight into measures which could reduce the probability of a large scale thermal reaction, if such a reaction is possible.

1.2.7 Siting

A more extensive evaluation should be made of possible offsite consequences via liquid pathways for postulated accidents involving core melt for a broad range of land-based sites whose characteristics are reasonably representative of reactor sites in use, projected for use, or of potential interest in long-term planning. Such an effort has already been initiated as part of the NRC research program. The depth of the program should be sufficient to provide the background information needed for the possible development of hydrologic siting criteria which allow for the possibility and probability of accidents beyond those currently designed for.

A study should be made of the relative and absolute accident risks, with uncertainties, for a wide range of potentially suitable sites. The study should examine the costs and benefits associated with different types of sites and should include the possible interaction of a serious accident in one reactor on other reactors at the site. The intent of the study should be to provide insight into the relative advantages and disadvantages of more remote siting and power parks.

1.2.8 Plant Operations

A systematic effort should be made to identify research needs relating to the safety implications of procedures for operation, maintenance, testing and surveillance. Operating experience should be reviewed to identify existing problems in these areas and to determine problems important to safety.

1.2.9 Transient Simulation in Research and Licensing

Early consideration should be given to augmentation of the range of NRC capability to simulate various postulated transient and accident sequences to varying degrees of sophistication, including but not limited to real time analysis and permitting a simulation of operator action and intervention. Development of such simulation capability should enable a more detailed understanding of the course of events for various transients, and would be useful in the development of improved operator procedures and training, diagnostic instrumentation, and computer-aided guidance to the operator.

1.2.10 Systems Behavior and Interaction

A new research program should be established in systems behavior and interaction which includes an interdisciplinary approach to safety research including electrical, thermal-hydraulic, mechanical, control, and heating, ventilating and air conditioning systems, under operational, transient and accident conditions. Such a program should provide increased insight into the suitability of existing operational limits, the effect of system arrangement on its ability to withstand abnormal transient conditions, and the degree to which system design changes can be made to improve safety in one way without adversely influencing safety or reliability under other sets of conditions.

1.2.11 Application of Probabilistic Methodology

The ACRS recommends emphasis on the application of probabilistic and other methodology to an evaluation of the adequacy of the single failure criterion and to studies of alternate design approaches to systems and groups of systems important to safety in order to provide a better basis for decision making concerning the optimization of plant design for safety.

1.2.12 Water Specification and Crack Growth

The Committee recommends that programs be initiated to develop appropriate water chemistry specifications, particularly in the BWR primary coolant

and PWR secondary coolant, and to establish the effect of environmental, fabrication, and operating variables on crack growth rates in the coolant system boundary. Cracking is a recurring problem and the NRC lacks a basis for establishing conservative practices to prevent it.

1.2.13 Disturbance Analysis

The ACRS recommends that both the licensing and research arms of the NRC Staff place considerable priority on the development of methods for real-time analysis of system disturbances, in an effort to provide improved diagnostic information to the operator concerning abnormal sequences and, as possible, to suggest favored courses of action. The ACRS anticipates that the efforts devoted to the development of such disturbance analysis systems will, of themselves, provide considerable insight into reactor behavior which will be useful in design and in operator training.

2. COMMENTS ON FY 1980 SUPPLEMENTAL REQUEST FOR TMI-RELATED RESEARCH

2.1 Proposed Request

Much of the NRC Reactor Safety Research Program will be redirected toward TMI-related problems in FY 1980. A portion of this will be funded by reallocations within the RES budget, but a total of $29.8 million has been requested to fund the remainder. The amounts requested are listed by programs in Table 2.1, together with the changes proposed by the BRG.

The original request from RES was for $29.8 million. This was modified by the BRG as follows:

- Delete $1.6 million for items 1.d, e, f, with the proposed research being funded through internal reprogramming.
- Delete $0.4 million for item 3.b; no reason given.
- Add $3.0 million to item 8 for FY 1980 and delete a corresponding amount from FY 1981 to provide for a more orderly growth of the program.
- Delete $0.2 million for item 9.a with the proposed research being absorbed in the base program.
- Delete $3.4 million for item 11 and set aside for Commission consideration and decision on NRC policy direction.

2.2 General Recommendations

The ACRS supports a significant redirection of portions of the safety research program in FY 1980 to deal with questions raised by the accident at TMI. Because of the size of the program required, and since an attempt to fund all of this research by reprogramming FY 1980 funds would disrupt seriously the continuity and progress of important ongoing programs, the ACRS agrees that supplemental funding is needed for FY 1980.

The ACRS believes that the proposed level of supplemental funding for FY 1980, at about $30 to $31 million, is appropriate to the extent of the overall program and the portion to be funded by reprogramming.

It is noted that $3 million additional is proposed for research on Waste Management, not specifically for TMI-related research, but to provide

more orderly growth of this program during FY 1980 and 1981. The ACRS finds this acceptable.

The ACRS recommends strongly that the $3.3 million for research on Improved Reactor Safety be restored to this request. This is commented on further below.

Although the ACRS agrees that additional funds are needed for FY 1980, and that the amount proposed is appropriate, in some cases it does not necessarily agree with the specific programs proposed or with the allocation of funds among them. Those programs for which the ACRS believes the content, emphasis, or direction should be changed are given in the following section. In making these comments, the ACRS realizes that in many cases the programs have not yet been defined in detail and that changes may be forthcoming in response to its comments.

2.3 Specific Comments

The following comments are referenced to the items in Table 2.1.

1.a. Systems Engineering - Upgrade Semiscale for PWR Transients

The ACRS has reservations concerning the proposed upgrade of Semiscale to study PWR transients. The small scale of the facility makes the extrapolation of observations to full scale very difficult, and the NRC Staff has not had time to study in detail the usefulness of experiments from the proposed upgraded facility. The Committee is not able to endorse this program at this time.

1.f. Systems Engineering - TMI Postmortem

The ACRS supports the general idea of NRC participation in a TMI postmortem of safety-related equipment and questions of requalification. However, it is not clear to the Committee that the timing of such work will be soon enough to justify the proposed level of expenditure.

3.a. Code Development - Modifications and Checking of Existing Codes to Handle Transients

The ACRS wishes to emphasize the importance of using available codes to study small LOCAs and anomalous transients.

3.b. Code Development - Establish Data Bank for Each Operating Reactor

The ACRS believes that establishment of the proposed data bank for each operating reactor could be deferred in relation to other higher priority matters.

4.a. Fuel Behavior - Coolability of Damaged Cores

The support of the proposed augmentation of the PBF program to examine phenomena related to degraded cooling and damaged cores is in the context of the general recommendation by the ACRS that the PBF program emphasize experiments related to core damage and to small and large scale fuel melting in the coming years.

11. Improved Reactor Safety

The ACRS recommends strongly that this item be restored. The original FY 1980 budget request for $4.3 million was barely sufficient to begin work on the initial program proposed in NUREG-0438 at the request of the Congress. The budget for this item was reduced to $1 million by the OMB, and its final disposition by the Congress is still uncertain. The supplemental request of $3.4 million will restore this item to its original level. Since all of the research originally proposed for this program as well as that now proposed for the revised program can be related to the TMI accident, the ACRS considers it essential that the NRC increase significantly the pace of this program.

TABLE 2.1

PROPOSED FY 80 SUPPLEMENTAL REQUEST

		Budget in Millions	
1.	SYSTEMS ENGINEERING	RES	BRG
	a. Upgrade semiscale for PWR transients	$3.0	$3.0
	b. Upgrade TLTA for BWR transients	2.2	2.2
	c. Separate effects and thermal hydraulics tests	1.3	1.3
	d. Instrumentation needs developed	0.2	0 (1)
	e. Response of plant equipment to accidents	0.5	0 (1)
	f. TMI postmortem of safety related equipment and requalifications	0.9	0 (1)
		$8.1	$6.5
2.	LOFT		
	a. Modify LOFT to accelerate small LOCAs	$1.0	$1.0
	b. Install improved control room display and diagnostic system	1.0	1.0
		$2.0	$2.0
3.	CODE DEVELOPMENT		
	a. Modifications and checking of existing codes to handle transients	$3.1	$3.1
	b. Establish data bank for each operating reactor	0.4	0 (2)
		$3.5	$3.1
4.	FUEL BEHAVIOR		
	a. Coolability of damaged cores	$2.4	$2.4
	b. Maintaining containment integrity under fuel melt conditions	0.5	0.5
	c. Examination of TMI fuel (planning and transportation)	1.0	1.0
	d. Fission product chemistry and plateout	0.6	0.6
	e. Improved understanding of coolant chemistry	0.5	0.5
	f. Hydrogen behavior in coolant and containment	0.6	0.6
		$5.6	$5.6
5.	PRIMARY SYSTEM INTEGRITY		
	a. Hydrogen embrittlement	$0.4	$0.4
	b. Thermal shock of vessel at high pressure	0.6	0.6
		$1.0	$1.0

TABLE 2.1 (Cont'd)

		Budget in Millions	
		RES	BRG
6.	SEISMIC ENGINEERING SAFETY		
	a. Containment failure modes	$0.2	$0.2
	b. Response of plant equipment and structures to accident conditions	1.0	1.0
	c. Benchmark testing of structural and piping system analysis codes	0.8	0.8
		$2.0	$2.0
7.	REACTOR ENVIRONMENTAL EFFECTS		
	a. Emergency planning and response requirements including data generation and transmission relating to off-site environmental conditions	$0.7	$0.7
8.	WASTE MANAGEMENT	$ 0	$3.0(3)
9.	SAFEGUARDS		
	a. Effects of emergency conditions of safeguards effectiveness	$0.2	0(4)
10.	RISK ASSESSMENT		
	a. Risk implications of decontamination alternatives	$0.2	$0.2
	b. Develop event-trees of accidents leading to core damage	1.4	1.4
	c. Analysis of human error rates and impacts of human errors in risk	1.2	1.2
	d. Operational failure data analysis	0.5	0.5
		$3.3	$3.3
11.	IMPROVED REACTOR SAFETY		
	a. Develop improved control room display and diagnostics	$0.8	$ 0
	b. Develop improved status monitoring	0.8	0
	c. Define data transmission requirements	0.1	0
	d. Improved containment concepts	0.5	0
	e. Improved safety systems	1.0	0
	f. Improved value/impact methodology	0.2	0
		$3.4	0(5)
	TOTAL RES SUPPLEMENT	$29.8	
	BRG RECOMMENDATIONS		$27.2 + $3.4 set aside

TABLE 2.1 (Cont'd)

NOTES:

(1) BRG agreed in the need for the indicated efforts but recommended a budget level of $6.5 million. This allowance was stated to be for the higher priority items and the three programs marked should be funded through internal reprogramming.

(2) BRG deleted these funds.

(3) BRG concluded that for an orderly growth of waste management programs $3.0 million scheduled for FY-81 should be transferred to FY-80.

(4) BRG deleted these funds and recommended that this study be absorbed in the base program of $5.0 million.

(5) BRG set aside these funds for Commission decision. The BRG commented that this was done "in view of the Adminstration's position on Improved Reactor Safety during the FY 80 budget reviews and Congressional action to date on the FY 80 program...."

3. COMMENTS ON FY 1981 BUDGET

3.1 Introduction

The following sections contain the recommendations of the ACRS regarding the funding levels and programs in each of the major areas of reactor safety research. The figures referenced are those requested by RES and those resulting from the BRG mark-up as of July 10, 1979. These items are listed in Table 3.1.

3.2 LOCA-ECCS

This section includes items from the following program areas:

Systems Engineering

LOFT

Code Development

The proposed budget has many items of heavy financial commitment of a long-range nature. Such budgetary commitments are sometimes necessary but may also contribute to the continuation of significant gaps in the program. The Committee would view favorably some reallocation of funds from the budget request for a few of the specific items covered in this section to the study of topics indicated in the first chapter of this report.

The budget requests for LOCA-ECCS are listed in Table 3.1 together with changes proposed by the BRG. Comments on specific items follow.

3.2.1 Systems Engineering

a. The budget for Semiscale includes some "upgrade" in the facility and some corresponding extensions in the test series. The ACRS recognizes the technical limitations of this facility and believes that it is undesirable to view it as an "integral" facility. It believes, further, that some reduction in the budget for this item could be made to make funds available for other studies already described in this report.

b. The ACRS supports this budget for Blowdown and Reflood Heat Transfer.

c. The budget request for NRC participation in the international 3-D Flow Distribution studies is $12 million and has been reduced by the BRG to $10 million with $2 million set aside. The ACRS has no comment on this action.

d. The ACRS recommends that the funds requested for ECC Bypass Research be reallocated to other research projects having higher priority.

e. The proposal for Model Development Experiments has an expanded budget which includes some containment intercompartment flow tests which could contribute to improved code description of containment. The objectives of the program are reasonable and should be approved.

f. & g. These items are Operational Safety and Technical Support. The ACRS notes that the BRG has set aside totally the request for Operational Safety and has reduced the budget for Technical Support. The ACRS believes that the increase in the budget request is, in part, a consequence of ACRS recommendations in its 1978 Report to Congress. In particular, those recommendations related to human factors (man-machine interface, applicable to both operator action and maintenance action), computer controls, and operational safety studies (evaluation of operational experience and incidents). The ACRS recommends that the funds requested for these programs be provided.

The programs on fire protection, qualification testing, and noise diagnostics are well along and should be completed, but some attenuation and elimination can be tolerated here if other priorities so require.

3.2.2 LOFT

The budget request for LOFT is $49.3 million and the BRG recommended $48.0 million by reducing the Facility Support item from $11.3 to $10.0 million. The ACRS supports the request for $49.3 million since it believes that the test programs in the facility would thereby be accelerated.

3.2.3 Code Development

The request for this budget item is $15.2 million which has been reduced to $13.2 million by the BRG. The entire reduction was in TRAC Assessment and Applications which the BRG indicated contained some duplication in TRAC Application funds in RES and NRR. The ACRS cannot comment on this point except to say that TRAC Assessment and Applications are important activities.

3.2.4 Concluding Remarks

It is evident that the LWR safety research on LOCA-ECCS, which has long been concerned with the large break problem, has properly been broadened to consider the complete spectrum of loss of coolant accidents. The ACRS strongly urges a rapid and thorough expansion of safety research to include an extended examination of safety problems which arise on

the secondary side of PWRs. Loss of coolant on the primary side can be initiated by failures elsewhere than in the primary system. The loss of electrical power, for example, could produce loss of pumps and valves on both the primary and secondary sides simultaneously as a consequence of loss of motor and/or control power. Loss of environmental control for equipment may cause rapid and permanent loss of critical equipment long before actual core damage occurs.

3.3 Fuel Behavior

3.3.1 Clad and Fuel; Fuel Codes

This work is of substantial aid in reaching regulatory decisions, and should continue at current levels. Work on modeling severe overheating, as in TMI, is encouraged.

3.3.2 In-Pile Testing (PBF)

PBF represents about 60% of the total fuel behavior research budget. The information on fuel behavior during reactivity insertion accidents (RIA) is still felt by NRR to be inadequate. If these accidents are of sufficiently low risk (low probability and/or low energy insertions), such research is not necessary. NRR should reevaluate the regulatory requirements. If consideration of RIA is unnecessary, then the PBF program should probably be phased out over the next few years unless the reactor can be of appreciable aid in studying flow starvation and fuel melting accidents.

3.3.3 In-Pile Testing (Other)

These are confirmatory programs related to core behavior following a large LOCA. The priority is probably low. The NRU work should be terminated in FY 1983 as planned. Although the ESSOR program has attractive aspects, it should be reviewed carefully before commitments are made.

3.3.4 Fuel Melt

This work currently includes steam explosions and interactions of molten fuel with concrete. In NUREG-0496 the ACRS recommended that work on phenomena important to the course of postulated core melt accidents should continue to have high priority. In sections 1.2.4 and 1.2.6 of this report, the ACRS has recommended an augmented research program on steam explosions and a conceptual study to examine the practicality of core retention within containment. The ACRS recommends that the existing program be reoriented and strengthened accordingly.

3.4 Primary System Integrity

Primary system integrity is concerned with detecting the presence of incipient cracks in the primary system and predicting their growth.

3.4.1 Fracture Mechanics

This ongoing program addresses important questions. It should continue as planned.

3.4.2 Operating Effects

This program consists of two areas, Irradiation Effects and Dosimetry, a valuable well organized program, and Steam Generators, about which the ACRS has reservations. The main theme of this latter program involves a detailed, destructive examination of one of the Surry steam generators at PNL. The work should be limited to the correlation between NDE indications and tube integrity until a careful study has indicated the positive contribution to be made by additional work.

3.4.3 Non-Destructive Examination

This is an expanding program on an important topic. The coherence, as well as coordination, with regulatory needs, leaves something to be desired. The program should be funded, but the ACRS urges that the NRR and RES managements improve the coordination of the programs on Primary Vessel Integrity and regulatory needs.

3.4.4 Corrosion and Cracking

The recurrent problems of pipe cracking in BWRs and PWRs are disquieting. The new program on cracking in BWR piping should be encouraged and should be broadened to consider the corrosion accelerated cracking being found in PWR systems. The question of water chemistry limits required to approach more trouble-free operating conditions should also be addressed.

3.5 Seismic Engineering Safety

The requested budget proposes growth from $8.4 million in FY 1979 to $19.9 million in FY 1981. The major growth is proposed in the areas of structural and mechanical engineering. The BRG has proposed a funding level of $13.9 million in FY 1981.

3.5.i Structural Engineering

With regard to the Seismic Safety Margins Research Program (SSMRP), the ACRS agrees, in principle, to the proposed growth in funding. However, the ACRS wishes to defer detailed comment at this time.

The ACRS agrees that a program which would lead to the benchmarking of structural codes and to the development of an inhouse analytical capability for spot audit calculations by the Staff has merit. The ACRS recommends that such a benchmark program be designed to use many of the existing experiments to test the vendor codes and that an experimental program not be developed as part of this effort. The benchmark problems should be designed so that input parameters are exercised over the full range, and resulting sensitivities and validity limits can be identified.

The ACRS agrees that a program on water hammer is needed. The planning of such a program should be interdisciplinary, involving personnel expert in mechanical components, thermal hydraulics, accident analysis and probabilistic and system considerations.

The ACRS supports the program on load combinations, and recommends that the work be planned in cooperation with the Probabilistic Analysis Staff.

With regard to containment studies, the ACRS wishes to support work on the buckling failure modes. The experimental program should be designed to yield information directly relevant to such failure. The ACRS wishes to see a better defined program before offering a recommendation on the containment safety margins program.

The ACRS supports the proposed work on engineering characterization of seismic input motion and on flood hazards and flooding effects.

Other proposed projects deserving attention, but at a lower priority, include the following:

Adequacy of codes and standards - concrete

Safety margins for structures other than containments

Dynamic testing

Damage assessment of structures

Ductility under impactive loads

3.5.2 Mechanical Engineering

The ACRS supports the SSMRP program and the work on load combinations. The latter program should be planned jointly with the Probabilistic Analysis Staff.

The ACRS supports an analytical program on the benchmarking of piping codes and the proposed ASME code assessment effort. The remarks made with respect to the benchmarking of structural codes apply also here.

With some reservations, the ACRS supports the proposed program on pump and valve operability, with a caution that considerable care will be required to limit the costs and yet make the results of generic value.

The ACRS agrees that some means of ascertaining the degree and significance of damage after a serious earthquake is important for the long-term and supports minor participation in the HDR program in the FRG while an appropriate U.S. program is developed.

The ACRS also supports a program on the seismic qualification of mechanical and electrical equipment.

Other proposed projects deserving attention, but at a lower priority, include the following:

Snubbers (with no experimental program)

HDR mechanical component analysis and testing

HDR monitoring and test evaluation

3.5.3 Site Safety

The ACRS supports the research programs on seismicity and tectonics. The Committee notes the absence of research programs on hydrology as it might reflect on site suitability, particularly in the event of a serious accident involving core melt.

The ACRS recommends that within either the seismicity program or under the SSMRP, priority should be given to provision of an estimation of the recurrence interval for earthquakes of successively greater intensities, together with an evaluation of the uncertainties in such estimates for present or projected reactor sites, as well as on some suitable regional basis. The recurrence intervals examined should extend as far as a million or ten million years.

The ACRS is not prepared at this time to endorse the large proposed growth in the program on atmospheric transport and diffusion of radioactive materials.

3.5.4 Summary

The ACRS recommends a funding level of about $17 million for FY 1981. The Committee also suggests that further attention be given to the reliability of electrical systems and components under earthquake conditions.

3.6 Fast Breeder Reactors and Advanced Converters

This section relates to Items 7 and 8 in Table 3.1. The tentative budget for FY 1980 shows an allocation of $13.7 million for Fast Breeder Research. There is some indication that an additional $3.7 million may be allocated by Congress, specifically for research related to Gas Cooled Reactors. RES has requested $22.1 million for Fast Breeder Research in FY 1981 and $3.9 million for Advanced Converters.

The BRG has set aside for Commission decision all of the requested funds in this category. In its 1978 Report to Congress the ACRS commented:

> "Unless the LMFBR and other advanced reactor development programs are to be deferred for an extended period of time, the ACRS recommends that the Congress continue to regard advanced reactor safety research as a high national priority because of the time required to resolve important safety questions. Many of the current safety problems associated with light-water reactors have resulted from the fact that safety research lagged behind reactor development. If an advanced reactor program is to be pursued in the U.S., related safety research should be carried out concurrently with development. This will permit licensing to proceed in an orderly fashion when specific projects for advanced reactors are submitted."

The ACRS reiterates its conviction that an Advanced Reactor Research program should be carried on.

RES states that the $22.1 million represents a 25 percent increase over the original 1980 requests of about $16 million, plus escalation, and identified this increase as needed to respond to the recommendations of the ACRS as given in its 1978 report. The ACRS endorses the level of $22.1 million for Fast Reactors, and $3.9 million for Advanced Converters for FY 1981 as requested by RES.

The ACRS has the following comments based on the programs proposed for Fast Breeder Reactors and for Advanced Converters.

3.6.1 Fast Breeder Reactors

a. Analysis

This is primarily code development and qualification, but includes some work on accident delineation which purports to be responsive to the ACRS recommendation of 1978 that "NRC undertake a comprehensive study of the safety questions that are likely to arise for commercial LMFBRs.... The ACRS believes that there is a high-priority need to review all possible sources of serious accidents (e.g., loss of shutdown-heat removal capability), their probabilities, and their level of seriousness in plants of commercial size. Considerable use of probabilistic analysis techniques should be made. Preliminary conceptual designs should be utilized in the studies as a means for focusing on an integrated approach to the solution of problems such as post-accident heat removal." However, the ACRS also commented concerning the SIMMER code. "... it is doubtful that the code can ever be validated in the sense of precise calculations of such parameters as pressure, temperature, energy release, etc. Rather, the ACRS believes that the primary value of the code will lead to increased understanding of the event.... The ACRS expects that reduction of the code development goals will lead to more modest experimental needs and lower costs than previously anticipated." The intent was that addditional emphasis be given to investigation of a broad spectrum of accidents. The ACRS does not believe that the proposed FY 1981 allocation gives enough emphasis to non-CDA related accidents. Attention is directed again to the recommendation quoted in part above. It is believed that both accident delineation and accident prevention should receive greater attention than now seems indicated. In addition, the accident delineation work that is proposed seems to put too much emphasis on the CRBR. However, the SIMMER code and the other analytical activities are viewed as important and valuable activities, and need to be continued at a level adequate to sustain those activities.

b. Safety Test Facility Studies

These are stated by RES to be in response to the ACRS comment that "It is recommended that the NRC carry out a study to determine whether new experimental facilities or programs will be needed to demonstrate the validity of natural convection cooling on commercial-sized LMFBRs for both pool- and loop-type reactors." It is proposed to reactivate STF studies and use SSC and COMMIX for this purpose. It is not clear that the necessary determination can be carried out using this approach. We recommend that RES carry out additional planning of methods to resolve this issue, and review it with the ACRS.

c. Aerosol Release and Transport

This is a combination of analyses and experiments aimed at an important problem area. The work seems well planned and is producing results.

d. Materials Interaction

This item includes funds for loop design and fabrication and for a series of fuel tests. It is clear that fuel research needs to be done. While the NRC needs to do work on problems crucial to licensing concerns, more determined effort should be made to have the fuel developers assume a larger part of the investigative burden. In addition, more effort is needed to obtain a more precise formulation of the questions to be asked and how the answers are to be obtained with these facilities.

e. System Integrity

The proposed program involves testing of the CONTAIN code and carrying out a set of experiments associated with core melt retention, core debris coolability, and container cell liner response to accident loads. Some of the work on core melt retention is also useful in connection with licensing concerns of the FNP. The work associated with this item seems appropriate to future needs in the development and licensing of fast reactors. However the ACRS believes, as recommended in its 1978 report, that specific attention should be given to the study of alternate containment systems and to conceptual studies of systems for retaining a molten core in containment.

3.6.2 Gas Cooled Reactors

The funds requested would be used primarily to support Fort St. Vrain related questions on structural graphite, the response of the core to seismic loads, and primary system integrity. The proposed work is needed, especially if eventual development of the GCR is anticipated. The approach being used is somewhat fragmented.

In general, as in last year's report to the Congress indicated, the ACRS recommends that a broader spectrum of possible fast reactor accidents be examined. The Advanced Reactors program proposed for FY 1981 moves very slightly in that direction. The movement should be accelerated as soon as feasible.

3.7 Reactor Environmental Effects

In a broad sense, this subject area involves three specific subunits:

(a) identification and control of the sources of radiation within

nuclear power plants and their potentiality for release; (b) the avenues through which released radionuclides can be environmentally transported to population groups, and (c) the health impacts of the resulting exposures. The last two items in this list appear to be adequately addressed within the current program; this is not the case with respect to the first. In fact, the ACRS was unable to identify a research project specifically directed to this topic. Therefore, the Committee reiterates the recommendations given in its 1978 report, namely, that the NRC develop and implement programs to address the following areas:

(a) Research to determine the basic factors that govern radionuclide buildup in reactor cooling systems, including the possible influence of operating practices such as rapid temperature variations, load-following, end-of-fuel-cycle operation, and variations in coolant chemistry.

(b) Research to develop improved means for removing radioactive materials from the primary coolant circuit. Before such systems can be developed, however, there is a need for the acquisition of much better data on the chemical and physical properties of the material deposited, and on the mechanisms of its formation, deposition, and removal. These data are required to help establish criteria for controlling the amount and character of radioactive material present in the coolant circuit for purposes of meeting the as low as reasonably achievable (ALARA) criterion.

In the case of item (a) a research program needs to be developed and funded. Since EPRI is active in this area, this program should be closely coordinated with that organization. In the case of item (b), the program as outlined in the proposed FY 1981 budget is both unfocused and inadequate; this needs to be corrected.

In addition to the above, the ACRS recommends that efforts to improve the measurements of neutron exposures in nuclear power plants be continued. The proposed FY 1981 funding for research on this item, which is covered under item 9.f., "Occupational Radiation Exposure," appears adequate.

The ACRS also recommends that greater attention be directed to research on reduction of occupational exposures during repairs, inspection, or replacement of major nuclear power plant components. Estimates show, for example, that with current practices, occupational exposures associated with the replacement of the steam generators at several U.S. power plants will be high. Since the building layout, for example, the size and location of equipment hatches, can have important effects on the

complexity of major maintenance operations, such factors should be analyzed in detail. Research to confirm improved decontaminating procedures that could be applied prior to the removal of such units might also be beneficial. The budget allocation for research on these needs (Item 9.h., "Decommissioning") appears reasonable if the work is properly oriented.

Another area that needs to be addressed within this program relates to emergency planning and post-accident recovery. The Three Mile Island accident revealed a number of deficiencies in our ability to assess and respond to such situations. Specific needs in this area include:

(a) Research on steps that might be implemented in the recovery and reentry phase following an accident. This program should include evaluations of designs and procedures to facilitate the decontamination and recovery of major nuclear power plant systems. It should also include research on procedures to aid decisions by medical and other authorities concerning the affected offsite population; methods for decontaminating and reclaiming offsite land, buildings, and equipment; and the establishment of dose limits or guides for population groups desiring to return to areas that have been evacuated. These types of problems do not appear to be adequately covered in the current budget.

(b) Research on the development of instrumentation, and methods for quick interpretation and estimation of the timing, nature, and quantity of radionuclide releases in the event of a serious accident. Current budgetary allocations for research on these types of problems (contained within items 9.a. and e.) appear to be inadequate. The Committee recommends that they be increased.

To assist in complying with the recommendations given above, the ACRS suggests that certain projects now planned within this budgetary category might be reduced and/or deleted. Candidates to be considered include several sub-elements listed in "Ecological Processes," "Ecological Impacts" and "Socioeconomics and Regional" (Items 9.b., d., and e.). Reductions or deletions might also be considered under "Effluent Control" (Item 9.g.), particularly those projects directed to further refinements in techniques for assessments of compliance with 10 CFR 50, Appendix I.

The ACRS believes that the BRG recommended overall level of funding at $6.2 million is adequate. However, we urge that greater efforts be directed to establishing priorities for research in these areas and that care be taken in developing better procedures for the identification and selection of projects to be funded.

3.8 Fuel Cycle and Waste Management

These two categories are discussed jointly inasmuch as several of the perceived needs in the Waste Management category are included within the Fuel Cycle budget.

In its review, the ACRS has noted an urgent need for the NRC Staff to define clearly the goals of its waste management program and to establish priorities for the various tasks to be performed. Complicating this situation is the fact that NMSS, which has a projected FY 1981 budget of $18.1 million and conducts extensive research in this subject area, has been assigned lead responsibility for waste management activities within NRC. The proposed FY 1981 RES waste management budget, in contrast, is $12.9 million.

Although the long-term disposal of high-level wastes is a problem, the NRC faces immediate challenges relative to setting criteria for the disposal of low-level wastes, for the management of uranium mill tailings, and for the handling of spent fuel from commercial nuclear power plants. The current research program does not appear to reflect the relative urgency with which each of these problems needs to be addressed. Attention to research problems associated with the handling, storage and retrieval of spent fuel, for example, appears to be inadequate. In addition, the lack of clearly defined goals and specification as to how each research project fits into the overall program plan have resulted in a plethora of ongoing projects which are difficult to review and manage. The need for better coordination and direction is obvious.

A portion of these problems appears to be due to a shortage of qualified personnel. This is particularly true with respect to needs in the geological area. At present, the NRC does not have a sound concept of research needs associated with the determination of geologic and subsurface conditions that affect the storage of nuclear waste underground. The proposed FY 1981 budget, for example, allocates only $200 thousand for research on "Geochemical Processes" associated with high level waste disposal. Funds for research on "Geotechnical Engineering" also appear minimal, and no funds have been designated for research on "Shaft and Borehole Sealing Technology Evaluation". It is urged that these portions of the program be examined by competent geologists who are trained and experienced in subsurface investigation, design and construction. Until such time as full-time staff members qualified in this area can be employed, use of consultants should be explored.

Another factor contributing to problems in waste management research is the lack of adequate communication by the NRC Staff with other agencies and organizations active in conducting research or developing policy related to this subject. These groups include the DOE, USGS, and EPA as well as the NAS-NAE and NCRP. Even within NRC, there appears to be a lack of adequate interaction and communication among the major program offices. However, the recently instituted Waste Management Review Group should help to resolve these problems. The importance of such communication is illustrated by the fact that the current DOE radioactive waste budget is approaching $1 billion per year. To the maximum possible extent, the NRC should keep abreast of the work being done by these other agencies and use every possible avenue to ensure that their work yields results of maximum benefit to NRC needs.

3.8.1 Specific Research and Technical Needs

Comments on specific areas are given below.

Criteria for Waste Disposal

One of the major roles that NRC will play in the management of radioactive wastes will be to develop criteria for their safe disposal. Although additional data are needed, the ACRS urges that the NRC begin now to develop such criteria. Even a cursory effort in this regard would help identify needed program elements and would assist in establishing priorities for research on topics such as site selection and monitoring, the effects of radionuclide migration, and requirements for waste disposal operations associated with decontamination and decommissioning. This would, in turn, provide guidance as to how each program element assists in meeting the overall need. The development of such criteria would also serve as a guide for determining when adequate research had been completed and engineering design could begin.

Increased Attention to Low-Level Wastes

Data presented to the ACRS indicate that over 90% of the total volume of radioactive wastes being generated today are in the low-level category. Although these contain less than 1% of the total radioactivity to be handled, the volume of such wastes for calendar year 1977 was about 2.5 million cubic feet. Indications are that the handling of such wastes at the burial sites is largely done by hand (with associated high personnel doses). Because the waste containers are randomly placed in the trenches, space utilization is poor, voids exist, and retrievability would be difficult. Because of poor planning and management, several existing low-level waste disposal sites have had to be shut down and will represent continuing problems for years to come. Because of the lack of

criteria for disposal of such wastes, commercial companies are continuing current operations and planning for the future without clear guidance on proper procedures. The ACRS urges that the NRC address these problems as promptly as possible and provide the industry with the guidance it needs. To the extent that research is needed to solve certain aspects of these problems, it should be given top priority. These efforts should include increased research on methods, such as incineration and acid digestion, that can be used for reducing the volumes of the wastes to be handled, taking into account the active DOE programs in this area. Proposed FY 1981 allocations in this area (Item 10.b.) appear inadequate. In addition, no funds have been included in the proposed budget allocation for research on seeking "Alternatives to Shallow Land Burial". This is an important area that should be addressed in a meaningful way. Lastly, funds for research on the decommissioning and long-term care of low level waste burial sites (Item 11.b.) appear to be totally inadequate (only one of four designated research project areas is to be funded and then only at a level of $100 thousand.)

Ground Water Hydrology

Research on both high level and low level waste management includes items directed to ground water hydrology. The ACRS recommends that these efforts be closely coordinated with related studies on core melt accidents so as to assure maximum interchange of information.

Methods for Assaying Wastes

One area not apparently addressed by the current research program is the need for the development of equipment for assaying the radionuclide content of waste packages as received at waste disposal sites. Such equipment is necessary for determining whether wastes as received are within the overall radionuclide limits and whether they contain acceptable concentrations of the transuranics. No funds are allocated to these needs in the proposed FY 1981 budget. The Committee recommends that this situation be corrected.

Management of Gaseous Wastes - Fuel Cycle

NRC research on waste management is directed almost exclusively to the handling and disposal of liquid and solid wastes. The Committee recommends that attention also be directed to research needs for the removal, confinement, and long-term storage of gaseous wastes. The experience at TMI, for example, showed that problems were encountered in the holdup system for gaseous waste releases. The proposed FY 1981 budget allocates $150 thousand for research in this area (Item 10.a.). To the extent practicable, these problems should be more adequately addressed.

Emergency Planning

The proposed FY 1981 budget includes an item (10.c.) directed to research on "Decorporation Techniques for Radionuclides". The objective of this effort would be to evaluate methods for effecting the removal of radionuclides deposited internally. Unfortunately, this effort is not at present scheduled to be funded. The ACRS recommends that funds be provided for research in this area and that it be directed primarily to counter-measure actions in nuclear accidents.

3.9 Safeguards

The proposed budget for research on safeguards and security in FY 1981 is $4.9 million, which is about the same as the amounts for FY 1980 and FY 1979.

In each of these areas (safeguards and physical security), major and increasing expenditures will be devoted to the development of criteria and procedures for assessing compliance with the new and more exacting rules being put in effect (10 CFR 73.55, already promulgated, and 73.45 and 73.46, in preparation). The major additional items relating to safeguards are directed at the establishment and exercise of a system for material control and accounting; though supporting (non-research) funds are still needed for the development of measurement standards for the great variety of materials containing SNM which require accurate accounting. The major additional items relating to physical security are directed at the assessment of effectiveness of security provisions (alarm, and access control systems; selection, training and performance of guard forces; etc.), and the analysis of vital areas requiring maximum protection, along with studies of possible plant design options which might provide improved protection for vital areas.

The particular programs just mentioned constitute a reasonable and desirable continuation of work initiated during the past few years. The funds required for these studies are expected to decrease, and the work now seems to be needed in these areas is expected to be completed by or about FY 1983. Some useful results have already been obtained from work on these problems; the need for and the form of the new upgraded rules have been influenced by these studies; some new perceptions of sensitivities have been uncovered; and some of the models for assessing effectiveness of physical protection systems have been used by the Staff and by applicants. There is also an evident need for the guidance documents to provide criteria, methods and procedures to assist licensees in complying with the new, more stringent rules. (As an indication of this, the number of items of noncompliance reported as a result of physical security inspections of power plants increased between CY 1977 and 1978 by a distinctly larger factor than did the number of inspections.)

The programs already referred to would appear to be among the most important current objectives for safeguard research; and would warrant a higher priority than, for example, a project to assess the impact of an event such as the TMI accident upon safeguards performance, from which the most probable outcome would be the preparation in retrospect for a repetition of that event. A really low present priority could properly be assigned to a project to evaluate the safeguards issues associated with laser isotope separation, important as that may become when laser separation should reach the stage of a practically feasible technology. This situation does not, of course, apply to centrifuge separation, since a large number of these are running effectively, and have been for some time.

Considering the time that may be required to solve some of the main problems posed in the safeguards and other fields, the ACRS would judge that the funding level for safeguards research is reasonable.

3.10 Risk Assessment

The requested budget for Risk Assessment is $12.6 million for FY 1981; the BRG reduced this to $7.3 million.

The ACRS has previously urged an increasing level of research effort in probabilistic analysis. The ACRS strongly supports the requested funding level of $12.6 million.

The ACRS has several comments related to specific tasks delineated for work under Risk Assessment.

(a) The proposed studies on Class 3-8 accidents appear to be of relatively low priority and their discontinuance should be considered.

(b) A concentrated effort should be made to develop possible quantitative risk acceptance criteria for proposed NRC use.

(c) The nuclear fuel cycle risk program might be maintained at an equivalent FY 1979 dollar level, to help fund other activities of higher priority, some of which are identified in Part 1 of this report.

(d) The studies on risk from flood should be focused to provide at least preliminary input into the licensing process before FY 1981.

(e) The work on human error rate analysis should be organized so as to provide as much input as practical into the provision of guidelines for improved human performance and operating procedures. The probabilistic methodology should be used to evaluate operating procedures for possible misinterpretation and other sources of human error in order to help reduce the probability of degradation of a transient into an accident.

(f) The development of computer-assisted operator guidance to help reduce the chance of human error due to the complexity of a transient or the existence of false or contradictory signals will require an interdisciplinary approach in which probabilistic methodology will play an important role. Appropriate steps should be initiated by the Probabilistic Analysis Staff (PAS) soon, and if necessary, funding should be reallocated within PAS to begin work on the relevant methodology.

(g) The development and application of probabilistic methodology within the NRC Staff has been slowed by the lack of knowledgeable personnel. PAS has run a one-week intensive course. However, a course of this duration appears to be too short to provide the training and appreciation needed for the application of these methods. It is recommended that a longer (four to six week) course be developed, possibly in conjunction with some university, which would enable provision of a greater capability within the NRC Staff with regard to the application of probabilistic methodology.

(h) The PAS Program includes some plans to look at time-dependent failure rates. However, it is not clear whether there are plans to study the possible implications to safety of the potential for system degradation. Time-dependent failure rates should be developed for various significant system components and the possible effects on safety estimated for their possible impact on inspection requirements and other licensing considerations.

(i) With regard to emergency preparedness, the ACRS recommends that a short research program be implemented soon to develop means, as practical, of ascertaining the time, rate, type, and amount of radioactivity that might escape from containment into the atmosphere during postulated accidents.

The ACRS has the following general comments concerning the Risk Assessment program:

(a) The ACRS believes that rather than risk assessment, per se, this

group should be pursuing primarily the development and application of probabilistic methodology for use in improving the safety of reactors and to assist in the licensing process. Risk assessment would remain an activity but one having a lower priority.

(b) The PAS has provided recommendations to NRR concerning the potential for risk reduction arising from generic issues and other licensing issues. The same approach should be applied to a review of the NRC safety research program in order to help assess whether the current levels of funding are in rough balance with the risk reduction potential and other factors of potential importance in judging the priority to be given various research tasks and programs.

(c) There is a need for closer interaction between the PAS and the NRC Staff in the offices of Nuclear Reactor Regulation, Inspection and Enforcement, and Standards Development. Need exists for close interaction between PAS and an NRR group that includes experts in the several kinds of systems (electrical, mechanical, air, thermal-hydraulic, control, etc.) important to reactor safety, so that a continuing and current assessment can be made of the safety implications of potential design changes or of operating experiences in a manner that includes interactive aspects and reliability and risk aspects.

(d) Several of the general recommendations made in Part 1 will involve efforts by PAS beyond those delineated in their proposed work scope for FY 1981. These include: 1.2.3, Accident Studies; 1.2.4, Molten Core Retention; 1.2.7, Siting; 1.2.9, Transient Simulation in Research and Licensing; 1.2.11, Application of Probabilistic Methodology; and 1.2.13, Disturbance Analysis.

The ACRS recommendation of a funding level of $12.6 million in FY 1981 is made in recognition that these efforts will require additional resources.

3.11 Improved Reactor Safety

In 1977, the Congress directed the NRC to prepare a long-range plan for research to improve reactor safety. This plan was developed and presented to the Congress in April 1978 (NUREG-0438). In late FY 1979, work was begun on this program, at a very low level, using reprogrammed unobligated FY 1978 funds and some obtained by reallocations within the RES budget. The FY 1980 budget request for $4.3 million was reduced by the OMB to $1.0 million. Congress has not yet approved an appropriation

for FY 1980, but an additional $3.4 million has been included in the NRC's supplemental request for FY 1980. The ACRS support for this increase has been indicated in Part 2 of this report.

The budget request of $6.6 million for FY 1981 has been set aside for Commission decision by the BRG in view of the uncertainties in direction provided by OMB and the Congress in view of their actions on the FY 1980 budget requests.

The ACRS has indicated repeatedly its strong support for a vigorous and well-funded program of research to improve reactor safety, in its report to the Commission on NUREG-0438 and in its reports to Congress in 1977 and 1978. It continues to support this program and urges strongly that the full amount requested be restored to the FY 1981 budget.

Although the ACRS supports the level of funding proposed for FY 1981, it does not agree with the currently proposed allocation of funds among the various program areas originally listed in NUREG-0438. Specially, the ACRS recommends the following changes in scope and emphasis, within the proposed budget level:

(a) Alternate Containment Concepts.

This program should be augmented in both FY 1980 and 1981, with the objective of examining all types of containments in greater depth.

(b) Alternate Decay Heat Removal Concepts.

This program should be augmented in both FY 1980 and 1981, in directions leading to conceptual design studies for both PWR and BWR systems. The goal by the end of FY 1981 or 1982 should be completion of studies leading to two or more possible design approaches for each type of reactor system.

(c) Alternate ECCS Concepts.

The proposed funding for this program is considered adequate at the levels requested for FY 1981.

(d) Human Interaction.

The proposed funding for this program is considered adequate at the levels requested for FY 1981.

(e) Advanced Seismic Design.

The ACRS believes that work in this area might well be deferred until after FY 1981 in order to permit the augmentations in other areas recommended above. Such deferral will also permit the new data, knowledge,

and insights that are expected to be obtained from the Seismic Safety Margins Research Program to be used in the planning and execution of research on advanced seismic designs.

(f) Scoping Studies of Other Possible Improvements.

This program should be augmented in FY 1981, in order to provide timely guidance for further work in subsequent years. In view of the TMI accident, a promising area deserving of early study is core retention measures and their potential for mitigating the release of radioactivity through the liquid pathway.

(g) Improved Value-Impact Methodology.

The ACRS believes that the development and use of this methodology is important but that its application is not limited to the evaluation of proposed concepts or systems to improve reactor safety. It can and should be used to evaluate the values and impacts of such new criteria as those relating to pipe breaks inside and outside containment, fire protection, and ATWS, and to determining the extent to which these improvements in safety should be applied to new plants, plants under construction, and plants already in operation. This methodology can be used also in determining the potential value of research programs considered to be chiefly confirmatory in nature. At the same time, the ACRS believes that this methodology has only marginal value for the selection of new topics relating to improved reactor safety. The procedures followed in arriving at the five areas listed in NUREG-0438 were considered by the ACRS to be quite adequate at the time. This judgment has been confirmed by the fact that all the proposed TMI-related research to improve reactor safety falls well within the scope of the principal areas identified in NUREG-0438. For these reasons, the ACRS believes that, although research on improved value-impact methodology is desirable and should be conducted, the funds for this research should not be taken from the relatively small sums requested for research to improve reactor safety.

TABLE 3.1
FY 81 BUDGET

	BUDGET (In millions) RES	BRG
1. SYSTEMS ENGINEERING		
a. Semiscale	$ 8.1	$ 8.1
b. Blowdown & Reflood Heat Transfer	8.4	8.4
c. 3-D Flow Distribution	12.0	10.0/2.0[1]
d. ECC Bypass Research	0.9	0.9
e. Model Development Experiments	3.5	3.5
f. Operational Safety	9.8	0.0/9.8[2]
g. Technical Support	2.6	1.9
	$45.3	$32.8

[1] BRG set aside for NRC consideration due to change in scope of the effort and also because $1 million is for contingencies not included in NRC directed ceiling of $59 million for this program.

[2] BRG set aside for NRC consideration because this funding is generally for new efforts proposed by RES and out-year impacts reflect significant growth.

	BUDGET (In millions) RES	BRG
2. LOFT		
a. Program Planning and Analysis	$ 5.0	$ 5.0
b. Fuel	8.3	8.3
c. Operations	8.9	8.9
d. Instrumentation	9.0	9.0
e. Facility Support	11.3	10.0[3]
f. Engineering and Physics	6.5	6.5
g. Advanced Fuel Instrumentation	0.3	0.3
	$49.3	$48.0

[3] BRG said that accuracy and timing of scheduling and testing not precise or exact enough that full request is required by FY 81.

TABLE 3.1 (Cont)

	BUDGET (In millions) RES	BRG
3. CODE DEVELOPMENT		
a. Systems Codes	$ 6.3	$ 6.3
b. Component Codes	1.6	1.6
c. TRAC Assessment and Applications	7.3	5.3[4]
	$15.2	$13.2

[4] BRG said that RES has not adequately demonstrated that $2.0 million TRAC application is not duplicative with the NRR program.

	BUDGET (In millions) RES	BRG
4. FUEL BEHAVIOR		
a. Clad and Fuel	$ 2.6	$ 2.6
b. Fuel Codes	1.5	1.5
c. In-Pile Testing (PBF)	16.1	16.1
d. In-Pile Testing (Other)	4.2	4.2
e. Fuel Melt	4.1	3.5[5]
	$28.5	$27.9

[5] BRG deleted low priority fuel melt effort for FNP.

	BUDGET (In millions) RES	BRG
5. PRIMARY SYSTEM INTEGRITY		
a. Fracture Mechanics	$ 5.9	$ 5.9
b. Operating Effects	6.3	6.3
c. Nondestructive examination	2.9	2.9
	$15.1	$15.1

TABLE 3.1 (Cont)

	BUDGET (In millions) RES	BRG
6. SEISMIC ENGINEERING SAFETY		
a. Structural Engineering	$6.0	$ 3.9
b. Mechanical Engineering	7.4	3.8
c. Site Safety	6.5	6.2(6)
	$19.9	$13.9

(6) BRG reduction was based on lr · priority of this research (as assigned by RES). BRG level was said to be sufficient for RES to pursue a logical progression of effort started with FY 80 supplement.

	BUDGET (In millions) RES	BRG
7. FAST BREEDER REACTOR		
a. Analysis	$ 7.8	-
b. Safety Test Facility Studies	.7	-
c. Aerosol Release and Transport	3.0	-
d. Materials Interactions	4.6	-
e. Systems Integrity	6.0	-
	$22.1	0.0/22.1(7)

(7) BRG set aside entire amount for Commission consideration. BRG recommended that NRC priorities should be on LWR programs.

	BUDGET (In millions) RES	BRG
8. ADVANCED CONVERTERS		
a. GCR Program	$ 3.9	0.0/3.9(8)
	$ 3.9	$0.0/3.9(8)

(8) BRG set aside entire program based on the Administration's decision to terminate domestic program in FY 79.

TABLE 3.1 (Cont)

	BUDGET (In millions) RES	BRG
9. REACTOR ENVIRONMENTAL EFFECTS		
a. Physical Transport and Effluent Characteristics	$2.1	$1.3
b. Ecological Processes	0.6	0.4
c. Radiation Dosimetry and Health Effects	1.2	1.1
d. Ecological Impacts	1.7	0.3
e. Socioeconomics and Regional	1.2	0.5
f. Occupational Radiation Exposure	1.1	0.9
g. Effluent Control	1.0	0.8
h. Decommissioning	0.9	0.9
	$9.8	$6.2 (9)

(9) BRG provided minimum level on many areas (except those dealing with problem of low level radiation exposure) because of low priority of programs.

	BUDGET (In millions) RES	BRG
10. FUEL CYCLE		
a. Effluent Control	$0.7	$0.3
b. Safety	1.4	1.3
c. Occupational/Health	1.6	1.2
d. Environmental Impacts	0.1	0.1
e. Transportation	1.5	1.5
f. Decommissioning	0.6	0.6
	$5.9	$5.0 (10)

(10) BRG reduced funding as some parts of program are not clearly supported by user needs or are supported by outdated requests.

TABLE 3.1 (Cont)

	BUDGET (In millions) RES	BRG
11. WASTE MANAGEMENT		
a. High Level Waste	$ 8.1	-
b. Low Level Waste	5.7	-
c. Tailings	2.1	-
	$15.9	$12.9 (11)

(11) BRG fully funded these programs but recommended a shift of $3.0 million to FY 80 to provide for a more orderly growth of the program.

	BUDGET (In millions) RES	BRG
12. SAFEGUARDS		
a. Evaluation Methods	$2.2	$2.1
b. Inspection Methods	0.5	0.5
c. Alternative Strategies	4.0	2.3
	$6.7	$4.9 (12)

(12) BRG reduced level because program contained efforts that are not expected to be needed in the near future. $0.4 million set aside on Breeder Safeguards for Commission decision.

	BUDGET (In millions) RES	BRG
13. RISK ASSESSMENT		
a. Methodology and Software	$ 2.5	$ 1.8
b. Reactor Systems Analysis and Licensing Support	3.6	1.6
c. Nuclear Fuel Cycle Risk	2.0	1.4
d. Training Program	0.1	0.1
e. Reliability and Human Error Data Analysis	2.6	2.1
f. Acceptable Risk Criteria	0.3	0.2
g. Improvements to Reactor Safety Study	0.3	0.1
h. Operational Safety Data Analysis	1.2	-
	$12.6	$ 7.3 (13)

(13) BRG said that program appears to be expanding at too rapid a pace for the number of qualified people that are available.

TABLE 3.1 (Cont)

	BUDGET (In millions) RES	BRG
14. IMPROVED REACTOR SAFETY		
a. Alternate Containment	$0.8	-
b. Alternate Decay Heat Removal	0.4	-
c. Alternate ECCS Concepts	1.0	-
d. Human Interaction	2.7	-
e. Seismic Design	1.0	-
f. Scoping Studies	0.4	-
g. Improved Value-Impact Methodology	0.3	-
	$6.6	$0 (14)

(14) BRG set aside entire program in view of the Administration's position on Improved Reactor Safety during FY 80 budget reviews and Congressional action to date on FY 80 program.

655 198

NRC FORM 335 (7.77)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER *(Assigned by DDC)*
NUREG-0603

4. TITLE AND SUBTITLE *(Add Volume No., if appropriate)*
Comments on the NRC Safety Research Program Budget

2. *(Leave blank)*

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S)
Advisory Committee on Reactor Safeguards

5. DATE REPORT COMPLETED
MONTH July YEAR 1979

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*
Advisory Committee on Reactor Safeguards
US Nuclear Regulatory Commission
Washington, DC 20555

DATE REPORT ISSUED
MONTH July YEAR 1979

6. *(Leave blank)*

8. *(Leave blank)*

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.

13. TYPE OF REPORT

PERIOD COVERED *(Inclusive dates)*

15. SUPPLEMENTARY NOTES

14. *(Leave blank)*

16. ABSTRACT *(200 words or less)*

Recommendations of the Advisory Committee on Reactor Safeguards are presented to the Commissioners for their consideration for both FY-80 supplement and FY-81 budget for the NRC safety research program. Special attention to both short- and long-term implications of the Three Mile Island accident and their significance to research for both the short- and long-term research programs are included.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

655 198 800

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT
Unlimited

19. SECURITY CLASS *(This report)*
unclassified

21. NO. OF PAGES

20. SECURITY CLASS *(This page)*

22. PRICE
$

Steve Scott
NRR 1220

120555031837 2 R1XAAN
US NRC
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655 199