UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Title: BRIEFING ON AGENCY HUMAN FACTORS INITIATIVES

Location: ROCKVILLE, MARYLAND

Date: JULY 6, 1989

Pages: 72 PAGES

NEAL R. GROSS AND CO., INC.

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Washington, D.C. 20005
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JULY 6, 1989

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The briefing was held at the Nuclear Regulatory Commission, One White Flint North, Rockville, Maryland, at 10:00 a.m., KENNETH M. CARR, Chairman, presiding.

PRESENT:

KENNETH M. CARR, Chairman of the Commission

KENNETH C. ROGERS, Member of the Commission

JAMES R. CURTISS, Member of the Commission

ALSO PRESENT:

SAMUEL J. CHILK, Secretary

WILLIAM C. PARLER, General Counsel

FRANK COFFMAN

EUGENE TRAGER

DENNIS SERIG

JACK ROE

THOMAS E. MURLEY

JAMES TAYLOR

ERIC S. BECKJORD

BRIAN SHERON

EDWARD L. JORDAN

THOMAS NOVAK

ROBERT BERNERO

P-R-O-C-E-E-D-I-N-G-S

(10:00 a.m.)

CHAIRMAN CARR: Good morning, ladies and gentlemen. Commissioner Roberts will not be with us today.

The purpose of today's meeting is for the NRC staff to brief the Commission on the status of the Agency's human factors initiatives. The Commission was last briefed on the subject of human factors activities on May 1st, 1988 and subsequently on October 13th, 1988, received responses to a number of questions which had been raised at that briefing.

Copies of the slide presentation should be available at the entrance to the meeting room.

Do my fellow Commissioners have any opening comments?

(No response.)

Mr. Taylor, you may proceed.

MR. TAYLOR: Good morning, sir. This briefing today is an integrated briefing reaching across all of the major program offices. And they are represented here and will participate in the briefing.

It is, I think, important to note that the staff worked collectively across offices to pull the

various pieces of the human factors initiative and work together in its paper to you. The briefing today will span across the program offices.

Beginning, and in the lead role, was the Office of Research. And I will ask Mr. Beckjord to commence the detailed briefing.

MR. BECKJORD: Thank you, Mr. Chairman.

Human performance contributes to about half of the significant events at nuclear power plants and a larger percentage at non-reactor facilities. An understanding of the factors that affect human performance can focus regulatory attention and guide regulatory actions pertaining to licensee personnel.

In order to understand personnel error, more research is needed to characterize and measure human capabilities and limitations. The Human Factors Regulatory Research Program provides the framework for this research into the many factors that shape human performance, such as thinking processes, training, qualifications, organization, supervision, procedures, performance aids, and the relationship between people and the systems.

The human factors research supports regulatory decisions affecting operators, maintenance personnel, technicians, and managers within the

nuclear industry and incorporates human reliability analysis into probablistic risk assessments.

I think that this program is a good response to the various user needs that have been defined to the Research Office, and I am enthusiastic about the program.

Dr. Sheron will begin the presentation on the program details.

COMMISSIONER ROGERS: If I could just ask. I don't want to derail anything. This 50 percent figure of human factors, being responsible for that kind of a percentage of incidence, without elaborating on the point, certainly, right now, I wonder if someplace along the line of your presentation you could address this question of just where one draws the line as to what you call a human factors-related event and not.

If you look deeper and deeper and deeper into the process, you can always find a person someplace in there. How comfortable do we feel with making some kind of a separation into a human factors root cause versus in a plant event of some sort versus a technical unreliability, which ultimately, if you trace it back, might come to the designer of the equipment in the first place? So we know there is

this fuzziness in the definition.

I wonder if someplace along the line, you could just say what your feelings are about that.

MR. BECKJORD: Well, I use the word "contributed," that the human error contributes to it because when you look into incidence, you find that it is generally quite a mixture of human factors and technical faults that occur in this system. So I agree with your point.

COMMISSIONER ROGERS: Well, this distinction, I wonder if it is purely an academic one, the concern, or whether there really is something we ought to understand a little bit better about where to draw the line between a root cause being the human factors-related cause and something else.

MR. BECKJORD: Yes, we will.

COMMISSIONER ROGERS: Okay.

DR. SHERON: Could I have the first slide, please? The first one here just tells basically the content of the briefing. We will tell you a little background again, the objectives of the programs and initiatives, and then we will give you an update on the various programs in the program offices and a quick overview of our first revision to the Human Factors Research Program Plan.

Next slide, please. If you recall, in May of '88, last year, about a year ago, we submitted our first Human Factors Research Program Plan, which was SECY-88-141.

In July of that same year, we received a staff requirements memo directing us to submit an information paper on seven specific items, to update our initiatives and to define issues addressed by the Research Program.

We responded in October of '88. We provided a Commission paper which answered the seven specific items, and we acknowledged our plans to update our Research Program, which is the initiatives and issues that were mentioned.

We were working with the ACRS all along in developing this program. In January of '89, after we had completed our first draft of Revision 1 to the research plan, we met with the ACRS Subcommittee on Human Factors and reviewed the draft research plan. This is chaired by Dr. Remick.

Then in February of '89, the EDO directed the staff to expand the scope of the proposed Commission paper so not only did it provide you with an update of the Research Program, but provided you with an update of the Agency-wide programs in the area

of human factors.

The ACRS also had made this recommendation. And in April of '89, we met again with the Subcommittee on the Agency-wide programs. This was not just research, but NRR, AEOD, and NMSS. We met with the Subcommittee in April.

In May we gave a presentation to the full Committee on these programs. On May the 9th we received a letter from the ACRS, which I am sure you have all seen. I think the key words in that letter were, "We recommend proceeding with the proposed Human Factors Research Program and initiatives."

In June of '89 we sent to you the NRC human factors programs and initiatives, which contained Rev. 1 of the human factors research plan. That was in SECY-89-183.

Next slide, please. Quickly, the objectives of the human factors program plans in the Agency can be summed up in the following four bullets. They are: to assure that the human factors issues affecting safety are considered appropriately in all regulatory activities; to provide an adequate human factors research resource to ensure all user needs are met and a base research program is performed. It is to coordinate and integrate the Agency activities in

human factors and to assure that the research programs that we are carrying out are properly structured and responsive to the user offices.

COMMISSIONER ROGERS: Just tell us who the "users" are, how that word is defined here.

DR. SHERON: Okay. The users are the program offices which carry out the regulatory activities. This would be AEOD, NMSS, and NRR. And Dr. Coffman will be telling you a lot more about who these users are and the types of research requests that we have gotten.

COMMISSIONER ROGERS: How realistic is it to try to meet all user needs?

DR. SHERON: Right now I think I feel very comfortable that we have put together a program that is responsive to all the requests that we have gotten so far.

I think, as we learn more in this area, there may be more requests coming. And that may be a matter of balancing the resources.

MR. TAYLOR: May I add that during the course of past months, we have had numbers of meetings with key people across the staffs to try to get that focus, you know, of knowing always that only some many resources will be there to try to focus the issue. So

in most of the cases, there has been a lot of cross-discussion with staff to focus.

COMMISSIONER ROGERS: Well, the problem that comes to mind is that this is a relatively new initiative for us. We used to do it. Then we stopped it. Now we are starting again.

MR. TAYLOR: Right.

COMMISSIONER ROGERS: As this kind of expertise and knowledge begins to become available, appetites will grow.

MR. TAYLOR: They are big already, sir.

COMMISSIONER ROGERS: I think eventually you won't be able to meet all of the needs. You will have to prioritize and cut it off someplace.

DR. SHERON: I would point out, though, that the research that is done is not like other research where it involves big experimental facilities, which are very expensive and financially draining. You can perform a lot of research without the big experiments that go along with it. So you can get a lot more done for the dollars.

On the next slide, Slide 7, this is just a quick summary of the resources that are being expended in the program offices in '89 and '90. I think it is self-explanatory. As you can see, I think that the

level of effort was pretty well-stabilized in most of the offices.

I see the research budget coming up in an accent now towards a mature program. I would also point out that this is not truly reflective of all of the activities that involve human factors.

There are many activities that are very related to human factors that go on, like the operator licensing and so forth, that are not really reflected here. So if you wanted to have every FTE that was, you know, actually involved in human factors, I think these numbers would be a lot larger.

With that, what I would like to do now would be to let each of the program offices give a brief description of their programs. I think Dr. Murley wants to introduce the NRR presentation.

DR. MURLEY: Yes. Thank you, Brian.

Commissioner Rogers, it is quite true that much of what we do in NRR, at least, touches on human factors. It is difficult to draw the line that separates it, but one could kind of arbitrarily divide the aspects of reactor safety into three parts.

One is the design of the plant, how it is laid out. The second is how equipment and materials behave. The third would be how it is operated, how

humans actually maintain and operate the plant.

As you know, we are in the phase now where we are almost purely looking at the operations, how plants are maintained and operated.

The design, of course, we still look for weaknesses, and we still look at operating experience to tell us where weaknesses are. Where we see it, we correct it through backfits.

Materials, of course, are always a problem. There, we have programs in aging, and whatever. But, by and large, today I would say a large part of our safety focus in on aspects of human factors.

Jack Roe is going to describe in a moment the human factors activities in NRR that support the safety mission. Some of them, you will see, are well-defined programs, like the detailed control room design review.

Others are more of a loose, I would call it a "loose," collection of activities, like the emergency operating procedure inspections that we did. The inspections themselves were well-focused, but it is not a human factors program. It is detailed.

We also work in collaboration with AEOD. In effect, I would say we are a user, probably the primary user, of the AEOD program results.

And, finally, we also support research in their programs to develop insights and methods that can help us in our mission.

We have carefully reviewed this human factors program plan. In fact, I have reviewed it myself personally. And so it reflects very much the NRR office view of what should be done in the Agency.

MR. ROE: First I would like to talk overview and then about EOPs as the first program. We have several programs in the human factors area. These programs are primarily operationally focused. They are well-coordinated with other program offices and our regional offices. Many of these programs are supported by the activities of the Office of Research.

The first slide, EOPs. The objectives of our inspections are: to determine if the emergency operating procedures are technically correct; second, can they be physically carried out in the plant; third, can the control room crew perform the procedure properly.

The inspections are focused on walk-through of the procedures in the plant, simulator scenarios requiring control rooms to actually use the EOPs and walk them through.

We have had a three-phased approach. The

reason for the three-phased approach was we did not know exactly what we were going to find as we went through these particular inspections.

The first phase was 16 inspections, primarily among the 4 vendor types.

The second phase was inspections of 13 Mark 1 boiling water reactors because of our interest in that particular containment type and the capability of venting that containment type.

We are now into our third phase of inspections, which is the remaining reactors. Those are to be completed by the end of fiscal year '90.

In the transition period between the second phase and the third phase, we issued a document, which was "Lessons Learned From the Special Inspection Program of EOPs." We wanted the industry to get the word out on what we found at the various inspections that we conducted across the country.

We also issued another document that was associated with techniques of preparing flow chart-formatted EOPs, provided that as guidance and information for the industry.

In addition, this last week we held two workshops for the industry on emergency operating procedures. The workshops were co-hosted by the NRC

and NUMARC and they were well-received by the industry. We believe that this inspection program has had an impact and that the results are enhanced reactor safety.

COMMISSIONER ROGERS: What has happened as a result of NUREG 1358? Have you seen any changes in anything? You are not through your entire inspection program. So do you have some indications that people are using --

MR. ROE: Early indications. And I think we will have to wait until we see the results of the third-phase inspection to get the word completely out since we just issued the document and held the workshops.

We have sort of a slow pace of the inspections to allow people to accommodate the changes until we pick them up again.

COMMISSIONER ROGERS: Do you expect to update that as you complete more inspections?

MR. ROE: I think that time will tell whether we need to update or not, depending upon what we find in the future.

DR. MURLEY: Commissioner, I would say that we have learned something from those inspections. It affected our thinking on venting, for example, and on

our recommendations on the Mark 1 vent, some of the things that we found when we talked with operators when we looked at their procedure. So, in that sense, it has had an impact on our thinking.

I think it is probably a little slower to diffuse out to the industry, although I have heard some indications from utility managers that they have a high regard for this type of inspection.

They think it is focusing on the right thing and, presumably from that, they are looking at the results at least, although, like Jack said, we haven't got any specifics we can point to.

MR. ROE: The emergency operating procedures also are utilized in our re-qualification inspection because it is a tool that the control room crew has to use. So there is a continuing inspection program in that facet also.

COMMISSIONER ROGERS: On this flow chart format for EOPs, is there any implication there that that is an NRC-preferred tool or is this just an assist for those who want to develop that kind of thing?

MR. ROE: I would say it is preferred, but that is only in general guidance, not a requirement. They can use whatever --

COMMISSIONER ROGERS: There is some disagreement --

MR. ROE: Yes.

COMMISSIONER ROGERS: -- in the plants as to which is the best assist to have. I was just wondering how we stand on that, whether we feel -- I mean, the implication is that it is a preferred --

MR. ROE: That is the implication, but they do have the latitude to develop and implement them at their own discretion as long as they meet the needs of the operators.

COMMISSIONER ROGERS: Well, I would hope we would understand what the realities are of the disagreement because I think there probably are some good points.

Neither the narrative form or the flow chart form is perfect on its own.

MR. ROE: That's right.

COMMISSIONER ROGERS: And so I think we should be alert to ways to improve the entire process.

MR. ROE: The Office of Research is also supporting our longer-term efforts in the area of accident management, which is related to this particular inspection program.

The next slide deals with our man-machine

interface. The objective of our efforts in this area is to aggressively complete the actions associated with our detailed control room design reviews and the safety parameter display system.

For our detailed control room design reviews, we are conducting an accelerated audit program at the remaining facilities that we have not looked at previously. We plan to complete all of these audits by March of 1990.

Research is supporting our efforts in the control room area with projects on, annunciator systems, designs of advanced control rooms, expert computer systems, local control stations, and computer displays and controls.

In the area of SPDS, we have issued a generic letter with an enclosed NUREG report. The letter requests that licensees certify that their SPDS now meets the requirements of NUREG 737, Supplement 1 or certify that their SPDS will fully meet the requirements of NUREG 737, Supp. 1 and if a certification cannot be made, describe compensatory actions.

CHAIRMAN CARR: On that one, it seemed to me that the research is ongoing in both of those areas on what we ought to be doing. Does this mean that these

guys are shooting at a moving target?

MR. ROE: No, sir. The requirements are well-established and articulated in our NUREG report. There is information that will be developed as far as our research activities that will come into the regulatory environment later, but then we will have to make a decision of whether or not to back-fit those requirements.

So as far as the utilities should be looking at it is they have a firm target.

CHAIRMAN CARR: Well, I guess my question, then, is: Is the research worthwhile in these two areas?

MR. ROE: I believe that the research is worthwhile. We are going to have advanced reactors. We should take into consideration what we can learn now and when they start to develop the requirements for those control rooms and start developing them.

CHAIRMAN CARR: Okay.

COMMISSIONER ROGERS: Those SPDS requirements, how specific are they? Do they, for example, set a specific time, elapsed time, between screen refreshments?

MR. ROE: Many of the requirements are somewhat general in nature. What we have done is: In

our reviews, we have taken and basically bracketed times, I would say, in this particular instance.

In the NUREG report, we have reported to the industry which screen update times we have found acceptable and which ones we have found unacceptable because they really don't meet the intent of the basic requirement. The basic requirement is pretty much qualitative and not quantitative.

COMMISSIONER ROGERS: Is there a range of times, depending upon the parameters that are being displayed? For example, in some of the plants I visited, -- at least one I know of -- there seemed to be an indication that there was as long as 5 to 10 minutes between screen refreshments for some parameters.

Do we have anything that says that that is acceptable or unacceptable?

MR. ROE: Yes, we do that would address that. What I recall in our previous reviews is that is probably too long. That would not meet the basic requirement for even a logical interpretation of what that requirement is directed at.

COMMISSIONER ROGERS: Do we check for that? Are we checking these?

MR. ROE: That will be part of their

certification. They will take a look at that and respond. If theirs falls within the brackets of what we have previously approved and found reasonably met those requirements, then they will be able to certify. If it is outside, then they will have to bring that to our attention.

COMMISSIONER ROGERS: Okay.

MR. ROE: The staff plans to finish our reviews and close these out for those plants that certified their SPDS's meet or will meet the requirements of NUREG 737, Supp. 1.

As of today, we understand we have received two responses to that particular generic letter and expect a large amount of responses in the very near future.

The next area we would like to discuss is training and qualification. As the Commission is aware, the staff has worked closely with INPO and NUMARC on this particular area of training and qualification, with the Nuclear Training Academy, and with program accreditation over time.

We are now evolving our focus to include implementation of training programs at facilities, along with the accreditation of the programs and continued work with NUMARC and INPO.

We have developed and pilot-tested a new inspection procedure for plant training programs. We pilot-tested it as part of a special team inspection, which was conducted at Nine Mile Point. And our first inspection was conducted at Turkey Point after the facility was found unsatisfactory in the operator recall area.

We had planned to conduct an inspection, and Turkey Point's performance provided us a reason to pick that particular facility. We plan on continuing these inspections and conducting several each year.

Research is also supporting us in this area by developing criteria and methods to assist in the measurement of training effectiveness, which is a very difficult task.

Next, I would like to talk just briefly about operator examinations and licensing. The Commission has received several briefings from the staff recently about this particular subject.

As you know, the objective of our program here is to examine operators using content-valid, operationally focused activities and methods. Our initiatives in this particular area are on target and we feel are very successful.

Our re-qual program is running rather well.

The second pilot test of our fundamentals examination was conducted on June 28th, and we are planning on fully implementing the program in October. We are currently evaluating the results of that particular examination.

Also, we have implemented a national exam schedule that generally provides for two site visits for each site per year from now into the future. This approach will provide stability for our and the facilities' schedules and will allow us to use our certified examiners in a more effective manner, one that will be more stable and where we would have exams given at various times in the year that were pretty much driven by the utilities.

This will straighten out and provide a lot of stability to both their process and our process and allow us to give re-qual exams and initial exams at the same period of time.

CHAIRMAN CARR: Does that meet with general utility acceptance?

MR. ROE: Yes. All they needed was a little bit of negotiating room on the date and also the capability to make changes if something happened with respect to their operations.

We gave them sufficient time. Now they find

it quite satisfactory, and they are looking forward to it.

In the area of organization and management, in this area, we support the team inspections conducted by NRR and the diagnostic evaluations by AEOD. We put a large amount of effort into that.

I would like to go on to the next area, which is additional programs incorporating human performance data. First of all, in the maintenance area in the inspections, we in our inspection at the site use a review of the human performance evaluation system developed by INPO and implemented by the utilities to determine their approach towards human factors.

We also look at human factors in the engineering support area, how they are actually carrying out the support to the overall design implementation and operation of the facility.

Also, we have human factors branch members who, upon occasion, will participate in a maintenance team inspection.

In the SALP area, we have recently revised the SALP manual chapter. Now the evaluation criteria are more specific to incorporate human performance issues.

With respect to the senior management meeting, we have provided a great deal of support to that particular process from the staff from all the aspects of human factors endeavors, whether it be from operator licensing, emergency operating procedures evaluations, SPDS.

Wherever we have information that is relevant to the performance of a facility, we provide that to the senior management process.

Next I would like to speak about our efforts in the human reliability area. The objective of our program is to understand the sensitivity of risk to human error rates.

We have concluded part of our program on this particular subject, and we recently published a very interesting NUREG on risk sensitivity to human error rates. We are planning to incorporate the lessons we have learned from that particular project into our inspection program.

The Office of Research is continuing to support us in this particular area.

Lastly, I would like to talk about a future initiative, which is root cause analysis of events involving human factors. The objective of this particular future initiative is to coordinate with

AEOD and Research and our regions: to look at the development of an effective method to assess the root cause of human errors; secondly, to obtain detailed event-related human performance information; and then to evaluate the effectiveness of the LER system in providing us the information from the industry.

Research is supporting us fully in this particular effort.

These are highlights that I have brought out on the programs conducted by NRR. There are other aspects of our program that we have not highlighted, but to give you the highlights, we will conclude at this particular point.

MR. TRAGER: The AEOD programs involving human factors are integrated into the AEOD programs. We feel we have very close communications with NRR, Research, NMSS in this integration. We both obtain support and provide support in human factors reviews.

The six program areas that I think most nearly typify the level of human factors support are listed on the slide. The routine operational event assessment; for instance, case studies on motor operated valves and the service water system, some of their dominant findings were regarding training and procedures, human factors-driven aspects.

The performance indicator program, we briefed the Commission earlier this year on a developed, validated performance indicator based on licensee event reports that extract cause codes and corrective actions from that data and is available for use by the Agency.

Those performance indicators were developed with Research support.

Incident investigations program, that program, AEOD provides the oversight, the staffing through the other offices. We provide an annual training program.

That program emphasizes the human contribution to help the investigators if they were called to do an investigation to look deeply into the root cause of that particular event in terms of the human contribution.

The diagnostic evaluation program, as was mentioned earlier, utilizes NRR and Research personnel in the human factors area of management training. And so we use the Agency's resources, I think, very well in the diagnostic program. Certainly the findings include management aspects of training, personnel errors.

The non-reactor assessment program, the

staff is developing, with contractor assistance and with NMSS coordination, a training video on medical administrations, the personnel errors side of medical misadministrations.

And, finally, through the Technical Training Center in Chattanooga, a very important aspect of that is understanding for the inspectors and for the reviewers the role that the operator plays, that the operating personnel play in human errors that they may commit, their response to events, to give an appreciation through our inspection programs and through our review programs for those potential human errors.

So, in summary, we feel that the program is well-integrated with the other offices, and we both receive support and provide output related to human factors.

CHAIRMAN CARR: What is the status of that training video for non-reactor assessment?

MR. TRAGER: We have a contract with Oak Ridge to produce it. I believe it is with Oak Ridge. Is that right?

MR. NOVAK: Yes. Tom Novak of the staff, sir. Yes, the contract is in place with Oak Ridge-associated universities. We have formed a

technical committee that will provide the input. It is moving along. We clearly expect to have it by the fall of this year.

CHAIRMAN CARR: Thank you.

MR. SERIG: NMSS' interests encompass a broad spectrum of activities related to the production and use of nuclear material. Potential impact of human error on public health and safety is common to all of those activities.

In response, Bullet 1 indicates that NMSS has developed a human factors program with two key functions. One is the direct application of existing human factors technology now. The second is the identification of needed research to improve applications tomorrow.

I would like to illustrate how these two functions are being conducted through discussion of several priority areas. In the area of medical use, shown in Bullet 2, there has been a direct application of human factors effort.

Those applications have involved the participation and development of contractor surveys to survey training and medical industry, participation in the review of the "Quality Assurance Rule and Regulatory Guide," which the Commission now has just

reviewed.

In addition, we have had early and extensive participation in regular and special inspections. That participation has had a mix of purposes. One is to provide assistance where possible; in particular, to show the errors are not random, that they have a cause, and that, once that cause is determined, a proper cure can be developed.

The second is fact-finding. As a result of several inspections, human factors notes have been prepared, and those have been distributed to the office, to the region, and to licensees as appropriate.

There have also been a number of briefings of meetings. They have included activities with the Food and Drug Administration, regional workshops involving medical licensees and other groups. These activities serve to provide information, again, to NMSS and to develop awareness in others.

Now, we feel it is particularly important to develop early awareness in others of human factors problems because the solutions to these problems may be beyond NRC purview in some cases. We are trying to promote willingness to contribute to the solutions to those problems now rather than later.

Direct application activities, I have just discussed. I have shown that the technical basis for dealing with human errors in medical use is inadequate.

As a result, we have developed several research needs. Some of these are based on interactions with AEOD and have fed into user need statements to the Office of Research. Of particular interest are user needs developed in the area of teletherapy, brachytherapy, and use of computers in treatment planning.

The first objective of each of these projects is to identify the factors contributing to human errors leading to medical misadministrations, to prioritize problems those factors cause in terms of their safety impact of their resolution, and then to identify and evaluate alternative resolutions for those problems.

A key example of a problem area is the use of high-dose rate after loading brachytherapy devices, where humans are being subjected, either internally or on their skin, to high-dose sources being used for very short durations and in very few fractions. The consequence of error is fairly high. It appears at this time that there is room for improvement in that

area.

Another priority area is industrial radiography. Direct application has involved participation in review of the equipment rule, which was recently forwarded to the Commission, and participation in the discussions involving certification of radiographers.

As in the medical use area, direct application has shown the technical basis to be slim. And so we have developed a user need statement for human factors evaluation in industrial radiography.

At this time, the development of the statement of work is in process, as it is for teletherapy and the medical area.

Other areas are getting attention as time and resources permit.

DR. COFFMAN: My purpose is to briefly summarize the Human Factors Regulatory Research Program. The purpose of the research itself is to provide the technological bases for regulation.

On Page 19, you will see that it is characterized by a multi-disciplinary endeavor. It relies heavily on the behavioral sciences and involves a variety of engineering disciplines.

The program is mainly to support regulatory

actions and the regulatory programs and initiatives listed in the SECY paper 89-183. From these regulatory programs and initiatives come the user needs.

There is also some base research, which is to anticipate human performance issues. I will describe that briefly.

On the next page, 20, to support the regulation, regulatory user needs are identified. These come out of the regulatory offices, where they identify their user needs under different conditions: one, where the technical basis for regulation or regulatory action is not mature or needs confirmation. And then another is where the actual nature of the potential safety problem is not well-defined.

On the next page, 21, the development of the user needs itself is an important and an interactive process. Following the April '87 reorganization, the user offices were busy organizing their own programs, and little effort had been given to the definition of user needs. So Research actively sought human factors research needs from the user offices.

Research is now currently working in the human factors area on a total of 11 user need memoranda from the 4 offices. Out of these 11

memoranda, there are 35 specific user needs, which I will summarize briefly in just a moment.

The Human Factors Regulatory Research Program is reaching maturity, as Dr. Sheron had mentioned.

Some more comments about the development of user needs on Page 22. The Research Program is interactive, and the projects are revised as the regulatory needs change or evolve with the regulatory process.

Formally, we meet with users approximately quarterly at the division director level. And then formally we have meetings at the branch chief level more frequently. Plus, there is this backdrop of frequent interactions, discussions, and phone calls.

At the staff level, it is almost daily interaction. And, on some occasions, there are interactions more than once a day.

CHAIRMAN CARR: I guess while we are at this point, I need to ask: Who is responsible for coordination and monitoring to ensure we are consistent and accurate in our outcome?

I mean, we have spread this across a lot of ground, as you have said. There are the 35 projects going on, as you say, almost daily. So where does it

come together? Who is making sure we are all marching in the same direction?

DR. COFFMAN: Well, it comes together at the different levels, beginning with the staff up, but it comes together more formally when, at the branch level, we have what are called "research project review group" meetings. There are two research project review groups within the branch.

We call those meetings to review specific projects that are at the stage where they need to be reviewed or where there is some question about the next step to be taken on the project.

Formal meeting minutes are issued on those meetings. They are issued to the division level review group, steering group, which is also an interoffice steering group.

That is probably the most effective way of doing it. We have other layers of review for coordination and consistency.

MR. TAYLOR: I believe that we would want to at least each year, and certainly as the results are attained from research, review it across the office director level to be sure.

I think your question is, really: Are we getting a payoff?

CHAIRMAN CARR: I want to be sure I know who is following the plan and making sure the plan is being carried out and the budget is going to meet the plan.

I am looking for the guy in charge, I guess, instead of all these different offices.

MR. TAYLOR: That is the EDO. It took work from the EDO's office to help pull this together. And I think the effort paid off.

CHAIRMAN CARR: That is all I am encouraging you to do, is to tighten the noose a little bit, because --

MR. TAYLOR: We can do that.

CHAIRMAN CARR: Okay.

COMMISSIONER ROGERS: How about just shortening the chains?

CHAIRMAN CARR: Chains?

DR. COFFMAN: If I could go to Page 23, I will mention that, alongside the user need research, there is some base research that is done, and this is human factors research in areas where there is no explicit or documented user need.

This base research is done to provide an information base, and it is in anticipation of future regulatory needs.

COMMISSIONER ROGERS: Could you give us some examples there, just a little bit, of how decisions get made with respect to whether you are going to do a particular kind of base research for which there isn't an explicit user need identified?

DR. COFFMAN: Well, we have two ways. One is that there are others who advise us on the research that is needed, including National Academy of Sciences, and we have a Nuclear Safety Research Review Committee, and the ACRS. And so some of the base research is developed from that source.

Then, in addition, through staff interaction, sometimes we are able to anticipate research needs that are on their way, but not yet formalized and sent over to us. So that is the other source of that information.

CHAIRMAN CARR: What percentage of the budget is base research?

DR. COFFMAN: At this time it is about in the 20 percent category.

An example of base research in this anticipation area is this operator vigilance, which is work that was initiated in October of '88 at the Institute for Circadian Physiology.

Then there is, in addition, another type of

base research, where we are looking to broaden our base in selected areas. An example is the work we are doing as joint funders of National Academy of Sciences' Human Factors Committee core research. That work was initiated in December of '88.

CHAIRMAN CARR: I would also encourage you to make sure you look and see if 20 percent is the right amount for base research when we are organized to a problem-solving area here.

DR. COFFMAN: Yes, sir.

MR. JORDAN: I would add an example of where the base research has been beneficial. The operator vigilance review provided some useful information to us for the Operations Center, which is a 24-hour station.

We run 12-hour shifts there. And so we were examining the shift time and duration with respect to that research, to see if there were improvements we could make in our arrangement. So it is very beneficial.

CHAIRMAN CARR: Well, I am not against research as long as it is proportionate to the rest of the work we have to do.

COMMISSIONER ROGERS: Well, I am just a little puzzled here, too, as to how you finally arrive

at what you are going to do, because it may be at this stage that you are able to do whatever is suggested, within something like 20 percent.

But how do you really get at how much of your resources you are going to direct to base research that, at the moment, does not have an explicit user need?

Now, I am not saying everything has to be that, but I wonder what the process is that, somehow or other, at least assists with users eventually using that, or potential users using that.

You know, if someone has not asked for it and it is done, they may just forget about it. And it sits on the shelf, even though it might be useful to them.

I wonder if you shouldn't have some mechanism of the potential users being alerted to the status of this base research for their own purposes in the future.

DR. COFFMAN: If I might address the process whereby we pick up base research, the recommendations -- maybe the best thing to do is pick an example. The National Academy of Sciences, you recall, last year recommended 44 different areas to do research in. We had not addressed them all. We had addressed all but

nine.

Subsequently, over the year, we have, in looking into their recommendations, rethinking where it might fit into the program, how it might support user needs or broaden the base for supporting the user needs, as we can and as the funding can be justified, we then fold that into the overall program; where, as this point, I think we are pretty much addressing all but two of the NAS recommendations.

So it is somewhat of an evolutionary process, where we have to find the right place that it is, in fact, coherent to the program in the reliability sense, that it contributes to the program. But it is an evolutionary process.

MR. BECKJORD: This matter of the base research, the number that Frank gave you of 20 percent is not just a number that comes out of human factors. I think, looking at the rest of our programs, it is in the 20 to 25 percent range that we spend on base research.

I don't know of any theoretical argument that says that that is what it ought to be. But, based on experience, that has worked out pretty well, long experience, that a lot of the things that come out of the base programs turn out to be useful,

perhaps not immediately, but after a couple of years.

And so I think that is just a general rule of thumb that we are applying now. We want to maintain the basic work at about that level. It has worked in the past.

CHAIRMAN CARR: My number is usually 10 percent in that same area, but we have worked on different things, obviously.

DR. SHERON: I would just add that the philosophy that we tend to follow is that we develop research programs that first meet the users' needs. If there is a user need, we make sure that the research needed to address that is funded at the right level and that the users are satisfied that that is the right program.

Then we turn our attention to the base program. As Eric said, it seems to historically have come out around that level. When we get additional needs; for example, NRR just sent us one on interfacing system LOCA. That research we estimate now is going to be about $1 million in various disciplines.

So what we are doing is we are again shifting and moving money and the like so we can meet that user need.

CHAIRMAN CARR: I think that is the right way to go as long as we can afford to level budgets, the level of research budget that works.

MR. TAYLOR: The program put quite a high priority on that effort. So we are prepared to make the necessary adjustments, I think, to fund that. Right, Brian?

DR. SHERON: Yes.

MR. TAYLOR: That is the intention. Okay.

DR. COFFMAN: User needs are mostly satisfied by the completion of the research projects. However, some user needs are met by intermediate results and some by expected byproducts.

To manage the research, the projects are grouped. Similar projects from the different offices are combined, and these related projects are directed by the appropriately qualified human factors analysts.

To provide you with a descriptive overview of some 35 specific user needs across 54 research projects would be excessive detail. So what you see in the following 5 view graphs, Pages 24 through 28, is I provide an overview by combining the 54 projects into their nine 5-year-plan activities.

These are the formal 5-year-plan budget activities, and it combines the 35 specific user needs

into 26 titles and the associated office that provided the user need.

On Page 24, you will see that the underlined "human factors" is a five-year-plan program element. That is just the hierarchy.

Then the first activity is personnel performance measurement. It is in this area where we are looking to get more credible evidence on exactly how the causes of human error can be divided and studied.

It was earlier there was a question about this distinction of human error from hardware error. Probably the closest reference for that is an AEOD report that indicated about 65 percent. There are other reports.

The projects in this personnel performance measurement activity are those projects which relate to developing the methods, improved methods, for data collection and screening, for storage and retrieval and analysis of data on the causal factors involved in human performance as it relates to safe operation.

It is in this area that all of the NMSS activities, projects are located because that is the stage of the research process that the NMSS effort for us is at.

Personnel subsystem is another activity. That contains those projects that are for developing the objective bases for regulatory actions related to staffing qualification and training.

COMMISSIONER ROGERS: Shift scheduling and overtime.

DR. COFFMAN: Yes, sir?

COMMISSIONER ROGERS: That is kind of old as the hills, isn't it? What really has to be done there in the way of research? What are open questions? And what, in a sense, really, should we, as a regulatory body, be concerned with?

Some of the considerations in shift scheduling have to do with the morale of the staff, and so on and so forth, that is on shift. But what should we be dealing with, from a purely safety point of view?

What represents unanswered questions in shift scheduling? I know there have been many, many studies of the way you rotate shifts forward, backwards, the number of people, length of shift, all this sort of thing.

Is there something new that has to be done here, or is this simply just getting together some reasonable collection of what has been done and then

sorting it out, from our point of view, to see if there is some basic safety issue involved?

DR. COFFMAN: The work we are doing I can address. As far as the position for the whole Agency, others would have to address. But we are doing work basically in two areas.

There is a policy that has been issued through a generic letter on shift scheduling and overtime. That policy was based upon evidence taken from industries other than nuclear.

So the one task we have in that area is to confirm. It is confirmatory research to assure that, in fact, the policy based upon non-nuclear evidence applies to nuclear. That is one area.

The other area is the more base research, where we are looking at operator vigilance. There we are doing some rather physiological life science work to determine effects on performance between 8-hour and 12-hour shifts.

To do that, we are doing that at the Institute for Circadian Physiology. It is extended research over several weeks. It involves the use of actual operators, not in power plant simulation, but in high tech simulation, measuring things like potassium levels, body temperatures, and then some

more subjective measurement for operator vigilance, all in support of the basic research thrust to provide objective evidence for regulation to support some of these other areas.

COMMISSIONER ROGERS: These studies have not been done anywhere else prior to this time?

DR. COFFMAN: No, sir. I don't think we are duplicating anything.

DR. MURLEY: So the answer, Commissioner, is that there is both some new work that needs to be done. What Frank has just mentioned is aimed at: How do we assure that operators stay alert during boring night hours?

There is another aspect, though, which is --you are quite right -- to collect the information that has been done in the past on the information regarding forward rotation, backward rotation, and so forth. We are embodying that and we have embodied that in policy statements on working hours.

I think there are still some questions open, though, with regard to whether, for example, 8-hour shifts are optimal for some, whether 12 hours are best for others. And it is not clear to me that there is a universal answer.

So I think we still need to be probing in

that area.

COMMISSIONER ROGERS: I guess what my concern is -- I have a number, but one of them is to what extent we are really getting into what amounts to, in a way, a management decision at the plant in how to deploy their human resources in the most effective and efficient and safe way and whether we really have an objective, well-documented basis for some kind of intervention on our part and how that is carried out.

And if we do and we have a real concern, then I think we should pursue it, but I think we should be careful that we are not simply stepping into what might be a management prerogative that doesn't have a high safety implication.

I don't know what the answer is there, but I think we have to be very careful that, just because something is interesting and naturally follows from what we have been doing, we don't automatically pursue it. You know, we have to be careful on how far we go there.

DR. MURLEY: I agree we have to be careful. We have to draw the distinction between having the knowledge and the information and what we do with it. Your caution, it seems to me, is that we ought to be

careful about drawing up regulations or guides, or whatever, in things that are management prerogative. I understand that.

However, I think at least I would very much like to know the impact on alertness of forward rotation versus backward rotation, and these kinds of things, even though we don't feel we know enough yet to write any regulations or something in this area.

CHAIRMAN CARR: I think that is the point of the research, is to come up with --

DR. MURLEY: Yes.

CHAIRMAN CARR: -- a definite decision one way or the other that you can substantiate.

DR. MURLEY: Yes.

MR. TAYLOR: And you would be aware of that if we did reach that in our justification.

COMMISSIONER ROGERS: I would hope that if we can't identify a right way to go, that we decide that we can't, I mean, that that is the answer, that there is no better way that is substantially different and that we should face up to that if that is the result.

I am not saying that is what the result should be, but we should be prepared for that possibility.

DR. COFFMAN: Go to Page 25. This activity, the five-year-plan activity, human system interface, is where we have grouped the projects that provide measures for evaluating the interface or the surface between the machine and its operators and maintainers.

As was mentioned earlier, the focus here is on advanced instrumentation and controls. The industry is already implementing expert systems in some non-safety-related systems and processes.

These expert systems offer the potential to improve safety by reducing initiating events. We are working to establish measures, subjective measures, for verification and validation of both the software and the interface design.

We completed an international workshop in January, which was to define measures and experiments to evaluate advanced instrumentation and control. One experimental method was identified already as a result of our participation in the Halden project.

Also, planned Halden work is to compare the effective differences between computer-based procedure formats and paper-based procedures.

In the area of organization and management, this activity combines those projects to develop methods and measures for systematically assessing the

safety impacts of organizational practices.

We completed an international workshop in November to define research models and methods to assess organizational practices. So an approach was developed in December of '88, and the approach is being tested at a fossil fuel plant even now.

Back in October of '88 we issued a report on a method for developing programmatic performance indicators. And then we also have used the Technical Training Center simulators already for developing some methods to evaluate control room team performance.

On the next page, 26, a shift to a new 5-year-plan program element, reliability assessment. This combines the activities that are research projects that will contain both the human and the hardware contributions.

Not only is it helpful to separate out and focus in on what are human causes versus hardware causes and to explore the mechanisms that lead to human error, but in order to look at total system reliability, one has to also combine these in a balanced way. That is what the activities and projects in this five-year-plan program element do.

The results of these projects are to provide methods and tools to do two things: rank the safety

issues and resolve between sources of uncertainty in a manner that gives balanced consideration of both hardware and human contributors. Some of our results today are being used in PRA reviews.

This first activity, data acquisition and quantification, is to be contrasted with the first activity under the human factors program element in that this is probablistic data, reliability data for use in probablistic analyses. It is on causes of operator error.

The data management systems. In July of '88, we issued Version 1 of the Nuclear Computerized Library for Analysis of Reactor Reliability, NUCLARR. Then Version 2 was issued in March of this year.

NUCLARR is a computerized database management system that contains both human error probabilities and hardware failure rates. It was issued in both diskette form for direct application on a PC and in paper format.

In addition to being used by the NRC offices and the ACRS, NUCLARR is currently being used by seven utilities, six firms who practice PRAs, two universities, research groups in six countries, NASA Ames, Army Research Institute, and Electrical Power Research Institute.

COMMISSIONER ROGERS: How often does that get updated, the database?

DR. COFFMAN: We are at the front end of these updates, and it is about six to nine months, depending upon the flow of data.

And we don't just take data. The data has to be systematically screened so that we don't duplicate data that is already in the system. It has to be appropriately qualified for the citation. So our two revisions ran about nine months apart.

On the next page, 27, the projects in the human reliability analysis and probablistic risk assessment integration five-year-plan activity are to integrate human factors expertise into the probablistic safety assessments.

We are doing work for modeling cognitive errors. We are using currently a code called "Slimmod," a technique called "Slimmod," which was developed by research. There are four applications of that that are ongoing.

We are developing some work further in this area of cognitive errors, developing a cognitive environment simulation method. And we are exercising this method at the NRC's Technical Training Center simulators.

We are tieing the analysis of human error into having the simulator drive the plant response. This work is being done with researchers from two universities.

For modeling execution errors, we are making use of a code, simulation code called "maintenance personnel performance simulation." We are doing work to make that more user-friendly.

This item here on organization and management, O and M, organization and management factors, is the quantification algorithm part of the organization and management activity that I mentioned earlier.

As far as HRA and PRA results applications, there are two, the tech spec configuration control work that is ongoing in NRR. Our project is to develop evaluation methods for measures that -- I'm sorry -- evaluation measures for this work, where they are trying to manage the configuration so that they control to minimize risk, even within what is allowed by tech specs.

As far as risk-based performance indicators, we briefed the Commission and issued a research information letter on an indicator called "safety system function trend." This was in support of AEOD

work and the maintenance policy.

RES Human Factors Branch also provided some guidance on the human reliability analysis part of the individual plant examinations document. And we participated in the IPE workshop at Fort Worth.

COMMISSIONER ROGERS: Just before you leave that slide, the tech spec configuration control work, does that relate to the risk-based tech spec activities?

DR. COFFMAN: Yes. Yes, that is it.

COMMISSIONER ROGERS: That is it.

DR. COFFMAN: That is our part of it.

COMMISSIONER ROGERS: Yes.

DR. COFFMAN: On Page 28, there is one activity in the five-year-plan program element called "generic and unresolved safety issues." There are some human factors issues which we inherited, and they are listed there.

In addition to these that are listed there, we have already closed out some that we had inherited. It was TMI Action Item 1D4 on control room design standards, Human Factors Generic Issue 1.1, which involved a revision to Reg. Guide 1.114; and than a TMI Action Item 2C4, which was done in October.

On the last page, there are listed other

research human factors activities that are there to illustrate the integration and coordination of the human factors within the NRC.

We are working on four of the Chernobyl follow-up items. In fact, last month we issued a closeout report on 1.2B, the NRC testing requirements. This was done jointly with NRR because of work that they had been doing in this area. We were able to close that out.

CHAIRMAN CARR: The Chernobyl database is fixed? It is not moving, is it? Are we still getting data? Are we getting more follow-up from the Soviets?

MR. TAYLOR: The only data that we are getting or intend to get is health physics and environmental effect type of information.

CHAIRMAN CARR: Are we getting that?

MR. TAYLOR: That is part of the cooperation with --

CHAIRMAN CARR: We've got a promissory note for it?

MR. TAYLOR: Right. The first meeting on that is in September in the Soviet Union. In fact, we discussed that yesterday with the Department of Energy. Those trips are set for Kiev and Moscow.

CHAIRMAN CARR: Okay.

DR. COFFMAN: Ed Jordan has already

mentioned that we are doing some support for the design of the new NRC Operations Center. We provide direct staff support on some management inspections and some human system interface reviews on the SPDS.

We are participating with AEOD in looking at what simulator upgrades might be beneficial. And, in fact, I might say that our program is progressively using more and more the NRC simulators. And we are working to use other simulators that are available in the industry?

CHAIRMAN CARR: Have they made those available? Has the industry made their simulators available to us?

DR. COFFMAN: Not directly available to us, but, in working through standards committees and working with EPRI, we are participating in work that we will benefit from.

CHAIRMAN CARR: So they are being used in this?

DR. COFFMAN: Yes, sir.

Then the last item is the direct support to NMSS in defining their human factors issues on material licensees.

What I have tried to do is briefly summarize the Human Factors Regulatory Research Program on

methods and models development, on causal data, and on valid measures of human performance because the program is focused to provide the technical basis for adequate regulation.

Then, in addition, there is the base of information that we are trying to develop in anticipation of regulatory issues.

MR. TAYLOR: That concludes our formal presentation, sir.

CHAIRMAN CARR: Any questions from my fellow Commissioners?

COMMISSIONER ROGERS: Well, I have asked quite a few, but it has been very helpful, I think. But I didn't hear anything about the recommendation that the ACRS made in its May 9th letter that you develop a human factors research effort to improve the methodology for selection and training of resident inspectors. And they made quite a little point of that.

I wondered what the follow-through is that is projected.

DR. COFFMAN: I can't say much because the Office of Research doesn't control the resident inspectors, and that would be a user need that would have to be identified.

DR. MURLEY: We are still looking at that, Commissioner, but I have asked the staff to go back and list for us the process that we go through now in selecting resident inspector.

In fact, it is quite a lengthy screening process. We almost never hire someone straight from outside and put them in a resident's spot. We train them. We observe them, and so forth.

So it is not clear that we need to undertake a research program, but we are still looking into that.

CHAIRMAN CARR: The ACRS didn't have any specifics.

DR. MURLEY: No.

COMMISSIONER ROGERS: No.

DR. MURLEY: They just pointed out the importance of the resident inspector to our program, and we agree with that.

CHAIRMAN CARR: It might be worth having them look at the current --

DR. MURLEY: Yes.

CHAIRMAN CARR: -- way you do it and see if we can come with some because, certainly, it is important to us to have the best qualified inspectors out there we can.

COMMISSIONER ROGERS: Do we run potential candidates for resident inspector jobs through some kind of a -- well, I will say a psychological capability test? I don't know. I am not talking about psychological state of mind, but --

CHAIRMAN CARR: Aptitude test.

COMMISSIONER ROGERS: Aptitude test. Thanks. That is what I was groping for here.

Do we run them through some kind of a standardized aptitude test that is tailored for this particular kind of activity?

DR. MURLEY: No, we don't. We get into questions about treating these special groups of NRC employees different from other special groups. But I don't know that that is absolutely necessary either.

If we do have a rigorous management oversight procedure where we observe the candidates for a year or two in other settings, I think we can come to some management judgments that are probably as good.

MR. TAYLOR: We lean to hiring -- even when we have in view a resident-type assignment, we lean to hiring people with experience, either in the industry or military applications, heavily.

Then usually the process is to get them in a

region assignment if they are new type hires. Then they can get familiar with the whole process of the Agency better. So that is the way this has evolved through the years.

And, of course, we do have a prescribed training program and qualification criteria set up through the regional office that the residents go through.

So there is structure, and I think the ACRS question is reasonable. We will respond to it, but with what we do do. Perhaps there will be suggestions of things we aren't.

CHAIRMAN CARR: I guess it would be of interest to know the dropout rate in the trainee program through the TTC the first year or so before they become qualified RIs.

MR. TAYLOR: We do have some who fail. I know. I can't give you their names.

COMMISSIONER ROGERS: And also any kind of a longitudinal study of people who somehow we have felt ultimately were inappropriate for that job, even though they did get into it and could we have picked that up earlier, and so on and so forth.

That is all I have. Thank you.

COMMISSIONER CURTISS: I don't have any

further questions. Thank you.

CHAIRMAN CARR: We mentioned earlier on about other researchers wanting access to our simulators in order to find answers to questions. Are you able to do that?

I guess these were outside consultants and laboratories who wanted to be able to get use of simulators.

MR. JORDAN: As time is available, we are making them available for research purposes through the Office of Research, not for an outside request, and so that it is integrated with our programs.

CHAIRMAN CARR: So do we get to monitor their program a little bit to make sure that they are using our simulators for something we think would be useful to us or is it for basic research for them?

MR. JORDAN: Well, the availability is: The Agency's training has first priority. And if there is time available after that, then we will provide it, but through the Office of Research ascertaining that it is worthy and coordinated through them, rather than directly with the Training Center.

CHAIRMAN CARR: Okay. On the NMSS area, given the potential consequences for exposure from human error in that area, I noticed we are zero-funded

in '90 for the NMSS part and only 2 FTE.

I noticed the ACRS also asked the question. Are the current levels of resources devoted to human factors in the NMSS area adequate, do you think?

MR. TAYLOR: The Office Director says the answer is, "Of course not."

MR. BERNERO: My name is Bernero. I am Director of NMSS. If you see, that one slide has a zero. We did have an option. We could have plugged a number in there; for instance, in the medical QA, we have a major contract on medical quality assurance, which, by another measure, could be counted as human factors. We are applying resources as quickly and as carefully as we can in the NMSS arena. As Dennis said in his briefing, we are trying to get direct application out in the field and at the same time identify intelligent, coherent needs, at the same time.

We treat this with high priority, and we will apply the resources as rapidly as we can intelligently identify them. I think we are giving it the necessary priority.

We do have a need, I would say, to identify what are human factors and what is safety review, and so forth, because a lot of our material work, material licensing work in particular, is easily put into the

human factors bin just to make the number look big.

And so it was a conscious choice not to put that in.

CHAIRMAN CARR: So zero doesn't really mean zero?

MR. BERNERO: No.

CHAIRMAN CARR: Okay.

MR. BERNERO: Zero is not really representative, but if you would look at new initiatives that come in under the umbrella of new human factors initiatives, the zero is accurate.

CHAIRMAN CARR: Okay. And I read that to say that you have enough resources now to carry out your program since you are trying to do it as sensibly as you can?

MR. BERNERO: Yes. And as fast as we can identify user needs to research, they have been responsive to identifying particular projects, like in the brachytherapy, and that sort of thing.

CHAIRMAN CARR: Thank you.

Human Factors Research Program Plan discusses development of programmatic indicators and management and organizational culture. How do you plan to use these in the regulatory program once you figure out what they are? That is a kind of a

sensitive area.

DR. COFFMAN: Our work in programmatic and risk-based indicators is in to support the work that is ongoing with AEOD and the work that is being done in maintenance.

As far as its impact on regulation, it goes through AEOD and is input to the senior management meeting that is -- the input is coordinated through NRR.

Maybe I am not addressing --

CHAIRMAN CARR: Maybe I ought to ask somebody else.

DR. MURLEY: I think I know what you are getting at, Mr. Chairman. There were two studies that we asked for at NRR sometime ago. One was the impact of human errors on risk. In fact, that program got started many years ago, and it is putting out very, very good work, I think.

It shows us where human errors affect risk, where we should be putting our attention, and our resources. In fact, I have used it quite a bit in restructuring our program at NRR and focusing on the importance of operations.

Now, the second aspect of it is more research. And that is, how do we get a handle on

human error rate at a plant? That is, from the things that we measure, like SALP reports, like performance indicators, and those observables, is there a model that you can put those into so that the output is human error rate, so that we could use it in studies like this?

I guess another way of saying it is: How can we relate SALP reports, performance indicators to the risk of a plant? And we don't have --

CHAIRMAN CARR: I am a little more interested in the management and organizational culture and how you plan to use that particular portion of it.

DR. MURLEY: That is the model that they are attempting to develop; that is, to try to relate observable things to human error rate through a kind of a management model.

It is not at all clear that it can be done, that it can be done successfully. So we are keeping a very close eye on it. I have spoken recently with Eric Beckjord, and we will keep a close eye on it. We will reorient, as necessary, if it seems like it is not producing what we think we need.

But the output, what I would like at least, is pretty clear in my mind, is how to take the things

we do observe and relate it to risk.

CHAIRMAN CARR: Okay. Are you getting help from the utilities in this program?

DR. MURLEY: Yes.

DR. COFFMAN: Yes.

DR. MURLEY: Can you say just a bit more about it?

DR. COFFMAN: Yes. I see where I missed on the question. I answered it from a programmatic standpoint. I think you were more interested in the technical aspect of the program.

To answer your last question first, yes, we are getting cooperation from the utilities. Some utilities are more aggressive in it. It is a nuclear utility, but a fossil plant that we are currently exercising the method on.

As far as the technical aspect of the method, when you said "performance indicators," I was thinking plant performance indicators, but you are really saying as an indication of organizational effectiveness and the impact.

CHAIRMAN CARR: I think the word were "programmatic indicators," is what your plan says, but I was trying to analyze the culture in the plant and decide --

DR. COFFMAN: Well, there are --

CHAIRMAN CARR: -- whether it was a good one or a bad one, I suppose.

DR. COFFMAN: There are established instruments for measuring organizational culture. Now, that doesn't say that they are 100 percent accurate, always apply totally to the given situation, but there are standardized instruments for measuring cultural impact.

And then, after making those measurements, the next step is to translate those measurements into figures, into human error rates that can be accepted by the risk assessment, which is a creative part of the work to try and take measures.

CHAIRMAN CARR: How much? Define for me what an instrument is. Is that a public opinion poll or is that a --

DR. COFFMAN: No, sir. The two --

CHAIRMAN CARR: -- bottom line on the worksheet or --

DR. COFFMAN: No. The two instruments we are using in the fossil plant, one is called an "organizational culture inventory," involves some 120 questions where it asks about people's expectations as far as their communication with their supervisors,

their peers, and their subordinates.

CHAIRMAN CARR: That is what I call a "public opinion poll," but I understand what you mean.

DR. COFFMAN: Well, it is a soft area. It is not something that -- well, yes. Okay. It is a soft area. It is a softer science.

And then we are using an observational technique, where the supervisors and managers are observed and the way they allocate their time is measured.

CHAIRMAN CARR: I understand that. How about INPO? Are their human factors research area and yours working together?

DR. COFFMAN: We are aware of several initiatives that INPO has. We have tried to get with them for the purpose primarily of sharing data out of their human performance evaluation system and have not been too successful in convincing them that they should share that data with us.

CHAIRMAN CARR: Are we sharing ours with them?

MR. BECKJORD: We had a briefing some months ago from people at INPO on their human performance evaluation system. What I learned at that was that it has a very different focus and purpose than the work

that we are doing.

Essentially, I think the way I would characterize their effort is to help the people at a plant conduct their own program to search out root error causes. It is essentially the support of their clients.

It does not have the purpose of gathering human error data or anything like that.

CHAIRMAN CARR: I would hope that our programs weren't in disagreement. Do you think they are?

MR. BECKJORD: I don't think they are in disagreement.

CHAIRMAN CARR: Okay.

MR. BECKJORD: I think they just are different programs.

DR. COFFMAN: Another area, though, that you may already be aware of is that we are relying upon the INPO accreditation system for training programs. And so we are beginning to do some work to look at effective means for measuring that.

CHAIRMAN CARR: Okay. And would you talk a little bit more about your human factors notes that you are putting out from NMSS? And maybe would you mind sending them to the Commission?

MR. BERNERO: Several of them have been sent to the Commission, sir.

CHAIRMAN CARR: Are these just sporadic or when-occurring type thing?

MR. BERNERO: Yes. Primarily they have occurred as a result of an inspection accompaniment, where someone will walk through a typical human factors protocol and try to determine what things in this setting can contribute to the human errors we are seeing leading to misadministrations.

Most of it confirms what we know from our reactor experience. Human-machine interfaces are certainly a problem and need to be looked into very carefully.

But there are a number of other factors that come into play as well, anything from something as simple as housekeeping and communications problems to the social context of some of the operations and whether or not a person can make a decision, a safety decision, within that social context or whether it is a caucus that has to make the decision.

CHAIRMAN CARR: I would be interested in seeing it if you would put us on the routing. I don't know about my fellows.

COMMISSIONER CURTISS: I am happy to see.

CHAIRMAN CARR: Any other questions?

COMMISSIONER ROGERS: No.

CHAIRMAN CARR: Well, I would like to thank the staff for our update here. I think it has been a very informative briefing. And I think you have done a good job in revising the plan. I think it is better described than coordinated. I am still worried a little bit about the span of control over the whole operation.

I appreciate the ACRS letter and its comments. I think that we can take a look at those and listen.

I think, in view of the continuing large fraction of errors that can be contributed to personnel, even if it is maintenance, or whatever, I think it is very important. I think that we ought to do all we can to help knock that number down.

I encourage you also to continue to expand the human factors initiative in the NMSS area, especially in radiography, where we seem to be able to have as many people exposed as any other part of the area, and the medical use area.

As I say, that area concerns me, I guess, because the potential seems to be that we can expose people there with a lot more frequency than we do in

any other area that we work with.

Close coordination within the staff is obviously going to be necessary, and it seems that it is ongoing. I encourage that.

I also would encourage the continuing interaction between the industry groups and the professionals in the field so that we don't reinvent the wheel and take advantage of as much data as is out there.

Unless you have any other comments, why, we stand adjourned.

(Whereupon, the foregoing briefing was adjourned at 10:32 a.m.)

CERTIFICATE OF TRANSCRIBER

This is to certify that the attached events of a meeting of the United States Nuclear Regulatory Commission entitled:

TITLE OF MEETING: COMMISSION BRIEFING ON AGENCY HUMAN FACTORS INITIATIVES

PLACE OF MEETING: ROCKVILLE, MARYLAND

DATE OF MEETING: JULY 6, 1989

were transcribed by me. I further certify that said transcription is accurate and complete, to the best of my ability, and that the transcript is a true and accurate record of the foregoing events.

Sarah Veach

Reporter's name: Trevor Goodchild

NRC HUMAN FACTORS PRESENTATION WILL COVER:

- BACKGROUND
- OBJECTIVES OF AGENCY HUMAN FACTORS PROGRAMS AND INITIATIVES
- UPDATE ON HUMAN FACTORS PROGRAMS IN NRR, NMSS, AND AEOD
- OVERVIEW OF REVISION 1 TO HUMAN FACTORS RESEARCH PROGRAM PLAN

BACKGROUND

MAY 1988 HUMAN FACTORS RESEARCH PROGRAM PLAN TO COMMISSION (SECY-88-141)

JULY 1988 SRM M880531 DIRECTED THE STAFF TO SUBMIT AN INFORMATION PAPER ON SEVEN ITEMS, UPDATE INITIATIVES, AND DEFINE ISSUES ADDRESSED BY THE RESEARCH PROGRAM

BACKGROUND (CONT)

OCTOBER 1988	STAFF RESPONSE TO SRM M880531 (SECY 88-294) ANSWERED SEVEN ITEMS AND CONFIRMED PLANS TO UPDATE INITIATIVES AND ISSUES
JANUARY 1989	ACRS SUBCOMMITTEE MEETING ON HUMAN FACTORS REVIEWED DRAFT RESEARCH PLAN

BACKGROUND
(CONT-2)

FEBRUARY 1989 EDO DIRECTION TO ADDRESS AGENCY-WIDE PROGRAMS FOR THE CONTEXT OF THE RESEARCH

APRIL 1989 ACRS SUBCOMMITTEE MEETING ON NRC HUMAN FACTORS PROGRAMS, INITIATIVES, AND RESEARCH

BACKGROUND
(CONT-3)

MAY 1989 ACRS FULL COMMITTEE ON NRC HUMAN FACTORS PROGRAMS, INITIATIVES, AND RESEARCH

JUNE 1989 "NRC'S HUMAN FACTORS PROGRAMS & INITIATIVES" WITH REVISION 1 OF HUMAN FACTORS REGULATORY RESEARCH PROGRAM PLAN TO COMMISSION (SECY-89-183).

OBJECTIVES OF AGENCY HUMAN FACTORS PROGRAMS

- ASSURE THAT HUMAN FACTORS AFFECTING SAFETY ARE CONSIDERED APPROPRIATELY IN ALL REGULATORY ACTIVITIES
- PROVIDE ADEQUATE HUMAN FACTORS RESEARCH RESOURCES TO ENSURE ALL USER NEEDS ARE MET AND A BASE RESEARCH PROGRAM PERFORMED
- TO COORDINATE AND INTEGRATE AGENCY ACTIVITIES IN HUMAN FACTORS
- THAT RESEARCH PROGRAMS ARE PROPERLY STRUCTURED AND RESPONSIVE TO USER OFFICES.

RESOURCES

OFFICE	FY 89 FTE	CONTRACT $	FY 90 FTE	CONTRACT $
NRR	11	$1.3M	11	$1.3M
RES	8	$6.5M	10	$8.4M
AEOD	3	$ .4M	3	$ .4M
NMSS	2	$ .3M	2	$0M

ALL $ ARE CONSISTENT WITH FYP

HUMAN FACTORS PROGRAM AND INITIATIVES

OFFICE OF
NUCLEAR REACTOR REGULATION

CURRENT EOP INSPECTION PROGRAM

O THREE PHASES:

-EOP-1: PILOT PROGRAM, 16 INSPECTIONS DIVIDED AMONG VENDOR TYPES

-EOP-2: FOCUSED ON BWR'S WITH MARK I CONTAINMENT; EMPHASIS ON CONTAINMENT VENTING PROCEDURE

-EOP-3: INSPECTIONS OF REMAINING U.S. PLANTS DURING TWO YEAR PERIOD

NUREG 1358 "LESSONS LEARNED FROM THE SPECIAL INSPECTION PROGRAM FOR EOPs"

NUREG/CR 5228 "TECHNIQUES FOR PREPARING FLOWCHART-FORMAT EOPs"

MAN-MACHINE INTERFACE: TWO INITIATIVES

DETAILED CONTROL ROOM DESIGN REVIEW

IMPROVE THE ABILITY OF OPERATORS TO PREVENT ACCIDENTS OR COPE WITH ACCIDENTS IF THEY OCCUR BY IMPROVING THE INFORMATION PROVIDED

SAFETY PARAMETER DISPLAY SYSTEM

AID OPERATORS IN RAPIDLY AND RELIABLY DETERMINING THE SAFETY STATUS OF THE PLANT DURING AN EMERGENCY

GENERIC LETTER 89-06

LICENSEES CERTIFY THAT THEIR SPDS FULLY MEETS REQS, OR WILL FULLY MEET REQS, OR PROVIDE REASONS FOR NOT CERTIFYING.

TRAINING INSPECTIONS PROGRAM

- NEW INSPECTION PROCEDURE (41500)
- FIRST TRAINING IMPLEMENTATION INSPECTION AT TURKEY POINT, MAY 1-5, 1989
- SEVERAL MORE BEING PLANNED

OPERATOR EXAMINATIONS AND LICENSING

PROGRAM INITIATIVES

- REQUALIFICATION PROGRAM
- FUNDAMENTALS EXAMINATION
- NATIONAL EXAM SCHEDULE

ORGANIZATION AND MANAGEMENT

SUPPORT FOR:

- TEAM EVALUATIONS
- AEOD DIAGNOSTICS
- NRR SPECIAL INSPECTIONS

ADDITIONAL PROGRAMS INCORPORATING HUMAN PERFORMANCE DATA

- MAINTENANCE INSPECTIONS
- SYSTEMATIC ASSESSMENT OF LICENSEE PERFORMANCE (SALP)
- SENIOR MANAGEMENT MEETING

ROOT CAUSE ANALYSIS OF EVENTS INVOLVING HUMAN ERRORS

FUTURE INITIATIVE (IN CONJUNCTION WITH RES AND AEOD)

- DEVELOP A STRUCTURED PROTOCOL FOR ASSESSING ROOT CAUSE OF EVENTS INVOLVING HUMAN ERROR
- OBTAIN DETAILED HUMAN PERFORMANCE INFORMATION

DREP/NRR PROGRAM

SENSITIVITY OF RISK TO HUMAN ERROR RATES

- ESTIMATE THE SENSITIVITY OF PRA RESULTS TO VARIATIONS IN HUMAN ERROR RATES
- IDENTIFY RISK-IMPORTANT CATEGORIES OF HUMAN ACTIONS
- INVESTIGATE DIFFERENCES IN THE SENSITIVITY OF NSSS DESIGNS TO THESE VARIATIONS

AEOD PROGRAMS INVOLVING HUMAN FACTORS

- ROUTINE OPERATIONAL EVENT ASSESSMENT
- PERFORMANCE INDICATOR PROGRAM
- INCIDENT INVESTIGATION PROGRAM
- DIAGNOSTIC EVALUATION PROGRAM
- NONREACTOR ASSESSMENT PROGRAM
- TECHNICAL TRAINING CENTER ACTIVITIES

NMSS HUMAN FACTORS PROGRAM

- DIRECT USE TODAY AND IDENTIFICATION OF TOMORROW'S NEEDS
- MEDICAL USE: TELETHERAPY
  BRACHYTHERAPY
  TREATMENT PLANNING
  PHARMACIES
- INDUSTRIAL RADIOGRAPHY
- OTHER

HUMAN FACTORS REGULATORY RESEARCH PROGRAM

- PURPOSE: TO PROVIDE THE TECHNOLOGICAL BASIS FOR REGULATION
- CHARACTERISTICS:
  1. A MULTIDISCIPLINARY ENDEAVOR RELYING HEAVILY ON THE BEHAVIORAL SCIENCES AND INVOLVING A VARIETY OF ENGINEERING DISCIPLINES.
  2. MAINLY SUPPORT TO REGULATORY PROGRAMS & INITIATIVES.
  3. SOME BASE RESEARCH ON ANTICIPATED HUMAN PERFORMANCE ISSUES.

RESEARCH USER NEEDS

- REGULATORY OFFICES ORIGINATE NEEDS WHERE (1) THE TECHNICAL BASIS FOR A REGULATORY ACTION IS NOT MATURE OR NEEDS CONFIRMATION OR (2) THE NATURE OF THE POTENTIAL SAFETY PROBLEM IS NOT WELL DEFINED.

RESEARCH USER NEEDS DEVELOPMENT

- FOLLOWING APRIL 1987 AGENCY REORGANIZATION, USER OFFICES WERE ORGANIZING THEIR OWN PROGRAMS. LITTLE EFFORT TO DEFINE USER NEEDS.
- RES ACTIVELY SOUGHT HUMAN FACTORS RESEARCH NEEDS FROM USER OFFICES
- CURRENTLY WORKING ON A TOTAL OF 11 USER NEED MEMORANDA FROM 4 OFFICES.
- PROGRAM IS NOW REACHING MATURITY (SETTLING DOWN).

RESEARCH USER NEEDS DEVELOPMENT (CONT.)

- THE RESEARCH PROGRAM IS INTERACTIVE AND PROJECTS ARE REVISED AS REGULATORY NEEDS CHANGE.
- WE MEET WITH USERS APPROXIMATELY QUARTERLY AT DIVISION DIRECTOR LEVEL
- MEETINGS AT BRANCH CHIEF LEVEL MORE FREQUENT
- STAFF INTERACTIONS ARE ALMOST DAILY

BASE RESEARCH

- HF RESEARCH IN AREAS FOR WHICH THERE IS NO EXPLICIT USER NEED
- BASE RESEARCH IS DONE TO
  - PROVIDE AN INFORMATION BASE IN ANTICIPATION OF FUTURE REGULATORY NEEDS (E.G., OPERATOR VIGILANCE)
  - BROADEN KNOWLEDGE BASE IN SELECTED AREAS (E.G., NAS HF COMMITTEE)

OVERVIEW OF USERS NEEDS BY RESEARCH ACTIVITIES

HUMAN FACTORS

- PERSONNEL PERFORMANCE MEASUREMENT
  - CAUSES OF HUMAN ERROR (NRR, AEOD, NMSS, RES)
  - INVESTIGATION PROTOCOLS (NRR, AEOD)
  - MEDICAL USES (NMSS)
  - INDUSTRIAL RADIOGRAPHY (NMSS)
- PERSONNEL SUBSYSTEM
  - TRAINING EFFECTIVENESS (NRR)
  - PERSONNEL QUALIFICATIONS (NRR)
  - OPERATOR LICENSING (NRR)
  - SHIFT SCHEDULING & OVERTIME (NRR)

OVERVIEW OF USERS NEEDS BY RESEARCH ACTIVITIES (CON'T)

- HUMAN-SYSTEM INTERFACE
  - ADVANCED I&C INTERFACES (NRR)
  - EXPERT SYSTEMS (NRR)
  - PROCEDURES (NRR, AEOD)
- ORGANIZATION & MANAGEMENT
  - O&M INFLUENCES ON RISK (NRR, REG. 1)
  - HF OF ACCIDENT MANAGEMENT (NRR, RES)
  - CONTROL ROOM TEAM PERFORMANCE (NRR)

OVERVIEW OF USERS NEEDS BY RESEARCH ACTIVITIES (CONT)

RELIABILITY ASSESSMENT

- DATA ACQUISITION & QUANTIFICATION

  PERFORMANCE INDICATORS (AEOD)

  CAUSES OF OPERATOR ERROR & RELIABILITY DATA (NRR, RES)

- DATA MANAGEMENT SYSTEMS

  CAUSES & FREQUENCY OF BOTH HUMAN ERRORS AND HARDWARE FAILURES (NRR, AEOD, RES)

OVERVIEW OF USERS NEEDS BY RESEARCH ACTIVITIES (CONT)

- HRA/PRA INTEGRATION
  - MODELING COGNITIVE ERRORS (NRR, AEOD)
  - MODELING EXECUTION ERRORS IN PRA (NRR)
  - O&M FACTORS (NRR, REG. 1)
- HRA/PRA RESULTS APPLICATION
  - TECH SPEC CONFIGURATION CONTROL (NRR)
  - RISK-BASED PIs (NRR, AEOD)

OVERVIEW OF USERS NEEDS BY RESEARCH ACTIVITIES (CONT)

GENERIC & UNRESOLVED ISSUES

- HUMAN FACTORS ISSUES

  ALARM REDUCTION (NRR, HF 5.2)
  LOCAL CONTROL STATIONS (NRR, HF 5.1)
  OTHER PROCEDURES (HF 4.4)
  CRITERIA FOR ACTIONS (B-17)

OTHER RES HUMAN FACTORS ACTIVITIES

- CHERNOBYL FOLLOWUP
- SUPPORT TO DESIGN OF NEW OPERATIONS CENTER
- DIRECT SUPPORT ON MANAGEMENT INSPECTIONS AND HUMAN-SYSTEM INTERFACE REVIEWS
- SIMULATOR UPGRADES AT TTC
- DIRECT SUPPORT TO NMSS FOR DEFINING HUMAN FACTORS ISSUES AT MATERIALS LICENSEES

POLICY ISSUE
(Information)

June 16, 1989

SECY-89-183

For: The Commissioners

From: Victor Stello, Jr.
Executive Director for Operations

Subject: NRC's HUMAN FACTORS PROGRAMS AND INITIATIVES

Purpose: To provide the Commission with a status update on the Agency's human factors programs and initiatives and an updated description of the research planned to support the regulatory programs and initiatives.

Summary: The NRC's human factors programs and initiatives provide an understanding of the factors shaping human performance in the nuclear industry to serve as the technical basis for regulatory actions taken to ensure public health and safety. Human factors research supports the regulatory process by ensuring that the technical basis is adequate for the regulatory actions and provides base research in anticipation of regulatory issues.

Background: On May 23, 1988, SECY-88-141 (Human Factors Initiatives and Plans) was submitted to the Commission. That paper described the NRC's human factors initiatives and plans and included an initial version of the Human Factors Regulatory Research Program Plan prepared by the Office of Nuclear Regulatory Research. That paper also responded to the recommendations of the National Research Council's February 1988 report entitled Human Factors Research and Nuclear Safety.

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In a July 21, 1988, Staff Requirements Memorandum, the Commission directed the staff to address seven items related to the agency's human factors programs and initiatives and indicated that the staff should submit an information paper that updates those programs and initiatives and provides a clear definition of issues to be addressed by research. The staff responded to the seven items in SECY-88-294, October 13, 1988, and indicated that a revision to the Human Factors Regulatory Research Program Plan would be submitted in early 1989.

This paper responds to the Commission's directive to update the agency's human factors programs and initiatives and provides the context for the research program. Revision 1 to the Human Factors Regulatory Research Program Plan is enclosed.

The Advisory Committee on Reactor Safeguards (ACRS) reviewed the draft of this information paper and enclosed research plan during a subcommittee meeting April 19, 1989, and a full committee meeting May 5, 1989. The ACRS issued a generally favorable letter dated May 9, 1989, and recommended proceeding with the research program and initiatives.

Discussion: Personnel errors contribute to about half the significant events each year at nuclear power plants and to a larger percentage of events at nonreactor facilities. An understanding of the factors shaping human performance can focus regulatory attention and guide regulatory actions. This paper provides an update on human factors programs and initiatives in NRR, AEOD, NMSS, and RES, discusses the integration among the Offices' programs, identifies new initiatives, and describes the needed research. Finally, this paper summarizes the current Human Factors Regulatory Research Program (Revision 1), including the RES funding, resource projections, and the base research for anticipated future issues.

The paper is organized by Office beginning with the regulatory offices and ending with the research office.

OFFICE OF NUCLEAR REACTOR REGULATION

The Office of Nuclear Reactor Regulation (NRR) has initiated significant programs in the area of human factors since the accident at Three Mile Island. Human factors programs that addressed emergency operating procedures, control room design, safety parameter display systems, training and qualifications of plant personnel, operator examinations and licensing, organization and management, and maintenance issues have been developed. NRR human factors programs currently emphasize plant operation aspects of the above issues as compared to licensing aspects. NRR is also involved in the evaluation of human performance, the assessment of risk associated with human factors issues and risk-based improvements to the Technical Specifications.

Root Cause Analysis of Human Errors. Licensee Event Reports (LERs) continue to identify problems that relate to human performance. NRR plans to initiate a program to investigate the root causes of personnel errors. Actions will be initiated to ensure accurate and complete human performance information. Following this review, the guidance to the LER system will be evaluated to determine whether modifications are needed. The program will be coordinated with AEOD and RES.

RES is working on a standardized investigation protocol tool for use by NRC staff to identify the human factors root causes involved in a reportable event and will develop methods to handle causal information for both nuclear power plants and material licensees.

Emergency Operating Procedures. NUREG-0737, Supplement 1, provided guidance on the upgrade of emergency operating procedures (EOPs). The primary intent is to ensure that EOPs are function oriented and designed in accordance with recognized human factors principles, thereby improving human reliability. This in turn should enhance the operator's ability to mitigate the consequences of a broad range of initiating events and postulated multiple failures without being required to diagnose the specific event. Licensees have been required to reanalyze transients and accidents and prepare technical

guidelines. The required analysis was also to identify operator tasks, information, and control needs.

Licensees submitted for NRC review procedure generation packages (PGPs) that provide the basis for writing EOPs. On an audit basis at selected facilities, the staff reviewed upgraded EOPs that incorporated the guidance in the PGP. These audits found numerous deficiencies in the EOPs.

Early in 1988, a program of accelerated inspections (EOP-1) was begun in tandem with the continuing review of PGPs. A sample of 16 plants across all vendor groups was inspected. Shortly after the initiation of EOP-1, it was decided to also inspect the remaining 13 BWRs with Mark I Containments (EOP-2). The major conclusion emerging from these inspections was that, while the EOPs were capable of being used to bring plants to safe shutdown, the EOPs generally did not meet NRC expectations. Accordingly, EOP-3, which will inspect the EOPs at the remaining 47 plant sites, has been initiated. NUREG-1358, "Lessons Learned from the Special Inspection Program for Emergency Operating Procedures," was issued. Vendor group meetings and utility workshops are being conducted to communicate to the industry the inspection results and to facilitate necessary corrective actions. This will permit the industry to act promptly to correct existing problems.

RES will support the staff's efforts on accident management described in SECY-89-012, "Staff Plans for Accident Management Regulatory and Research Programs."

Control Room Design Reviews. In accordance with the requirements of NUREG-0737, Supplement 1, licensees must conduct a Detailed Control Room Design Review (DCRDR). Most of the plants have completed their DCRDR reviews. However, corrective action programs are still under way at many plants. Only a few plants have fully implemented control room improvements. The staff plans to complete audits at all licensee facilities by March 1990.

To improve control room responses to emergencies, NRR needs research on guidelines for review of annunciator systems, designs of advanced control rooms, expert systems, local control stations, and computer-driven displays and controls. RES has ongoing projects in these areas.

Safety Parameter Display Systems (SPDS) One of the requirements of NUREG-0737, Supplement 1, was that an SPDS be installed in each nuclear power plant. The objective of the SPDS is to provide a concise display of critical plant variables to the control room staff to aid them in rapidly and reliably determining the safety status of the plant. Based on audits at 57 units, the staff has concluded that many licensees will not meet the requirements for SPDS as set forth in NUREG-0737, Supplement 1.

The staff issued on April 12, 1989, Generic Letter 89-06, "Task Action Plan Item I.D.2-Safety Parameter Display System-10 CFR 50.54(f)" that requests all licensees to certify that their SPDS complies or will comply by a specified date with regulatory requirements as described in NUREG-0737, Supplement 1. Enclosed with the generic letter is a report, NUREG-1342, "A Status Report Regarding Industry Implementation of Safety Parameter Display Systems," which provides a detailed staff evaluation of methods that licensees have used in implementing the SPDS.

Training and Qualifications. On March 11, 1985, the Commission issued a Policy Statement on Training and Qualification of Nuclear Power Plant Personnel (50 FR 11147). The policy statement endorsed the INPO-managed Training Accreditation Program, and the industry, through NUMARC, committed to have 10 programs at 61 sites ready for accreditation by December 31, 1986. In November 1988, the Commission extended its endorsement of the accreditation program and amended its Policy Statement (53 FR 46603) to normalize the staff's inspection of training.

The staff has developed a new inspection procedure based on the Policy Statement's five elements of the Systems Approach to Training and will utilize the procedure to inspect training. To assist in this effort, RES will initiate a project to

develop additional criteria and methods to measure training effectiveness.

With regard to the Policy Statement on Working Hours, NRR is being supported by RES with research on shift scheduling and overtime through acquisition of plant-specific data.

A Policy Statement on the Conduct of Nuclear Power Plant Operations was issued on January 24, 1989 (54 FR 3424). The Policy Statement states that the Commission believes it is essential that utility management at each nuclear power reactor facility establish and maintain a professional working environment with a focus on safety.

Operator Examinations and Licensing. Section 107 of the Atomic Energy Act of 1954, as amended (42 U.S.C. 2137), requires the NRC to prescribe uniform conditions for licensing individuals as operators of production and utilization facilities, to determine the qualifications of these individuals, and to issue licenses to such individuals. Regulations to implement these requirements are set out in 10 CFR Part 55. These regulations were updated in March 1987 to meet NRC responsibilities under Section 306 of the Nuclear Waste Policy Act of 1982.

Written examinations and operating tests for reactor operator and senior reactor operator licensing are scheduled and administered through the NRC Regional Offices. Regional Office personnel also conduct operator requalification examinations and requalification program evaluations at all licensed facilities. The NRC also evaluates the certification of simulation facilities by licensed facilities. The evaluations are used to ensure that simulators are adequately designed for use in the conduct of operating tests. RES has been requested to develop criteria for evaluating control-room team performance in a simulator.

Program oversight of the operator licensing function is maintained at headquarters in the Division of Licensee Performance and Quality Evaluation. Responsibilities include support and oversight, examination development, and simulation

facility evaluation.

Three major program initiatives have been undertaken to upgrade the operator licensing program.

The requalification program was recently revised to be significantly more operationally oriented and performance based.

A fundamentals examination program is being developed to cover the fundamentals of reactor theory, thermodynamics, and equipment components. The examination program is currently undergoing pilot testing and, once implemented, will be administered in a central location on a routine basis.

A national examination schedule, which designates specific examination periods for each licensed facility, has been promulgated. This will allow the NRC to more efficiently allocate examiner resources.

The NRC has also issued a notice of proposed rulemaking that would increase the academic requirements for senior reactor operators (SRO). The proposal contained two degree requirement options relating to SRO applicant eligibility and shift supervisor requirements. Based upon comments received on the proposed rule, the Commission has decided not to proceed with the rulemaking. Instead the Commission has directed the staff to develop a Commission Policy Statement to encourage facility licensees to initiate a degreed operator program.

Organization and Management The Division of Licensee Performance and Quality Evaluation has provided support to the human factors evaluation of licensee organization and management through its active participation in special team assessments, e.g., the evaluation of management effectiveness at the Peach Bottom plant. In addition, organization and management evaluations were an integral part of the AEOD diagnostic evaluations conducted at Fermi, McGuire, and Dresden and the NRR special inspections at Nine Mile Point and Calvert Cliffs. Moreover, with support by the Performance and Quality Evaluation

Branch, management effectiveness is evaluated, as appropriate, by NRC senior managers during the semiannual Senior Management Meeting.

AEOD and NRR are considering how the experience gained from past diagnostic inspections can be summarized in a standardized protocol for special team assessments and whether further research in this area is needed.

Maintenance Inspections. As part of NRR's focus on operational safety, the NRC has conducted team inspections of maintenance at approximately twenty nuclear power plant sites. Inspection areas include management support and involvement; interface and communications among maintenance operations, engineering, health physics, and quality control staffs; personnel training and qualifications; overtime; labeling of components; and use and quality of procedures. Inspection activities relating to human factors are specifically called out with respect to the application of industry initiatives (i.e., participation in HPES) and engineering support.

Systematic Assessment of Licensee Performance. As part of the TMI Action Plan, NUREG-0660, a Systematic Assessment of Licensee Performance (SALP) was begun. The SALP is an integrated agency effort led by the Regions to collect and evaluate available insights, data, and other information on a plant/site basis in order to assess and characterize a licensee's performance. Licensee performance is evaluated from the standpoint of management control, involvement, and effectiveness in their ability to achieve quality, to identify and resolve technical issues, to respond to NRC initiatives, to respond to operational events, and to take corrective action. NRC Manual Chapter 0516, "Systematic Assessment of Licensee Performance (SALP)," was recently revised to incorporate human performance issues in the evaluation criteria.

Senior Management Meetings. The principal mechanism to focus NRC senior management attention on plants of concern and associated operational performance is Senior Management Meetings. Senior agency managers meet semiannually to assess

and analyze those plants that have either been previously identified or are currently perceived as poor performers.

Human Reliability and Risk Assessment. The Division of Radiation Protection and Emergency Preparedness has a project under way to estimate the sensitivity of risk to human error rates. The objective of this effort is to identify and characterize risk-significant human actions or categories of actions using state-of-the-art PRAs for two plants. As part of the effort, human factors specialists will be utilized to address the adequacy of the data base and the modeling of human errors in the PRAs. In parallel, RES is developing a method for systematically reflecting the influences of organization and management on risk at plants. The NRR and RES projects will be linked to provide insights regarding the contribution of management influences to risk in operating plants.

Technical Specifications. Early work in the Procedures for Evaluating Technical Specifications (PETS) project involved risk estimates associated with changes in surveillance test intervals and allowed outage times. Continuing RES work in the PETS project that involves testing strategy modeling (staggered vs. sequential/semistaggered) where common cause/human error reduction is important could be useful. RES has initiated further work to develop the technical basis for criteria to evaluate risk-based approaches to plant configuration control.

OFFICE FOR THE ANALYSIS AND EVALUATION OF OPERATIONAL DATA

As noted in SECY-88-141, "Human Factors Initiatives and Plans," AEOD has several programs to identify and evaluate human factors concerns related to the safe operation of nuclear power plants. The programs include routine operational event assessments, incident investigations, diagnostic evaluations, performance indicators, nonreactor assessments, technical training of staff members associated with EOP reviews and operator licensing, and participation in human factors research initiatives.

In SECY-88-352, "Selected AEOD Priority Issues," the staff discussed how human factors aspects are evaluated and factored into AEOD analyses. AEOD continues to address human performance problems during the analysis and evaluation of operating experience. The AEOD ability to analyze the human factors aspects of events is being strengthened through technical assistance contracts. The technical assistance has been discussed and coordinated with RES to ensure that the work complements and contributes to the regulatory research program.

Routine Operational Event Assessment. As noted in SECY-88-352, LERs are a major source of information on nuclear power plant operations. AEOD conducts case studies, engineering evaluations, and technical reviews of operating events described in LERs and other sources. Findings and conclusions in the reports influenced programs intended to improve human performance. For example:

- AEOD Special Study Report AEOD/S401, "Human Error in Events Involving Wrong Unit or Wrong Train," and further joint study with NRR (culminating in NUREG-1192) found that the contributors to these events were inadequate labeling of areas, equipment, and components; inadequate personnel training and experience; and inadequate procedures. As a result, NRR began to address the wrong unit/wrong train concerns in the broader context of the current EOP inspections and other programs.

- AEOD/C504, "Case Study Report on Loss of Safety System Function Events," indicated that improvements in the areas of management and administrative control, procedures, and training could have a significant impact on reducing the number of these events and that licensed operators, nonlicensed operators, and other personnel (technicians and maintenance personnel) were responsible for roughly equal numbers of errors. This indicated the need for programs to ensure that all types of personnel are well qualified and trained. NRR considered the results of this study during work on plans for the Maintenance and Surveillance Program

and the Human Factors Program and review of the INPO Training Accreditation program.

- AEOD/S801, "Significant Events Involving Procedures," found that procedures were a contributing factor in about 85% of the events that involved human performance and that reportable events associated with procedures were experienced in all modes of operation, during power operations, maintenance, testing, and other activities. The report was forwarded to RES and is part of the value/impact analyses on whether licensees should be required to upgrade procedures other than emergency operating procedures.

To resolve problems identified during the review of operating experience, AEOD makes specific recommendations for action by other NRC offices. The status of action in response to these recommendations is published annually in the AEOD Annual Report. SECY-88-352 gives additional examples of recent AEOD studies that included recommendations for changes to improve human performance.

Incident Investigation Program. The Incident Investigation Program (IIP) is designed to determine the nature and causes of significant events to reduce the frequency and consequences of these events. Consistent with the IIP objectives, all Incident Investigation Teams (IITs) will include an expert(s) in the field of Human Factors, and all potential IIT members are expected to be certified through formal training in incident investigation. Human Factors guidance has been developed by NRR and is part of the curriculum for the IIT training program. The training includes information on the human factors aspects of the events that should be considered.

Diagnostic Evaluation Program. The Diagnostic Evaluation Program evaluates the level of plant performance and the causes of performance problems. Thus, evaluations include plant operations, maintenance, testing, engineering support, organization, and management. Management consultants are used to assist the Diagnostic Evaluation Team (DET) in assessing management and

organizational climate factors and their relationship to the overall safety performance of the plant. Each DET is composed of staff from AEOD, NRR, and the Regions.

The methods to evaluate organization and management have evolved since the first diagnostic evaluation at Dresden. Currently there is no standard protocol for the management and organization evaluations. Such a protocol would be useful for future diagnostics and possibly for routine self-evaluation by licensees. AEOD and NRR are considering whether further research in this area is needed.

Performance Indicator Program. AEOD has the responsibility for developing and evaluating licensee performance indicators and producing a quarterly performance indicator report. Working with AEOD, RES conducts conceptual and other longer term studies and makes recommendations regarding the suitability of alternative indicators.

In the past, RES began work to determine whether event cause data could be used in a performance indicator and AEOD subsequently performed further analyses of operational data to refine this indicator. AEOD then recommended and received approval by the Commission to use LER causes (cause codes) as an additional indicator. These cause codes provide insight into errors by licensed operator, maintenance, and other personnel; errors due to administrative control deficiencies; and hardware failures. AEOD expects to complete implementation of cause codes in FY 1989. AEOD is currently evaluating the use of an indicator based on the corrective actions described in LERs.

Nonreactor Assessment Program. AEOD undertakes various studies of events in the nonreactor area to identify the causes of the events. At the present time, AEOD is studying multiple medical misadministrations that involved the use of computers and has identified several areas that involve human factors. Another study is under way on the use of iodine procedures that may also identify human factors improvements to reduce the probability of error. AEOD can also provide searches of event files to accumulate data on the frequency and characteristics of nonreactor events.

Technical Training Center Activities. The NRC Technical Training Center (TTC) is participating in human factors research. For example:

- Team Skills and Behavior Research. TTC staff simulating operating crews at a typical facility ran scenarios on the NRC SNUPPS simulator. The crew actions were observed and recorded to validate the methodology.

- Simulator Fidelity Research for Critical Parameters. TTC staff participated with a standards working group from the American Nuclear Society involving the Electric Power Research Institute, contractors, and the NRC staff in RES-sponsored human factors research to determine the accuracy of simulator fidelity required for training. The research focused on requirements for functional fidelity as opposed to physical fidelity and on steady-state operations as opposed to transient conditions.

- Man-Machine Workshop. AEOD supplied TTC staff with practical operating and training experience to participate in the RES workshop on Man-Machine Interfaces along with cognitive psychologists. The workshop was to propose tools and experiments for evaluating computer-driven interfaces in control rooms.

Other Technical Assistance. AEOD is completing a "Component Failure Data Handbook" to provide a convenient source of component failure data. The Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR), developed by RES, is a personal-computer-based data base originally designed to permit storage, processing, and retrieval of data on human error probabilities. In 1987, RES modified NUCLARR to include a module to permit the processing of component reliability data in addition to human error probability data, and RES and AEOD began a cooperative effort to select plant-specific data for inclusion in NUCLARR. The AEOD data is currently being added to NUCLARR.

Plans for Future Activities. SECY-88-294, "Human Factors Program," dated October 13, 1988, stated that AEOD planned to (1) review foreign events in the Incident Reporting System file for human factors events, (2) analyze events where cognitive errors led to a series of inappropriate actions, (3) survey NRC requirements to evaluate the impact on operators, (4) summarize human factors concerns raised in previous AEOD studies, and (5) develop capabilities to investigate human factors concerns from operating events. Work is under way on all these activities.

OFFICE OF NUCLEAR MATERIALS SAFETY AND SAFEGUARDS

NMSS has recognized for some time that human error associated with nonreactor uses of byproduct material makes an important contribution to incidents that result in unnecessary or excessive public and occupational exposures. But, in contrast to the reactor program, there has been no systematic application of the human factors discipline to the materials program. A human factors initiative begun in May 1988 is a step toward remedying this situation. The Director of NMSS has advised that Office and the Regions that NMSS human factors resources are available to provide support in the materials area. Managers have been briefed on human factors and their potential contribution to public health and safety.

The NMSS human factors initiative is currently helping the Office accomplish its mission through direct support to appropriate activities and through identification of research needs. NMSS resources are divided about equally between those two interdependent activities. Early in the development of the NMSS human factors initiative, managers were invited to identify any needs for human factors support. Medical use, industrial radiography, and high-level waste management were judged to be of the highest priority. The following paragraphs provide a synopsis of current and planned human factors efforts in those areas.

Medical Use. The NMSS human factors initiative has included support to NMSS and RES in the development of the medical quality assurance rule and regulatory guide. Regional inspections of medical facilities have also been supported, and the results of a nationwide nuclear pharmacy licensee's evaluation of its operations have been reviewed. The latter activities led to the preparation of "Human Factors Notes." Those Notes identify and discuss important issues related to human error at licensee facilities. They have been distributed to NMSS, RES, AEOD, the Regions, and appropriate licensees to stimulate the application of human factors technology to materials areas.

Concurrent with these direct support efforts, human factors research needs associated with the medical use of byproduct material were identified and tentatively prioritized. That activity was completed in coordination with the medical section in NMSS, the Human Factors Branch in RES, and the Nonreactor Assessment Staff in AEOD. The current list of needs, in tentative order of priority, encompasses human factors in teletherapy, treatment planning computers, brachytherapy, nuclear pharmacies, and nuclear medicine.

Ongoing coordination between NMSS and RES involves the preparation of statements of work to satisfy the higher priority needs listed above. Input from AEOD, the Regions, and the Food and Drug Administration's Center for Devices and Radiological Health is contributing to the process. Early results suggest the importance of human factors research on brachytherapy using

remote afterloading devices (i.e., devices for irradiating tumors involving computer-controlled insertion and withdrawal of small sealed sources in applicators placed in the patient). A recent event, in which human error resulted in twice the planned patient exposure during the last of three treatment fractions, highlights the importance of this research. This is being assigned a high priority based on the potential consequences of a single error, the expectation of a growing patient load for remote afterloading devices, and an indication that the potential for human error in the use of the devices is higher than it need be.

Currently there is an effort to address human factors issues in nuclear pharmacy operations through direct contact with the industry. A Region III workshop for nuclear pharmacy licensees will include a presentation on factors that can contribute to human errors in such facilities and on programmatic measures to reduce the impact of those factors. There is also an effort to get pharmacy licensees to improve their performance through voluntary human factors initiatives.

In the broader area of nuclear medicine, a video produced by the American Society of Hospital Pharmacists entitled "Medication Errors - A Closer Look" is being circulated to the Regions to assist them in evaluating licensee responses to misadministrations. The nuclear medicine area may also benefit from human factors research in higher priority medical use areas.

Industrial Radiography. The NMSS human factors initiative has supported efforts to reduce human error in industrial radiography. That support has included participation in the review of current rulemaking on radiography equipment improvements and a brief review of the training and qualification of radiographers.

Human error is a dominant contributor to excess exposures involving radiography. NMSS and RES are currently collecting background information about the factors that may contribute to that error. Regional and industry input/assistance is anticipated as the effort continues.

High-Level Waste Management. The operational aspects of a High-Level Waste Repository will be far less complicated than that of a reactor, but the potential for human error in the site characterization program, the development of the license application (including design), construction, operation, and maintenance in the high-level waste management program may have safety significance and affect the ability to complete the mandated review of the license application within three years. In order to avoid such consequences, human factor technologies should be integrated into the process for developing the high-level waste management system from the outset.

The staff is in the pre-licensing stage (consultation mode) with DOE on the proposed Yucca Mountain High-Level Waste Repository. DOE does not expect to submit a license application prior to 1995. In order to reduce the probability of human error, the staff is requiring (as agreed to by DOE/OCRWM) the implementation of a detailed quality assurance program that incorporates 10 CFR 50, Appendix B, and NQA-1 as appropriate. At this time, DOE is in the very early stages of its Site Characterization Program. The staff will consider human factors with regard to human-system interfaces in the design and operation of surface facilities including the Monitored Retrievable Storage facility and waste-handling equipment.

The Division of High-Level Waste Management is implementing a program architecture activity through the Center for Nuclear Waste Regulatory Activities that will systematically evaluate the adequacy and eventually the implementation of the regulations. This examination may indicate the need for specific human factors activities. Further, the staff implements internal quality assurance for its own activities.

Future Direction of the NMSS Human Factors Initiative. As indicated by the discussion above, activities are currently focused on several high-priority areas. Future activities will provide detailed knowledge about factors leading to human errors in those areas and about appropriate means to reduce those errors. This will require continued coordination with other NRC Offices, the

Regions, other government agencies, and the "industries" involved. Although the focus on currently identified priority areas will be sharpened, NMSS will continue its broad coordination effort in order to integrate the application of human factors technology into its overall program.

OFFICE OF NUCLEAR REGULATORY RESEARCH

The purpose of human factors research at the NRC is to provide the technical basis for regulatory actions taken to ensure nuclear safety and to explore human performance to identify potential problem areas. Human factors research is a multidisciplinary endeavor relying heavily on the behavioral sciences and involving a variety of engineering disciplines. The research is mainly in support of regulatory needs, includes some base research that anticipates future regulatory needs, and will incorporate human reliability assessments in probabilistic risk assessments.

As described by each regulatory office, research needs are identified out of regulatory situations where the technical basis for a regulatory action is not mature or where the nature of a potential problem is not well defined. A user need identifies something that RES can produce to support a regulatory action.

RES periodically requests formal regulatory needs from each Office. Specific research projects and the research programs are periodically refined based on considerations of ongoing research and past accomplishments. The Human Factors Regulatory Research Program Plan included with SECY-88-141 addressed the research needs formally requested by the NRC regulatory users as of early 1988. Coordination with other offices has continued to identify, refine, and prioritize human factors research needs. Revision 1 to the Human Factors Regulatory Research Program Plan reflects research developments to date and further integration among the research areas (Revision 1 is attached as an enclosure).

The present and planned research addresses the regulatory needs identified in the NRR, AEOD, and NMSS programs and initiatives described above.

Research is being performed for NRR on the causes of human error, procedures, human-system interfaces, training effectiveness, personnel qualifications, operator licensing, organization effectiveness, the contribution of management to risk, and plant configuration control. Research is being performed for AEOD on investigation protocols, performance indicators, and the causes of human errors. Research is being planned for NMSS on the causes of human errors in medical use and industrial radiography. The formally identified research needs from the regulatory offices are grouped into research program elements that generally follow the factors shaping human performance. The grouping is mainly to facilitate the administration of the research. Similar needs from different regulatory offices are generally combined into common projects, and related projects are administered by the appropriately qualified human factors analyst. The grouping is not unique and may change over time with changes in the character of the regulatory needs.

The Human Factors Regulatory Research Program provides the framework for researching the many factors that shape human performance and the interfaces between humans and systems. Experience has shown that integrating both human and hardware reliability is important in NRC licensing, inspection, and regulatory decisionmaking. As the knowledge gained from the study of human capabilities and limitations, human performance analysis, and reliability assessment is integrated, the technical basis will exist for evaluating overall safety performance issues and proposed regulatory initiatives.

Research Program Elements. The Human Factors Regulatory Research Program is divided into five distinct and interrelated program elements: (1) Personnel Performance Measurement, (2) Personnel Subsystem, (3) Human-System Interface, (4) Organization and Management, and (5) Reliability Assessment.

The purpose of the Personnel Performance Measurement element is to improve the Agency's understanding of the effect of personnel performance on the safety of nuclear operations and maintenance by developing enhanced methods for

collecting and managing personnel performance data. Personnel Subsystem research will broaden the understanding of such factors as staffing, qualifications, and training that influence human performance in the nuclear system and will develop information necessary to reduce the negative impact of these influences on nuclear safety. Research in the Human-System Interface element will provide the measures for evaluating the interface between the system and the human user from the perspective of safe operations and maintenance. Organization and Management research will result in the development of tools for evaluating organization and management issues within the nuclear industry. And, lastly, the Reliability Assessment element includes multidisciplinary research that will integrate human and hardware considerations for evaluating reliability and risk in NRC licensing, inspection, and regulatory decisions.

Other RES Activities. The RES Human Factors Branch staff supports other initiatives that, although not described in the program plan, illustrate the integration of human factors programs within the agency. For example, human factors support is being provided to AEOD for technical oversight of their contractor's effort to design the NRC Operations Center for the new White Flint building. Direct staff support has been provided to NRR and regional offices on human factors matters affecting the human-system interface and plant personnel. The staff is working with AEOD to upgrade the simulation capabilities at the Technical Support Center, which will in turn result in the improved usefulness of the simulators both for training and for conducting human factors research.

RES is working closely with NMSS to refine the research needs and to develop research projects addressing human factors issues in teletherapy, computer use in treatment planning, industrial radiography, and remote afterloading brachytherapy devices. This coordination effort is FTE intensive presently and may require additional Five Year Plan allocations to support research projects.

Resources. Ample and reliable resources are needed to support this research. The RES Human Factors Branch research budget in fiscal year 1989

is $6.5M. Planned for fiscal year 1990 is $8.3M, for fiscal year 1991 is $9.3M, and in fiscal year 1992 is $9.1M. The research is being directed by a staff of senior professionals qualified by experience and education in human factors. Since May 1988, six human factors professionals with nuclear regulatory experience were added to the RES staff. The contracted research is being conducted by an aggregation of national laboratories, private enterprise, international cooperatives, and universities.

Victor Stello, Jr.
Executive Director for
Operations

Enclosure:
Revision 1, Human Factors
Regulatory Research Program
Plan

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HUMAN FACTORS REGULATORY RESEARCH PROGRAM PLAN, Revision 1

Human Factors Branch
Division of Systems Research
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission

June 1989

EXECUTIVE SUMMARY

Purpose. The purpose of human factors research at the NRC is to provide the technical basis for supporting regulatory actions taken to ensure nuclear safety. Human factors research is a multidisciplinary endeavor relying heavily on the behavioral sciences and involving a variety of engineering disciplines. The objectives of human factors research are to (1) broaden our understanding of human performance and identify the causes of human errors related to safe operations in the commercial nuclear industry (2) accurately measure human performance for the purpose of identifying methods for enhancing safer operations and precluding critical errors and (3) develop technical bases for nuclear regulatory requirements, recommendations, and guidance.

Personnel performance contributes to about half the significant events each year at nuclear power plants and to a larger percentage of events at nonreactor facilities. An understanding of the factors shaping human performance can focus regulatory attention and guide regulatory actions pertaining to licensee personnel. To understand personnel error, research to characterize and measure human capabilities and limitations is needed. The Human Factors Regulatory Research Program Plan provides the framework for researching the many factors that shape human performance such as cognitive processes, training, qualifications, organization, supervision, procedures, performance aids, and interfaces between humans and systems. The human factors research supports regulatory decisions affecting operators, maintenance personnel, technicians, and managers within the nuclear industry and incorporates human reliability analyses into probabilistic risk assessments.

Detailed information on the causes of human errors is needed to support regulatory actions. Planned human factors research will provide the methods and causal data required to establish the technical basis for actions that depend on an understanding of human performance during operations and maintenance for both nuclear power plants and materials licensees.

Another aspect of human factors research is to integrate both human and hardware reliability in NRC licensing, inspection, and regulatory decision making. As the knowledge gained from the study of human capabilities and limitations, human performance analysis, and reliability assessment is integrated, the technical basis will exist for evaluating human performance issues and proposed regulatory initiatives.

Background. The Human Factors Regulatory Research Program Plan describes the ongoing and planned research within the Human Factors Branch, Division of Systems Research, Office of Nuclear Regulatory Research (RES). In 1981, RES established a branch to conduct human factors research. In 1985, budget limitations and the completion of several projects led to a sharp reduction of resources dedicated to human factors research to the extent that only human reliability assessment activities were pursued between 1985 and 1987. By 1987, however, the persistence of human errors in reportable operating events and the recommendations from the National Research Council (December 1986) led to the revitalization of human factors research.

In April 1987, the Office of Nuclear Regulatory Research reestablished a human factors regulatory research program. Formal needs from the other offices of the agency were requested and reviewed, and projects were defined based on consideration of ongoing research, past accomplishments, and recommendations of the National Research Council's February 1988 report entitled Human Factors Research and Nuclear Safety. The result was the publication of a Human Factors Regulatory Research Program Plan (SECY-88-141, March 23, 1988) that addressed the research needs formally requested by the NRC regulatory users and many of the broader National Research Council's research recommendations. This revision to the Human Factors Regulatory Research Program Plan reflects research developments to date and further integration among the research areas.

Plan Organization. This document is organized in five sections describing the human factors research effort. In section 1, INTRODUCTION, a historical context for the influence of human factors on nuclear safety is presented and the role of personnel is discussed. In section 2, HUMAN FACTORS RESEARCH, the current regulatory issues associated with human factors in the nuclear system are presented and the purpose of the research plan is provided. Section 3, RESEARCH PROGRAM ELEMENTS, introduces each of the program elements and the research process that will be applied to perform the research. In addition to summarizing the research being conducted within each element, the discussion includes the purpose and objectives of each program element, provides background information, and describes expected regulatory products. Section 4, RESOURCES SUMMARY, provides budget forecasts, and section 5, REFERENCES, provides appropriate bibliographic references.

Research Program Elements. The human factors research program is divided into five distinct and interrelated program elements: (1) Personnel Performance measurement, (2) Personnel Subsystem, (3) Human-System Interface, (4) Organization and Management, and (5) Reliability Assessment. The purpose of the Personnel Performance Measurement element is to improve the Agency's understanding of the factors influencing personnel performance

and the effects on the safety of nuclear operations and maintenance by developing improvements to methods for collecting and managing personnel performance data. Personnel Subsystem research will broaden the understanding of such factors as staffing, qualifications, and training that influence human performance in the nuclear system and will develop the technical basis for regulatory guidance to reduce any adverse impact of these influences on nuclear safety. Research in the Human-System Interface element will provide the technical basis for ensuring that the interface between the system and the human user supports safe operations and maintenance. Organization and Management research will result in the development of tools for evaluating organization and management issues within the nuclear industry. And finally, the Reliability Assessment element includes multidisciplinary research that will integrate human and hardware considerations for evaluating reliability and risk in NRC licensing, inspection, and regulatory decisions.

Resources. An ample and reliable resource allocation is needed to support this research endeavor. The Human Factors Branch research budget in fiscal year 1989 is $6.5M, in fiscal year 1990 is $8.3M, in fiscal year 1991 is $9.3M, and in fiscal year 1992 is expected to be $9.1M. The research is being directed by a staff of senior professionals qualified by experience and education in the study of human factors. The contracted research is being conducted by an aggregation of national laboratories, private enterprise, international cooperation, and universities.

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1 INTRODUCTION

The safety of the nuclear system has been significantly affected by such human factors as training effectiveness, procedures adequacy, control station ergonomics, stress, organization and management, and shift scheduling. The events summarized below are examples of how human performance has affected safety even when the event was initiated by another failure.

1.1 HISTORICAL CONTEXT

Three Mile Island Unit 2, March 28, 1979 -- "A simple equipment malfunction that could have been controlled without difficulty touched off what has been called the worst commercial nuclear accident in U.S. history. ... Most investigators agreed that the accident was caused by a combination of factors, including equipment malfunctions, inadequate operator training, poor designs, and inadequate operating and emergency procedures." (Comptroller General's Report to the Congress, September 9, 1980)

Rancho Seco, December 26, 1985 -- A loss of integrated control system (ICS) power led to an overcooling transient made worse by factors in the control station design, procedures, training, communications, physical stress, and the availability of protective clothing and equipment. The emergency operating procedures did not address the loss of the ICS. Further, operators indicated that neither classroom nor simulator training was provided on the overall plant response to the total loss of ICS dc power or the restoration of ICS dc power.

Peach Bottom Units 2 and 3, March 1987 -- "In March 1987, the NRC received information that control room operators had been observed sleeping while on duty in the control room, reading materials not directly job related, and being otherwise inattentive to the obligations of their license. The NRC... determined that all levels of plant management at that time either knew or should have known of these facts and either took no action or inadequate action to correct this situation." (PBAPS Restart SER, September 1988). The utility's "Commitment to Excellence Plan" (August 7, 1987) identified four root causes of these problems, including poor leadership, failure to implement timely operator replacement training programs, a station culture that had not adapted to changing nuclear requirements, and slowness on the part of corporate management to recognize the developing severity of these problems and take sufficient corrective action.

Riverside Methodist Hospital, January 1976 -- Nearly 400 cancer patients were overexposed as a result of human error apparently caused by inadequate supervision, failure to follow recommended calibration schedules, staffing and qualifications issues, lack of training, and poor administrative procedures. The failure to calibrate the hospital's cobalt-60 machine allowed an error in the calculation of exposure times to go undetected with patient overexposures eventually reaching as high as 40%.

Sacred Heart Hospital, November 17, 1988 -- A series of teletherapy misadministrations caused by miscommunications and failure to follow procedures resulted in the overexposure of 33 patients receiving palliative brain tumor treatments.

The above examples illustrate that hardware upgrades alone have not ensured safe operations. A recent study of the causes of unplanned reactor trips at two power plants revealed that the majority of the causes were human performance. As part of the same study, an analysis of industry data revealed that approximately 50% of the power industry's significant operating events resulted from human errors. Further, probabilistic risk assessments conducted at Brookhaven National Laboratory indicate that core melt frequency is sensitive to human error (NUREG/CR-5319). Clearly, human factors and hardware reliability have significantly affected the safe use of nuclear technology.

1.2 THE ROLE OF PERSONNEL IN A NUCLEAR SYSTEM

A nuclear system, whether it involves nuclear power plants or nuclear materials licensees, is composed of three subsystems: the personnel subsystem, the machine subsystem, and the environment.

The personnel subsystem consists of the personnel involved in a nuclear system and includes personnel whose performance directly and indirectly influences the safe operation of the nuclear system. The personnel of interest include, but are not limited to operators and maintenance workers at nuclear power plants (NPPs), instrumentation and control technicians, nuclear-medicine technicians, industrial radiographers, operators and maintenance personnel at large irradiators, and managers. Factors that influence the performance of the personnel subsystem include shift length and rotation, training, organization and management, cognitive processes for intent formation, operating culture, staffing and qualifications, and the assignment of responsibilities.

The machine subsystem consists of hardware and has historically been that subsystem most objectively understood in terms of its functions and capabilities. The machine subsystem influences the physical and psychological environment in which the human performs and is considered to include the procedures used by the

personnel to perform their tasks. The research described in the Plan is concerned with the machine subsystem to the degree that the machine and the associated procedures influence human performance, capabilities, and limitations. Such an understanding complements the regulatory evaluation of the machine subsystem.

The final subsystem, the environment, refers to the influences of the physical environment on human performance within the nuclear system. Such influences include temperature, humidity, radiation, noise, lighting, and spatial requirements. Human capabilities and limitations in performing tasks in harsh physical environments also need to be considered in regulatory criteria on the acceptable allocation of functions and tasks between the human and the machine.

Factors in each of the three subsystems interact to shape the overall performance of the nuclear system. The human factors programs at the NRC are designed to address the major regulatory issues associated with human performance within the context of the nuclear system. The goal of the research described in this Plan is to develop technology to support optimizing the safety of an entire nuclear system rather than maximize the effectiveness of any individual subsystem. Human factors technology works toward this goal by seeking to understand human capabilities and limitations and the factors that affect them and then modifying the appropriate part of the nuclear system, i.e., optimizing the entire nuclear system by coherently matching the subsystems and interfaces among them.

1.3 ORGANIZATION OF THE PLAN

This document is organized in five sections. In section 1, INTRODUCTION, examples of the influence of human factors on nuclear safety are presented and the role of personnel is discussed. In section 2, HUMAN FACTORS RESEARCH, the current regulatory issues associated with human factors in the nuclear system are presented and the purpose of the research plan is provided.

Section 3, RESEARCH PROGRAM ELEMENTS, describes each of the program elements and the research process applied to the human factors research issues. The elements are Personnel Performance Measurement, Personnel Subsystem,Human-System Interface, Organization and Management, and Reliability Assessment. The research being conducted within each element is summarized along with the objectives, background information, and expected regulatory products.

Section 4, RESOURCES SUMMARY, provides budget and FTE forecasts and a summary of contractors performing some of the ongoing research. Section 5, provides references. Appendix A contains a

chronology of human factors research at NRC, and Appendix B describes the research approach.

2 HUMAN FACTORS RESEARCH

Human factors research is a multidisciplinary endeavor relying heavily on the behavioral sciences and involving a variety of engineering disciplines. The purpose of human factors research at the NRC is to provide the technological basis for supporting regulatory guidance that is needed to ensure commercial nuclear safety. The objectives of the research are to (1) broaden our understanding of human performance and identify the causes of human errors related to safe operations in the commercial nuclear industry (2) accurately measure human performance as related to the nuclear system for the purpose of enhancing safer operations and precluding critical errors, and (3) develop technical bases for nuclear regulatory requirements, recommendations, and guidance.

2.1 CURRENT REGULATORY ISSUES

The current regulatory issues associated with human factors in the nuclear system are posed below. The issues are categorized according to the subsystems (of the model discussed above) and performance measurement. Also outlined are the research projects planned to address the regulatory issues.

Personnel Subsystem. The current regulatory issues for the personnel subsystem are generally:

- Adequacy of staffing, qualifications, training, quality assurance programs, and test and surveillance programs to ensure safe operation of the nuclear system.
- Adequacy of organizational structures, policies, and procedures; allocation of prerogatives and responsibilities; and communication networks.

The planned research on the personnel subsystem will:

1. Identify the performance-shaping factors that influence human behavior in the nuclear system, e.g., training, organization, and management.
2. Develop criteria for evaluating such performance-shaping factors as shift length, shift rotation, overtime, training, organization, management, corporate culture, and plant culture.
3. Develop methods to assess the roles of personnel and groups involved in severe accident management at nuclear power plants in accordance with NRC's accident management research program and industry efforts.
4. Develop the technical basis for criteria for evaluating the adequacy of the NRC operator licensing examination process.

Machine Subsystem. The current regulatory-issues focus on the human interfaces with the machine subsystem and are generally:

- o Adequacy of human-system design and workspace layout to ensure safety for next-generation systems.
- o Adequacy of current regulatory guidance for evaluating advanced systems based on artificial intelligence (e.g., expert systems).
- o Adequacy of procedures and job performance aids to ensure safe nuclear operations and maintenance.

The planned research relating to the machine subsystem will:

1. Develop evaluation criteria for advanced technologies, including decision aids, anticipated for control rooms and local control stations.
2. Identify, in coordination with accident management research, the information and control capabilities needed to support operator tasks in managing severe accidents at NPPs.
3. Identify the appropriate allocation of functions between the human and the machine in advanced NPP designs as opposed to existing designs.

Environment Subsystem. The current regulatory issue for the physical environment is:

- o Adequacy of habitability criteria to ensure the operability and maintainability of nuclear systems.

The planned research related to the environment subsystem will:

1. Identify physical stressors and their effects on human performance as they relate to nuclear safety.
2. Develop evaluation methods and acceptance criteria for defenses against physical stressors.

In addition to the issues that are directly related to the subsystems of the model, another issue, the measurement of human performance, supports the entire research program.

Personnel Performance Measurement. The current regulatory issue for human performance measurement is:

- o Availability and accuracy of human performance data (probabilistic and deterministic).

The planned research on human performance measurement will:

1. Identify, through standard protocols, the causes and, through data management, the frequency of human errors in nuclear events and their influence on the risk associated

with the nuclear system.
2. Use an integral process (e.g., HRA/PRA) to identify human errors for regulatory attention.
3. Identify feasible regulatory actions to reduce the frequency and severity of events resulting from human error.

2.2 PURPOSE OF THE PLAN

The purpose of this Human Factors Regulatory Research Program Plan is to describe the currently ongoing (FY 1989) and planned (FY 1989 to FY 1992) research within the Human Factors Branch, Division of Systems Research, Office of Nuclear Regulatory Research. The human factors research supports regulatory decisions related to operators, maintenance personnel, technicians, and managers within the nuclear industry. The support provides technical bases allowing the NRC to understand, measure, and regulate for safe operations.

3 RESEARCH PROGRAM ELEMENTS

The human factors research program is divided into five distinct and interrelated program elements that were defined for administrative convenience: (1) Personnel Performance Measurement (2) Personnel Subsystem (3) Human-System Interface (4) Organization and Management and (5) Reliability Assessment. Each of the program elements is briefly summarized here. Further details of each are provided in Sections 3.1 through 3.5.

To effectively reduce human error, it is necessary to understand the contributors to human performance and error by collecting and evaluating human performance data. The Personnel Performance Measurement program elements provides the methods for improving data collection, screening, storage, retrieval, and analysis for the other program elements.

The Personnel Subsystem includes those aspects inherent to the human as well as external influences that contribute to the likelihood for error; i.e., inherent aspects such as qualifications, training, mental workload, physical limitations, and external aspects such as physiological and psychological stress.

The interface between the human and the hardware continues to be a source of error. The Human-System Interface element of the Plan addresses the equipment contributors through the study of controls and displays, especially concerning advanced instrumentation, expert systems, and artificial intelligence. In addition, human performance can be affected by task information (procedures), function allocation, and job performance aids, and thus are subjects of this program element. The Environment component of the model is addressed in this element in that aspects of the physical environment such as workspace, lighting,

physical stress (e.g., temperature), and distractors (e.g., noise) can contribute to human performance and error.

The Organization and Management element will develop modeling techniques and performance measurement tools for systematically assessing the impacts of organization and management under normal, emergency, and accident conditions on safety.

The Reliability Assessment element employs multidisciplinary research to integrate human and hardware evaluations of reliability and risk in NRC licensing, inspection, and regulatory decision making. Reliability Assessment projects use the results from other program elements by quantifying for reliability and risk assessments the contribution of human and hardware performance to safety performance. The results of these assessments can then be used to rank and to improve the definition of safety performance problems. The Reliability Assessment element supports regulatory analysis of proposed initiatives to reduce significant problems.

Regulatory issues and formal user needs are translated into well-defined researchable questions through an interactive process involving both the regulatory office and the RES staff. For each defined issue, the RES staff develops a technical resolution by means of an interdependent four-step research method that includes a feasibility study of potential resolutions followed by development, evaluation, and implementation of the research resolution. Then the regulatory user, often with assistance from the RES staff, applies the product to the issue for which it was developed. A more detailed description of the general approach taken to regulatory research is provided in Appendix B.

The general research approach satisfies users' needs mostly by bringing research projects to completion; however, some user's needs have been satisfied by either intermediate results or byproducts. Occasionally a user's need is satisfied across different regulatory offices by the same research project. Currently there are thirty-five formal user-needs and a total of fifty-four research projects. A user's need can require more than one research project, and conversely, several research projects are working to satisfy more than one user. To display the integration of thirty-five users'needs across fifty-four research projects would be excessive because there are potentially 1,890 intersections.

Therefore, as a summary, Table 1 provides an overview of the integration and correlation between the users' needs and the research projects that are within the Human Factors Regulatory Research Program. The Table 1 overview (1) combines the fifty-four individual research projects into the nine Five-Year Plan "Activities" that relate to human factors, (2) combines the thirty-five users' needs into twenty-five titles of needs, (3)

identifies the associated users, and (4) provides a cross-reference between the users-needs titles and the activities.

3.1 PERSONNEL PERFORMANCE MEASUREMENT

3.1.1 Purpose and Objectives

The overall objective of the activities in the personnel performance measurement element is to improve the NRC's understanding of the influences on personnel performance in nuclear operations and maintenance by developing enhanced methods for collecting and managing personnel performance data. These data could then be used in reliability analyses to identify the importance of human actions and for studying methods to reduce human error. The Personnel Performance Measurement element responds to the Commission guidance to "...identify sources of operational errors, root causes, and suggest ways to improve plant safety through reduction of human related errors" (SRM M880531, July 21, 1988).

3.1.2 Background

The investigations conducted in the aftermath of the accident at Three Mile Island identified the causes of the accident and defined the Agency's initial human factors efforts. The human factors programs and guidance that were established addressed control room design, the safety parameter display system, emergency operating procedures, plant staffing, personnel training, plant personnel working hours, operator examinations and licensing, event reporting, and licensee organization and management concerns.

As the programs in these areas are maturing, the focus of the Agency's human factors efforts is shifting toward operations and maintenance issues. One reason is that personnel performance continues to be implicated in about half the significant events each year at nuclear power plants. Each of these events can provide diagnostic information about the factors that influence human performance and the effect that such performance has on nuclear safety. In turn, this understanding of the role of personnel can focus regulatory attention and guide regulatory actions pertaining to licensee personnel.

Limited in-depth information on causes of human performance problems are currently available through the existing sources of incident/event information. For example, an analysis of LER data led to the identification of a class of errors referred to as "wrong unit/wrong train" errors. However, the information available through LER reports was not sufficient for understanding the causes of these errors. In this example, on-site investigations were conducted to identify the primary contributors to these errors. The review team identified a

number of root causes, including plant labeling, procedures, and training (NUREG-1192).

Detailed information on the causes of human errors is needed to support regulatory actions. A standardized investigation methodology could improve the staff's capability to evaluate the influences of human factors on human performance during events and to better understand the effect of shift schedule, the reasons for failure to follow procedures, and the nature of design deficiencies of instruments and displays. The research in the personnel performance measurement element is directed toward providing the methodologies and data required to establish the technical basis for decisions that require an understanding of the cause of human error during operations and maintenance for both nuclear power plants and materials licensees.

3.1.3 Research Topic Areas

Personnel performance is influenced by a host of variables that shape human behavior, including equipment design, procedure adequacy, training, management and organization, communications, environmental factors, and an individual's own characteristics. The Personnel Performance Measurement element is an initiative that will identify root causes of human error during nuclear events that may suggest ways to reduce human errors. Improved tools for investigating events involving human error will be developed. A data management system will be developed to support the storage, analysis, synthesis, evaluation, and reporting of personnel performance information. Improved guidance for human performance investigation will be developed, and the technical basis for an agency decision on a third-party event-reporting system will be provided. The projects within the Personnel Performance Measurement element include:

1. Develop a protocol, and training on its use, to investigate human errors during operating events of interest both to NRR and to NMSS.

2. Develop a working library of data on the root causes of human errors during operational and maintenance events that is easily accessible to regulatory users. This library will build upon existing data management systems such as NUCLARR (see section 3.5) as feasible.

3. Develop the technical basis for improved guidance for investigating and reporting events involving human errors.

4. Complete the technical basis for an agency decision on the trial use of the Nuclear Power Safety Reporting System (NPSRS).

A brief description of the projects is provided in the following

sections.

3.1.3.1 Personnel Performance Investigation Protocol

It has been estimated that roughly 50 per cent of significant operating events at NPPs involve human performance issues (AEOD/S801, March 1988). Human error is also a significant contributor to events occurring in the nuclear industries regulated by the NRC's Office of Nuclear Material Safety and Safeguards (NMSS). The impact of personnel performance on safe operations and maintenance is a significant consideration in the Agency's decision processes and determinations of corrective actions. Yet a standardized tool does not exist for NRC to use for identifying the causes of human errors during events. The lack of such an investigation tool could result in differing investigations of human performance and the unavailability of standardized causal information.

A draft human performance investigation protocol was developed in 1986 for use by Incident Investigation Teams (IIT). This investigation protocol has not yet been pilot-tested to determine its usability. The protocol will be pilot tested and modified as necessary to support the identification of root causes of human error during events. The data collection and summary tools associated with the INPO Human Performance Evaluation System (HPES) and other relevant investigation programs will be considered and will be incorporated as appropriate into the protocol (INPO, Review, Fall 1985). A standard investigation protocol would be preferable for use by the entire Agency; however, it may be necessary to modify the investigation protocol used for NPPs for application to NMSS licensees.

3.1.3.2 Personnel Performance Data

Data on the primary contributors (or causes) of human errors during events come from a variety of Agency activities, including (1) operating event assessments performed by NRR, (2) safety-significant operating events involving personnel performance issues identified and tracked by AEOD for trends and patterns studies and diagnostic evaluations, (3) team inspections of operating events such as Augmented Inspection Teams and Incident Investigation Teams, (4) regional NPP inspections, (5) materials licensee inspections and other NMSS data sources, and (6) independent assessments conducted at nuclear power plants with special problems. The Agency has additional documented sources of information at its disposal concerning personnel performance during operating events including Morning Reports and Licensee Event Reports. Base research is anticipated to develop means to systematically investigate and integrate the causal information into an accessible data base to support both the identification and prioritization of human performance issues.

Research activities under the other program elements also result in the collection of human reliability data (e.g., during emergency operations in a simulator setting). One activity for the Personnel Performance Measurement element is to provide guidance for such data collection for potential inclusion in the data base. The proposed data base will be coordinated within the Agency to ensure that it contains data that will support user needs, including the identification and prioritization of human performance issues. A training program will be developed on the investigation of human performance during nuclear events, the use of the standardized investigation protocol, and the data entry taxonomy. The accuracy and usability of the data base are objectives.

3.1.3.3 Licensee Reporting of Operating Events Involving Human Error

A project is planned to develop improved guidance to the nuclear industry for investigating and reporting events involving human error. The project is expected to draw on current event reporting guidance, the IIT human performance investigation protocol and associated guidance, and the INPO HPES methodology to develop a taxonomy of root causes of human errors that reflects the state of the art in investigation and accounting for human performance during operating events. The guidance will address the level of detail in investigation and documentation needed to support regulatory decisions. This effort will initially address the Licensee Event Reporting system and medical misadministration reporting.

3.1.3.4 Nuclear Power Safety Reporting System (NPSRS)

Research (NUREG/CR-4132) on a voluntary, anonymous, third-party-managed reporting system indicated that such a system (1) is being successfully used in other U.S. agencies and other countries (e.g., the U.S. Department of Transportation commercial aviation and maritime administrations, the Canadian and British ministries of transportation), (2) is feasible for use by a regulatory agency, (3) appears capable of providing performance and causal information not currently available to the NRC from other reporting systems and (4) might provide performance information for use in probabilistic assessments and other plant personnel performance assessments. The NPSRS research remaining is to complete the technical basis for an agency decision on a trial use. The technical basis will be provided by a Research Information Letter that comprehensively describes both advantages and disadvantages of a third-party-managed reporting system.

3.2 THE PERSONNEL SUBSYSTEM

3.2.1 Purpose and Objectives

The purpose of the Personnel Subsystem element of this plan is to broaden the understanding of the factors that influence human behavior in the nuclear system. The objective is to develop the technical basis for regulatory guidance to reduce the negative impact of these factors on nuclear safety. Because experience had shown that humans have the potential to initiate, exacerbate, ameliorate, and recover events in the nuclear system, research is planned on selected factors. The internal factors include knowledge, experience, stress, and fatigue. The external influences include training, education, information, distractions, and environmental stressors.

3.2.2 Background

In 1978, research in the personnel subsystem was performed on "Operational Readiness", which addressed those personnel tasks, jobs, and functions that are directly related to operational safety in a nuclear power plant. At that time, RES was studying the operating crew's time response to an initial symptom of an off-normal event. However, it was the TMI-2 accident in 1979 that demonstrated the importance of an operating crew's performance in the safe operation of nuclear power plants and emphasized the need for increased technical responsiveness to the factors that shape operator behavior.

Human factors research efforts following the TMI-2 accident were part of the NRC Human Factors Program Plan elements of staffing and qualifications, training, procedures, licensing examinations, and organization and management. Operational readiness research provided empirical data and a methodology for use of training simulators and provided a foundation for acceptance of the systems approach to training by the nuclear community.

The objective of the research program was to provide a technical basis for development of regulatory guidance that focused on the control room operators. There is now increased recognition that other personnel (e.g., auxiliary operators, maintenance technicians, and supervisors) are significant components in the personnel system, both at nuclear power plants and at material licensees' facilities. They design, maintain, and repair equipment; they supervise and manage other personnel and programs; they write procedures; they develop and deliver training programs; they prescribe and dispense nuclear medicine; and they transport nuclear material. Hence, Personnel Subsystem research will be applied to all the significant components of this subsystem.

3.2.3 Research Topic Areas

Personnel Subsystem research is divided into three interrelated areas: (1) training; (2) qualifications; and (3) shift scheduling, shift rotation, and vigilance.

3.2.3.1 Training

The Commission's Policy Statement on Training and Qualification of Nuclear Power Plant Personnel (50 FR 11147, March 11, 1985) indicated that the industry should take the lead in improving the quality of training through the INPO accreditation of training. Currently, neither INPO nor the NRC has reliable measures of training effectiveness related to job performance. Therefore, the staff is initiating research in FY 89 to develop guidelines for use in NRC reviews and inspections to evaluate the effectiveness of training to acquire and maintain knowledge and skills. A study will be initiated to develop measures for evaluating industry improvements and changes in training programs. The research will build on work already done in training effectiveness outside the nuclear industry. Evaluation of the long-term retention of the knowledge and skills acquired in training for rare events will be given special attention. The evaluation guidance developed will be used for reviewing the training for rare events included in accident management plans that will be submitted by the nuclear power industry.

Recent NRC rulemaking (10 CFR 55) with respect to operator training and licensing has mandated that each nuclear utility have a full-scope plant-referenced simulator by 1991. In addition to using such simulators for the conduct of license examinations, these simulators are extensively used as training tools. The staff will defer consideration of research on training simulator effectiveness for the short term because the industry is in the midst of simulator procurements and upgrades in order to comply with the regulation. However, research that could result in improvements in the use of simulators for accident management training will be pursued.

3.2.3.2 Qualifications

Studies have been conducted to determine the technical basis for educational qualifications of NPP operating personnel, e.g., the need for a college degree (NUREG/CR-4051 and -4411). Further research in the area of degrees for operating personnel at current NPPs is not contemplated at this time. However, the potential changes in the role of operating personnel at advanced NPPs could change the qualifications for operating personnel which needs to be researched. Other planned research would provide the technical basis for determining qualifications of NPP personnel other than licensed operators and STAs, especially maintenance personnel and materials licensees.

The degree requirement is one part of the qualifications issue; another is the NRC-administered examination for licensed reactor operators. The NRC has recently improved the examination process, including (1) revised requalification examinations, (2)

specifications for examination development, (3) examinations that emphasize knowledge and abilities based on their importance, (4) a performance-based simulator examination using simulator scenarios to test important knowledge and abilities and (5) a standardized "Generic Fundamentals" examination that will be centrally administered. On a schedule to be coordinated with HRA, a research project will be initiated to evaluate these changes to the examination process to support management oversight.

3.2.3.3 Shift Scheduling, Shift Rotation, and Vigilance

The staff has initiated research on shift scheduling and vigilance that builds on previous work in this area (NUREG/CR-4248, "Recommendations for NRC Policy on Shift Scheduling and Overtime at Nuclear Power Plants") and ongoing research at EPRI and at individual plants. The research will make use of information obtained from the recent problems of operator alertness on shift. Planned research on shift scheduling will be of two types. One type will consist of confirmatory. research on shift schedules and overtime. NPP data on the effects of overtime, shift scheduling, shift rotation, and staffing on operator errors, operator performance, and plant performance will be collected and analyzed to assess the adequacy of the current technical basis for present NRC policies, which were based on data from non-nuclear industries. The results of this research will provide a basis for updating policy revisions if appropriate.

The second type of research is base research into shift duration, shift rotation, and operator alertness, it has been initiated with the benefit of developments in circadian physiology. Workload, social interaction, and wake-sleep cycle will be examined. The research is expected to identify biological, social, and environmental influences on operator alertness.

3.3 HUMAN-SYSTEM INTERFACE

3.3.1 Purpose and Objectives

Human-System Interface research is concerned with the "surface" at which the human interacts with the system. Research in this area is intended to ensure that the interface supports safe operations. Such research will address a broad range of issues that affect the performance of human tasks in the nuclear industry. On the system side of the interface, display and control design, placement, and integration are important concerns. On the human side, procedures and performance aids, control activities, and human capabilities and limitations are important aspects of the interface.

The objectives of the planned research are (1) to investigate the

potential safety impact of advanced instrumentation and controls that may be backfitted into existing control rooms, (2) to establish acceptance criteria for advanced technology, including artificial intelligence and expert systems, and (3) to identify the human factors affecting the design and use of procedures. The results of these research efforts will be used to develop regulatory review criteria.

3.3.2 Background

Based on human engineering experience accrued during control room design reviews conducted at NPPs, research is planned to address (1) the introduction of advanced technology into current plants and (2) the potential human factors of NPP control rooms for advanced reactors. This research will evaluate the impact of digital and integrated controls and displays on human performance. Particular attention will be paid to the use of computers, computer graphics, and artificial intelligence.

Emergency operating procedures (EOPs) for NPPs underwent major changes due to post-TMI requirements. These changes addressed human factors and converted EOPs from event-based to symptom-based procedures. Research will be conducted to determine whether such improvements should be extended to other procedures at NPPs and to procedures used by NMSS licensees. The research will consider the human factor issues related to graphic (flow-chart) and computer-based procedures, both of which are seeing increased use in the industry.

The research products from the Human-System Interface element will be integrated with the work in the Personnel Subsystem element and the Reliability Assessment element. That is, technological developments in human-system interface may result in a redefinition of the role of operators, with attendant modifications to qualifications and training requirements. In addition, advanced interfaces may well provide the technology to apply reliability engineering to equipment configuration control during surveillance and outage activities.

3.3.3 Research Topic Areas

The Human-System Interface element addresses human engineering and procedures topics, including (1) local control stations, (2) annunciator systems, (3) advanced controls and instrumentation, (4) impact of automation, (5) computer classification, (6) expert system verification and validation methodology, (7) the Halden project, (8) normal and abnormal operating procedures, (9) procedure violations, (10) safety-related operator actions, and (11) future procedures research. The research approach consists of surveys and interviews, controlled experiments, workshops, and the development of review guidance.

3.3.3.1 Human Engineering

Local Control Stations. The risk to public health and safety resulting from human error at local control stations at NPPs and the cost of potential modifications was identified as a human factors generic issue (HF 5.1) in 1984. Using the results of previous work on local control stations (NUREG/CR-3696, 1984), a value-impact assessment was initiated in FY 88 to determine the safety significance of human factors deficiencies in local control stations. Future efforts will focus on the development of regulatory guidance and a regulatory position relating to local control stations. This generic issue is scheduled for resolution in FY 1991.

Annunciator Systems. Unstructured, irrelevant, and distractive information from control board annunciators was identified as a human factors generic issue (HF 5.2) in 1984. A value-impact assessment was performed to evaluate specific annunciator upgrade alternatives. That assessment recommended that a small-scale field experiment be performed to develop a means of evaluating annunciator upgrades. This work is now being completed, and regulatory guidance along with a regulatory position regarding annunciator system upgrades will be developed. This generic issue is scheduled for resolution in FY 1991.

Advanced Controls and Instrumentation. A project to develop review criteria for human factors aspects of advanced controls and instrumentation includes a survey of the commercial nuclear power industry's current and planned use of artificial intelligence, expert systems, and computers for this application. The survey is identifying existing and proposed uses of these high technology systems and the schedules for their implementation. The survey also addresses the proposed use of such systems in advanced control room designs. This survey effort will be completed in FY 89. The safety concerns identified by the survey will be prioritized, and future research efforts will address the identified concerns so that appropriate review criteria can be developed.

Evaluation of the Impact of Automation in the Human-System Interface. The National Academy of Science's February 1988 report discussing the current development of computer-based support systems within the nuclear industry states "...there is an immediate need for effective tools to evaluate and measure the impact of new aids and automation on the human-technical system. Developing these measuring techniques is the highest immediate priority in this area." The purpose of this project is to develop effective tools to measure and evaluate computer-driven interfaces. As a first step, a workshop of experts from several disciplines and industries was conducted in January 1989 to propose interface guidelines, needed experimental research, and evaluation methods. The ultimate goal of this effort is the

development of review and inspection guidelines for evaluation of anticipated automated systems.

Computer Classification. The use of computers to provide information to plant personnel is increasing at NPPs. This project will develop guidance and criteria for the qualification of computer systems for both safety and nonsafety applications. This guidance and criteria may apply to the design, test, verification and validation, maintenance, and reliability of computer systems.

Expert System Verification and Validation. Artificial intelligence and expert systems are being introduced into NPPs, but available review methods are insufficient to verify and validate such systems. This project is intended to develop acceptance criteria and guidelines for the evaluation of expert systems and their verification and validation. This research is planned as a joint project with the Electric Power Research Institute during FY 89 and 90.

Halden Project. The NRC is a participant in the ongoing OECD Halden Reactor Project. The Halden Project conducts research on reactor fuels and on computerized human-system communications within control rooms. During FY 88, the Halden Project conducted an experimental evaluation of the Success Path Monitoring System. The data, knowledge, and test methodology resulting from this experiment will serve as the basis for additional research and the development of effective tools to evaluate and measure the impact of new technologies and automation in the nuclear system.

The Halden Project's research plan for FY 1989 includes (1) experimental evaluation of DISKET (Diagnosis System), an expert-system-based diagnostic aid, (2) experimental evaluation of COPMA (Computerized Operating Procedures), an expert-system-based computerized procedure system, (3) test results for the HALDIS (Handling of Logics) system, which displays plant control and safety systems, and (4) design and testing of a computer-based Integrated Surveillance and Control System (ISACS) as an operator interface in NPPs. The experimental results will be useful in understanding the differences in operator performance when using computer-based procedures versus paper-based procedures and will support development of review guidelines for expert systems. The results of this work will feed directly into future procedures research discussed below. Future products from the ISACS program may provide the basis for review guidelines in the safety evaluations of advanced instrumentation and controls.

3.3.2 Procedures

Normal and Abnormal Operating Procedures. In addition to the procedures research being conducted at the Halden Project (see Section 3.3.3.1), a number of other projects will investigate

procedures issues. Generic Issue 4.4, "Guidelines for Upgrading Other Procedures" calls for the development of a long-term plan for upgrading plant procedures other than EOPs. The project is continuing to assess the costs and benefits of expanded regulatory guidance to other than emergency procedures. Specifically, a value-impact assessment will determine the amount of upgrade effort necessary for improving normal and abnormal operating procedures.

Procedure Violations. Several procedure violations committed at Chernobyl have been determined to be key contributors to the accident. Procedure violations at NPPs may be committed by licensed and non-licensed operators, plant technicians, maintenance personnel, contractors, and management. While the NRC believes that purposeful violation of procedures is infrequent at U.S. plants, the exact nature and extent of such violations and their potential and actual consequences have not been established. In response to Chernobyl Follow-up Item 1.1.B., a project is under way to (1) distinguish intentional procedure violations from procedure errors, (2) determine the extent, nature, and consequences of procedure violations at NPPs, and (3) recommend methods for minimizing any safety problems discovered.

Safety-Related Operator Actions.
ANS 58.8, "Time Response Criteria for Safety-Related Operator Action," was published in 1984. This standard will be revised to appropriately reflect new data from EPRI-sponsored simulator research. The NRC's endorsement of this revised industry standard, as well as the industry's implementation of symptom-based EOPs and enhanced operator training, will constitute closure of Generic Issue B-17, "Criteria for Safety-Related Operator Actions."

Future Procedures Research. In addition to the research projects described above, future research will address (1) the impact on safe plant operations of differing EOP presentation formats, (2) criteria for evaluating procedures formats, and (3) an improved technical basis for evaluating a utility's means of determining the causes of human error during the use of procedures.

3.4 ORGANIZATION AND MANAGEMENT

3.4.1 Purpose and Objectives

A variety of events during the past decade, including the TMI-2 and Chernobyl accidents, provide evidence that organization and management factors contribute to the likelihood of such accidents, the immediate response, and the degree of success achieved in recovery. Therefore, organization and management research is directed toward credible modeling techniques, data-gathering instruments, and performance indicators for

systematically assessing NPP organizations under normal, emergency, and accident operating conditions. In this element of the Human Factors Research Program we will concentrate on the NPP organization, including operations, maintenance and support that affects the safety of the plant. The functions to be assessed include policy implementation, policy interpretation, policy development.

The specific objectives of organization and management research are to develop credible models, data gathering instruments, and performance measures for systematically (1) distinguishing between NPPs by their organizational characteristics from a safety perspective, (2) measuring performance effectiveness of organizations within the NPP (3) monitoring programmatic performance indicators of NPP technical support programs (e.g., maintenance, training), safety management, and overall NPP safety performance, (4) integrate organization and management influences into probabilistic risk assessment (PRA) studies, and (5) inspecting organizational performance by a standardized protocol.

3.4.2 Background

Region I, RES, NRR, and AEOD users have requested that research be performed to improve our understanding of organization and management influences on safe operations and maintenance by means of descriptive models of NPP operating characteristics, instruments for gathering data on performance, and performance indicators. Therefore, in responding to these requests, this program element is directed toward the following products:

1. Descriptive techniques for modeling the operating characteristics of single- and multiple-unit NPP organizations under both normal and abnormal operating conditions as a framework for systematically investigating:

    - o differences between operating characteristics critical to safety during normal, abnormal and emergency conditions.
    - o distinctions between organizational and management characteristics, and their relative impacts on safety,
    - o organizational functions and roles that have a significant impact on safety performance and ways they affect performance (e.g., policy execution),
    - o distinctions between the characteristics of effective management and leadership
    - o multidimensional interactions among organizational elements that suggest candidate indicators of technical support programs (e.g., maintenance, training),

management, and overall NPP performance,

- o NPP modeling and data requirements to support PRA.

2. Instruments for gathering and scaling NPP organization and management status information guided by modeling results from item 1 to support:

   - o reliability and risk calculations,
   - o indicators of technical support programs, management, and overall NPP performance, and
   - o research on other human-system interface, personnel subsystem, personnel performance, and reliability assessment topics.

3. Indexing scaled measures to performance levels for the data-gathering instruments mentioned above.

Modeling and performance-measurement research undertaken within this program element benefitted from NRC research performed during 1982 on modeling and during 1985 on performance measurement. NUREG/CR-3215 and -4378, published as a result of these activities, provided a point of departure for organization and management research begun during FY 1988 within this program element. FY 1988 research on organization and management resulted in (1) a modeling technique for describing NPP organizational characteristics during normal operations, (2) candidate data-gathering instruments employing survey and direct observation approaches, and (3) a NPP process model developed as part of programmatic performance-indicator research.

3.4.3 Research Topic Areas

FY 1989-92 organization and management research is divided into three interactive research topics, i.e., modeling techniques, performance measurement instruments, and indexing. Findings and products of the modeling techniques topic area are expected to provide a framework for selection and evaluation of data-gathering instruments and performance indicators within the performance-measurement instruments topic area. In turn, findings and products of both of those topic areas are expected to provide the structure, context, and data for pursuing objectives of the indexing topic area. Additionally, organization and management program element findings and products from these topic areas are expected to contribute to and interact with the other human factors research program elements. For example:

- o Modeling techniques guide acquisition of human factors information to support plant modeling segments of Reliability Assessment element research.

- o Performance-measurement instruments (e.g., surveys,

interviews, direct observation, job sampling) are expected to provide input data to the Reliability Assessment element which, in turn, will provide an algorithm to translate the input data into error probabilities for use in PRA.

- Performance-measurement instruments (e.g., technical support program, management and organizational indicators) are also expected to provide measures to the Personnel Performance Measurement element.

FY 1989 organization and management research comprises ten distinct but interrelated projects. Two projects are being performed by an in-house team, two by Department of Energy (DOE) national laboratories, three by commercial firms, and one each by a DOE laboratory/university team, a commercial firm/university team, and the National Research Council. During the next three years, it is expected that organization and management research could comprise the projects briefly summarized in Table 1 along with a general schedule.

Research is guided by the sequential four-step process described in Appendix B to this plan. Research begins with a Feasibility Analysis followed, if appropriate, by Technology Development, Evaluation, and Implementation or transfer of findings and products to the intended users. For example, those interested in techniques for modeling NPP organizations under normal operations can read from Table 2 that their evaluation is scheduled for completion in FY 1990 although useful results are expected prior to that time.

3.4.3.1 Modeling Techniques

The objective of this topic area is to develop qualitative and quantitative modeling techniques systematically describing the operating characteristics of human organizations involved in operating single- and multiple-unit NPPs during all normal operating configurations (e.g., full power, refueling) and during off-normal, emergency and accident operating conditions. In turn, these modeling techniques will be used to (1) identify organization functions that have the potential for influencing safety performance during NPP operating configurations of interest, (2) determine the manner in which the identified organization and management factors influence safety performance, and (3) guide collection of organization and management status information.

In accomplishing its objectives, this research takes advantage of (1) the state of knowledge concerning organization and management behavior in complex high-reliability systems and (2) documentation and lessons learned from ongoing NRC activities directed at assessing the adequacy of organization and management performance such as its Systematic Assessment of Licensee

Performance (SALP) and Diagnostic Evaluation Team (DET) programs. Findings and products from this topic area provide a framework for (1) reliability and risk assessment studies in the areas of plant modeling and quantification of human error and its causal factors, (2) NPP programmatic performance indicator development studies, and (3) indexing studies. Ongoing (FY 1989) and planned (FY 1990-92) modeling research is briefly described in the following paragraphs and is summarized in Table 2.

FY 1989 Technology Development and Technology Evaluation research by a joint team of Brookhaven National Laboratory (BNL) and McGill University scientists is directed toward completing a modeling technique, currently known as the Nuclear Organization and Management and Analysis model (NOMAM), for analyzing NPP organizational characteristics during normal operations. A field evaluation of this modeling technique is scheduled for late in FY 1989.

FY 1990 Technology Evaluation research will involve application of the NOMAM concept in a test-bed facility to investigate its practicality, acceptability, and usefulness for supporting probabilistic risk analysis, NRR and AEOD plant evaluation programs, and risk-based and programmatic performance indicator development. FY 1991 Technology Implementation research involves transferring the modeling technique to NRC users.

FY 1989 Feasibility Analysis research at BNL focuses on extending the NOMAM concept to NPP organizational configurations during emergency and accident operating conditions, and during transitions from normal to accident configurations. If determined advisable based on FY 1989 results, FY 1990 Technology Development research will focus on actually extending the concept to emergency and accident conditions. FY 1991 Technology Evaluation and Implementation research will then investigate its practicality, acceptability, and usefulness for supporting PRA, performance indicator development, and plant evaluation programs.

FY 1992 Feasibility Analysis research is also planned to examine the advisability of extending modeling techniques for changes over time.

3.4.3.2 Performance-Measurement Instruments

The first purpose of this topic area is to verify existing organization and management data-collection instruments (involving survey, interview, direct observation, and job-sampling approaches). The existing instruments are psychometrically validated but not yet ready for use in a nuclear setting. To acquire credible data and minimize intrusiveness on NPPs, the research will focus on instruments that address management effectiveness. The second purpose of this research is to develop and validate both programmatic indicators and overall

indicators of NPP safety performance, e.g., maintenance, training, management, organizational culture, and combinations thereof. Ongoing (FY 1989) and planned (FY 1990-92) performance-measurement research is briefly described in the following paragraphs and is summarized in Table 2.

FY 1989 Feasibility Analysis research is being perfected by joint participation on the National Research Council's Committee on Human Factors. The Committee has initiated research on (1) potential relationships between individual, team, and organizational performance in complex high-reliability systems and (2) candidate performance indicators for assessing individual organizational effectiveness. During FY 1990, Technology Development research by the Committee will lead to procedures for implementing the performance indicators identified during FY 1989. Subsequently, FY 1991 Technology Evaluation research by a contractor will investigate the practicality, acceptability, and usefulness of these implementing procedures and performance indicators. FY 1992 Technology Implementation research will then involve transferring successfully evaluated procedures and indicators to interested users.

FY 1989 Feasibility Analysis research is directed toward composite or organizational indicators of overall safety performance. This research builds on (1) results of programmatic performance-indicator research, (2) performance-indicator and diagnostic-evaluation work completed to date by AEOD, and (3) SALP and DET evaluations completed to date by the Regional Offices, AEOD, and NRR. FY 1990 Technology Development and FY 1991 Technology Evaluation and Implementation research will identify overall indicators of plant safety performance; investigate their practicality, acceptability and usefulness; and incorporate them into AEOD's Performance Indicator Program and, as appropriate, into NRC inspection and PRA activities.

FY 1989 Technology Evaluation research by a team of BNL, Purdue University, and University of California at Berkeley scientists focuses on implementing survey and direct observation instruments for gathering, scaling, indexing, and evaluating organization and management information. FY 1990 Technology Evaluation research will investigate the practicality, acceptability, and usefulness of applying these instruments in an NRC-licensed NPP facility. FY 1991 Technology Implementation research will focus on transferring instruments that are determined adequate during the previous year to users (e.g., RES, NRR, AEOD) involved in PRA studies, in monitoring performance indicators, and in plant evaluation programs. FY 1991 Technology Development research will also focus on candidate instruments involving interview and job-sampling approaches. FY 1992 Technology Evaluation research will then investigate the practicality, acceptability, and usefulness of candidate instruments in an NRC-licensed facility and, subsequently, their implementation in PRA studies,

performance-indicator monitoring, plant reliability programs, and plant evaluation programs.

FY 1989 Technology Development research by Pacific Northwest Laboratories (PNL) focuses on indicators of control room team performance during emergency operating conditions. FY 1990 Technology Evaluation research will examine the practicality, acceptability, and usefulness of the control room team performance indicators developed during FY 1989 using training simulator performance as the data source. FY 1991 Technology Implementation research may involve transferring these indicators to the NRC operator licensing and severe accident programs. New research is planned during FY 1990 on indicators of performance for other than control room teams. FY 1990 Feasibility Analysis research will determine the feasibility and advisability of developing this type of indicator. If appropriate, FY 1991 research will focus on Technology Development. FY 1992 research will then focus on Technology Evaluation employing simulator sessions and retrospective analyses of real incidents as data sources, and additional FY 1992 research will focus on implementation of these indicators.

FY 1989 Technology Development research by Science Applications International Corporation (SAIC) is directed toward programmatic indicators of maintenance and training performance. FY 1990 Technology Evaluation research will focus on the practicality, acceptability, and usefulness of maintenance and training indicators developed during FY 1989 employing training simulator sessions and operational experience as data sources. Later in FY 1990, these indicators will be available to be incorporated into the AEOD Performance Indicator Program. Feasibility Analysis research will also be undertaken during FY 1990 on other technical support programs (e.g., staffing, qualifications, scheduling) identified as potential sources of safety performance variation by other human factors research program elements. If feasible and advisable, FY 1991 Technology Development and FY 1992 Technology Evaluation research will be undertaken on these latter indicators using current NRC plant reporting systems as data sources, followed in FY 1992 by their evaluation and implementation.

FY 1989 Technology Development research by a team of Minnesota, Wayne State and American University scientists focuses on indicators of management performance under normal operating conditions. FY 1990 Technology Evaluation research will focus on the practicality ,acceptability, and usefulness of management indicators developed from FY 1989 research employing current NRC plant reporting systems as data sources. Later in FY 1990 completed indicators will be recommended for incorporation into AEOD's Performance Indicator Program. Feasibility Analysis research is planned for FY 1991 on indicators of management performance during off-normal, emergency, and accident operating

conditions. If it is determined practical and advisable, FY 1992 Technology Development research will focus on development and validation of candidate indicators.

3.4.3.3 Indexing

This topic area focuses on indexing for regulatory use of results from modeling and measuring topic areas to calibrate these results with a range of performance. It also supports analysis and resolution of generic issues and NRR and AEOD reviews pertaining to organization and management. Ongoing (FY 1989) and planned (FY 1990-92) research on indexing is briefly described in the following paragraphs and is summarized in Table 2.

FY 1989 research being conducted in house focuses on two Chernobyl follow-up tasks (Tasks 1.6A and 1.7A in NUREG-1252). The proposed Task 1.6A is to assess the potential adverse impacts of current regulations on the ability of NPP and utility management to respond to emergency and accident situations. FY 1989 Feasibility Analysis research involves a review of NRC requirements, determination of any deficiencies, and recommendations for redressing the deficiencies. Technology development, evaluation, and implementation research that may follow based on FY 1989 findings will be performed as part of FY 1990-92 research on accident management (Section 3.4.3.1) and performance-based regulations described below.

The purpose of Task 1.7A of NUREG-1252 is to review Chernobyl lessons learned. FY 1989 Feasibility Analysis research involves a comparative analysis of Chernobyl lessons learned and the focus and content of the current NRC Accident Management Program. It will identify differences between the two, if any, and recommend appropriate actions. Technology development, evaluation and implementation research that may follow based on FY 1989 findings would be carried out as part of FY 1990-92 research on accident management.

New research into the effects of changing NRC regulations using as a technical basis (1) indicators of overall plant safety developed under the performance measurement instruments topic area and (2) findings of in-house research on Chernobyl follow-up tasks is planned for FY 1992 by a DOE laboratory. FY 1992 Feasibility Analysis research will determine whether measures of the effects of performance-based regulations can be developed and validated.

3.5 RELIABILITY ASSESSMENT

3.5.1 Purpose and Objectives

The Browns Ferry fire and the TMI-2 and Chernobyl accidents

demonstrated the potential for human error and hardware failures and their interactions to significantly influence plant safety. Therefore, reliability research was initiated by the NRC in the late 1970s; plant reliability program research began in 1985 and risk-based indicators research in 1986. In continuing these efforts, the current Reliability Assessment Element (RAE) is directed toward multidisciplinary research full integrating human and hardware reliability analysis data and methods into (1) probabilistic risk assessments (PRAs) and (2) NRC licensing, inspection, and regulatory decisionmaking. RAE findings and products are being adopted and applied by the NRC through cooperative agreements by domestic and international governmental agencies outside the NRC and by other human factors and risk assessment analysts at universities, national laboratories, and independent engineering firms.

The specific objectives of RAE research are obtaining probabilistic data, developing data-management systems and analysis methods, and integrating procedures for (1) doing quantitative and qualitative human and systems reliability analyses and integrating their results into PRAs, (2) monitoring programmatic and risk-based performance trends, (3) establishing reliability-based and risk-based guidelines for implementing and monitoring the effectiveness of plant reliability programs, and (4) systematically employing PRA processes to address safety issues of concern to regulators.

3.5.2 Background

Needs for RAE research have been identified by Region I, NRR, AEOD, and RES users for better probabilistic data for input to PRA, systems for managing PRA inputs and results data, and methods for quantifying influences of human and equipment on NPP reliability and risk. Therefore, in responding to these requests, this program element is directed toward the following products.

1. Improved methods making use of automated data processing wherever possible for systematically quantifying and trending:

    - o the likelihood of cognitive human error in decisionmaking, diagnosis, and system recovery.
    - o influences of individual and management and organizational practices on human error.
    - o systems reliability fully accounting for dependent and common-cause failures involving both humans and hardware.

2. Management information systems making use of automated data

processing wherever possible for systematically organizing, storing, and making available to PRA practitioners:

- o human error and hardware failure rate data, including commoncause, root-cause, and conditional probabilities, for input to reliability and risk assessments.

3. Improved sequence evaluation methods and methods for systematically using PRA and trending data as:

   - o indicators of overall plant and safety systems performance criteria for specifying technical areas for training and licensing examinations for station personnel.

   - o criteria and guidelines for technical specification improvements.

   - o criteria and guidelines for generic issue resolution and preparation of technical analyses to support NRC regulatory decision making.

   - o criteria and guidelines for evaluating the impact on human error and equipment failure frequencies of replacing analog hard-wired equipment with digital technology.

4. Procedures to fully integrate human factors, behavioral science and engineering expertise into the PRA process to ensure that pertinent human, hardware, and plant operating characteristics and combinations thereof are fully analyzed, taking maximum advantage of state-of-the-art modeling, quantification, and trending tools.

5. Procedures for applying PRA-based data, quantification tools, and sequence evaluation methods to support implementation and monitoring of in-plant reliability programs.

6. Improved means for defining the need for data on human error and hardware failure and for evaluating the adequacy uT existing data sources inside and outside the nuclear industry to support probabilistic analyses, especially PRA.

3.5.3 Research Topic Areas

RAE is divided into six interactive research topic areas to respond in a timely manner to immediate and long-term needs of Region I, NRR, AEOD, and RES users. The first four topic areas are directed toward improved data, data management, quantification tools, and sequence evaluation methods that

address human and hardware performance separately and in combination. The last two topic areas integrate results and products from the first four topic areas into (1) multidisciplinary procedures for doing PRAs, (2) methods for systematically applying PRA results to regulatory activities, and (3) programs, performance indicators, and criteria for improving technical specifications.

FY 1989 research within RAE comprises 17 projects. Four of these projects are being performed by Department of Energy (DOE) national laboratories, five by Joint DOE laboratory/commercial firm/university teams, two by commercial firms, three by universities, two by means of international agreements, and one by the National Research Council's Committee on Human Factors. FY 1990-92 research within RAE comprises the projects briefly summarized in Table 3 along with the general schedule.

Research is guided by the sequential four-step process described in Appendix B to this plan. Research begins with a feasibility analysis followed, if appropriate, by technology development, evaluation, and implementation or transfer of findings and products to the intended users. For example, those interested in data acquisition from nonnuclear sources can read from Table 3 that development of techniques for doing so will be completed in FY 1989.

3.5.3.1 Probabilistic Data Acquisition

The first RAE research topic area focuses on acquiring human and hardware failure rate data. A major problem for PRA practitioners to date is a lack of credible data to support those assessments. This is especially true in the areas of human performance and dependent failures. Therefore, research focuses on potential data sources and data from inside and outside the commercial nuclear community. Resulting data are used primarily as anchors or bounding values to derive situation-specific probability estimates and to become part of the data-management systems discussed in Section 3.5.3.3. Ongoing (FY 1989) and planned (FY 1990-92) probabilistic data acquisition research is briefly described in the following paragraphs and is summarized in Table 3.

FY 1989 Feasibility Analysis research by the National Research Council's Committee on Human Factors focuses on the state of the knowledge concerning our ability to classify mechanisms!s of human error in complex high-reliability systems. Included are definitions and taxonomies of human error as an adaptive behavior, as a biological dysfunction, and as a cognitive phenomenon. FY 1990 Technology Development research will focus on classification of human error mechanisms in complex systems inside and outside the nuclear industry.

FY 1991 Technology Evaluation research will investigate the practicality, acceptability, and usefulness of research findings from FY 1990 work. FY 1992 Technology Implementation research will involve incorporation of findings into NRC PRA studies and, as appropriate, into NRC licensing and inspection programs.

FY 1989 Technology Development research by the George Mason University focuses on criteria for equating human tasks performed in nuclear settings with human tasks performed in nonnuclear settings on the basis of their common or similar behavioral and psychological characteristics. The objective of this research is to supplement, with data from nonnuclear settings, the limited data now available from nuclear settings. Supplementing these data from sources outside the nuclear industry will reduce uncertainties currently associated with estimating human error probability. More specifically, criteria resulting from this research will allow PRA analysts in nuclear settings to use human error probabilities based on operational data from nonnuclear settings as anchor values (default values) with RAE quantification tools or as point estimates with RAE sequence evaluation methods. Feasibility Analysis research was completed during FY 1988. FY 1989 research involves developing criteria for equating human tasks and locating nonnuclear sources. FY 1990 Technology Evaluation research is expected to involve field applications of criteria for equating human tasks and data from nonnuclear sources with those in a nuclear power plant setting. These field applications will help to assess the practicality, acceptability, and usefulness of both criteria and data for ongoing human reliability analysis (HRA) in a nuclear setting. FY 1991 Technology Implementation research will focus on (1) incorporating criteria in procedures and guidelines for doing HRA segments of PRAs and (2) preparing nonnuclear data for input to the Nuclear Computerized Library for Assessing Reactor Reliability (NUCLARR) discussed in Section 3.5.3.3.

New research in this topic area will be undertaken during FY 1990 to identify alternative operational data sources, collect data from those sources, and prepare the resulting data to support future risk-based indicator development, evaluation, and implementation. FY 1990 Feasibility Analysis research is expected to investigate the existence of alternative data sources and the advisability of establishing data acquisition mechanisms using either voluntary or nonvoluntary reporting concepts. FY 1991 Technology Development research, if determined advisable based on Feasibility Analysis findings, will focus on mechanisms for collecting operational data of interest. FY 1992 Technology Evaluation and Technology Implementation research is planned to field-test and institutionalize the data-collection mechanisms.

3.5.3.2 Quantification Tools

The second research topic area focuses on improving techniques

for deriving human error and equipment failure probability, causal factors, and uncertainty bound estimates. Past research has developed an initial set of quantification tools for estimating human error and equipment failure probabilities that apply multiattribute (NUREG/CR-4016), paired comparison, and direct numerical estimation (both in NUREG/CR-3688) techniques to consensus expert judgment for estimating human and equipment failure probabilities using field reports (NUREG/CR-3519) and training simulator data (NUREG/CR-3309). Feedback currently being collected on these quantification tools will be used for refining each as part of this research program element during FY 1991-92. Ongoing (FY 1989) and planned (FY 1990-92) quantification tools research is briefly described in the following paragraphs and is summarized in Table 2.

FY 1989 Technology Development research with Massachusetts Institute of Technology (MIT) George Washington University, United Kingdom Atomic Energy Authority (UKAEA), and Commission of European Communities (CEC) is ongoing to refine a sample of existing quantification tools that take into account human and hardware common-cause, root-cause and dependent failures and the effectiveness of defenses against each in estimating error and failure probability. FY 1990 Technology Evaluation research will investigate the practicality, acceptability, and usefulness of quantification tools refined as part of FY 1989 work. FY 1991 Technology Implementation research will incorporate refined quantification tools, where successfully evaluated, into procedures and guidelines for doing PRA-related studies.

New research is planned for FY 1991 to refine and update, based on user feedback, current methods for estimating human error and hardware failure probabilities that are not being included in the studies described above (e.g., tools that apply multiattribute, paired comparison, and direct numerical techniques to consensus expert judgment and those that utilize field reports and training simulator data). FY 1991 Technology Development research is expected to involve a review of feedback received and revision of selected tools. Priority will be given to tools developed earlier as part of the NRC human reliability and systems analysis programs. FY 1992 Technology Evaluation and Technology Implementation research is planned to investigate the practicality, acceptability, and usefulness of the revised tools and their incorporation into procedures and guidelines for doing PRA-related studies.

3.5.3.3 Data Management Systems

The third research topic area focuses on developing automated systems capable of processing and storing human error and hardware failure data for input to PRAs. Past research has resulted in a data base management system known as NUCLARR for storing human and hardware failure rate data. Ongoing (FY 1989)

and planned (FY 1990-92) data management systems research is briefly described in the following paragraphs and is summarized in Table 3.

FY 1989 Technology Development research by (Idaho National Engineering Laboratory) INEL focuses on a direct or mediated interface between the NUCLARR data store and sequence evaluation methods such as IRRAS. Technology implementation research by INEL involves collecting and implementing user feedback in further versions of the NUCLARR operating system and data store. Finally, Feasibility Analysis research by INEL focuses on expanding the NUCLARR data taxonomy to common-cause, root-cause, group-performance, and multiple-component/multiple-system failure data. FY 1990 Technology Development research will involve preparation of computer software to handle the aforementioned data types; FY 1991 Technology Evaluation research will involve tests of its adequacy; and FY 1992 Technology Implementation research will involve its integration as part of the NUCLARR data-management system. FY 1990 Technology Evaluation research, also by INEL, is expected to involve testing the adequacy of a direct method of mediated interface between NUCLARR and sequence evaluation methods such as IRRAS. FY 1991 Technology Implementation research is expected to involve transferring the interface capability to users inside and outside the NRC.

FY 1989 services are also being procured from INEL to provide NUCLARR management and data acquisition and to act as a NUCLARR user interface and clearinghouse. It is anticipated that these services will also be procured during FY 1990-92.

3.5.3.4 Sequence Evaluation Methods

The fourth research topic area focuses on developing techniques for applying error and failure probability estimates developed as part of other topic areas to quantify and interpret the relative effects of human and equipment reliability in safety-related event sequences (scenarios). Past research has led to the development of (1) a prototype Maintenance Personnel Performance Simulation (MAPPS) stochastic computer code capable of simulating overt behavior of maintenance personnel, (2) a prototype Cognitive Environment Simulation (CES)/ Cognitive Reliability Analysis Technique (CREATE) artificial intelligence computer code capable of systematically analyzing the cognitive aspects of human behavior (including recovery strategies), (3) a Multiple Sequence Failure (MSF) method for systematically quantifying dependencies (conditional probabilities of error) between consecutive steps in human performance segments of accident sequences, (4) an Operator Action Tree (OAT) method for carrying out human reliability analysis segments of PRAs using a time-reliability curve approach, and (5) a handbook and workbook applying the Technique for Human Error Rate Prediction (THERP) for carrying out the HRA segment of PRAs using an event/fault

tree approach. Ongoing (FY 1989) and planned (FY 1990-92) sequence evaluation methods research is briefly described in the following paragraphs and is summarized in Table 3.

FY 1989 Feasibility Analysis research by Lawrence Livermore National Laboratory (LLNL) focuses on the advisability of computerizing major data handling, recordkeeping, and auditing functions of the PRA process. FY 1990 Technology Development research, if deemed advisable, will focus on preparation of computer software to perform the aforementioned functions. FY 1991 Technology Evaluation research will investigate the adequacy of the computer software package. FY 1992 Technology Implementation research will involve transferring the final computer software package to the PRA practitioner community.

FY 1989 Technology Development research by a joint team of BNL and University of California at Los Angeles scientists focuses on techniques for integrating the influences of organizational and management factors into error and core melt frequency estimation. FY 1990 Technology Evaluation research will investigate the practicality, acceptability, and usefulness of the methods developed during FY 1989. FY 1991 Technology Implementation research will focus on incorporating the aforementioned methods into NRC-published procedures and guidelines for doing PRA analyses.

FY 1989 Technology Implementation research by teams of INEL, Felix Kopstein Associates, and Westinghouse Research and Development Center scientists focuses on the IRRAS, MAPPS, and CES/CREATE computer codes described above. These codes are being subjected to field trials for the purpose of collecting data on their operability, user friendliness, and responsiveness to user needs and the advisability of further development. Future Technology Implementation research on each of these codes may involve expansion of their processing capabilities: in the case of the MAPPS stochastic code, increasing its task library; in the case of the artificial-intelligence-based CES/CREATE code, expanding its knowledge base and processing mechanism networks; and in the case of IRRAS, providing capabilities for constructing fault trees and displaying plant status and using schematics and equations for core melt frequency calculations.

New research is planned for FY 1990 to develop and implement, based on user feedback, refinements to the current MAPPS stochastic computer code (e.g., user friendly features, training, and maintenance documentation). FY 1991 Technology Evaluation and Technology Implementation research would involve field tests of MAPPS revisions, transfer of the code from a mainframe to a personal computer, and preparation of final training, operation, and maintenance documentation. New research is planned for FY 1990 to extend the knowledge base and process mechanism networks of the CES/CREATE artificial-intelligence-

based computer code to selected nonlicensed operators at NPPs. FY 1991 Technology Evaluation and Technology Implementation research will involve assessing the adequacy of the nonlicensed operator knowledge base and process mechanisms and incorporating this new capability into procedures and guidelines for performing reliability and risk assessments in the areas of decision making and intention formation.

Contractor selection is in process for FY 1989 Feasibility Analysis research that focuses on methods for analyzing the influences of digital technology and complex system feedback loops on human error and equipment failure rates.

FY 1990 Technology Development research, if deemed advisable, will involve preparation of one or more sequence evaluation methods; FY 1991 Technology Evaluation and FY 1992 Technology Implementation research will involve testing these methods for their adequacy and transferring them to users inside and outside the NRC.

3.5.3.5 HRA/PRA Integration Procedures

The fifth research topic area focuses on integrating both human factors and engineering expertise fully into the PRA process to achieve more realistic estimates of the relative contributions of humans and equipment separately and in combination to NPP reliability and risk. The success of research within this topic area, along with probabilistic data acquisition, is vital to the success of the overall RAE activity. That is, no matter how adequate quantification tools and sequence evaluation methods are, if they are not fully exploited by qualified human factors and engineering specialists, realistic assessments of human and hardware performance separately and in combination will not be achieved. Ongoing (FY 1989) and planned (FY 1990-92) HRA/PRA integration procedures research is briefly described in the following paragraphs and is summarized in Table 3.

FY 1989 Technology Development research by LLNL focuses on procedures for fully integrating human factors and engineering expertise throughout the PRA process in order to achieve more realistic estimates of the relative impacts of human errors and hardware failures separately and in combination on overall plant risk. FY 1989 research also involves incorporating, as appropriate, findings and products from other RAE research topic areas and other program elements into these procedures. Technology Evaluation research is planned for FY 1990 to investigate the adequacy of procedures developed during FY 1989; FY 1991 Technology Implementation research is expected to involve transferring the aforementioned procedures to users inside and outside the NRC.

3.5.3.6 PRA Results Application

The sixth research topic area focuses on applying results from fully integrated reliability and risk assessments to (1) prioritize and resolve generic issues, (2) develop risk-based regulatory tools to support such applications as improving technical specifications, (3) validate risk-based performance indicators, and (4) support development of training and licensing curricula for NPP personnel. To date, research in this topic area has resulted in Operational Safety Reliability Program (OSRP) guidelines and a model for risk-based indicators of the unavailability of selected safety systems. These results are being used to resolve such safety issues concerning how to ensure reliable equipment operation as B-56, "Diesel Generator Reliability," and to support the Agency's Procedures to Evaluate Technical Specifications (PETS) Program. Ongoing (FY 1989) and planned (FY 1990-92) PRA results applications research is briefly described in the following paragraphs and is summarized in Table 2.

FY 1989 Feasibility Analysis research by a joint team of LLNL and PNL scientists focuses on (1) identifying types of generic data required to resolve regulatory issues and to support licensing, inspection, and regulatory decision making and (2) assessing the degree to which procedures being developed within the topic area of HRA/PRA integration procedures can accommodate those needs. Subsequent FY 1990 Technology Development research will focus on methods for systematically applying PRA results to those regulatory needs., FY 1991 and FY 1992 research is expected to involve applications methods evaluation and implementation within the regulatory community.

FY 1989 Technology Implementation research by a joint team from BNL and SAIC focuses on OSRP guidelines. A field trial of the guidelines is being undertaken to acquire data on their implementability, user acceptability, and responsiveness to user needs and for setting alert levels and preventing common-cause failures.

FY 1989 Technology Implementation research, also by a joint team of BNL and SAIC scientists, focuses on risk-based indicators of safety system unavailability and their incorporation into AEOD's Performance Indicator Program. FY 1990 Technology Development research will extend the risk-based indicator concept to non-safety-grade systems and human-system interface and personnel subsystem aspects of NPP operations. FY 1991 research will focus on field validation of non-safety-system indicators developed during FY 1990 and on their incorporation into AECD's Performance Indicator Program.

FY 1989 Technology Implementation research by BNL focuses on risk-based criteria for refining technical specifications through the use of (1) risk-based configuration control to supplement or

replace Limiting Conditions for Operation (LCO) and (2) an integrated surveillance program that monitors NPP performance and safety status. FY 1990 Technology Development research is planned to focus on risk-based criteria for technical specification improvements; FY 1991 research is expected to focus on field evaluation and implementation of these new criteria in the PETS Program.

New research is planned for FY 1990 to develop risk-based criteria for identifying technical areas that should be addressed in reactor operator training and licensing examinations. FY 1990 Feasibility Analysis research will assess the practicality and advisability of using such criteria for this purpose. FY 1991 Technology Development research, if pursued, will focus on criteria preparation; FY 1992 research will focus on criteria evaluation and implementation in NRC training and licensing activities.

New research planned for FY 1990 will be directed toward performance-based regulations whose technical bases are findings from OSRP guidelines research, the PETS Program, and the risk-based performance indicator program. FY 1990 research will involve formulating a technical basis for performance-based regulations. FY 1991 and FY 1992 research is expected to involve their fieldtesting at selected NPP sites.

4.0 RESOURCE SUMMARY

As part of its responsibility for planning and coordinating the research, the Division of Systems Research (DSR) will continue to prepare recommendations to the Director, RES, for the resources needed (i.e., staff and budget) and the appropriate contractors.

4.1 STAFFING.

Management of the overall human factors regulatory research program and the direction of individual research tasks is the responsibility of the Human Factors Branch, DSR. Because of the broad scope of human factors technology, there is a multidisciplinary staff of 11 professionals directing the human factors research. The current staff is composed entirely of senior professionals, including nationally and internationally recognized experts in human-system interface designs, training, qualifications, human reliability assessment, and simulators. These professionals are qualified to direct research both by formal training and by applied experience.

By formal training, there are three staff members with doctorates and eleven with master's degrees. Every professional has at least one master's degree. The most prevalent professional discipline among the staff is psychology, with two PhDs, six master's degrees, and six bachelor's degrees.

There is a minimum of eleven years applied experience in any single topical area. The total applied experience is over 270 staff-years. More than 50 percent of the experience is in human factors and engineering psychology.

4.2 CONTRACTS

In contracting projects we look particularly for a well-qualified professional staff that is experienced in both human factors and any of several disciplines related to nuclear systems. Currently, there are contracts with internationally recognized experts in cognitive modeling, maintenance, simulation, advanced human-system interfaces, circadian physiology, organization and management, psychological experimentation, event investigation, and data management. Most of the research is performed through contractual support. The fiscal year's contract funds are distributed as follows: about 63% to National Laboratories, about 22% to universities and consulting firms, and about 15% to international cooperatives. The fiscal year's projects are currently distributed as follows: 23 projects are led by researchers at national laboratories, 11 projects are led by researchers at universities and consulting firms, and three projects are performed by international research cooperatives. We expect that the percentages for universities and consulting firms will be increasing.

4.3 BUDGET

Total budget projections for the human factors research program for fiscal years (FYs) 1989 through 1992 are presented in Table 4. Specifics, by program element, are presented for FY 1989 through FY 1992.

Table 1

Overview of Users Needs
by Research Activities

Program Element: Human Factors Research

Activity: Personnel Performance Measurement
Determine Causes of Human Error (NRR, AEOD, NMSS, RES)
Standard Investigation Protocols (NRR, AEOD)
Medical Uses (NMSS)
Industrial Radiography (NMSS)

Activity: Personnel Subsystem
Training Effectiveness Measures (NRR)
Personnel Qualifications (NRR)
Operator Licensing (NRR)
Shift Scheduling & Overtime (NRR)

Activity: Human-System Interface
Acceptance Criteria for Advanced I&C Interfaces (NRR, RES)
Verification and Validation Measures for Expert Systems (NRR)
Procedures (NRR, AEOD)

Activity: Organization and Management
Influences of Organizational Practices on Risk (NRR, REG I)
Human Factors Support to Accident Management (NRR)
Performance Measures for Control Room Teams (NRR)

Program Element: Reliability Assessment

Activity: Data Acquisition & Quantification
Validation of Performance Indicators (AEOD)

Activity: Data Management Systems
Causes & Frequency of Failures (AEOD, RES)

Activity: HRA/PRA Integration
Performance Indicator for Cognitive Errors (AEOD)
Modeling Human Errors in PRAs (NRR)
Organization and Management Factors (NRR, REG I)

Activity: HRA/PRA Results Application
Technical Specification Configuration Control (NRR)
Risk-Based Performance Indicator (AEOD, NRR)

Program Element: Generic and Unresolved Safety Issues

Activity: Human Factors Issues
Alarm Reduction Techniques (NRR, HF 5.2)
Local Control Stations (NRR, HF 5.1)
Other Procedures (HF 4.4)
Criteria for Operator Actions (B-17)

Table 2

Organization and Management Element Research Summary

Topic	FY 1989	FY 1990	FY 1991	FY 1992
3.4.3.1 Modeling Techniques				
Modeling Techniques for NPP Normal Operations	Tech Dev/Eval	Tech Eval	Tech Impl	
Modeling for NPP Accident Management	Feas Anal	Tech Dev	Tech Eval/Impl	
3.4.3.2 Performance-Measurement Instruments				
Individuals and Teams in Organizations	Feas Anal	Tech Dev	Tech Eval	Tech Impl
Overall Indicators of Plant Performance	Feas Anal	Tech Dev	Tech Eval/Impl	
Survey Instruments	Tech Eval	Tech Eval	Tech Impl	
Direct Observation Instruments	Tech Eval	Tech Eval	Tech Impl	
Interview Instruments		Feas Anal	Tech Dev	Tech Eval/Impl
Job Sampling Instruments		Feas Anal	Tech Dev	Tech Eval/Impl
Control Room Team Indicators Off-Normal Ops	Tech Dev	Tech Eval	Tech Impl	
Other Plant Team Indicators Off-Normal Ops		Feas Anal	Tech Dev	Tech Eval/Impl

Table 2 (cont'd)

Organization and Management Element Research Summary

Topic	FY 1989	FY 1990	FY 1991	FY 1992
3.4.3.2 Performance-Measurement Instruments (Cont'd)				
Maintenance Program Indicators	Tech Dev	Tech Eval/Impl		
Training Program Indicators	Tech Dev	Tech Eval/Impl		
Other Program Indicators		Feas Anal	Tech Dev	Tech Eval/Impl
Management Indicators Normal Ops	Tech Dev	Tech Eval/Impl		
Management Indicators Off-Normal Ops			Feas Anal	Tech Dev
3.4.3.3 Indexing				
Chernobyl Follow-Up Regulations	Feas Anal			
Chernobyl Follow-Up Lessons Learned	Feas Anal			
Performance-Based Regulations				Feas Anal

Table 3

Reliability Assessment Element Research Summary

Topic	FY 1989	FY 1990	FY 1991	FY 1992
3.5.3.1 Probabilistic Data Acquisition				
Human Error Mechanisms	Feas Anal	Tech Dev	Tech Eval	Tech Impl
Nonnuclear Data for HRA	Tech Dev	Tech Eval	Tech Impl	
Data for Risk-Based Indicators		Feas Anal	Tech Dev	Tech Eval/Impl
3.5.3.2 Quantification Tools				
Refined Tools for HRA/PRA	Tech Dev	Tech Eval	Tech Impl	
Other HRA/PRA Tool Refinements			(Tech Eval)*	(Tech Dev)
3.5.3.3 Data Management Systems				
NUCLARR Interface	Tech Dev	Tech Eval	Tech Impl	
NUCLARR Data Taxonomy Extension	Feas Anal	Tech Dev	Tech Eval	Tech Impl
NUCLARR Management	Tech Impl	Tech Impl	Tech Impl	Tech Impl

* Parentheses indicate that research focuses on extensions of or refinements to an existing research product.

Table 3 (Cont'd)

Reliability Assessment Element Research Summary

Topic	FY 1989	FY 1990	FY 1991	FY 1992
3.5.3.4 Sequence Evaluation Methods				
Computerization of PRA Functions	Feas Anal	Tech Dev	Tech Eval	Tech Impl
Org/Mgt Influences	Tech Dev	Tech Eval		
Org/Mgt Influences			Tech Impl	
MAPPS Stochastic Computer Code	Tech Impl			
MAPPS Stochastic Computer Code		(Tech Dev)*	(Tech Eval/Impl)	
CES/CREATE Licensed Operators	Tech Impl			
CES/CREATE Nonlicensed Operators		Tech Dev	Tech Eval/Impl	
Digital Technology Modeling	Feas Anal	Tech Dev	Tech Eval	Tech Impl
3.5.3.5 HRA/PRA Integration Procedures				
Human Factors/Engineering Expertise	Tech Dev	Tech Eval	Tech Impl	

* Parentheses indicate that research focuses on extensions of or refinements to an existing research product.

Table 3 (Cont'd)

Reliability Assessment Element Research Summary

Topic	FY 1989	FY 1990	FY 1991	FY 1992
3.5.3.6 PRA Results Application				
Methods and Data Requirements	Feas Anal	Tech Dev	Tech Eval	Tech Impl
Tech Eval/Impl				
OSRP Guidelines	Tech Impl			
Risk-Based Indicators Safety Sys	Tech Impl			
Risk-Based Indicators Non-Safety Sys		Tech Dev	Tech Eval/Impl	
Criteria for Tech Specs	Tech Impl			
Refined Criteria for Tech Specs		(Tech Dev)*	(Tech Eval/Impl)	
Criteria for Operator Training and Licensing Examinations		Feas Anal	Tech Dev	
Risk Criteria for Performance-Based Regulation		Tech Dev	Tech Eval	Tech Impl

* Parentheses indicate that research focuses on extensions of or refinements to an existing research product.

Table 4
HFB Research Budget ($1,000)

Program Element	FY 1989	FY 1990	FY 1991	FY 1992
Personnel Performance	550	655	700	700
The Personnel Subsystem	477	1,000	1,250	1,050
Human-System Interface	1,790	1,560	1,310	1,310
Organization and Management	965	1,495	1,300	1,300
Reliability Assessment	2,316	2,840	3,490	3,490
Human Factors Issues	375	800	1,250	1,250
Totals	6,473	8,350	9,300	9,100

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APPENDIX A
CHRONOLOGY OF HUMAN FACTORS RESEARCH IN NRC

The program described in Revision 1 to the Human Factors Regulatory Research Program Plan has evolved over the past nine years. A list of the major events that influenced NRC's human factors research program is provided in Table A1. Although individuals within the commercial nuclear industry had previously identified some human factors concerns, the NRC officially recognized the relationship between human factors and nuclear plant safety when the Reactor Safety Study (WASH-1400, 1975) was performed. In dramatic fashion, the 1979 accident at TMI-2 experientially corroborated analytical findings previously reported. Consequently, the NRC, in 1980, identified several human factors issues and established a Division of Human Factors Safety within the Office of Nuclear Reactor Regulation to address these issues.

In 1981, RES established a branch to conduct human factors research. Research was planned with the benefit of recommendations of the Human Factors Society, which had been contracted by the NRC to provide a critical review of human factors issues and a long-range plan to address these issues (NUREG/CR-2833, 1982). During the period from 1981 to 1985, research was conducted over the full range of human factors issues and the results are documented in 125 reports.

In 1985, budget limitations and the completion of several projects led to a sharp reduction of resources dedicated to human factors research to the extent that only human reliability assessment activities were pursued between 1985 and 1987. By 1987, however, the persistence of human errors in reportable operating events and recommendations from the National Research Council (Ref. 4) led to the revitalization of human factors research. In its Policy and Guidance for 1987, the Commission committed to "...explore methods to better understand the causes of human error and to point to methods to reduce its incidence" (Ref.1).

Starting in April 1987, a major task within RES was to revitalize human factors regulatory research. Formal needs from other offices were requested and reviewed, and projects were defined based on consideration of ongoing research, past accomplishments, and the recommendations of the National Research Council's 1988 report on nuclear safety research (Ref. 5). The result was the publication of a Human Factors Regulatory Research Program Plan (SECY-88-141, March 23, 1988) that addressed the research needs formally requested by the NRC regulatory offices and most of the broader human factors research recommendations that were

identified in the 1988 National Research Council report. This revision to the Human Factors Regulatory Research Program Plan reflects developments to date and the integration among the research areas.

Table A1

Major Events That Influenced NRC's Human Factors Research

1975	REACTOR SAFETY STUDY (WASH-1400) IDENTIFIED HUMAN FACTORS PROBLEMS RELATED TO PLANT SAFETY
1979	NRC IDENTIFIED ACTION ITEMS TO ADDRESS HUMAN FACTORS ISSUES AFTER THE TMI-2 ACCIDENT (NUREG-0660)
1980	NRC ESTABLISHED DIVISION OF HUMAN FACTORS SAFETY IN NRR
1981	RES ESTABLISHED BRANCH TO CONDUCT HUMAN FACTORS RESEARCH
1982	HUMAN FACTORS SOCIETY COMPLETED "CRITICAL HUMAN FACTORS ISSUES IN NUCLEAR POWER REGULATION AND A RECOMMENDED COMPREHENSIVE HUMAN FACTORS LONG RANGE PLAN" (NUREG/CR-2833) UNDER CONTRACT TO NRC
1983	NRC PUBLISHED NUREG-0985, "USNRC HUMAN FACTORS PROGRAM PLAN"
1985	NRC REDUCED FUNDING FOR HUMAN FACTORS RESEARCH (EXCEPT HUMAN RELIABILITY ASSESSMENT) AND DISSOLVED THE HUMAN FACTORS BRANCH IN RES
1986	ANNUAL REPORT ON HUMAN FACTORS PROGRAM PLAN TERMINATED. NAS REPORT, "REVITALIZING NUCLEAR SAFETY RESEARCH," RECOMMENDED INTENSIFIED HUMAN FACTORS RESEARCH
APR 1987	NRC REORGANIZATION - RELIABILITY AND HUMAN FACTORS BRANCH ESTABLISHED IN RES TO REVITALIZE HUMAN FACTORS RESEARCH PROGRAM
FEB 1988	NAS PUBLISHED REPORT, "HUMAN FACTORS RESEARCH AND NUCLEAR SAFETY"
MAY 1988	HUMAN FACTORS RESEARCH PROGRAM PLAN TO COMMISSION (SECY-88-141)
JULY 1988	OFFICE OF RESEARCH REORGANIZATION AND THE FORMATION OF A HUMAN FACTORS BRANCH
JULY 1988	SRM M8800531 DIRECTED THE STAFF TO SUBMIT AN INFORMATION PAPER ON SEVEN ISSUES
OCT 1988	STAFF RESPONSE TO SRM M880531 (SECY-88-294)

APPENDIX B

GENERAL APPROACH TO REGULATORY RESEARCH

Research assistance is frequently requested when a regulatory office identifies a potential regulatory issue that does not have either a current or an adequate technical basis for making regulatory decisions. RES then takes a general approach described in this Appendix to ensure a current and adequate resolution of regulatory issues. The approach is intended to (1) take full advantage of data and technologies that exist both within and outside the NRC, (2) develop coherent and viable candidate resolutions, (3) evaluate candidate resolutions for their practicality, acceptability, and usefulness in a nuclear regulatory setting, and (4) implement human factors research findings and products. Each element of the general research approach is summarized in the sections below and is illustrated in Figure B-1.

Identification of Significant Issues. The staffs in RES and the regulatory offices continually interact to anticipate human performance research issues. This step of the general approach often precedes the definition of researchable questions by seeking to discover latent safety-significant situations before they become critical. This step aids in reducing the unknowns about potential regulatory problems and classifying potential safety issues for systematic study. For example, research is being performed on the safety significance of advanced instrumentation and controls and how such technology might modify the role of the operators.

Definition of the Issue. For the research to proceed effectively to satisfy a user need, the user need is translated into one or more well-defined researchable questions. This involves both the regulatory office and the RES staff and is iterative as needed to ensure consistent perceptions of the issue throughout the duration of the project.

Research Method for Developing a Technical Resolution. The RES staff is responsible for developing one or more technically sound resolutions to each research question defined. The research develops technical resolutions by (1) feasibility analysis, (2) technology development, (3) technology evaluation, and (4) technology implementation.

Feasibility analysis applies primarily to user-need research. A feasibility analysis identifies existing information or technologies developed earlier by the NRC or

by others (e.g., aerospace, transportation, and military) that could be applicable to the question. When the information or technology exists, the project proceeds to the next step, technology development. When such information or technologies do not exist, the project continues to explore feasible alternatives to support development, acquire more information, or revisit the need that gave rise to the issue.

Technology development involves developing, revising, or expanding the needed information or the technologies. Technology development progresses until the model, data collection tool, set of normative data, or criteria measures are developed and can be tested for practicality, acceptability, and usefulness against the user's need.

Technology evaluation is a rigorous study of the proposed resolution or technology to determine its usefulness for resolving or contributing to the resolution of the regulatory issue of interest.

Technology implementation involves the transfer the resolution from the researcher to the regulatory user. The regulator applies the resolution, is trained in its use, and makes any needed refinements.

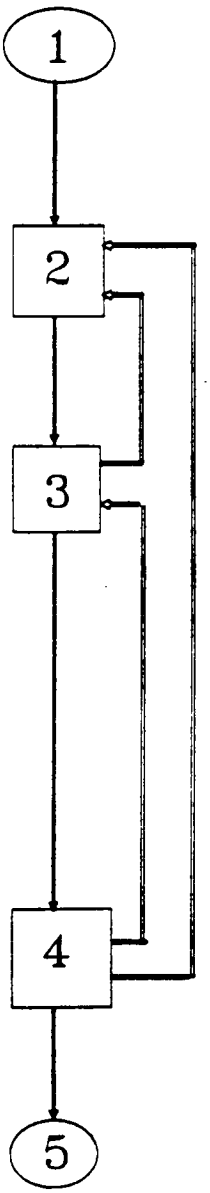
Applications Development. Once a resolution has been implemented, other applications of the resolution frequently become evident. Such applications usually require further work by the regulatory office and the RES staff. The additional applications have been a beneficial byproduct of having the development of resolutions conducted by an office separate from the regulatory offices.

Documentation. The final step in the research approach is to complete the project administratively and to finish documentation of the project and its results. This final step ensures a thorough and orderly resolution of the regulatory needs and reduces the likelihood of redundant research. Documenting the results also precludes repeating unfruitful efforts and enhances learning from those projects that fell short of fully satisfying the regulatory need.

The process for conducting human factors research determines the quality and usefulness of research products. The current issues associated with the regulatory research process are the feasibility and utility of (1) using research reactors and training simulators for exploratory and confirmatory research and (2) obtaining human performance information directly from the industry. The research process will (1) make use of several avenues to conduct research at simulators along with the participation

of industry personnel and (2) continue to coordinate the information being received by the NRC on human performance.

GENERAL APPROACH TO REGULATORY RESEARCH ON HUMAN FACTORS



SEARCH FOR SIGNIFICANT ISSUES

ISSUE DEFINITION

RESEARCH METHOD FOR DEVELOPING A TECHNICAL RESOLUTION

Feasibility Analysis
Development
Evaluation
Implementation

APPLICATIONS DEVELOPMENT

DOCUMENTATION