OFFICIAL TRANSCRIPT OF PROCEEDINGS

Agency: U.S. Nuclear Regulatory Commission
The Nuclear Safety Research Review Committee

Title: Public Meeting

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
Nuclear Safety Research Review Committee
Washington, D.C. 20555

November 1, 1990

MEMORANDUM FOR: Eric S. Beckjord, Director
Office of Nuclear Regulatory Research

FROM: David L. Morrison, Chairman
Nuclear Safety Research Review Committee

SUBJECT: CERTIFICATION OF THE MINUTES OF THE SEPTEMBER 25 AND 26, 1990 MEETING OF THE NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE

I hereby certify that, to the best of my knowledge and belief, the attached minutes for the September 25 and 26, 1990 meeting are an accurate record of the proceedings for that meeting.

David L. Morrison

David L. Morrison, Chairman

11/1/90
(Date)

MINUTES OF THE MEETING OF THE
NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE
SEPTEMBER 25-26, 1990
BETHESDA, MARYLAND

Enclosure 1, marked Tentative Agenda, is a copy of the agenda that was used for the subject meeting. Subcommittee meetings were held concurrently and were not open to the public; formal minutes of those meetings were not kept.

Enclosure 2, in two volumes, is a verbatim transcript of the Full Committee meetings, which were all open to the public. The transcript lists times, dates, place, committee members in attendance, and those making presentations and comments at the meeting. One member of the public attended the meeting.

One brief period of the Full Committee meeting was not recorded for the transcript. At 1:05 p.m. on September 25, 1990, after the court reporter had been excused, the Chairman reconvened the Committee to give instructions on Subcommittee activities, including who was to be on each Subcommittee and where the Subcommittees were to meet.

TENTATIVE AGENDA

Tuesday, Sept. 25

Full Committee

8:00 E. Beckjord. Review of current research program and RES view of NRC user needs.

10:00 D. Morrison. Open discussion of scope of NSRRC review, review approach, and final product.

Subcommittees

1:00 RES Division Directors. Detailed description of current research program and summary of past application of research results to satisfy user needs.

Wednesday, Sept. 26

Full Committee

8:00 EDO, DEDOs, and Program Office Directors. Role of RES and user needs for each program office.

Subcommittees

10:30 Subcommittee Chair. Caucus to consider current research program vis-a-vis user needs and to prepare comments for discussion in afternoon.

Full Committee

1:00 Subcommittee Chair. Comments on current research programs in relation to perceived user needs. RES will discuss their planned support of the Subcommittees.

3:00 D. Morrison. Open discussion on relation of current research to user needs and need for further information to prepare report, including RES staff role in preparation of report.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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THE NUCLEAR SAFETY RESEARCH REVIEW COMMITTEE

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PUBLIC MEETING

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Montgomery Room

Holiday Inn

Bethesda, Maryland

Tuesday, September 25, 1990

The Commission met in open session, pursuant to notice, at 8:00 a.m., DR. DAVID MORRISON, Chairman of the Committee, presiding.

COMMITTEE MEMBERS PRESENT:

DR. NEIL E. TODREAS

DR. HERBERT ISBIN

DR. ROBERT E. UHRIG

MR. SOL BURSTEIN

DR. DONALD L. TURCOTTE

PROFESSOR DAVID D. WOODS

MR. EDWIN E. KINTNER

DR. RICHARD C. VOGEL

DESIGNATED FEDERAL OFFICER:

DR. RALPH O. MEYER

STAFF AND PRESENTERS SEATED AT THE COMMITTEE TABLE:

ERIC S. BECKJORD

THEMIS P. SPEIS

PROCEEDINGS

MR. MORRISON: Well, since the appointed hour has arrived, everyone who is going to be on time is here, I would like to call the meeting of the Nuclear Safety Research Review Committee to order.

Several housekeeping items as first activities.

I'd like to officially welcome two new official members to the committee: Ed Kintner who was here at our last meeting as an observer has now gone through the appropriate review process and then deemed worthy of a full membership. So, Ed, we welcome you.

(Discussion off the record.)

MR. MORRISON: Our second new member today is David Woods. We welcome you, David, as a member of the committee.

Neil Todreas will be here.

Excuse me, Dick Vogel. Three members. I'm sorry, Dick.

MR. VOGEL: Just last week.

MR. MORRISON: Just last week. Right. We glad you were approved by then and could join us. We're a little light in our load today. A couple of our members won't be here today; although Spence Bush will be here tomorrow.

Neil Todreas will be in a little later. His flight this morning is supposed to arrive at 8:10 so he'll

be here later this morning.

I assume everyone has a copy now of the revised agenda.

Did everybody get them, Ralph?

MR. MEYER: I'm not sure.

MR. MORRISON: It doesn't differ too much from the earlier agendas but let's just look at it briefly to make sure we understand what we're about to do today.

This morning we'll meet as a committee of the whole. We really want to do two things this morning. First, Eric will review the current research program and his view of what the research needs are based upon his view of what the user needs are for the activities of the research program.

Then I think the committee of the whole should really address what our charter for the rest of the two days.

Just to refresh your memory as we start to go through this that the committee's activities today have been in response to a request from James Taylor, Executive Director of Operations, who is following up on a statement or comments made by the ACRS.

The charge is very general in the letter that was written by Taylor to Carlye Michelson in response to his letter. I'll just quote a couple of sentences from it.

(Reading) It is essentially that we clearly define the technical areas and merits of the research to support specific needs and the regulatory process. Thus, I have asked the RES Director to have the Nuclear Safety Research Review Committee consider what the strategy and content should be for a research program designed to meet NRC's essential regulatory requirement.

I think it's worth our while to spend an hour or so discussing that particular charge and see if we can come up with sort of a collective agreement of at least the general outlines of what the research program should be or the criteria it should meet.

Then this afternoon we will be breaking up into subcommittees to hear presentations by the various division directors on the specific research programs in accordance with the five-year plan that you should have received a copy of.

Tomorrow morning, then, we'll have the opportunity to meet with the executive director and the other program office directors and get their view of where research fits into the overall NRC needs;

Again, break up toward the end of the morning in subcommittees to tidy up our work on the individual parts of the program;

Then finally in the afternoon tomorrow we'll

convene as a full committee to hear the subcommittee reports, so to speak, and try to then combine all of that into a final recommendation for what the research program here should be within NRC.

It's a fairly full day or full two days but I think there will be ample time for discussion and I hope it will be very open and free discussion.

It's in part philosophical to find out what a research program should be and how it fits into NRC's needs.

In part it's a fairly high technical content of some fairly critical issues relying on that technical content. So at the end of the day it's really a balance between those two.

Are there any other general questions or housekeeping functions?

I guess one of the most important ones is that coffee is not available in this room. It was available earlier downstairs. I don't know whether it's still available downstairs. But we'll plan at least a coffee break at the middle of the morning so we can all go out and refresh ourselves.

Ralph, is there anything else from your side that we need to know?

MR. MEYER: No. There's no much. The subcommittee meetings are, of course, closed meetings. They

are not open to the public. The subcommittee rooms are nearby. This room will be used as one of them. The other room is right next door, and the New Jersey Room is upstairs, not fair away. So we have nice rooms that are close together for all the meetings.

MR. MORRISON: In case you haven't gotten the information, Ralph Meyer is now our designated federal official. He's replaced Bob Shepherd in that capacity. We're looking forward to working with Ralph and I hope Ralph looks forward to working with all of us.

There is an incredible amount of detail that has to be done in preparation for these meetings and fortunately Ralph has taken care of that quite well for us.

Just one other housekeeping item and then we'll move to you, Eric.

So that everybody has the latest list of committee members and their addresses I'll pass out a couple of sheets of paper here you can have for your record.

With that, Eric, let's turn it over to you to get sort of the overview of the research program and what your views of where it fits in and how it fits into the overall NRC needs.

MR. BECKJORD: Thank you, Dave.

I wanted to welcome the members of the Nuclear Safety Research Review Committee to this full meeting. I

think it's the fifth. Time goes by quickly. I could have missed that by one.

And I want to add my welcome, Dave, to yours for our new members: Ed Kintner, Dave Woods, and Dick Vogel.

You've covered already the purpose of the meeting related to Jim Taylor's letter of May 4 to Carlyle Michelson requesting your review of the strategy and content of research to meet NRC's essential needs.

That letter -- I'll add just a little more background to it. The letter that Jim Taylor was responding to was a letter dated April 11 of 1990 to the Chairman of the Commission on the Nuclear Safety Research Program Budget.

The ACRS advisory committee on reactor safeguards has been mindful since I came four years ago of the general decline in the safety research budget. I have discussed that subject with him on a number of occasions.

We met with him again last fall and it was my understanding that the ACRS intended to write a letter on the subject.

They had a second meeting early in 1990 with myself, with the executive director for operations, and with Tom Murley, Director of Nuclear Reactor Regulation, in order to discuss the subject which we did at some length with them.

The letter that they wrote on April 11 was an endorsement of the budget for the research program. They noted the trend which had been downward. They explored some of the possible causes of it and then turned to the benefits of the research which have been gained from it in the regulatory activities.

Many of the things that they refer to I'm going to be touching on in my own presentation.

Then they wound up with really the reasons for their endorsement of the research program. The cited not only the specific information that comes out and is applied to the resolution of problems but they referred, also, to the other benefits of that which is to build and maintain the sources of expertise that can pursue problems and develop solutions that can be applied in the future; in other words, maintaining a strong cadre of researchers in the field.

That's a very quick summary of their letter.

As I read it, I think it was a strong endorsement of the need for the research budget.

They also referred in the letter, which Dave touched on, to this committee and suggested that the Commission might ask your committee to take a look at the funding.

So, here we are.

I think what it really boils down to is that your independent review and conclusions on the budget would be useful; useful not only to me, to the executive director, but I think also to the Commission as it pursues the budget for the NRC and for research.

Your conclusions, I would say, will apply directly to the fiscal 1992 budget which is now part of the President's budget. We are not able to discuss those numbers because the President's budget is embargoed until he presents it to Congress early in 1991.

We cannot talk about that in the open meeting.

So, your views and comments, I think, will directly affect that budget as it goes through the usual process of review and discussion and finally approval in Congress.

But there is a budget matter related to fiscal 1991 that we also have to be mindful of. I'm going to say more that in a few minutes: the possibility of the Gramm-Rudman-Hollings budget cut.

So, as I say, it is possible, also, that your comments may be important to us relating to the budget which begins on the 1st of October.

We have the agenda. I think that's been covered adequately. I'm going to speak for probably 50 minutes or thereabouts on the budgets on the program activities that

have been underway in the fiscal '90 and '91 budget.

Then I will speak about future research. But, as I said, I cannot talk about the numbers for the fiscal '92 budget but you will have the opportunity to review that in detail in the subcommittee meetings.

(Slide.)

I think what I'd like to do this morning is to try and address the programs as units without getting into a lot of detail on each one. I think if we can see what constitutes the programs and how they are being used and applied to the issues before the Commission today, then that will give you a sense of what is important. Then you can pursue the programmatic details in the afternoon and tomorrow and subsequently as well in the preparation of the report.

The agenda. I would just like to comment on that briefly. I'm going to speak a bit at the end about the development of your report, presumably a letter report, and how we can undertake to produce that document. I think I'd like to aim for the end of November as a time when that might be produced, when you might be ready to send it to us.

We are prepared to work with you. We'll assign whatever of our staff is necessary to help out.

I think one of the things you'll want to discuss is whether another meeting is needed after this or whether

the matter can be handled by circulation of draft material and by working with the subcommittees. I think the latter possibility is possible.

(Slide.)

There is the contents.

I'm going to spend a few minutes, as I said, on the Gramm-Rudman-Hollings budget so you'll have the full picture of what might happen in fiscal '91.

I'm also going to spend a few minutes on the significant accomplishments. Really, my view on that is that we would like to show you what the research results of the last few years have made it possible to accomplish in their application to regulatory problems. In a way, I think if we can do that we can give you some confidence that the research office can produce on the future results which will be the focus later today.

(Slide.)

Okay. If we can turn to budget trends.

There are a couple of points I want to make on this graph here.

First of all, a little history before this graph. From 1982 through 1986 there was a specific reduction of the research budget from the order of about $180 million annually down to -- it reached a number in between $100 and $110 million in 1986.

Those were specific reductions of research programs which had blossomed in the period after Three-Mile Island. There were a number of reactor experiments which were under way in Idaho and integral thermal hydraulics systems testing; much of it related to the once-through steam generator system. And these were expensive experiments.

The specific reduction that took place in that period 1982 through 1986 was essentially the completion and closing down of the testing and the reactor facilities and also the phasing down of the integral loop testing.

From 1986 until the present there has been a more moderate decline to the budget related not specifically to research but to the general decline in federal budgets and specifically in the Nuclear Regulatory Commission budget as a whole.

So the period of the immediate past five years has been a general budget problem and not so much one that applied only to the research budget.

Now, that is the first point.

The second point I want to make is looking to the future my sense is at this point that the trend is going to be up, not with a high slope but with a moderate recovery. I expect that in relation to the development of advanced reactors, advance water reactors first and then possibly the

gas-cooled liquid metal cooled reactor, looking some years out. I see that research as in part exploratory because there are new concepts -- We'll be talking about that later -- but also confirmatory because we have details on some of the specifics in these designs.

We visited Pittsburgh the week before last, quite a number of us and reviewed the design of the Westinghouse AP-600. That was a very interesting two days out there. We got a briefing on the status of the design, their analysis of a number of the features, and we saw work that is underway at the R&D center, their own development work related to this concept.

There have also been meetings with General Electric on their reactor concepts. I have not visited San Jose myself in that connection but I expect that several of us, a number of us will be going out some time later this year to do that.

So my sense is that there is going to be more research related and the reason for it is advanced reactors in the future.

Now, at the same time I have to say that this matter of the Gramm-Rudman-Hollings reduction is likely to be a problem in fiscal 1991. As I said, I'm going to say more about that so I'll come back to it in a minute.

The next point I want to make on this graph is

that you also see the effect of inflation here from 1985 to 1991. The lower dotted line is expressed in constant 1985 dollars. So the effect of inflation has obviously a depressing result on the research effort. I think from 1985 until now that approximately, it's probably about an 8 percent reduction there. We have been able largely to recover by doing a better job, doing things more efficiently. It's essentially learning.

Now, I say that from 1985, 1986 until now. I don't make the claim necessary for the future because I don't know what the inflation is going to be but what I am saying is that with modest inflation I think for this period we have been able to stay even in terms of the results we have been getting from the research.

Another point is that during this period from 1987 until now there have been a number of new programs and revised programs that have come into the budget even though the budget was declining. These include a redefined and reorganized severe accident research program which we've reviewed with the committee several times, with a renewed human factors research program which, I think, has gotten under way. It's made a good start. It's producing results. I think you're going to see more results from that in this coming year. That's a significant program. It's in the range of $7 to $8 million annually now.

The accident management program which we'll be talking about today and tomorrow in some more detail is also new in that period. And an effort in radiation protection and health effects is under way relating to low level radiation and some other radiation protection problems of interest; for instance, hot particles and that type of thing.

Now, these programs when you take them together constitute a large sum of money. I mean, it's a large part of the budget and it was funded by really two things: a redirection of severe accident research and by the reductions in thermal hydraulic research and code development which had been under way for many years relating to the loss of coolant accidents and developing the tools to predict the consequences of loss of coolant accidents.

Another activity which I should mention is the probabilistic risk assessment. The NUREG-1150 which was completed recently and for which you have the peer review report which was completed this summer, that was a major effort over a number of years. The direct funding of NUREG-1150 was about a $17 million over a six-year period.

In addition to that, there were other funds that supported it through the severe accident research work which was not charged directly to it but, as I said, supported it indirectly.

That major effort is completed now and I expect with the receipt of the report of the peer review committee and their advice to publish the document that we will do so.

We have work under way to follow up on suggestions and comments that they made. I expect that will be ready, the final will be ready later this fall.

So, those are major activities that were funded during this time even in a declining budget.

As I said a few minutes ago, I think the next thing that we are addressing is the needs for research for advanced reactors, advanced reactor concepts. I do not think that we will be able to fund that within a constant level budget. So that I am saying we will need some new funding for that advanced reactor work.

(Slide.)

Just to clarify for you matters of definition of the work that we do, I think we discussed this with the committee before but I did want to bring it up again for our new members. We do really two kinds of research in the first category and that is, first, what I would call "short range," work that relates to issues, problems, answers that are needed over the next one to two years.

Most of it is in response to regulatory needs: things like the license renewal program which is under way now relating to issuing new license for plants as they

approach the expiration of their 40-year operating license.

Although there are several plants whose licenses expire in the '90s, there are growing numbers of plants for which that will be the case after the Year 2000. But there's quite a long lead time relating to decisions that utilities will make about these facilities. They want to know what the costs will be and what expectation they have for additional life in these plants.

So we have written the rule. That's done. And we're working on the regulatory guide. The rule will become final next year, in 1991, and the regulatory guides will be forthcoming over the next two to three years.

So it is that kind of thing that I'm talking about in the short range.

We also do longer range work, research requiring, perhaps, three years or more to complete. Examples of that are the ongoing research in reactor vessel materials and the irradiation embrittlement performance.

It's also in anticipation of safety issues, developing new knowledge for issues that we expect to come down the pike. An example there is what I've already mentioned, advanced reactor safety. We'll talk some more about that later.

So, there are those two categories of research.

Then there is a category which we call "technical

assistance." That's primarily application. We do most of that as you will see under the category of resolving safety issues and developing regulations. It relates to rules, standards, licensing decisions, policy development, that type of thing.

(Slide.)

This gives you the budget figures in the five categories for '89, '90, and '91 forthcoming so you can see the relative magnitudes of the programs.

You can also see here the share of -- we've shown this in two categories: research covering the definitions that I just gave you and also technical assistance.

Most of the technical assistance is in this last category of resolving safety issues and development of regulations.

We used to consider high-level and low-level wastes together as one category but, then, about two years ago with the new law on high-level wastes those budgets were split. So high-level waste now has a separate budget, separate from low-level waste.

There is a significant growth in the combination of those two in 1991 compared with the prior years.

There is some modest growth in the other areas.

MR. ISBIN: Eric, may I ask with reference to high-level waste: technical assistance can also be provided

by other groups within the NRC?

MR. BECKJORD: Yes.

MR. ISBIN: And that turns out to be quite significant, doesn't it?

MR. BECKJORD: Yes.

The technical assistance budget on high-level waste is primarily in the nuclear materials safety and safeguards office under Bob Bernero. The amount that they are spending on high-level waste -- I'll get that number for you, I don't recall, but it's a lot more than this. Most of that is expended at the Center for Regulatory Waste Analysis at the Southwest Research Institute in San Antonio. The research effort is centered there now as well as the technical assistance in that division.

(Slide.)

Now, this shows you what the Gramm-Rudman-Hollings problem is in fiscal 1991. I want to emphasize in talking about this that this is a potential. It is not a certain matter. I outcome is not certain. It really depends on the budget resolution which is presumably now underway, including today, downtown.

I guess you can say it's anybody's guess at this point but my expectation from what I've heard discussed in the agency and elsewhere is that there will be a resolution of the budget. It may not come about by the first of

October.

What will happen if there is not a budget resolution by the first of October is that there will be something like a continuing resolution and the executive branch of government will issue instructions to all departments to make reductions in their expenditures.

If the issue were unresolved throughout the year. We know approximately what that cut might be. It's shown here in the middle column.

By the way, the left-hand column says "Fiscal 1991 latest." Those are the same numbers that you saw in the preceding graph. The mid-column is the potential cut which would be operative for the entire year without a resolution. Then the right-hand column is the balance.

If it happens, undeniably it's a major cut in the program. The consequences would be considerable. It would be, first of all, a major deferral of research efforts. There would be a loss of researchers and people to the program, a loss of morale.

Based on past experience, the loss of people would probably be permanent. There would be facilities that we would not able to operate and would close down. And probably there would be termination costs in our work with laboratory, Department of Energy laboratories. And to the extent there were termination costs, the real research in

that right-hand column would be further depressed.

You know, looking beyond 1991 to a recovery, all I can say is it would be an expensive recovery because we would undertake to get programs that were deferred back underway. We'd have to find people to work on them.

So there are really major costs associated with this. I certainly hope this does not befall us.

My expectation with regard to Gramm-Rudman-Hollings, I think it is not likely that we will see this whole. But I think it is likely that we will have a budget below the $94 million which was the final budget approved by the House for fiscal '91.

(Slide.)

Now, the next slide shows you what the general basis for these reductions was. It was done in two parts. First of all, last spring, in April, we prepared for up to in terms of ranking a priority assigned to each project, we made up a list totaling $23 million of reductions in anticipation that there might be something like this.

In August the agency was directed by Office of Management and Budget to prepare for a number which when it finally came down to research it was an additional $11 million reduction. So the total of the two of those comes up to the $34 million shown on that previous slide.

Now, what I'd say about that is that we did a very

careful review of the priorities for the first $23 million. When the instructions came to come back with a program totalling $34 million as is usually is the case, there was a very short notice on that and the additional $11 million in cuts was done to the best of our ability in a very short time.

So my view on that is I think the priorities are lined up pretty well on the first $23 million. If there is a cut anything like this, we intend to look at it very carefully when the final number comes down. When the final number comes, it's not likely to be precisely on any one of these. So we will be looking at the whole program.

MR. VOGEL: When your final number comes, when do you get the final number? Sometimes there's a problem when you get the final number late, then you have to cut at twice the rate. It gets to be terrible.

MR. BECKJORD: Right. Well, the way that will work is that we will know on the 1st of October the issue is either resolved or not resolved.

If it is not resolved, then we have to undertake a cut right away. The money comes to us probably on a monthly basis and it will be in proportion to this $34 million cut. So we won't get very much money at the beginning of the year.

It turns out that we have enough forward funding

to carry most of our programs through December with no new money.

So that if the issue, let's say, resolved as late as December, if we had money to spend at the original planned rate, we would have precisely the problem that you're referring to. But in fact we won't be receiving that much money so the research will already have been scaled, the spend rate will have been scaled back.

MR. BURSTEIN: What you're saying, if I understand, if the problem is not resolved by October 1st, it can only get better from there.

MR. BECKJORD: Yes, that's right. It can only get better.

MR. VOGEL: That's unusual.

MR. BECKJORD: That's a good way to look at it.

MR. MORRISON: Eric, the information you had on the previous slide on the numbers, really all of your budget numbers, include both what it takes to operate your office as well the contractors, labs, whoever supports your office?

MR. BECKJORD: No, this money is just the money spent outside the wall.

MR. MORRISON: Just the money spent outside the wall?

MR. BECKJORD: Yes.

MR. MORRISON: So you have additional funds?

MR. BECKJORD: Our budget has about, I don't know, $12 to $13 million for the office expenses, salaries, and so forth.

MR. VOGEL: Would they be cut in proportion?

MR. BECKJORD: Possibly. I don't think that much. I don't think it would be cut that much in the proportion of 34 to 96.

MR. VOGEL: Are government employees facing reduction of work week? I know it's been talked about.

MR. BECKJORD: Yes. There has been a lot of that in the papers. The direction that I've received from the Commission is that it is not planning on furloughs in the NRC. I've heard that three times now and the last was Friday, that the agency is not expecting furloughs.

MR. SPEIS: At least not until the end of December. But if things get bad, there is the possibility after that.

MR. UHRIG: TVA is already issuing specifics on who will go on leave.

MR. SPEIS: This has happened to a number of agencies in Washington.

MR. BECKJORD: Well, if the past is any guide, in the last four years the time of resolution of the budget issue has varied from sometime in October to as late as December. I think a couple of years ago the issue was

resolved right around the holiday in December. So it could be any time in there.

Well, with that downer I'd like to get back to the budget and review, from here on out talk about the planned fiscal 1991 budget. We'll just have to deal with the Gramm-Rudman-Hollings problem if it arrives.

MR. MORRISON: Eric, when you discussed the budget, this chart you have up here reflects some priorities which I think may be of value to get your insights and the committee's perspectives on how you see the priorities. Maybe you'll be discussing that in your budget anyway.

MR. BECKJORD: Yes, yes.

MR. UHRIG: On individual programs, just a quick calculation, it goes from 17 percent to over 50. You just take the numbers: low level waste is 53 percent. The other extreme is the resolving safety issues which is only 17 percent under Gramm-Rudman-Hollings cuts.

MR. BECKJORD: Well, of course, what happens there, resolving the safety issues are near-term commitments that we have to the Commission relating to things like license renewal.

MR. UHRIG: This is really a reflection of the priorities?

MR. BECKJORD: Yes, it is. That's right.

The next impact of Gramm-Rudman-Hollings is on the

next slide.

(Slide.)

The way we have taken that, we have had to make cuts in programs. That large cut with Gramm-Rudman-Hollings would devolve under primary system integrity largely on piping. We concluded that we had already done the most that we felt comfortable with, with regard to reactor vessels.

So that certainly gives you an indication of where our priorities are.

I think the reactor vessel is probably the last thing we would work on; that is, we would continue to work on that as long as there was any money at all because of its obvious importance in safety.

We would have to defer major activities in severe accident research and we would have to defer work in the human factors and in waste management with that large a cut.

In each area the approach has been to maintain as much activity as we could so that we could start again in a recovery next year. In other words, we haven't just closed out any program in totality.

(Slide.)

This shows how you will be reviewing things. If we had five subcommittees, I think we would review it in the five categories that I've already discussed but we felt that we couldn't, we would be spread too thin to do that. So

there are basically your three subcommittees. One will be reviewing primary system integrity; second will be reviewing systems and severe accidents, and the third will be reviewing human factors and waste management.

These are the applications that each of the three of your subcommittees will be looking at in the right-hand column.

Primary system integrity follows the definition in the five-year plan information which you've received.

The systems and severe accidents includes the risk and reliability, the accident management, severe accident research, the individual plant examination.

The human factors, which is normally in that program, was moved into the third subcommittee in order to get some balance in your review activity.

So when you go into the sessions this afternoon, you'll be following this outline. However, I'm going to keep referring back to the original organization of material that we've had that you've been reviewing in the past and that was in the five-year plan because I would, it will really be convenient for us if your report addresses the original five categories appearing in the five-year plan if we can separate it out that way.

MR. ISBIN: The item resolving safety issues and developing regulations and so forth, that's not included in

any of these?

MR. BECKJORD: Well, since that's mostly application, you'll be hearing about that in terms of when we're presenting the research, people are going to be talking about the applications. Since the resolving safety issues is not really a research category, we did not devote specific -- but you're going to be hearing about it throughout.

MR. KINTNER: Eric, you're making these adjustments whether Gramm-Rudman or just the annual budget adjustments. How do you take into consideration the work being done by others? I don't know how much is being done by reactor manufacturers; certainly not near as much as it used to be. I don't know how much is being done in foreign laboratories.

Clearly that affects your priorities as well.

Are you able to talk to that? I'm sure some of the other members here already know all that -- how it fits with the decisions you make and priorities and budget adjustments?

MR. SHAO: We're going to cover that in the subcommittees.

MR. BECKJORD: We are specifically in planning this research on advanced reactors, that's one of the issues we're looking at now. That's one of the reasons that we had

the meeting with Westinghouse and we'll have meetings with General Electric, to make sure that we understand what they're doing so we want to avoid any duplication.

There are some additional things that we will undoubtedly encourage them to do. Then we will undertake work in the NRC that is appropriate to the NRC. Generally that follows the definitions that were suggested by the National Research Council Committee's report of four years ago. They addressed a lot their report to the question that you raise. They gave a pretty good treatise on how you do it.

Specifically there's a lot of work underway at EPRI which you are well aware of. We meet periodically with EPRI. We have cooperative programs in several areas with EPRI in which they do some of the research and we do some of the research. We meet with them annually to find out about their plans and they find out about our plans for the next year and we try to coordinate it.

In the international area we have many, many agreements. The most important ones are with Japan, with United Kingdom, with the Federal Republic of Germany. We have important cooperation with the Swedes in waste research and there's cooperation with the Italian study now on advanced reactors. So we're pretty well aware of what they're doing and we're able to coordinate.

MR. SPEIS: This is an integral part of prioritizing our efforts. For example, in the area of severe accidents because some experiments are so expensive, we have done activities with EPRI. I don't know if you're aware of the program Ace/Mace. The only way to do it is to do it jointly.

MR. BECKJORD: Okay. Let me move, then, rapidly through the next five or six.

(Slide.)

First on the accomplishments, the reactor pressure vessel programs: You'll be hearing about those programs in detail. I just want to point out the applications. The past research results have been applied to the resolution of the pressurized thermal shock issue dealing with what may happen to a reactor vessel in a condition of rapid overcooling in which the temperature is sharply reduced down into the range where the material no longer has its original ductility due to irradiation.

This was a very important issue a few years ago and the work that was done in research enabled the resolution by analytical means.

Reactor vessel supports. This has contributed to the review of that problem; the potential embrittlement of the supports for the reactor vessel due to low level, low flux irradiation.

Thirdly, there are 17 vessels in the U.S. that have nickel and copper content in the wells due to the Linde flux material that was used in welding. Those are more subject to embrittlement than the vessels that have been fabricated since. We're watching those very carefully. Here I'll talk a little bit about the Yankee-Rowe vessel which is kind of a first test case on license renewal coming up.

Then, of course, this has been and will continue to be applied to aging and the license extension question for all of the reactors.

(Slide.)

Piping research, the work that's been completed under there cite three things: primarily the proof of the high capability of piping systems to withstand high seismic loading. That's been one of the big, important results of the program.

Secondly, the leak before break work on pressurized water reactors. That's the conclusions of the studies and experiments that were done on the large reactor coolant piping and the conclusion if the chemistry is right and if the pipes are properly inspected that you're not going to have this sudden circumferential rupture, that such pipes will leak before they will break. That's made it possible to remove unnecessary restraints in operating

plants. There will be no unnecessary restraints put in new plants as a result.

Finally, the removal of those has made it possible for operators to save a great deal of labor and exposure while plants are shut down. They don't have to remove so much of the restraints from piping and so they are more quickly inspected. So the total exposure in the course of maintenance has been significantly reduced as a result of that.

Thirdly, the validation of the repair procedures for the recirculation piping on the boiling water reactors which was a serious problem a few years ago. I think the research program contributed considerable to the resolution of that issue and the approvals of the weld repair processes and so forth.

(Slide.)

Next, in aging research. That, of course, I think the aging research is one of our most important programs now because of the potential economic savings for the country in the renewal of these licenses beyond the 40 years for an additional 20 years. I think the investment value of that in terms of, you know, the financial discounting, I've seen numbers of $200 billion and more for the value of the additional life of those plants over that 20 years. So it's obviously of very considerable importance.

In the seismic and structural area, the work that's done there has contributed a great deal to the external events review which is getting underway now for all of the operating plants; the external events being earthquakes, wind, fire, and flood.

The seismic and structural programs were devoted to defining what the issues were and looking at the methods that would be acceptable in working with industry to develop agreement on how to carry that job out.

A week before last we had a workshop in Pittsburgh on the external event IPE in preparation for getting that program underway. I think it was a very successful meeting.

Reactor containment structural integrity. Certainly one of the main things that came out of that program was the proof of the very large margins over design pressure that the steel sphere containments and that the reinforced concrete containments had.

That has had a big effect on the things like the review of containment performance. Because if you look at the studies, the difference between NUREG-1150 and the studies five years ago, the probabilities of containment failure are reduced because of that additional capability which has been established.

(Slide.)

The next slide, reactor and plant systems.

The Appendix K best estimate analysis, that represents many years of work and very large expenditures. That's having a number of applications. One of them is that it has made possible the reshaping power in the core so as to reduce exposure at reactor vessel walls and thereby help to prolong life.

The thermal hydraulic method development also made it possible to resolve by analytical means the question of this low temperature overpressure for vessels, that problem for sudden overcooling.

Under severe accident evaluation, the work done there, the work done in 1150 has contributed a lot to the individual plant examinations of the containment performance improvement programs which we have reviewed with you and to accident management.

The work on hydrogen has had a number of impacts in the Mark I, Mark II and ice condenser containments; the requirements for igniters in Mark II and ice condenser containments.

(Slide.)

Next is human factors.

The past work relates mostly to the man-machine, person-machine interface in the control rooms, improvement of instrumentation and alarm systems.

The PRA. I've already mentioned 1150. It's worth

noting that in every one of the five plants that was reviewed in 1150 there have been physical improvements comparing the analysis as it was first one on the plants to the final conclusion because each of those plants made changes in the course of the work when they uncovered various problems.

The service water at Zion was one of the big examples of that; a problem in service water piping. There's a single run of pipe for which there's no alternate means of supplying service water.

As a result of that Commonwealth Edison has undertaken to make some modifications to address that. With they are completed with those modifications, the core damage frequence at Zion will be reduced by a factor of 10 or more.

So in each one of these plants there were significant improvements as a result of the PRA that was done.

Another thing that's come out of it is on the last line. As a result of that work, it's possible to do the PRA analysis on PC desk-top machines now. That has greatly reduced the costs of that and reduced the turn around time.

(Slide.)

Next, in the waste area the work on water flow hydrology and underground has already given us some important results relating to analysis of the Yucca Mountain

project. That work was done mostly at Arizona nearly the University of Arizona at a place called "Apache Leap."

In low-level waste research, most of that activity is devoted to assistance of the states in the regulation of low-level waste disposal sites.

MR. VOGEL: Is there a problem in timing on the waste work of not getting ahead of DOE? I would think it would be a little complicated.

MR. BURSTEIN: I don't think anybody can get ahead of DOE -- or everybody can.

MR. BECKJORD: Well, you have mixed feelings about that because the delays in the DOE program, our people felt that was important to them because they felt that with the delay that took place a year ago that their schedule was more realistic; that is to say, they would be able to produce the results needed for the review of the license on that new schedule. So that was a benefit of the schedule.

However, I'm not advocating a continued delay of that schedule just to say that our program was better coordinated as a result of that.

MR. TURCOTTE: Just as an aside. I don't know if everybody saw this article (indicating) in "Science" last week on high-level waste. Maybe it would be interesting to distribute it. It's sort of an editorial on high-level waste.

MR. BECKJORD: Yes. We'll get copies of it.

Of course there was a big meeting at the National Academy -- You may have been there -- a week before last. I think we sent you the report on rethinking high-level waste. The Academy has now met and there was a frank and open discussion.

I wasn't able to go to that meeting. But my understanding was that there was considerable comment on EPA requirements. So now it remains to be seen what will happen as a result of that.

MR. KINTNER: This talks and I think the Academy report talks primarily of the tail-end of the system and very little head-end. Are you doing research at all on glass containers and so forth, not just what happens after a fail.

MR. BECKJORD: We're doing work on the containers, on the metal containers, not on the glass, though.

MR. KINTNER: One of the reactions I had to that National Research Council report is it paid no attention at all to the form the material was in.

MR. SHAO: The container is supposed to last for a thousand years.

MR. KINTNER: A thousand?

MR. SHAO: Yes.

MR. KINTNER: Glass doesn't do any good?

MR. BURSTEIN: You're talking about processing now and that's an entirely different ball game.

MR. BECKJORD: We're looking at spent fuel.

MR. KINTNER: I'm talking about high-level wastes. I'm sorry. I just wondered if you were doing anything on that.

MR. BECKJORD: On the metal containers, on the materials.

MR. BURSTEIN: The package?

MR. BECKJORD: Right.

Earth sciences. We talked about the external event, independent plant examination, and adding to the seismic data base.

There has been quite a change in the view on earthquake magnitudes in the eastern U.S. and that would have contributed to it.

MR. BURSTEIN: Incidentally, Eric, if I may, did you indicate in your transmittal of that National Research Council report on "you can't get there from here" on waste, that you would be responding or commenting on it to us?

MR. BECKJORD: We prepared jointly with nuclear materials safety and safeguards a response to that. It went through several drafts because the final was not like the original. I think there is agreement on the comment that's made about the EPA standards. One of the comments in the

National Research Council report was that NRC should reconsider its regulations, that the regulations are too inflexible.

Bob Bernero presented his view on that at this National Research Council meeting.

I've reviewed that since and I think there's some misunderstanding because the regulations are flexible. They kind of followed the model of reactor licensing regulations in the early days. There is flexibility to modify them as experience develops.

So the agency's position is that they can make modifications as time goes on.

MR. BURSTEIN: But there is no formal response?

MR. BECKJORD: Yes, there will be.

MR. BURSTEIN: Oh, there will be?

MR. BECKJORD: There will be.

MR. BURSTEIN: There is none yet.

MR. BECKJORD: There is none yet.

I think I can certainly get the committee a copy of what was prepared. I'll do that.

MR. MORRISON: It sounds as if there's interest in this matter.

MR. BECKJORD: We'll get you a copy of that.

I think is going to be the basis of probably a Commission-approved response shortly. The Commission had

not approved that so that's one of the reasons we're waiting.

(Slide.)

I'm just putting this on to recall the structure. This is the structure in the five-year plan of the reactor component integrity under these four categories.

I think I don't need to say any more about that. In fact I'm running out of time so I'm going to move ahead quickly.

(Slide.)

The future research. Here's an outline and examples of the things that you're going to hear about in detail this afternoon.

I would say that the most important issues before us now, the urgent issues relate to aging and license renewal.

I mentioned Yankee-Rowe.

Yankee-Rowe is operating now. It had a shutdown this summer. As the information was presented to go back to operation, the matter of the mill ductility transition temperature was reviewed carefully again.

A couple of things turned up that had not really received a lot of attention before. Probably the most important one is that the operating temperature of the Yankee vessel is about 50 degrees lower then most of the

other pressurized water reactors, about 500 Fahrenheit instead of 550 Fahrenheit.

The temperature of the vessel affects the rate of embrittlement; that is to say, the lower the temperature of the vessel for a given NDT, the higher the increase in mill ductility transition temperature.

So although the flux is not higher than expected, the transition temperature is higher than expected. There is some considerable uncertainty about it but the best estimate now is about 350 degrees Fahrenheit.

Now, this would present a problem is there was, you know, a sudden reduction in temperature in that vessel. That plant is such that the probability of such an event is a very low probability. And it was on that basis that approval was given for the plant to go back into operation for the next cycle.

The license extension is coming up and this is going to get a very careful review. It has been reviewed by NRC's consultants.

We're going to be doing some more work, more research relating to the questions on the Yankee-Rowe vessel, not only for Yankee-Rowe but in the anticipation of many of the same questions that will come up with respect to the 17 other vessels that I referred to.

So we prepared a program. We are going to be

starting some new work this year relating specifically to the Yankee-Rowe vessel and to other vessels that will be following along.

MR. UHRIG: Does it have any copper?

MR. BECKJORD: Yes. It has high copper and nickel. In addition to that the cladding is stitched. You know, it's spot-welded cladding as opposed to deposited cladding. So there are some unique features about that vessel.

MR. SHAO: It has very high nickel, .62 percent nickel content. Very high.

MR. SPEIS: Versus?

MR. SHAO: Versus around .1.

MR. BECKJORD: For the others, yes.

Let me move on, then.

MR. ISBIN: Is annealing part of your research?

MR. BECKJORD: Yes, yes. We're going to cover that.

(Slide.)

Seismic and structural research.

On that first item, prestressed concrete containment vessels, there has been a lot of interest in Japan and possible cooperation with Japan in doing a test somewhat a model test as was done in the case of reinforced concrete that's an important part of our expected work.

We're still working on the seismic questions for advanced reactors; that is to say, the operating basis earthquake and the safe shutdown earthquake.

I guess the most important thing we have to do there is the last one on the list which is to resolve the issue between the two hazard curves for seismic disturbances: one the EPRI hazard curve and the Lawrence Livermore curve.

We've discussed this with you in the past and there is a discussion on it in the peer review document 1150 which you have.

(Slide.)

Core damage prevention. Just to remind, again, this is the structure of that program, the one which is discussed in the five-year plan.

(Slide.)

If I could go to the next now on human factors.

We completed this year two studies: one done at a fossil-fired Pittsburg, California, station of Pacific Gas & Electric on management and organization. That was a year ago.

Then we completed this year a similar study at the Diablo Canyon unit.

On the basis of that work we think that we have a workable method of characterizing and describing the

organization and management at a nuclear plant. Now we need another plant to go out and test that method: to do kind of a control test on it.

So I hope we will be able to work that out in this year.

With regard to the risk assessment, we have completed 1150 but we've undertaken some new studies of risks at low power and shutdown modes of operation when a plant is in maintenance. We learned from the French who undertook studies in their plants. This was a couple of years ago. Brian Sheron was there and he heard about the study which they had initiated. We thought about it and he recommended getting that work underway here and that work is underway now.

The surprising thing about it is -- it may seem counterintuitive -- the risks of activity release are more than you would think for the shutdown conditions. There are various reasons for this.

MR. BURSTEIN: The question is whether they are significant from a public health and safety point of view to establish a level of priority for you.

MR. BECKJORD: That's right and that's what the study will show; whether it is and to what extent it is.

MR. ISBIN: Did the French find that about half of the total risk was in these other modes?

MR. BECKJORD: Yes. But it's due to outages of equipment for maintenance and repair and it's something that you can manage, I think, quite readily by just paying attention to what's out of service at any one time, including diesels and that type of thing.

The last item on the page is another activity which is getting underway. Research some years ago with the help of Oak Ridge developed precursor analysis, a way of analyzing operating data at plants to single out the really important events and to thereby not only get that information just to find out what they were but also to infer what the potential core damage frequencies would be from those events.

The models that were used and in fact are used today are generic models. As a result of what's been done on 1150 and with these improvements in the codes, PRA codes SARA and IRRAs, it's possible, we think, to be able to load the information coming out of the individual plant examination into these codes rather quickly and do an improve precursor events analysis; we'll get better information from it. That's getting underway this year.

(Slide.)

Okay. Reactor containment performance.

These three categories are the ones you're going to be looking at.

(Slide.)

Future research.

On that completion of the TMI reactor vessel sample investigation and completion of the work on characterizing that accident.

Direct containment heating is the second items.

Completion of work on Mark I containments.

MR. BURSTEIN: That's a wonderful word. I see it for the first time, the word "completion," the word "closure," the word "let's get something done, declare victory and go on."

Nothing ever seems to get finished under the term "research.

Some day I hope there will be a criterion established that one of the definitions is when do we sign off on something and go on to the next thing. I realize the ongoing nature of information and development and its potential application. But when were fighting this budget battle and we're trying to indicate certain accomplishments, it seems to me, Mr. Chairman, we ought to find a way of finishing something once in a while.

MR. BECKJORD: I accept that. I think we're doing that. Since I'm taking longer than I thought here, I'm not going to respond to that directly.

MR. BURSTEIN: It will take a couple of weeks to

do it.

MR. BECKJORD: I want you gentlemen give two examples each at least in each of your areas where we've signed off on something.

MR. MORRISON: Sol, I hope you'll bring up that point again in the second part of this morning because I think that's something we ought to factor into our overall review of the research programs and the guidance we can give with regard to completion of work.

MR. BURSTEIN: Larry and I have had some particular interest and discussions on this subject far into the night.

MR. BECKJORD: Okay. I want to try and finish up in a very few minutes.

(Slide.)

Let's go on to the next chart here on the future research in high-level waste.

We've already talked about the container and barrier performance. A lot of work to do in the geohydrology.

And in low-level waste these matters which, as I said, are primarily in support of the state and other regulatory agencies.

(Slide.)

Next one, future research in support of advanced

light-water reactors. That doesn't say "light-water reactors" but I think for this coming year it means essentially light-water reactors.

The Commission is in the process of setting its priorities on the review of advanced reactors. The ones that are on the candidate list are the new boiling-water reactor, the Westinghouse pressurized-water reactor, the Pius, the Kandu reactor which the Canadians want to get licensing approval in the U.S. for, the gas reactor, and the liquid-metal cooled reactor.

There has been discussion of that in Commission hearings and they are in the process of setting the priorities.

We are preparing -- you could go into this more in the later sessions -- a program for advanced reactor research on light-water reactors. We will have that plan in draft form the end of October. The subjects of that research are the ones that are listed here in engineering and in systems research.

There are new materials forthcoming in these plants. Steam generator tubes is one example.

There are significant changes in the design: piping and fittings for the pressurized water reactor.

In the systems area there is a very different approach being taken to the engineered safety functions.

There are passive systems that are proposed now and there is a trade-off between, there are fewer of these passive systems; that is to say, whereas you had three active systems for a low-head pumping for core cooling, now you might have a one passive system for higher pressure and one passive for lower pressure.

A very important question relates to the reliability of these passive systems. We're going to have to study that and understand how to do it. In a sense it makes the passive engineered system somewhat analogous to the reactor vessel.

So you're going to have to set up some means of establishing from time to time that it does have the reliability. It's a very different problem from the --

MR. KINTNER: Eric, I'm really surprised at that statement because it's news to me. I thought that every acquired system was at least duplicative, no matter whether it's Westinghouse or what, but that's not what the requirement document says.

MR. BECKJORD: Well, I know there's that issue.

MR. KINTNER: That's beside the point here.

MR. BECKJORD: I mention that because it is an issue that is on the table.

MR. BURSTEIN: It seems to me that this is an important issue in the sense that if, indeed, the NRC is

going to engage in a long-term expensive research undertakings on the basis of misinformation or something that is not going to be reflected in a requirements --

MR. KINTNER: It's easy to square away.

MR. BURSTEIN: -- the basis needs to be established for it.

MR. BECKJORD: Well, --

MR. BURSTEIN: There are differences I think we recognize and they have to be understood by the regulators as well the industry.

MR. BECKJORD: I do think that as a general comment from what I saw of the Westinghouse design that they have extensively used all of the experience. So it has a great many features going for it in that respect. But there are some new concepts and we're going to be addressing those as to what they're doing about it and what we might have to do about it.

I think we could talk some more about that.

MR. KINTNER: That is really a fundamental point.

MR. BECKJORD: Right.

(Slide.)

A need for a strong research program.

These are the seven, I think, key points to be made on why we need a strong research program. Others can speak to this more than I can but since I've been here,

which is the last four years, the research program has been involved in many regulatory decisions taken throughout the year. We've talked about some of them. That's really the Number One priority that we respond to.

Rules, guides, and standards.

We have done some internal review this year and what we find as a result of that review is that we have many regulatory guides that need to be brought up to date. We're going to have to address that.

With regard to standards, with the resurgence of new plant construction as a strong possibility in sight, we have to thing about standards because the work that was done on standards is very good but it was done years ago and it does not in many cases incorporate experience and knowledge developed since then.

So that's going to become more important with the advanced reactors.

Resolution of technical issues.

The site there, the human factors issues, completion of severe accident work, the resolution of the severe accident issues on the operating plants.

Maintaining the technical capability.

It is very hard to sell programs on the basis of maintaining technical capability for some possible future need. In fact, I'd say that's probably the least successful

pitch that you can make. But the fact is it's important. If you don't have the capability, you're not going to be able to solve problems. I think I can convince you of that. It's more difficult to convince the --

MR. UHRIG: You're talking about in-house capability or contract capability?

MR. BECKJORD: Contract capability primarily.

Risk assessments.

As you saw in the report on 1150, that got a strong endorsement from the peer review group. That's a very important part of the individual plant examination program which is underway.

Develop waste disposal.

What we're really saying is that the information related to the licensing for the construction of the repository is what we're talking about.

And the advanced reactor requirements which we've touched on.

(Slide.)

Okay. The organization of the presentations to the subcommittees is given here on this. It refers to the elements of the five-year program. You may want to refer to that during your subcommittee meetings.

(Slide.)

If I could go on to the committee report now.

It seemed to me that I'm tossing these questions out for your consideration, some of the questions you may want to pursue in this review and in your report.

Our program is in response to regulatory needs. Are these needs clearly defined?

Do you have any comment on the needs? I add that to this list here.

Is the research focused on the needs?

Do you have any recommendations for changing emphasis on the research programs?

Are there gaps or missing elements? Or considering that our budget is going to be over the next year -- our budget is not going to expand in the coming year. If you feel there are gaps or missing elements, do you have any recommendations on scope that could be reduced in order to provide for a missing element.

So I think those are questions that you will want to consider in approaching the preparation of your report and there may be others that occur to you.

(Slide.)

I said when I started out I thought that we would like to see a report by the end of November, say something that's close to a final draft at the end of November.

There's a lot of work to do on that. We're prepared to help. In each of these areas the division

directors and the deputies will be available to help and we will assign a staff member to work with your subcommittee and we will assign more if need be in order to carry out the work on our side that is necessary.

I think we can provide information. We can answer questions. We can develop position papers at your request for consideration by the subcommittee. And we can take care of the word processing aspect of your report and circulation of drafts for comment and that type of thing.

I think I've talked long enough, Mr. Chairman.

MR. WOODS: You mentioned a draft report in October on the research plans for the advanced reactors?

MR. BECKJORD: Yes. We will have a draft at the end of October.

MR. WOODS: Will we be able to see that prior to putting out our report?

MR. BECKJORD: We can certainly communicate that to you. We can discuss it; what our ideas are today. It really isn't on paper yet but we can get that to you. In fact we can probably get a preliminary draft out.

MR. WOODS: That would be very helpful.

MR. KINTNER: When you make curves like the ones you showed at the beginning, the trend of the budget, do you ever add into that examination all the other expenditures on research that are going on? DOE is certainly going down

hill. The suppliers are certainly spending less money as time goes on.

The total, therefore, on research technology to be accurately reflected is probably deteriorating a lot faster than this curve shows.

MR. BECKJORD: Well, both the Westinghouse and the GE efforts are funded now in part by DOE.

MR. KINTNER: That's the advanced reactor.

MR. BECKJORD: Oh, you mean for the operating reactors.

MR. BURSTEIN: What does that imply? That they should be dropping faster to be consistent or picking up more to take up the vacuum.

MR. KINTNER: I think what this groups thinks as to research and I suspect maybe this committee thinks that there should be a stronger research program considering the size of the industry in the United States: 106 reactors. That's what it's running now. But the totality of funding associated with research supporting it is going down much faster than his curve; that's my suspicion. That, it seems to me, would be a strong argument for support in the future.

MR. BECKJORD: Specifically to answer your question, a couple of years ago we compiled information that we could get our hands on, on research expenditures outside of NRC. I don't have that for this year.

MR. UHRIG: Certainly the EPRI budget's gone down. Right?

MR. BECKJORD: Yes.

MR. SPEIS: I think possibly, Larry, you might shed some light on this if you take one area, aging in license renewal, the industry, of course, is committed to the program. We should take a look at what industry is doing in addition to what we're doing on this activity alone.

MR. SHAO: We have some idea about aging decisions for industry and we can give it to you this afternoon.

MR. TURCOTTE: It seems to me the basic question that keeps coming up is whether one is supporting research for a dying industry or whether there is really any hope for the future. It seems to me that the research part of it has to sort of focus on that question. I don't know how you do it.

MR. SPEIS: Well, what did you mean by a dying industry?

MR. TURCOTTE: There will never be another reactor built and no reactor will ever be recertified. I think that's a real possibility.

MR. SPEIS: But you still have a hundred or so reactors operating for quite a few more years.

MR. TURCOTTE: That's what I mean by a dying

industry.

MR. BURSTEIN: What is the justification between the number of reactors operating and continued research? That's a connection that I as a committee member would like to have you make; not that it's a prima facia fact that because one exists the other is essential. I don't think that's correct.

MR. SPEIS: No, you're right. That connection has to be made. The classic example again is aging. We have examples of that, the license renewal activities.

MR. BURSTEIN: Aging begins the day the plant goes into service; the minute you're born. If we haven't managed it properly since the Atomic Energy Act of its origins in 1947 or its amendments, there's a question as to what is new except information to understand it better.

Really, the initial term . . the operating license must include aging phenomena essential to safeguard public health and safety. If we haven't been doing that, you haven't been doing your job and a lot of us think you haven't been.

MR. SHAO: So there have been a lot of surprises. For instance, like the Yankee-Rowe vessel -- okay.

MR. BURSTEIN: Well, if you didn't lose the specimens, Larry, you'd know what was happening at Yankee-Rowe.

MR. SHAO: You're right. We had to guess. On Yankee-Rowe there are a lot of surprises we didn't know; that the low temperature has such a dominant effect. We know it's important but we didn't know it was that important.

MR. BECKJORD: Well, coming back to Don's point, I think that is a possibility but my sense is that over the past year there has been a shift in thinking about the future. I think it's shifted towards the expectation that there is going to be a future in this country for new nuclear plants. Maybe by the time five years is past there will be new orders.

MR. MORRISON: I think that's a subject worthy of discussion. We at Mitre held a conference about a week and a half ago on the subject of the future of the nuclear industry. We had a variety of parties there ranging from the vendors to the industry, to the regulators, and the financial institutions.

I think two of the very significant comments came out; one from the utility who said: "We will never order another nuclear plant. That's the early retirement for CEOs if you order another nuclear plant." And the financial community responded that "we will not fund a nuclear plant unless we're assured that it can be licensed and that there will be an ability to pay, back them up."

MR. BURSTEIN: These are institutional questions. It's interesting you should bring this up.

Did anybody in this conference identify a technical issue that might help or hinder future nuclear power?

MR. MORRISON: I think the underlying issue, Sol, that was raised was not technical, it was a matter of trust. How does one establish or reestablish trust first in institutions and as much blame was laid on the regulators as well as on the industry that there's a lack of trust in the institutions, a lack of trust in the process which hasn't to this day in most people's minds been a really open process on that. And then some discussion as to what would it take to reestablish trust and no real agreement unfolded.

Unfortunately that was the lack of the conference; that nobody got into the details of what it would take to convince you that things have changed after, say, maybe 30 years of good operation.

MR. BURSTEIN: This may indicate, Mr. Chairman, a question as to which direction or where the emphasis should be placed on our research activities.

One of the things that I think we are all aware of and perhaps we have different sensitivities to are the criticisms that have been levied against a number of parties to the nuclear field, including the regulators.

There have been some suggestions that regulation is uneven, it's unpredictable, it's uncertain. And the last blast that I know of is a letter from Larry Minnick which you may be aware of.

There has been some suggestion that the NRC itself needs to look within itself to perhaps -- for a number of different purposes that I won't enumerate.

But one of the questions is: Is there any ongoing internal NRC effort, including a research effort, required to examine the regulatory process and its implementation and if not, should there be?

Might we perhaps have an opportunity to discuss that internally to the subcommittees and later perhaps with the director?

MR. MORRISON: I think it's a real worthwhile topic to bring up. Certainly the obvious question is whether regulator is the organization that can do the soul searching and come up with the answer or whether it has to come from some place else.

But I will mention since Neil Todreas just came in that MIT is having a very similar conference in the very early part of October on the future of the nuclear industry so there will be a second set of information come out in a very short period of time just really addressing the question you raised on is it dying or is it reviving? Good

question.

MR. BECKWORD: There is a document, I think it's available now. It's called a regulatory impact survey which the agency has done interviewing representatives from the licensed utilities and getting very broad opinions on what the consequences of regulation have been.

One of the focuses that's come out of it is on inspectors and the need to do a better job of defining what it is that an inspector should do and follow up on that.

I'll look into that.

Is that available, Jack?

MR. HELTEMES: Yes, it is. It's a NUREG document.

MR. BURSTEIN: It's been published and I think some of us have seen it I'm sure.

MR. SPEIS: Minnick's letter is a result of that.

MR. BURSTEIN: And he refers to it.

MR. SPEIS: He refers to it. That was the incentive for him writing the letter.

MR. MORRISON: It sounds to me if we could get both of those documents it would be useful.

MR. BURSTEIN: I think it's 40 years of itching is what it really is.

MR. MORRISON: Well, let me propose we take a 15-minute break and come back, then, and talk about how the committee really wants to approach its task and where we

want to end up.

Eric certainly has given us some guidance as to what he is expecting which has been very useful. His presentation obviously has been very good for setting the stage for the work program this afternoon.

Let's take a 15-minute break.

(Recess had.)

MR. MORRISON: What I would like to do is reopen the discussion here on how the committee should go about doing this review and assessment we're going to do over the next day and a half.

First of all, I'll go back to the fact we're supposed to deal with the strategy and content of the research program designed to meet NRC's essentially regulatory requirements.

Eric I think in his chart on page 26 has laid out a number of the questions that we need to address from that standpoint.

But I think we as a committee need to try to get some common understanding of what we want to do here, what we believe is important so that in each of the subcommittees we have a set of marching orders somewhat in front of us.

What I would like to do and probably figure on breaking for lunch around a quarter to 12 so we can get a jump on the restaurants here in the area, that gives us

about an hour and a half; that if we could reach some agreement on what the requirements are for research within the Nuclear Regulatory Commission and what strategies at least appear to be preeminent from our standpoint before we break for lunch. Then as we get into the subcommittees we can address the individual program content and how that supports the particular strategies.

So let's open up the discussion, then, and talk about:

What are the general requirements for research within NRC and what are the various roles that the research should support?

What goals should it address?

What general aspects should guide its priorities?

Where does technology fit into all of this?

Eric, of course, started this morning and talked about the aspects of confirmatory research as well sort of exploratory research so that's one dimension of that particular problem.

I suspect maybe we should go back to what we were discussing just before the break. Don Turcotte raised the issue about a declining industry and whether that should be a guiding factor.

Are we talking about something that's stagnant or are we talking about the future?

Let's just start from there and see where we go on what's the requirements for NRC's research program.

MR. VOGEL: NRC takes the attitude that it is a declining industry. It might be a self-fulfilling prophecy. I'm a little reluctant to make that assumption and push it downhill.

MR. MORRISON: Well, let's put it in the positive mode, then.

What's the balance between advanced reactors and the existing reactors?

What are the requirements for research given those two modes, setting aside for the moment whether advanced reactors will be a reality?

MR. TODREAS: Let me take that as a lead in for a little soap box because I've been thinking about this meeting. I hope I come in on target with where you are.

You asked for the requirements for research and hence the different dimensions. My biggest reaction to that is, there's a golden opportunity which is probably once in the next 20 or 30 years to restructure or reexamine the whole regulatory framework because of the advanced reactor thrust which the NRC is going to have to deal with anyway. They can deal with it with the structure that's been used before with maybe a few little Band-Aids put on it which is the track they're on or between the regulatory side and the

research side they could review and attempt to put together a new framework.

In a sense we as a country have asked and pushed the industry to rethink the framework and the design of reactors. If you take, say, the medium-sized reactors, the whole approach is rethought and restructured. Yet from the government's side I see no motion really to come up with a parallel and a comparable approach to that initiative from industry.

I think that's bigger than the initiative that is possible from the research director's side.

I looked at the Commission's list of priorities twice now: originally when it was put out and I think it was the July issue that Ralph sent to us at my request.

An initiative like that has to come from the highest levels. It's not there. It's not on the agenda.

But coming back to our framework which is the whole structure of the research program, if such an initiative came, it would be very demanding on staff time and the number of staff involved.

Therefore it would curtail certain thrusts in the research side, certain programs.

There just wouldn't be enough people.

So it would be a major restructuring of the whole research program. It would be more than just what to do for

advanced reactors. It would be things cut off from existing reactor programs because of staff constraints. It would have major implications on the regulatory office side which is not our prime agenda.

That's basically my point.

I really favor that. I think as a country we're missing the opportunity. I think it undercuts the whole thing we're asked to look at because if that were to be picked up, that would change drastically, alter drastically the research approach.

MR. MORRISON: Neil, at the risk of going into a whole lot greater depth, I wonder if you could elaborate a little bit as to what you see the change in the framework and address it in the context of how does that affect the research that has to be done, recognizing that there still probably remain two classes of people performing the research: those that are being regulated and those that are regulating.

I think our charter addresses those who are regulating and what research should the regulating side do. Regardless what label is on it or what structure it has, how does this framework change affect that?

MR. TODREAS: Well, for example, we have a research program in human factors which deals with trying to assess the management of utility programs and how the

management of utility programs has an impact back down on safety. That program is a research program but it's basically an exploratory program on a major question which was requested from the regulatory side. If we were to ever answer that, it would affect how the regulatory side actually deals with management in their regulatory activities.

To me I call that research. We've accepted that as research. We've had a lot of discussions on the details but in principle this committee has agreed to its continuance.

What I'm talking about by a research activity in the broader sense is an activity defined at how to structure the licensing and review of the next generation of reactor plants.

It's not research where you go out and do experiments, thermal hydraulic experiments or electrical -- how motor operated valves open and close. It's a research effort nevertheless in how to restructure the regulatory process.

If you ask why is that needed, my understanding is that the regulatory process we have in place now is the one that evolved over the last 25 years in phases with layers of additional regulation for different issues that came up being evolved step by step but not integrated as a whole so

that there is inconsistencies, overlaps, and the whole label of proscription applied to that.

Let me st p here because we want a dialogue.

MR. KINTNER: Can I take another cut at this?

I would like to talk to two questions: First, the one that Don Turcotte raised and you raised and then to the one that Neil raised.

The first is, I'm coming from the utilities and seeing what is going on I think nationally in the utility framework.

I agree with your comment that somebody made at your meeting that it's a sure way to get fired for a chief executive officer to propose building a reactor system.

On the other hand, in the last six months there has been some indicatio.. chat is no longer true, at least subsurface.

Here is a case where we in the advanced light-water reactor program made a presentation to the NPOC -- I think you know what NPOC is -- and suggested a certain course of action. They pushed us to take a fur[illegible] course of action be[illegible]ond that. That was reported for the first time in "Science News" last week in which there is an overall program plan laid out with the various building blocks which need to resolved before there is a real resurgence in nuclear power in this country.

The nuclear power oversight committee accepted that plan this week and it is now public and I think is going to be made further public.

What it does is break down the elements of the nuclear power requirements for some new construction. There are 14 different areas. Some of them are obvious and some of them are less obvious.

One is public acceptance.

One is regulatory stabilization.

One is waste disposal.

One is the design in detail and certification of this new generation of reactors.

Each one of the various agencies like USCA, ANEC, EPRI, the utility steering committee, has assigned responsibilities to carry out that function.

There are the senior utility executives like the ones from Duke and Carolina Power and so forth who have significant interest in that going ahead.

Simultaneously the Department of Energy has indicated and has already proposed to spend $50 million in each of the passive plant designs to take us from conceptualization to preliminary design and there is now a discussion that there will be detailed design which would be industry shared 50/50.

What I'm suggesting is that all the elements of

opposition which leads to the kind of comment you make and that you report are there. But for the first time -- and I've watched this now for 10 years -- there is in the senior elements of the industry a need to put something together which could lead with the proper kind of work on the part of all hands to something that would cause new constructions to begin.

As part of the advanced light-water reactor program we have done, I think, a thoroughly good job of analyzing all the data out of the last 15 years of operation and coming up with new conceptual designs as represented in your requirements documents which have a demonstrated factor of 10 improvement safety core damage in the case of the evolutionary plants and another factor of 10 in my judgment, although it's far from complete, in the passive plants.

That is, I think, significant. I mean, nobody's going to argue about the specific definition but its' there.

Now we have just this last week sent to the NRC a full set of all the requirements documents on the evolutionary plant. We expect to have some sort of safety evaluation report by six months from now and a year after that on the passive plant. Then there will be established a technical basis for a new generation which is also a technical basis for standardization and a technical basis for a new regulatory approach to these designs.

I would now answer the second question -- and I don't want to create any havoc in the ranks of the regulatory people sitting here.

What we have said in the reconceptualization is two things: The first one is, we're going to concentrate on avoiding the accident first and foremost before we put in all the severe accident protections. And we've done that. A dozen different fundamental steps have been made: reducing the temperature, reducing power density, putting in reactor vessels that don't have welds where they can be affected by neutrons and so forth.

That's being accepted without much comment at all as if it's a given by the NRC staff.

We now get to talking about severe accident matters like cores on the floor and source terms and so forth.

In this case we say, a great deal has happened in the last 10 years. There is research data. There is information coming of TMI-2 and other places and ought now to look at these matters in as sound and technical way as we can first and foremost. Then we have to talk about how much of an additional protection to put on for uncertainties.

We're finding it very, very difficult in dealing with the NRC staff to get that attitude across; that the salvation in terms of additional safety and I think the

salvation in terms of a healthy, eventual new generation of reactor plants comes from a solid technical work on the design inputs and the expectations. And that's the hard thing that I see for regulators who have come up through 20 or 30 years of the present kind of circumstances to face up to honestly.

MR. BURSTEIN: May I ask whether you're pursuing the question of what is necessary versus what is possible?

MR. KINTNER: That's part of it.

What is necessary is the thing you deal with when you talk about it technically but what is possible is another matter.

Let's take the matter of hydrogen. We come to the point of trying to design a containment to really understand what should be done from a design point of view with regard to hydrogen, they come up with 100 percent zirconium and 13 percent technibility which I am absolute sure isn't right. But the answer is: "Well, you can put in a system that detects how much hydrogen there is and you can put in a computer that says what you do about what parts of the plant you burn. Then the computer will turn on the igniters. Now you take care of hydrogen."

I don't know if you understand what I'm trying to suggest.

That's the difference between what's possible and

what's really needed.

MR. BURSTEIN: Mr. Chairman, one of the things we have been struggling with has to do with the beneficiaries or the users or the clients of research as practiced by the division of research.

To what extent is the RES total effort governed by the requests of its clients as opposed to its own initiatives?

Does it have the opportunity to initiate any of the necessary research programs as we may suggest to it as opposed to what is mandated to it by other parts of the NRC that it is supposed to serve?

Is that a fair question to reemphasize again at this point?

MR. MORRISON: I think it's a fair question.

MR. BURSTEIN: If we take up, for example, the subject matters that both Neil and Ed have presented, we may be getting back to Mr. Taylor's question to this committee, fundamentally as to what the role is.

But it seems to me that a great deal of this effort on RES' part, if not all of it, is demanded by their clients.

Is it fair to be able to ask now whether we can distinguish between those?

MR. MORRISON: I think that's a fair question and

really break your subject into two parts.

One is, what is the current program? Can you identify distribution between request versus initiative?

And then open the discussion as a second part, what should it be?

Well, Eric, can you or someone on the staff respond to the first?

MR. BECKJORD: Well, the research program is in response to the Commission's needs and the various people define those needs.

The Commission defines needs.

The executive director will define needs.

The bulk of them come from the offices, nuclear reactor regulation, nuclear materials safety and safeguards, and the analysis and evaluation of operating events, those three offices.

Before this year about 75 percent of the research that was done was in response to the articulated needs.

MR. BURSTEIN: Established by others?

MR. BECKJORD: Yes on a 1-, 2-, 3-year time period for answers to be forthcoming and about 25 percent was exploratory, longer range effort that in practice has turned out to be productive. There are a lot of examples of this.

MR. BURSTEIN: May I ask who established the needs for the exploratory work?

MR. BECKJORD: The research office. But the expectation is that work will pay off for the agency. We're not in the development business.

MR. BURSTEIN: I understand that.

MR. BECKJORD: The fundamental charter in the legislation is very short. It says "confirmatory research" is the scope. The interpretation of that has been that includes this exploratory scope of work. As I say, the research office is one of the definers of regulatory needs because of the generic issue program which is the responsibility of the research office. So there are needs generated through that. Really there are two sources within the research office: the problem solving and issue resolution side and this exploratory longer range work of which, for example, I think the human factors -- the work that Neil brought up on human factors was exploratory when it began.

MR. TODREAS: I have one other broad issue which I'm sorry I'm bringing in a second thing before we finish the first but we can always come back to it because you're talking about the requirements for research.

I think if you look at this whole program, there's a fundamental mismatch in certain areas. Those areas are human factors, waste management, and health effects, between what could be defined as the needs and whatever could

possibly be done given the research money even with somewhat of an improvement in the money. Whereas i the primary system integrity and the systems and severe accidents, we could probably make adjustments -- we call it "tinkering" -- within some percent that's realizable.

But I think that's something that the committee has to deal with somehow in total: first, see if you agree with this whole presumption I'm saying, and second, whatever can you do with it? Because human factors was actually regenerated and put back on the table and it's been hell through all these constrictions and ups and downs.

That one, I think, may be debatable. But I think waste management and health effects -- there really has to be some thinking generated on how the NRC within what's realizable can actually meet the needs and be effective.

I think we're miles away in those areas.

MR. MORRISON: Neil, to kind of calibrate that a little bit, are you saying that's an all or nothing situation with regard to RES putting money into this area?

MR. TODREAS: Yes. I don't think I could bring myself to stop doing things there but I'm motivated to try to rethink the fundamental basis and criteria -- let's say waste management, health effects -- to try to define really what can be done or what should be done. I don't think we've gotten there and I guess I don't think the office has

really gotten there.

I think we've all been struggling to keep things alive, keep it technically based but we haven't been willing to face what I think is a brick wall between the needs and the resources over the next five years.

So I am not -- I didn't bring this up to advocate we ought to pull out completely. But I was trying to bring up what I think are the biggest global issues in this program. I think the things I've mentioned are what I think are the two.

MR. BURSTEIN: In looking at the specific budget numbers, one sees out of the professed FY '91 numbers some preponderance, almost -- well, I guess if you counted up the numbers, it would be over 80 percent in things like reactor component integrities, reactor core damage prevention, and containment performance. I can't separate from this summary sheet the protection from radiation of that. And what you're suggesting, do I understand, Neil, is that those amounts might be reduced, not eliminated, to see some of these other issues like waste issues, safety issues, and developing regulations increase?

MR. TODREAS: Yes. What you're doing is: I put an egg on the table and you're asking me to fry it and come up with an answer.

MR. BURSTEIN: If you don't mind.

MR. TODREAS: If I'm pushed, what I would say is we ought to strip off the mask and call the emperor an emperor without his clothes and really lay it out on those two issues.

I'm not saying we should emasculate the others and cover ourselves. In fact I'm saying just the opposite.

But I guess I don't feel in the reports I've written and we've summarized for the last 2-1/2 years that we've come together as a committee we've really called this fundamental mismatch in certain areas.

We didn't do that because our focus, I think, was first getting on the ground, making a technical assessment, trying to review the contract, the staff, things like that.

Now we have an opportunity, we're even asked, to make these global judgments and that's what I'm coming up with.

MR. TURCOTTE: It seems to me the committee is faced with a problem which there is engineering on one side and geological problems on the other side.

As long as you're talking about engineering problems, you can almost build a fail-safe system, maybe not absolutely.

Therefore when you come to reregulation and new plants and safety and all that, you can make an extremely convincing case that things are okay and you can

essentially guarantee that.

But when the critics come forth and want to prevent this, then they go to things you can't define like the seismic hazard. You simply cannot define a seismic hazard. You might start to make an effort. You might push forward but it's not absolute.

This is where the faults that are alive for so many millions of years come in and it's also a hundred-thousand-year lifetime or 10,000-year lifetime for a repository. These are sort of uncomfortable situations.

I think Neil's point is, maybe: forget about those.

But I think there has to be a balanced program but I don't know exactly how you're going to satisfy the critics with these. I think that's the problem you're going to be faced with for the next 10 or 20 years.

Certainly things have improved in seismic hazards.

It seems to me that seismic hazards are to some extent what made nuclear power plants uneconomical. Maybe that's too strong a statement. But certainly they drove the costs up an awful lot.

Now you're faced with a waste question and just how to satisfy people's concern that you don't get this dispersion of waste under some extremely improbable situations.

I think that's the crux of the dilemma.

MR. MORRISON: Eric, did you want to jump in with a comment here?

MR. BECKJORD: Well, I just wanted to ask Neil if you take these one at a time.

In the waste area, are you saying that the scope of what we're doing is not sufficiently inclusive?

The scope of what we're doing is really to support the process of licensing of the waste repository right now at Yucca Mountain.

Are you saying that with respect to the job that's on the table we should be doing more or are you saying that the licensing is too narrow, you ought to be doing something else in addition to answering questions relating to licensing?

MR. TODREAS: In the first instance I'm thinking that the scope doesn't include seismic and volcanic or the tectonic issues and that was pointed out in our previous letter. I remember the debate and the discussion we had versus site specific and general work and then the issue of whether we were relying on the DOE or the NRC.

I guess I'm not just limited to that.

One thing is the scope of the research but the other thing in the waste area is somehow gathering that research and thrusting it up, put the licensing issues up

front on display early enough to affect things.

I have the feel that we -- "we" being DOE -- are nationally kind of moving down a road and that the licensing base from the NRC, the issues are already recognized, somewhat recognized, but they're not joined and there's no corrections coming in.

I then take that feeling and somehow feel that the research program or its application is not vigorous enough because it's not producing the result of the correction or avoiding by being visible enough and active enough, a problem down the road.

MR. VOGEL: I sort of come up on the other side of that coin in that DOE has the primary responsibility for the waste. It seems to me even the siting of the waste storage facilities is in a state of flux.

It seems to me they need to settle down on what they're really doing before NRC should get in and do research on licensing.

So I think there's a serious matter of timing and how you pace these things. It's possible for the NRC to spend a fair amount of money on the assumption of certain ground rules and then have them changed on you.

MR. TODREAS: We can discuss this.

It's a question of who sets the ground rules. The licensing to me sets it up.

MR. BECKJORD: One budget action following --

MR. VOGEL: It depends on the site is what worries me. It makes a difference.

MR. MORRISON: Aren't these evolutionary; that you can hardly select a site without knowing what the requirements are going to be for licensing. It's kind of an iterative process. So you can't back out of it totally I don't think from the regulatory side.

MR. BURSTEIN: One of the things we did try to impress was the need for the regulating investigations, to identify show stoppers very early in the game no matter where they are. If we find there are none, which is a tremendous conclusion, then the things that go on from there might be refinements or massaging or validating or confirmatory but they do not preclude.

I think the decision as to whether you have something that you find out from a regulatory point of view cannot be done or can be done is essential to be determined very early on in the process.

Now, that's perhaps a very awkward and difficult thing. I would join Don in saying there's some things I don't know how to do.

MR. UHRIG: What would you consider a show stopper? The liquid pathway on a floating plant, for instance?

MR. BURSTEIN: Perhaps. I don't know. But if, for example, we can say that the nature of this seismic hazard is such that we cannot concede of a package or a construction or something else that would assure compliance with this criteria, the NRC type report, that is, the National Research Council report; that there's no way that we can comply with this EPA standard.

Now, you either say you abandon the job or you change the standard. But the identification of that early on requires some decision. Then you don't keep barking down the tree of solving the other 99 problems if this one is going to stop the process.

I think we've tried to emphasize that in some of our work.

This not only applies to waste but it applies to all these other things, including how we deal with the advanced light water reactor systems or other systems that we're looking at in the future.

Is there something about the passive nature of some of the advanced light water designs that are being proposed that from a regulatory point of view we find is not acceptable at this point in time?

If so, it is imperative from a regulating and an industry and a research combined point of view we know about it and address it up front, not after we have spend a

billion and a half dollars and some detail in a footnote to an engineering drawing tells us that.

MR. MORRISON: Well, let me use that comment to come back into the question of client and the distribution of the research budget between regulatory requirements and those longer range exploratory activities.

I think we came up with the number 75/25 in terms of client-ordered research, so to speak, and those that were exploratory.

Is it truly identified as a role for Eric's office to deal with these show stoppers or can you put the face somewhere else within the client list?

I'm not restricting the client list just simply to NRC because I think Don's issues in part of show stoppers are probably outside of NRC unless they're truly a surrogate for the public acceptance.

Is that the right break in some sort of budget?

MR. BURSTEIN: I think there have been -- in defense of some of the things and Ed is more current on some of these things. But years ago when we were developing a passive light water reactor system, we found that it was very difficult to demonstrate, at least analytically, the inherent level of safety that was attempted to be achieved by going much beyond the 600, 700 megawatt size of plant.

Now, we knew as an industry that the larger the

output, the lower would be the unit cost. But there was a compromise made or a decision made that could be a show stopper if we tried to make a 1,000 megawatt passive design.

So we deliberately at least as a part of that early effort said "there are a whole host of reasons but the one that we think is imperative is that we be able to demonstrate the safety level desired by limiting the thermal output of this core."

It was deliberately done to achieve that.

That I think is the kind of thing that perhaps industry has done on some occasions.

There may be a whole host of others.

MR. SHAO: Bernero in his talk at the National Council said there are no show stoppers; that volcanos or tectonics will be the show stoppers.

MR. BURSTEIN: All it takes is money.

MR. SHAO: Our waste management budget is very limited. As you see, we may have only $1.8 million to work on high-level waste. So mainly we are working on the user's request of what the MSS people want us to work on.

We were going to start working on volcano and tectonic work in '91 but now the budget got cut. Unless we get additional money we cannot study these.

MR. TODREAS: You're working on the user's request

in the priority that they presented them?

MR. SHAO: Right.

MR. TODREAS: And of the list in the priority that they've done, are you able to work on 5 percent, 10 percent of them?

MR. SHAO: I agree with you the budget is very low. You want us to work on the thing they want us to work on.

MR. TODREAS: Then my comment has some reverberation positive with you?

MR. SHAO: Yes. But even the low-level waste as the same problem. We have a lot of requests on low-level waste.

The Commission gave us additional money. If you note it was $3.4 million but with the Gramm-Rudman cut we'll be back to $1.8 million. There's a big issue on engineering barriers for the low-level waste. Also we should start working on it but now with the cut we cannot work on it.

MR. BECKJORD: On this point about the volcano and the seismic consideration there: We did get notice from the Comptroller that there was a couple of million dollars.

Now, has that completely disappeared?

MR. SHAO: It looks like it's not there any more. At that time they were going to give us $2 million additional money to work. That was cut by Gramm-Rudman.

MR. BECKJORD: But that money, I think, was carry over, wasn't it? It was money from the high-level waste that was left over. So I don't think that's finally decided, is it?

MR. SHAO: If we got the money back, we will start on that detail then.

MR. TODREAS: I would say just to raise this for the committee, I think the point Dick and I didn't debate but that we put on the table is really what the subcommittee could really examine and really decide whether this overall point has validity or not, whether in fact there is a whole host of activities that the NRC could initiate, should initiate to identify what Sol calls show stoppers or major issues and whether that's a valid point or whether based on the timing of this thing the NRC could stop, we could wait for DOE so we could be down at low level and we don't have to address this for two or three years, we could come back and discuss this later.

I think it's a reasonable point of issue to pick up.

MR. MORRISON: I think that's a valid approach, Neil. I assume when you say "subcommittee address it," you're broadening to include all three subcommittees?

MR. TODREAS: Well, no. I meant the first subcommittee when they review the whole waste program, that

could be a focus.

MR. BURSTEIN: But this would apply to all the others who offer that, Mr. Chairman.?

MR. MORRISON: It should apply to all the others. By implication the others would be all right.

MR. BURSTEIN: We all go through this all the time, that our work expands to fill the budgets and the time available. I don't know whether there is an absolute level of funding that anybody will be satisfied with, whether it's $100 million or $50 million or whether it's 25 percent or 50 percent of the total NRC budget authorization by the Congress.

One of the ways we build up the numbers that I think we might want to make, what is needed to do the job, and not perhaps what we did last year or the year before or 10 years ago because our needs were entirely different then. They may have no reflection on what the rest of the world is spending in terms of regulation or in terms of enforcement or in terms of other aspects.

I assume that's what we have done obviously.

But within the context of what we have by whatever means we got there, it seems we're getting back to what we've said before and that is: how do we best prioritize what we have available? Whether we're talking about a watermelon or a grapefruit in size, this is what we've got

and we may complain that it is inadequate to accomplish the task before us.

I think in most cases that's correct.

But it's obvious we can't do everything. I think we have to ask again how we establish these priorities. If, indeed, the majority, 75 percent of the needs are established elsewhere, then we have to address, I think, some emphasis to those authors of establishing the priorities. If they want to work on reactor safety as opposed to waste, it gives RES very little opportunity to change their own prioritization. This is what I mean earlier when I said we're addressing, really, what the Commission and the EDO has asked us to look at more than we are specifically, perhaps, what RES has, unless I've missed something.

MR. TODREAS: I was with you until the end.

I think the user needs, my thought was that the user needs are all presented within areas but they do not give the research officer the guidance or the input on how to split among these program elements.

MR. BURSTEIN: I don't know.

MR. TODREAS: Is that correct? How do you decide how much relative money goes in, say, waste versus preventing damage? I didn't think explicitly you got that from outside, the relative amount. I thought you got a list

of priorities on preventing damage effectively and a list of priorities on waste but then you wrestled with the split, maybe with Taylor.

MR. BECKJORD: Not so much between reactors and waste. I would say in the last year or so the amount of money for research on high-level waste has really been determined. We didn't determine that.

MR. TODREAS: Who did? That's what Sol and I are discussing.

MR. BECKJORD: I would say it's between the NMSS and the EDO and there has been some congressional guidance on that. I could did that out.

See, that money now comes from the waste fund; that is, it is returned to NRC from the waste fund.

MR. TODREAS: Well, I'd say Sol is right, then, that the user needs dictate not only the technology to check but the level of money, at least in the waste area if in fact you're right.

MR. BECKJORD: But I think a major factor in that is that in terms of where the safety research money is, I think the budget reflects where the consensus in the agency is, that the money should be spent. That division between waste and reactors, I think that's what the Commission has consensus over. I don't have a problem with that.

I think we should be spending more money on the

waste research in the future. But I think in terms of the issues before us today with the money that's available, that's about right.

MR. SPEIS: Neil, with the exception of the waste efforts, in the other areas nobody's telling us "you should spend 10 percent prevention, 20 percent investigation." But when we take all the needs, including the Commission initiatives and digest them and integrate them, this is how we come down.

For example, one of your three areas was health effects. You possibly implied that maybe we should be doing more in that area, yet we're doing less. Then the thing that comes into consideration there is what are all the other agencies doing. It would really depend possibly 90 percent in this area on the Department of Energy, DOE, EPA, and others and we put quite a bit of effort and understanding in providing input to those activities. So that's why you don't see as much effort in that area.

So when we do that integration, including what other agencies, we kind of reach that picture and then it will go back to the Commission for feedback.

MR. MORRISON: There is another aspect of this whole subject that needs to be thrown out on the table.

Who decides or what is the process of coming up with a decision of how much is enough? When have you

completed or fulfilled a need? When have you completed the task? Recognizing that these probably never get to a hundred percent but the curve eventually is a diminishing returns for monies invested.

Is that within RES? Does that go back to the user?

MR. BECKJORD: Well, the Chairman made a statement earlier this year and I'd have to go back and dig it out but he said that he felt -- his judgment was that the research budget that should exist was about $120 million. I don't remember -- $120 or $125 million. That was the range that he gave that he felt that was justified for the needs of the Commission to support the Commission's activities and responsibilities.

The budget is less than that because, you know, of all the pressures. But that was his view.

MR. MORRISON: Was that sort of an a priori top down estimate or had you stated from the bottom up and summed up everything that perhaps your office said would be required to satisfactorily address the needs that were laying on the table?

MR. BECKJORD: My own reading of that is that he had looked over the research program and he was aware of the cuts that had been made in arriving at it and that in round numbers is about 20 or 25 percent over what we had.

So I think he felt that, you know, there were additional unsatisfied needs that required about that amount of money to satisfy.

I think what he was saying was, he if had his druthers, the research budget would be $120 million.

MR. VOGEL: I would like to support Ed's earlier suggestion on paying a lot of attention to the work being done by other organizations and overseas. I know there's a certain disadvantage to this overseas work, for example, in that you don't have control of it, can depend on it, and they can drop it.

But on the other hand there are some awfully capable people over there doing good work. I certainly have been very much impressed by the Swedes, for example. A little program, a little country, but, gee, a lot of capable people and I don't even have a Swedish background.

I think some effort might be made to lay out a worldwide program. The mechanism for doing this might be through the OECD.

When I was attending committee meetings there, we tried to lay out the worldwide severe accident program and we had bar charts, et cetera, and so on. I think that's still an ongoing effort picked up by other people.

MR. BECKJORD: We have good information on what the OECD nations are spending in these areas through our

work on the Committee for the Safety of Nuclear Installations and subgroups under that. There are five subgroups which span most of the scope of our research programs. Our people are members, in one case chairman of the subcommittees, so we have good information on that.

I met with the German and the French authorities in March to review the safety severe accident and probablistic risk assessment work on a trilateral basis so we have pretty good information.

MR. VOGEL: It's gratifying to see closer coordination with the French.

MR. ISBIN: I'd just to let it be known that my silence here does indicate that I've heard very carefully what has been stated around the table. I've been involved with some of the subcommittees in the past.

I have some agreements and some disagreements.

I think the work of this committee lies ahead and that we need to address some of the questions which have been raised to make some determination but to do it in an open meeting such as this at this time doesn't seem quite appropriate to me.

I think it's important that questions be raised but how we resolve these questions should be decided by a little more thorough discussion and clarification of some of the issues which have been brought forth.

MR. MORRISON: Any particular burning examples there you think we ought to have more discussion on or get clarification?

MR. ISBIN: I would prefer to do this in the subcommittee.

MR. WOODS: I'd like to shift direction slightly.

We've heard this morning quite a bit about the administrative structure of planning a research program. But if I look back at the two National Research Council reports, the revitalizing nuclear safety research and the one that I happened to be involved in a little bit on human factors and nuclear safety, I think the points that those two groups were trying to make is that nuclear safety research needed an upgrading of research quality, fundamental research quality.

Now, that to some degree is at odds with the basic charter of the organization in terms of supporting the regulatory mission. But I think that stretching it is still the appropriate thing; that rather than focus on increasing the administrative levels, it's important to coordinate with many other countries' programs. But if we increase the bureaucracy in deciding what our research agenda is and where things are going, I think it's going to only decrease the quality of research output, not increase it through indirect means.

Both of those reports tend to focus on more bottom up where the administrative structure encourages talented people to get involved in meeting and solving challenging problems. That meant a variety of techniques were recommended in those reports, some of which were not direct funding of research through the normal channels but more leveraging activities where we are trying to attract people to recognize that there are fundamental problems that relate to the nuclear industry but that are much wide concern.

Human factors is a great example of that. It's one I can speak to.

The problems of human and automation interaction, the problems of using new progress in intelligence systems is a beautiful example of work that is going on in the 88 commercial aviation, it's going on in space systems, it's going on obviously here in the nuclear industry, it's going on in terms of medical equipment in the operating room.

In all of those areas people are concerned with essentially the same set of questions.

They are all concerned with a problem that a little more of this technology is not by and in itself going to make things better. It has the potential. It has considerable power for making things better. But that the experience to date with information technology and information-related automation, decision automation has been

spotty is an optimistic assessment of it.

If we don't understand more about how that stuff works in high consequence, high hazard industries like nuclear power, there will be failures in deploying that technology as well as successes.

It happens that the French are leading the way, probably on the way to a mixed bag of success and failure. It would be very interesting if we got honest and in-depth reports on their experience but my dealings with EDF and other people there, I don't think that is very likely to happen because of the organizational commitment to that control room.

I think the main point I want to get on to is that many of the mechanism I think this committee can provide in terms of advice to your organization is the issue of how do we get grassroots involvement? How do we get bright people to work on these challenging problems?

I think these sort of indirect ways to build up that research infrastructure are the most important things. I think we can go into various specifics that apply in subcommittees or overall. For example, smaller grants, more diversified contracts, more university partnership in things, let exclusive use of national laboratories that have been mentioned before in these committee meetings by other people in previous ones.

I think that's really the thing I want to bring up; that emphasis on the quality of the research. I don't think that comes from top down administration. That comes from creating an atmosphere and environment to get smart people to deal with challenging problems.

MR. TODREAS: Can I ask you: do you see a way to get that thrust in the charter or the objective that we have for this task? How do we do it or are we effectively excluded? We've been working on that bit by bit. But now I kind of see this charter and this task as taking us away from the ability to do -- to emphasize what you say.

MR. WOODS: I think that there has always been a -- we discussed this in terms of percentages a little bit earlier in terms of research initiated activities versus user initiated activities.

I think the fundamental problem in nuclear regulatory research for a long time has been, it has been driven by the various hot buttons.

Whether those things turned into three-year programs or whether they were technical assistance I don't think matters. I think they've been defined by events outside and there has not been enough of a strategic, coherent, and global view of what are the important problems to be dealt with.

MR. BURSTEIN: From what point of view? From the

world science point of view or from regulation?

MR. WOODS: From the science point of view.

MR. BURSTEIN: That's where we have a problem. That's where the charter for this group -- getting back to Neil's perhaps zeroing in on that -- makes it difficult to do that kind of work here.

MR. WOODS: What we proposed in the human factors and nuclear safety report that National Research Council report was a distinction between research activities that build or enhance the research base from which industry specific applications can be made and applied research that takes items from that research base and makes them work in a specific industry context.

We said even though that we understood the primary mission was focused on this kind of confirmatory research predominantly and industry specific things, that if they did not encourage and leverage the growth of that research base in ways that would be relevant to nuclear specific problems, the research base wasn't going to be there when the hot button question arose.

That has happened.

I'm speaking primarily from experience in human factors. That has happened time and time again in the human factors area where the research base, a problem arose, the research base was not developed, and so when a version of

that question arose later, there was still the inability to answer the question that was raised.

Now, I think there are ways to grow that research base from the NRC's perspective that do not require massive fundings of basic research. I think it has to do with more indirect mechanisms to generate leverage. There were a variety of those suggested in that human factors and nuclear safety report.

I think we get into those as the committee well knows in terms of emphasizing smaller, more diversified research programs, making sure that there is university involvement.

I think that there as been a problem with too much insularity in nuclear specific groups. So people talk about, well, let's take, for example, and I hate to criticize my friends in Norway but they're a good example. They do very interesting work, nuclear specific work in human factors. Yet they are not connected in the least to the international scientific community in the big questions of man/machine systems, human intelligence system interaction. It's a very insular program out there.

I think those kinds of boundaries have to be broken down.

The FAA and NASA are leading a major research effort on aviation automation and safety because they're

concerned that the increases in automation and information technology and the artificial intelligence may not always lead to improvements in aviation safety. They want to understand the issues in terms of the impact on human performance in the flight decks because of that concern and building links to that program.

So that at the same time that applied research for nuclear purposes is going on there is also something being put back into that research base, growing that research base. Because the problems in the nuclear world, at least from the human factors, human computer intelligence system world are the same problems that people are dealing with in aviation and space.

So we can all benefit if we think about it in a generic way as well as in an industry specific way.

MR. VOGEL: You gave an example of Norway. Of course I don't think they have any reactors. They have essentially no nuclear program.

MR. WOODS: The Halden project is what I was referring to.

MR. VOGEL: Well, that's tiny, and as you say, isolated. But there are no commercial reactors.

MR. WOODS: Right.

MR. VOGEL: They sort of flop out there all by themselves. They're not doing very much either.

MR. TURCOTTE: Following along here your discussion, we have seen this sort of activity of the directors going, as far as I understand it, the opposite direction in that it removed the small grant and moved to support essentially a large fraction of it in the high level waste program and moved it by creating essentially a new national laboratory and centering that in an area that is characterized by the lack of any national input to create an expertise, whether it's for high level waste, low level waste or just ordinary waste. So in essence there is no basis in the universities to prepare people that are needed to solve the problem because the major federal agencies, particular the USGS and now the NRC, provide no basis of support for university and the DOE does relatively little.

Now, I think we were faced with a fete accompli in this so there wasn't really anything we could do but as a prime example of where we sort of oversaw exactly the opposite of what you're pushing for.

MR. WOODS: I don't know in the waste area whether there are specific factors that would warrant going in a different direction. I can only speak from by broad view of human factors related things and that would be the wrong way to go and has been the wrong way to go in human factors, human automation types of areas.

MR. KINTNER: Eric, do you have any idea what

percentage of your $90 million is spent in university type work as compared to laboratory or major contractor work?

MR. BECKJORD: Yes, we have the figures on that.

MR. KINTNER: Do you think 5 percent? Ten percent?

MR. BECKJORD: The total nonlaboratory expenditures are a little over 20 percent, about 23 percent. That breaks down between the grants as a fixed number. Grants has been a million dollars.

There is some additional work at universities.

There are a number of what we call broad agency announcement decisions that are forthcoming. We have by design favored the universities in many of these BAAs, so-called.

Then the rest of it is -- the balance of those funds -- I can get the breakdown for you. I don't happen to have it here. The balance is at places like Bechtel which does a fair amount of work for us, is not a national laboratory. It's a private not-for-profit, and a few other places like that.

MR. TODREAS: Could I just take a moment, though, to amplify because there are some new members on the committee.

We put a table in a committee report. It probably was a year ago, six months ago, associated with that, that

we worked out.

My recollection of the table was that the university part was like 2 to 3 percent -- let me say only to emphasize that. And the intention of the office and Eric in particular was to try and increase that and the broad agency announcement which he mentioned is a mechanism relative to contracting to increase university participation within the framework he has.

But the reason I interjected was actually to put the spin the other way which is that although the intent of this office has been to move in the direction -- I say Dave is talking about.

How far the movement really will be is an open question because the broad agency announcements are new. I'm not sure where there have been any awards based on those. That's a direction. I think it's a wait and see and review.

MR. WOODS: What I would rather see rather than just simply not to see this debate as to whether I took a project that goes primarily to a university or primarily to some other research organization; it's really building the ties that there's a gradient moving from basic research to very nuclear specific developments and that there has been a loss of continuity on that gradient and that mechanisms are diverse for reestablishing and encouraging that.

A couple of quick examples in one program that I know in depth. It was a contract organization that was the prime contractor on the work for the NRC. But there was a critical element was subcontracted to one of the leading researchers in a university setting, one of the leading ones in the world, recognized by everybody and there were two review meetings held during the course of that project that included review committees of some of the very best people leading research in related areas to this particular contract who happened to all be from universities -- mo all from universities, not quite all of them but predominantly from universities so that there was a t between these are the problems this organization has, the NRC. This is where they want to make development and things and is this both going to make leverage and help the sponsor and is it also scientifically credible and advancing some aspect of the scientific research base relative to that so that we were able to say, yes, we're making progress in both ways in that particular project and it established a continuity, not that we were trying to do a basic research project or turn the NRC work into a pure basic research project but reestablish the continuity and connection so that all the people along this research understood what was going on, understood how their work could apply to it and establish the human resource base, I think, in terms of

problem solvers who can go out and deal with these challenging issues.

MR. VOGEL: I've sat on both side of the table on this sort of thing. Another aspect of university work is my experience has been that if you have in a rush to get an answer, you're likely to get entangled with a graduate student's thesis schedule and it becomes a very awkward situation.

Also the universities by tradition and by intent have independence which is not characteristic of contract research and sometimes come out with an answer to a question you didn't ask. It may be a very good answer but for something else.

I think universities if they make a plea for more work, need to address these as problems on the other side of the table.

MR. WOODS: First of all, I've only been at the university for two years. I'm not really trying to defend this one in one particular way.

In the human factors area, what you see happening is, there is a tremendous amount of work. There was a comment made earlier that perhaps in some areas the overall amount of work was going down on some of these problem areas, defined broadly, not just the NRC's and related organizations but in many of these problems of humans and

technology, it's just the opposite.

Work is exploding.

The question is, is any of that work -- it's going to get done. There are going to be dissertations. There are going to be professors leading laboratories working in this area. The question is will any of it at the end be relevant to the nuclear industry?

And the answer to date is, none of it is, virtually none of it and the reason is because they're not working on -- they're not using the nuclear world or situations that have characteristics like the nuclear world as their test beds.

They're using relatively small-scale static situations with low hazard. As a result the results on human computer interaction, intelligence system development, and so forth do not apply.

They show potential still but they do not apply.

It's only in the last two years that the artificial intelligence community has built the first intelligent reasoner that has any hope of reasoning in a situation like happens in a nuclear power plant control room.

Now people have been tallying expert systems for at least 10 years in the general public. It's only in the last two years you could find any publications that are

credible to really work, if you really look at them in detail and look at what happens in a nuclear control room in terms of dynamism and so forth that they could actually work in that situation.

That to me is appalling, that so much work in diagnostics and fault management went on for so long yet so little of it was relevant to a situation like a nuclear power plant control room.

You would think they would be jumping at the chance in the aftermath of Three-Mile Island to look at that kind of situation and prove that there technology could work in it but there was no hand reaching out in the other direction to try to pull them in and say "let's focus your energies and talents and resources in this direction, let's leverage it because nuclear power offers a great laboratory in a sense of tremendous challenges to your technology and to advancing your technology. Why not do it here which will also benefit the nuclear industry in developing specific applications?"

That's the kind of leverage I'd like to get.

MR. BURSTEIN: One of the reasons is some of us didn't want it to happen here until it had proved itself in a much more simple and less hazardous situation.

Forgive me, you cannot jump off the edge and say "I've got the answer now and I'm going to apply it to a

nuclear plant."

There's lot of things we haven't -- as you pointed out earlier -- been able to demonstrate when you have a two- or three-man situation, let along 200- or 300-man situation.

"Man"? Did I say "person"?

(Laughter.)

But, indeed, it is imperative, I think, that recognize what's going on globally in all of these areas. I guess, Eric, it's probably appropriate that we reiterate what we said before about our cognizance of these areas but there is this continual conflict about what a total or universal research effort in a discipline might provide, whether it's a metallurgical one in a reactor vessel application or a human factors one in a nuclear application. And this is where the difficulty comes, I think, in trying to administer a very specific part of a total research effort.

We cannot, as Dr. Vogel said, have the luxury of waiting until a research result emerges from the normal process, including the whole peer review and other processes. I think, Dave, you know that from all kinds of histories of your own.

I guess that's where I feel myself defending RES in respect to not being able to take full advantage of it.

But the maturity of the science is another very important issue. Well, it so happens that Dr. Uhrig and I have been debating this about intelligence or artificial intelligence for nuclear plants for, what, 15 years?

MR. UHRIG: Not quite that long.

MR. BURSTEIN: Maybe 10 anyway, or at least the use of control room simulators.

MR. UHRIG: There is another factor that comes into it and that is just the interaction between regulators and utilities in many of these applications. I go back a long time in the reactor noise business.

MR. BURSTEIN: Oh, God, not that.

MR. UHRIG: Well, this essentially died in the United States.

MR. BURSTEIN: Some of us tried to kill it.

MR. UHRIG: But if you go to Germany today, you have a diagnostic center that weekly gets measurements from every plant in West Germany. Any time they review these, they look for anomalies, they wind up any time there is a problem, there is an interaction between the utility and the center and it's functioning very, very well. There has been a tremendous interaction between the utilities and this particular center. It is a private center. It started out federal and --

MR. BECKJORD: Where is this?

MR. UHRIG: This is in Garshing.

MR. BECKJORD: GRS?

MR. UHRIG: Yes, GRS. They basically --

MR. BURSTEIN: Is this the nuclear noise or the thermal hydraulic noise?

MR. UHRIG: It's all of it.

They were, for instance, able to spot the broken spring in a fuel element and identify it as such.

They were able to predict the failure of a rotating shaft on a reciprocating charging pump well before it got to the point that it got to be a problem.

That's the kind of thing they're doing in a routine basis.

But the thing that killed it in this country was basically a position taken, I think incorrectly, by a representative of the NRC or the old AEC at the time saying in effect at a public meeting that if you find anything at all, even though it's not confirmed by any other method, you're going to have to shut down. That wasn't the policy. It never was the policy.

Examples were Palisades when they had the broken core barrel.

Here's a technology that is being extremely useful in certain parts of the world. It's just neglected totally in this country because of the culture, if you will, of what

went on between the regulators and the regulatees.

MR. KINTNER: I would ask the question: these issues you're talking about, what degree is that a part of the regulatory research responsibilities?

MR. WOODS: I think it is in the sense if they want answers to their questions where it relates to advanced INC and human factors, if they don't a leg in the -- the answer has always come up where you ask human factors and people in advanced INC where you're talking about computer technology, artificial intelligence, things like that, is that "we don't know yet." All right?

Every practical question virtually you can ask here is "we don't know" because we're going through a step change in information technology as applied to these kinds of worlds.

So if we have to make short-term provisional answers and assessments based on partial research or judgments or whatever, that's great but in some sense we have to invest. We have to sort of grow people whose charter is more in long-term research to say, "hey, guys, this is the real problem we wish we had an answer to."

A simple example is measures of the qualities of computer displays. What's a good computer display for this kind of situation?

There are people working on that but they're not

working on it in a way that's relevant to nuclear power. Most of the people working on it have never heard of a nuclear power situation. They don't know what operators do in control rooms. They don't know what goes on in an emergency operations in a nuclear power plant. They're working on doing them for text editors, for God's sake.

MR. UHRIG: But they're doing it in the sense that there are computer displays out there being used, have been for 15 years. There are commercial nuclear power plants where the operators rely almost entirely on computer displays, Susquehanna being a classical example of the GE -- I've forgotten the name of the system.

The ATR, advanced test reactor, has five son computers out here as the display system. There are people moving ahead in this technology. It's getting done and it's getting done in the aircraft industry. The French A-3-20 now is essentially computer controlled.

Decisions are being made albeit perhaps without -- and the Canadians. The Canadians have done a tremendous job. Some of the stuff they're using is programmable logic controllers with 8080 chips in it but they work and they're doing a great job.

MR. WOODS: You're referring to the trend that's going on.

MR. TODREAS: You fellow are agreeing, is that

right?

MR. UHRIG: I'm not sure we are. I'm saying things are going ahead. Dave is saying nothing that's being done in the basic sciences is relevant to the nuclear field and that's what I'm disagreeing with.

MR. TODREAS: Oh, okay.

MR. WOODS: The technology forcing function is moving ahead. In terms of understanding human technology interaction, okay? You brought up the aviation example, the A-3-20. The A-3-20 frankly scares a lot of people in U.S. aviation industry a lot --

MR. BURSTEIN: And some passengers, too.

MR. WOODS: -- in terms of issues about people and technology interact in managing high hazard situations. And there's a $25 million research program, the FAA, NASA, the other organizations, trying to understand how people and that level of automation interact in order to say "are there any unanticipated traps that are laying out there waiting for us and we'd like to anticipate and recognize those before we run into them."

So the people are concerned the technology forcing function is moving us ahead faster than we understand what the technology means in terms of managing hazardous industries. That's were, unfortunately, a lot of work in, say, human computer interaction and other human technology

interaction kinds of areas has been focused on application areas that do not directly transfer to nuclear power when they could just have well done their work in things that would be more relevant.

Part of the point here is that it's a level of interaction. It's not saying "take your budget and devote it to that." It's saying "if you're aware of building the links to those people, all right," and opening up to those people and encouraging them to come and work with you, when they need to do a dissertation, they've got a bring young person who's got some interesting ideas, that they're doing them in ways that will build that research base and the next time you ask the question "how to I evaluate a safety parameter display system? what's a good one?" there isn't a "gee whiz and by golly" answer and make it up as they go.

MR. TODREAS: The view I have which supports Dave is a mental image I'd like to leave with you or in a term, I think of this thing in terms of vertical integration starting with the problem in maybe the industry and then the lab, then the university. I think of the effort maybe as an upside down triangle in the sense that the university doesn't pick the problem and go off the wrong way but the university and even the national lab is integrated into a problem that's picked but integrated in the right way at the level they can respond, at the time they can respond, and

with the piece that they can really contribute which is the technology but entrain them in there.

This works on almost -- you brought up the question where? This works on almost any complex problem, particularly that we have in the nuclear industry.

For example, when you had that problem and couldn't see through the water in TMI-2, if you had time to develop a program, you probably went out and got an industry applied chemist who might be able to turn right away and solve the problem and then you built up with a small part of the pyramid, get some researcher at a university who knew the fundamentals who might do something a little bit longer term to help.

MR. KINTNER: We did that but it took us six months. We did or we wouldn't have gotten it done if we hadn't.

MR. MORRISON: Well, I think now might be a good time to break for lunch.

MR. BURSTEIN: I hope the pyramid rests on the base and not on the point.

MR. TODREAS: It's a funding pyramid, not a logic pyramid.

MR. MORRISON: With that let's come back about 1 o'clock.

(Whereupon, a lunchon recess was taken 11:55 a.m.)

(The committee met in closed subcommittee sessions which were not recorded.)

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission

in the matter of:

NAME OF PROCEEDING: Public Meeting

DOCKET NUMBER:

PLACE OF PROCEEDING: Bethesda, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Dean A. Robinson

Official Reporter
Ann Riley & Associates, Ltd.

U.S. NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REGULATORY RESEARCH

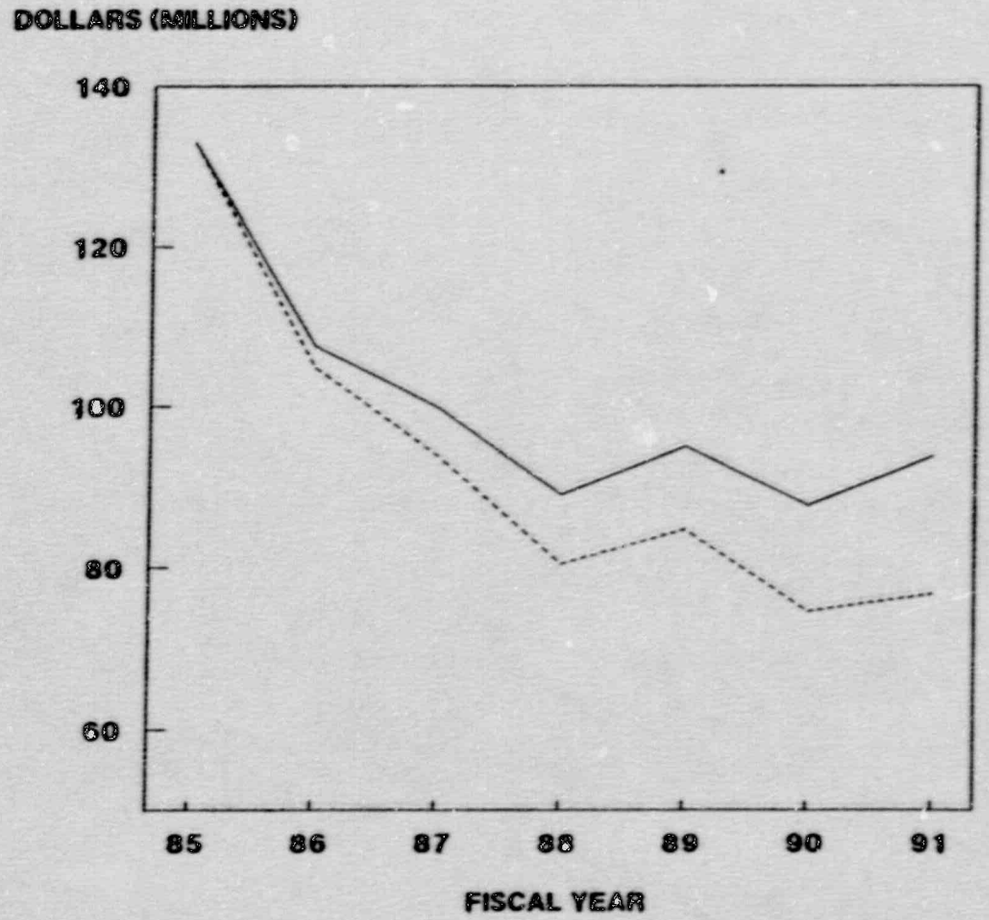
NSRRC MEETING ON THE SAFETY RESEARCH PROGRAM

SEPTEMBER 25, 1990

CONTENTS

NUCLEAR REGULATORY RESEARCH

BUDGET TRENDS FY 1985 - 1991



FY	TOTAL $	85$
85	$133.0	$133.0
86	107.4	104.7
87	99.8	94.0
88	89.1	80.5
89	95.2	84.8
90	87.7	74.7
91	94.0	76.8

DEFINITIONS

RESEARCH

DEVELOPMENT OF NEW INFORMATION, ANALYSES, AND CODES EITHER THROUGH EXPERIMENTS OR OTHER METHODS, IRRESPECTIVE OF THE ULTIMATE USE OF THAT INFORMATION WHETHER FOR A SPECIFIC REGULATORY END SUCH AS A RULE, GUIDE, ETC., OR WHETHER THE INFORMATION IS PURELY CONFIRMATORY IN NATURE.

TECHNICAL ASSISTANCE

APPLICATION OR EXTENSION OF EXISTING INFORMATION (EXPERIMENTS, ANALYSES, CODE RUNS) TO SUPPORT SPECIFIC, IDENTIFIED REGULATORY ACTIONS (RULES, STANDARDS, LICENSING DECISIONS, POLICIES, ETC.).

OFFICE OF NUCLEAR REGULATORY RESEARCH

BREAKDOWN OF FY 90 PROGRAM SUPPORT FUNDS
RESEARCH vs TECHNICAL ASSISTANCE

PROGRAM	FY 89		FY 90		FY 91	
	RES	TA	RES	TA	RES	TA
INTEGRITY OF REACTOR COMPONENTS	$28.0	$ 2.1	$25.0	$ 0.7	$26.9	$ 0.9
PREVENTING DAMAGE TO REACTOR CORES	18.2	0	20.4	0.9	21.9	0.6
CONTAINMENT PERF. AND PROT FROM RADIATN	25.1	0.8	17.2	0	17.9	0
HIGH LEVEL WASTE	4.1	0	4.6	0	4.0	0
LOW LEVEL WASTE	1.8	0	1.6	0	3.4	0
RESOLVING SAFETY ISSUES,DEVEL REGS	3.6	11.5	3.8	13.5	3.3	15.1
	$80.8	$14.4	$72.6	$15.1	$77.4	$16.0
TOTALS	$95.2		$87.7		$94.0	

OFFICE OF NUCLEAR REGULATORY RESEARCH

POTENTIAL G R H BUDGET REDUCTIONS

PROGRAM	FY 91 LATEST 8/90	FY 91 POTENTIAL G-R-H CUT	FY 91 REMAINING BAL - 9/90
INTEGRITY OF REACTOR COMPONENTS	$ 27.8	$ 8.9	$ 18.9
PREVENTING DAMAGE TO REACTOR CORES	22.5	10.0	12.5
CONTAINMENT PERF. AND PROT FROM RADIATN	17.9	8.8	9.1
HIGH LEVEL WASTE	4.0	1.8	2.2
LOW LEVEL WASTE	3.4	1.8	1.6
RESOLVING SAFETY ISSUES,DEVEL REGS	18.4	3.2	15.2
TOTALS	$94.0	$34.5	$59.5

BASIS FOR GRH BUDGET REDUCTIONS

- All RES programs have been prioritized at the "Activity" level with Pressure Vessel Safety and Direct Containment Heating near the top of the priority list and Core/Concrete Interactions and Thermal-Hydraulic Experiments near the bottom.

- Priorities reflect urgency of user needs, Commission objectives, and phenomena that dominate risk or uncertainty in risk.

- Lowest priority Activities have been eliminated or severely cut back.

- Some preference has been given to completing long-term projects that are almost completed to avoid undue losses of completed work.

- An attempt has been made to maintain a minimum level of expertise with our contractors to provide the capability to respond to new issues and emergencies.

IMPACT OF GRH BUDGET REDUCTIONS

(Examples of Lowest Priority Programs)

Primary System Integrity

64% reduction in Piping Integrity activity would delay decisions on ASME Fatigue Design Curves resulting in use of conservative estimates on aging. Reductions would also delay implementation of leak-before-break for balance of plant (GDC-4).

Systems and Severe Accidents

54% reduction in T-H Experiments would eliminate major parts of the effort to resolve the natural circulation issue related to PWR depressurization and DCH. 62% reduction in Core-Concrete Interactions would eliminate all independent research by the NRC and reduce our support for the industry program (EPRI/ACE).

Human Factors and Waste Management

74% reduction in Data Management Systems for Reliability Assessment would preclude converting NUCLARR software to be compatible with IRRAS. 58% reduction in Materials & Engineering for LLW would eliminate two programs and result in the use of overly conservative assumptions.

MAJOR THRUST OF RES PROGRAMS

RESEARCH	APPLICATION
PRIMARY SYSTEM INTEGRITY	REACTOR VESSEL EMBRITTLEMENT, FLAW EVALUATION, PIPING REPAIR, INSERVICE INSPECTION, OPERATIONAL PROBLEM RESOLUTION.
	LICENSE RENEWAL BASES, CONTAINMENT FAILURE PREDICTION, SEISMIC DESIGN MARGINS, EXTERNAL EVENTS FOR IPEs.
SYSTEMS AND SEVERE ACCIDENTS	SEVERE ACCIDENT POLICY IMPLEMENTATION INCLUDING IPE, CPI, AND A/M PROGRAMS.
HUMAN FACTORS & WASTE MANAGEMENT	LICENSING APPROACH FOR ADVANCED REACTORS FROM PRA INSIGHTS AND HUMAN-SYSTEM INTERFACE STUDIES.
	HLW AND LLW WASTE DISPOSAL ASSESSMENT, EARTHQUAKE HAZARD SURVEILLANCE AND ASSESSMENT, AND BASIS FOR REVISION OF GEOLOGIC SITING CRITERIA.

SIGNIFICANT ACCOMPLISHMENTS

REACTOR PRESSURE VESSEL PROGRAMS

- MATERIAL PROPERTY TESTING PROVIDED BASIS FOR FRACTURE TOUGHNESS CURVES (K_{1c} AND K_{1a}) USED IN ASME CODE.

- DOSIMETRY RESEARCH (ANALYSIS AND EXPERIMENTS) HAS VALIDATED REACTOR PHYSICS CALCULATIONS FOR DETERMINING THE NEUTRON FLUENCE. THIS WORK IS BEING INCORPORATED INTO A REGULATORY GUIDE ON DOSIMETRY.

- TEST-REACTOR IRRADIATIONS IDENTIFIED DELETERIOUS EFFECTS OF COPPER IN PRESSURE VESSEL STEELS. THIS LED TO CHANGES IN THE COMPOSITION SPECIFICATIONS FOR THESE STEELS.

- TEST-REACTOR IRRADIATION RESULTS AND LARGE-SCALE PRESSURE VESSEL TESTS RESULTS PROVIDED TECHNICAL BASIS FOR:
  - PTS RULE (10 CFR 50.61) AND REG. GUIDE 1.154
  - CRITERIA FOR EVALUATING MATERIALS WITH LOW CHARPY UPPER SHELF ENERGY ACCORDING TO 10 CFR 50, APP. G
  - ASME SECTION III, APP. G WHICH IS USED TO SET P-T LIMITS AND LTOP SET POINTS

SIGNIFICANT ACCOMPLISHMENTS

Piping Research Programs

- Experimental pipe fracture test results under various load combinations provided technical basis for:
  - Revision of 10 CFR 50, App. A, GDC-4 to accept leak-before-break for piping meeting rigorous acceptance criteria.
  - Flaw evaluation criteria in ASME Section XI, IWB-3640 & IWB-3650.

- Experimental evaluation of effects of BWR environment provided technical basis for selection and processing guidelines for BWR piping (NUREG-0313, Rev. 2).
  - Environmental guidelines
  - Material selection
  - Inspection guidelines
  - Repair guidelines, including weld overlay repairs

SIGNIFICANT ACCOMPLISHMENTS

Aging Research Program

- Developed technical basis to support license renewal rulemaking
- Developed basis for standard review plan for license renewal

Seismic & Structural Engineering

- Completed development and trial-plant evaluation of seismic design margins methodology, which will have immediate use for the individual plant examination for external events.
- Developed component fragility data base utilized in NUREG-1150, seismic margins, resolutions of A-46, etc.

Reactor Containment Structural Integrity

- Demonstrated failure modes and levels for steel and reinforced concrete containments and penetrations via tests to failure of large scale containment models and full size penetration specimens. These results have been utilized in NUREG-1150, PRAs and other severe accident studies.

SIGNIFICANT ACCOMPLISHMENTS

Reactor and Plant Systems

- Completed experimental research on ECCS performance and revised the ECCS rule (10 CFR 50.46 and Appendix K) to permit use of best-estimate analyses.

- Provided thermal-hydraulic methods that served as the basis for the pressurized-thermal-shock rule.

Severe Accident Evaluation

- Provided experimentally validated severe accident analytical models and results that formed the bases for NUREG-1150 and made possible the industry and NRC analytical methods for severe accident containment performance analysis such that meaningful Level-II PRAs could be performed at reasonable costs. This paved the way for the severe accident policy statement and the IPE program.

- Measured the flammability limits for hydrogen combustion in air and steam to provide a basis for the hydrogen rule and Level II-PRAs.

SIGNIFICANT ACCOMPLISHMENTS

HUMAN FACTORS

- DEVELOPED METHODS FOR THE ANALYSIS AND REVIEW OF ADVANCED DISPLAYS AND CONTROLS IN TERMS OF THE HUMAN, HARDWARE, AND SOFTWARE ASPECTS OF HUMAN-SYSTEMS INTERFACES.

PROBABILISTIC RISK ANALYSIS

- COMPLETED LANDMARK RISK ANALYSES FOR FIVE PLANTS WITH FULL DOCUMENTATION AND COMPREHENSIVE PEER REVIEW (NUREG-1150).

- NUREG-1150 ANALYSES LED TO PLANT IMPROVEMENTS IN SYSTEM DESIGN AND PROCEDURES AT PLANTS ANALYZED (E.G., USE OF FIRE WATER AS BACKUP TO RHR AT LASALLE, ALTERNATE COOLING OF CHARGING PUMP OIL COOLER AT ZION).

- DEVELOPED PC-BASED ANALYTICAL TOOLS (IRRAS AND SARA) THAT PERMIT MOST ASPECTS OF PRA ANALYSES TO BE PERFORMED ON PCS, AT A COST SAVINGS OF >$100K IN MAIN-FRAME COMPUTER COSTS PER PRA.

SIGNIFICANT ACCOMPLISHMENTS

High-Level Waste Research

- Developed a methodology and the associated computer programs for systematically analyzing the performance of a high-level waste repository in unsaturated, fractured tuff. While some component models are preliminary, such as source term, the flow and transport portions are more advanced (natural analogs have advanced state of the art in flow and transport modeling).

Low-Level Waste Research

- Developed inventory-based generic low-level waste source term model for use in performance assessments of LLW disposal sites.

Earth Sciences

- Jointly developed with NRR the probabilistic seismic hazard characterization that is part of the basis for resolution of the "Charleston Earthquake" issue and use by IPEEE.
- Established the national seismographic network to assure NRC long-term access to seismicity data needed for the continued safe operation of nuclear power plants.

INTEGRITY OF REACTOR COMPONENTS

- Reactor Vessel and Piping Integrity
- Aging of Reactor Components
- Seismic and Structural Research
- Engineering Standards Support

FUTURE RESEARCH

Reactor Vessel and Piping Integrity

- Continue test reactor irradiations to develop data base needed in evaluating integrity of vessels containing materials with low Charpy upper shelf energy. This will use material obtained from the cancelled Midland Unit 1 and special research welds.

- Develop regulatory criteria for vessel annealing, including methods for estimating and measuring recovery, reembrittlement rates, and engineering constraints.

- Develop data to improve the understanding of irradiation damage and to support predictive models to account for temperature effects, chemistry effects, microstructure effects, and general material condition.

- Develop data to support changes in the ASME Section-III fatigue life curves for use in license renewal evaluations of pressure vessels and piping.

- Perform pipe fracture experiments and analyses to support extension of leak-before-break to pipe fittings and balance of plant piping.

Aging of Reactor Components

- Develop technical basis to evaluate residual life of major LWR components and structures.

FUTURE RESEARCH

Seismic and Structural Research

- Demonstrate failure mode and levels of prestressed concrete containment.
- Develop degradation and aging database for concrete structure.
- Revise Appendix A to 10 CFR Part 100, Geologic and Seismic Siting Criteria
- Develop basis and position on the ratio of OBE/SSE for advanced reactors.
- Integrate dynamic piping research results into regulations.
- Continue assessment and surveillance of seismicity in central and eastern United States.
- Develop strong ground motion database to reduce the principal uncertainty in seismic hazard curves and resolve the issue of two hazard curves (EPRI and LLNL).

CORE DAMAGE PREVENTION

- Plant Performance & Reactor Applications
- Human Factors
- Reliability Assessment
- Accident Management
- Probabilistic Risk (Safety) Assessment

FUTURE RESEARCH

Human Factors

- Identify the human factors issues associated with medical and industrial uses of radioactive material and develop appropriate regulatory guidance.
- Develop a risk-based configuration management method for improving and simplifying technical specifications.
- Perform a trial application of the method developed for assessing organizational factors at operating nuclear power plants and develop appropriate regulatory tools in this area.

Probabilistic Risk Analysis

- Extend the NUREG-1150 analyses for two plants (Surry and Grand Gulf) to include consideration of the risk associated with low power and shutdown modes.
- Develop improved methods for precursor analyses and methods for incorporating operational events into PRAs.

REACTOR CONTAINMENT PERFORMANCE

- REACTOR CORE MELT AND COOLANT SYSTEM FAILURE
- REACTOR CONTAINMENT LOADING
- REACTOR CONTAINMENT STRUCTURAL INTEGRITY

FUTURE RESEARCH

Reactor and Plant Systems

- Provide the technical basis (including assessment of candidate strategies) to define the requirements for an acceptable accident management program.

- Assess existing capabilities to model gravity-driven flows in advanced LWRs, develop improved techniques if necessary, and perform independent safety analyses of these designs.

Severe Accident Evaluation

- Based on knowledge and insights gained by experiments and analyses conducted to date, complete research on core degradation and melting, containment loading phenomena, and fission product generation and release sufficient to reach closure on severe accident issues as required by the severe accident policy statement.

FUTURE RESEARCH

High-Level Waste Research

- Radionuclide release characterization; container and engineered barrier performance; geohydrologic flow thru unsaturated, fractured tuff; geochemistry of transport under repository conditions; potential disruptive scenarios (volcanic or seismic).

Low-Level Waste Research

- Source term and waste form characterization; contribution of engineered enhancements (e.g., concrete durability under burial conditions); infiltration through covers; mechanisms for radionuclide retardation and mobilization.

FUTURE RESEARCH
IN SUPPORT OF ADVANCED REACTORS

Engineering Research

- Assessment of Unique Construction Techniques and Unusual Configurations.
- Qualification of Advanced Instrumentation & Control Systems.
- Behavior of Materials that may be New or Operating at Higher Temperatures.
- Aging Evaluation for New Designs.

Systems Research

- PRAs for Passive vs. Active Systems.
- Integral Systems Tests in Scaled Loops.
- Human-System Interfaces and Automation for Advanced Instrumentation & Controls.
- Severe Accident Issues including Margins in Containment Performance, Unique Materials Interactions, etc.

NEED FOR A STRONG RESEARCH PROGRAM

- Confirm Regulatory Decisions
- Improve Rules, Guides, and Standards
- Resolve Technical Issues
- Maintain Technical Capability
- Perform Risk Assessments
- Develop Waste Disposal Requirements
- Develop Advanced Reactor Requirements

ORGANIZATION OF DETAILED PRESENTATIONS TO SUBCOMMITTEES

(REFERENCES IN PARENTHESES ARE TO FIVE YEAR PLAN)

PRIMARY SYSTEM INTEGRITY

1. REACTOR VESSEL AND PIPING INTEGRITY (IV-25, PROGRAM ELEMENT)
2. AGING OF REACTOR COMPONENTS (IV-42, PROGRAM ELEMENT)
3. SEISMIC AND STRUCTURAL RESEARCH (IV-51, PROGRAM ELEMENT)
4. REACTOR CONTAINMENT STRUCTURAL INTEGRITY (IV-143, PROGRAM ELEMENT)

SYSTEMS AND SEVERE ACCIDENTS

1. PLANT PERFORMANCE (IV-74, PROGRAM ELEMENT) AND REACTOR APPLICATIONS (IV-82, PROGRAM ELEMENT) -- THERMAL HYDRAULICS
2. ACCIDENT MANAGEMENT (IV-101, PROGRAM ELEMENT)
3. CORE MELT AND REACTOR COOLANT SYSTEM FAILURE (IV-127, PROGRAM ELEMENT) AND REACTOR CONTAINMENT SAFETY (IV-135, PROGRAM ELEMENT) -- SEVERE ACCIDENTS

HUMAN FACTORS AND WASTE MANAGEMENT

1. HUMAN FACTORS (IV-87, PROGRAM ELEMENT) AND RELIABILITY ASSESSMENT (IV-98, PROGRAM ELEMENT)
2. REACTOR ACCIDENT RISK ANALYSIS (IV-110, PROGRAM ELEMENT)
3. LOW LEVEL WASTE DISPOSAL PROGRAM (IV-146) AND HIGH LEVEL WASTE DISPOSAL PROGRAM (VI-29)
4. EARTH SCIENCES (IV-56, ACTIVITY)

COMMITTEE REPORT

QUESTIONS TO BE ADDRESSED

- DOES RES HAVE A CLEAR UNDERSTANDING OF NRC'S ESSENTIAL REGULATORY REQUIREMENTS?
- ARE THE PROPOSED RESEARCH PROGRAMS WELL FOCUSED ON THESE REGULATORY NEEDS?
- DOES THE COMMITTEE HAVE ANY RECOMMENDATIONS FOR CHANGING EMPHASIS OF THE RESEARCH PROGRAMS?
- ARE THERE GAPS OR MISSING ELEMENTS IN THE VIEW OF THE COMMITTEE?
- ARE THERE ELEMENTS IN THE PROPOSED PROGRAM WHOSE SCOPE COULD BE REDUCED?
- ARE THERE ELEMENTS IN THE PROPOSED PROGRAM WHOSE SCOPE SHOULD BE INCREASED?

COMMITTEE REPORT

STAFF SUPPORT AVAILABLE TO THE COMMITTEE

- PRIMARY SYSTEM INTEGRITY

  LAWRENCE SHAO, DIRECTOR, DE
  JAMES NORBERG, DE

- SYSTEMS AND SEVERE ACCIDENTS

  BRIAN SHERON, DIRECTOR, DSR
  ANDREW MARCHESE, DSR

- HUMAN FACTORS AND WASTE MANAGEMENT

  JOSEPH MURPHY, DEPUTY DIRECTOR, DSR
  ROBERT BOSNAK, DEPUTY DIRECTOR, DE

- OVERALL COORDINATION AND REPORT PREPARATION

  RALPH MEYER, RES