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NUCLEAR REGULATORY COMMISSION

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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BRIEFING ON NAS HUMAN FACTOR RECOMMENDATIONS

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[PUBLIC MEETING]

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Nuclear Regulatory Commission
Commissioners Conference Room
One White Flint North
11555 Rockville Pike
Rockville, Maryland

Thursday, May 19, 1988

The Commission met in open session, pursuant to notice, at 2:05 p.m., the Honorable LANDO W. ZECH, Chairman of the Commission, presiding.

COMMISSIONERS PRESENT:

LANDO W. ZECH, Chairman of the Commission
THOMAS M. ROBERTS, Member of the Commission
FREDERICK M. BERNTHAL, Member of the Commission
KENNETH CARR, Member of the Commission
KENNETH C. ROGERS, Member of the Commission

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

S. Chilk

W. Parler

E. Beckjord

N. Moray

P. Hammond

H. Van Cott

P R O C E E D I N G S

CHAIRMAN ZECH: Good afternoon, ladies and gentlemen. The purpose of today's meeting is for the National Academy of Sciences of the National Research Council to brief the Commission on their assessment of the current state of human factors in commercial nuclear power development and to make recommendations for future human factors research.

This is an information briefing. I would like to welcome Dr. Moray, Dr. Hammond and Dr. Van Cott to the Commission today. We appreciate very much your being with us. On December 19, 1985 the Commission directed the staff to proceed with a grant to the National Academy of Sciences to conduct a study of human factors research needs for the United States commercial nuclear power development.

In response to the Commission directive, the staff contracted with the National Academy of Sciences in March, 1986 to conduct a study of those needs. Further, the Commission directed the NRC staff to expand the human factors research program.

The NRC staff has been preparing a human factors research plan which will depend to the extent appropriate on recommendations from the National Academy of Sciences. The NRC staff will brief the Commission on the human factors program scheduled now on Tuesday, May 31, 1988.

I believe today's briefing by the National Academy of

Sciences and the NRC staff briefing, also, will assist the Commission in assessing future human factors research needs. During my visits to the nuclear power plants in the country, I generally spend some time with the control room operators in order to gain an appreciation of their sense of responsibility, their concern for safe operations and their general attitude.

I greatly respect the willingness that they have to take on the challenging tasks of operating nuclear power plants and the responsibilities associated with that. I emphasize to them that they are an extremely important part of nuclear power plant safety and that I believe that we should give them all the assistance that we possibly can in the form of well designed control rooms with good human factors engineering, useful and usable procedures and helpful operator aids and training.

I believe the NRC should apply focused and visible efforts utilizing human factors professionals to address these issues and we must provide operators with the best environment practicable to operate the plants safely.

Commissioner Bernthal is not with us now and I expect he will be joining us a little later. I understand slides of the presentation are available today. Do any of my fellow Commissioners have any opening comments to make before we begin?

[No response.]

CHAIRMAN ZECH: If not, Mr. Beckjord, are you going to begin or is Dr. Moray going to begin?

MR. BECKJORD: Dr. Moray is going to give the presentation.

CHAIRMAN ZECH: Fine. Dr. Moray, you may proceed please.

DR. MORAY: Thank you very much, Mr. Chairman.

DR. HAMMOND: Do you want me to do the slight introduction that we did before?

DR. MORAY: All right.

[SLIDE.]

DR. HAMMOND: I am Brett Hammond. I am here representing the other NRC, the National Research Council today, the National Academy of Sciences. I am the Acting Executive Director for the Commission on Behavioral and Social Sciences and Education, the fourth item, I think, you see up on the screen.

It was in our division that the study was done and I just wanted to spend 30 seconds and place this in context. You see before you Dr. Neville Moray, the Chair of the 14 member panel that did the study. You also see to my right Dr. Van Cott, the study director, staff of the NRC. The person you don't see is Beverly Huey, the research associate, who spent so much time. She is up in the control booth running the electronics, I think, at this point.

CHAIRMAN ZECH: Fine. We welcome Beverly, too.

DR. HAMMOND: We are very pleased to be here. The context I wanted to speak about is just ore major point and that is the way in which we do our work. We have at any one time about 900 panels at the National Academy of Sciences National Research Council working on projects like this and across a broad range of other subjects.

The chief goal in all of this is to ask each panel to make its conclusions and recommendations in light of a careful review of evidence and scholarly research and other kinds of information that might bear on a problem and the standards of evidence are extremely high.

We have as our goal the achievement of balance and of as much as we can objectivity in our reports and we have done that here, too, by a careful process of appointing the group of 14 panel members with a broad range of expertise in engineering, psychology, management, organizational issues and other types of expertise from throughout the country and we asked them to volunteer their services, no recompense.

In addition, we carefully review proposals. Our governing body occasionally reject proposals that staff would like to send out and we are careful to make sure that they meet our standards of objectivity before they are released.

Finally, we let committees do their work but at the end of that time we carefully review the results and we

jealously guard that privilege of careful review by asking groups of people who were not involved in that report but who were experts in the subject to look at every word of a report on the basis of the following question: are the conclusions supported by the evidence presented in the report.

Once that process has wended its way, we only then release a report and that is the thing that you see before you today, the "Human Factors Research and Nuclear Safety" that was sent to this body in February and we are very proud of it. We think it is a good job and I would like to ask Neville to spend the rest of the time talking about the specifics. Thank you.

CHAIRMAN ZECH: All right. Thank you very much.

DR. MORAY: Mr. Chairman and Commissioners, I welcome the chance to present this to you. I think you have now probably had time at least to look at the Executive Summary which we have given.

Throughout my presentation if I say, "NRC" I will normally mean your NRC and not our NRC for clarity.

CHAIRMAN ZECH: Thank you.

DR. MORAY: I would like to add my thanks to the members of my panel and to Beverly Huey and to all those who gave us support. On the side of NRC, I would like particularly to pay tribute to Dan Jones and Tom Ryan who went to enormous trouble to provide us with material and taking a lot of their time and were extremely helpful. In fact, everyone in NRC with

whom we had any contact was extremely helpful and supportive of the study and we certainly appreciated that.

Beverly, next slide, please.

[SLIDE.]

DR. MORAY: The panel's charge you see up on the screen and I would just like to comment very briefly on this and I will try to run through what I have to say relatively quickly to leave most of the time for you to ask questions which I think is more important.

We were not asked to criticize the past program of NRC in human factors. We were asked to decide what we thought was most important in work which remains to be done in the field of human factors in order to ensure the safe operation of nuclear power plants in the United States.

There were a number of topics we might have considered and did not. We did not consider radioactive waste disposal programs. We did not consider matters of security. We did not consider, for example, quality control during manufacture.

These we decided to leave aside simply because given the time and scope of the study and its urgency, we would rather do better what we could do in detail. Those topics certainly deserve review from the point of view of human factors but you will not find references to them in the report.

We also found it necessary to rather extend the

definition of human factors. Human factors is sometimes thought of as almost synonymous with what is in Europe perhaps called ergonomics, knobs and dials, lay-outs of panels and things of that kind.

That work although not widely used systematically in industry is well understood. There is no reason why going to existing data bases anyone who is constructing a large and complex human machine system should not be able to solve all their problems with those sort of designs merely by looking up what exists. There is no need for research in that.

However, we did feel that it was apparent from our collective knowledge and from the literature that we searched that there were problems to do, for example, with management and with maintenance which much widened the scope of human factors compared with what, for example, the Human Factors Society which is a professional organization in the United States would normally consider part of human factors.

This comes out in the report in our deliberate espousal of the systems approach and I will come back to that later but it is important to realize what we have called human factors is wider than many in the human factors community would normally include and we think it is absolutely vital that that extension be made.

Next slide, Beverly, please.

[SLIDE.]

DR. MORAY: In the report, you will find a list of the people who were on the people and I just want very briefly not to go through that list but to look at the way that we carried out our work.

We had severn collective meetings as you can see here. We had a fairly tight time schedule because nobody was devoted full time to this study. We were doing it at the same time of all our usual work. Nonetheless, I think we managed a fairly thorough access to the relevant information.

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[SLIDE.]

DR. MORAY: We were helped by briefings from a number of organizations including the Nuclear Regulatory Commission who gave us a particularly thorough briefing which we very much appreciated. We talked also with various people from the national laboratories, the Department of Energy and also representatives from the industry of one sort or another.

Next slide, please, Beverly.

[SLIDE.]

DR. MORAY: We made a couple of site visits to the Electric Power Research Institute which is a body which has its own research program which is related closely in some respects to the demands for human factors work in the nuclear industry and also to Three Mile Island, particularly with the view to letting those members of the panel who were not closely

familiar with the nuclear industry to have a first hand view of the nature of the industry, what control rooms are like and so forth. We appreciate the trouble that those bodies also went to to allow us to visit them and to give us a briefing.

Next slide.

[SLIDE.]

DR. MORAY: The background of the report, I think, should be seen against the accepted fact in a wide variety of industries and government agencies and the military that somewhere between 50 and 80 percent of accidents, incidents and errors in almost all industries arise through some form of human error or are at least human induced in some sense.

The figure of 50 to 80 percent I take, in fact, from a report of the Atomic Industrial Forum of a few years ago. That figure or variations on it you can find in as I say almost industry that is looked at.

When one says, "human induced" or "human error" one is not talking only about operators. It includes everything. If one can imagine a fully automated industry in which the human errors might turn up in the form of design errors which are usually very difficult to find although not impossible; it may be quality control during construction.

It is certainly during maintenance. In fact, there is good evidence, I think, that a major component of the impact of human error on the industry is through maintenance

activities.

Three Mile Island, in fact, was in one sense a maintenance induced incident and also, management. It is becoming increasingly obvious that management and management attitudes and organization has a major role in determining the frequency and severity of the impact of human errors on an industry.

There is always particularly, I think, if you look at Chernobyl. That was a management accident essentially. We feel in view of this figure of 50 to 80 percent, that it is unwise--

CHAIRMAN ZECH: Excuse me, let me interrupt.

DR. MORAY: Yes.

CHAIRMAN ZECH: You don't have to get into this now if you don't want to but when you say that it was a management accident, it seems to me that it was more than that.

DR. MORAY: The sense in which I meant that is that had the decision not been made to carry out the particular experiment, the accident would not have happened.

CHAIRMAN ZECH: All right, but there were design problems and other features.

DR. MORAY: Certainly. That is really the point that I wanted to make. The decision to do something unusual was not an operator fault. It was a decision higher up the hierarchy which resulted in the plant being moved into an unsafe domain

at which point the design features certainly played a major portion.

CHAIRMAN ZECH: All right. Thank you.

DR. MORAY: Really the point I am trying to get around to is that given the 50 to 80 percent figure which is accepted, it would be unwise to conclude that all is well with human factors in any industry. There remains a lot of research which can be done in order to support safer and indeed more productive operation.

Now the first recommendation we made was that NRC should show a commitment to human factors research, a public commitment and a firm one. This would require a decision to increase staffing and financial support for those activities.

I am aware that a program has been or is the process of being re-instituted. At the time this report was written, of course, which is six or eight months ago now we were not sure that that was, in fact, the case and we welcome very much, very warmly, the decision to re-institute human factors research.

The problem is that NRC had a number of very good people who have now been scattered to the winds of other careers and other employment leaving you with one or two very good people still and we feel that some kind of public signal is going to be needed in order to reinstate the program.

If you are to attract people of the caliber that are

required to deal with these very difficult problems in a very complex industry, you are going to have to try to attract people who have seen the demise of the earlier phase of the human factors research program and convince them that this is a long term and serious commitment to human factors research.

I think the panel collectively felt that might be difficult in view of the demise of the program earlier. It is also important that by making such a public commitment, it sends a message to industry. In the absence of such a commitment, we feel that many utilities would say that well if NRC is not strongly supportive of human factors, clearly we need not bother about it either.

As I am sure you know, it is frequently difficult to convince industry that everything cannot be solved by hard engineering. I think there has been a change in the last few years but nonetheless, a signal needs to be sent.

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[SLIDE.]

DR. MORAY: The next point which we regard as very important is the idea of a systems oriented approach. Now it is very fashionable and has been for a number of years to use the words, "systems approach" when talking about almost any large and complex plant, organization or system.

We wish to underline this very firmly. Following the incident at Three Mile Island, a great deal of effort was put

into reviewing and improving control room design in nuclear power plants in the United States.

That work, I think, has been extremely valuable and has certainly resulted in significant improvements. However, it would be a mistake to think that the interface between the plant and the operator is the only point at which human factors has an impact. It is clearly a very important one. If that is bad, it is going to be very difficult for people to operate plants well.

But beyond that, there is a whole hierarchy of different levels of factors which have an impact on the way in which people operate plants.

Next slide, please.

[SLIDE.]

DR. MORAY: It is this that we want particularly draw attention to. On page 19 of the report, there is something called a scenario in which we try to show this by discussing the way in which one or two what seem to be fairly simply and straight forward decisions to make changes in a plant have a much wider impact than might be expected.

Next slide, please.

[SLIDE.]

DR. MORAY: That can also be sort of formally shown by the picture on page 16 which is also shown here, I am happy to say has come up visibly on the screen, I was a bit worried

by it, and this is sort of our organizational diagram.

If you look in the middle here, the technical engineering system is the plant hardware and between that plant hardware and the operators, there is an interface which we here label "A" and that is the traditional control room, control room panel interface or equipment which people are using.

That is where most of the research has been concentrated and it is important as we will see later to distinguish between research and application. It was clear that the control room, for example, at Three Mile Island did not support very adequately the information processing which was done by the operators.

I personally think that the operators did an extremely good job under trying conditions and when you look at the impact and the way in which people behave under stress in industrial accidents across-the-board, not just nuclear, one is, I think, impressed by the fact that usually operators behave very well under stress. There is remarkably few occasions of panic or, "When in danger, when in doubt, run in circles, scream and shout" as it is sometimes put. That really doesn't seem to happen very often.

But nonetheless, humans are relatively limited information processes and they do need to be supported by the best possible design of displays and controls. However, if we come in from the outside of this diagram, we are here talking

about environmental factors such as the public's view, public perception of the industry, PUCs, regulations made by the Commission and all of these determine to some extent what kind of changes can be made in the inner parts of the diagram.

An industry is not free, for example, if they thought it were a good thing to adopt an artificial intelligence support for decision making or artificial intelligence operating procedures without agreement from regulatory bodies and people on the outside.

Therefore, the regulations, the regulatory style and the regulatory content here determines to some extent what hardware can be used in the inner parts of this diagram. Similar, management's choices determine that.

Let's suppose that a decision is made to computerize emergency operating procedures, a suggestion that has been made from time to time by people who are in the computer and software business and human factors. That immediately throws up a number of problems.

For example, if you do that, how many displays are you going to have to put in the control room? Is more than one operator going to share the same console? If so, does one of them overwrite the display which the other one is using every time he changes it? If not, somebody has to decide, presumably management, how many consoles and what type they are going to put in there.

It is going to have an impact on training. It is going to have an impact on manning levels. Do you need extra people? Do you need fewer people? Management is entirely responsible really for decisions such as shift work, patterns of shift work and quality control both of materials and of work.

You cannot solve a problem at any one level here. It is important to realize that any change you make in an inner loop here has an impact all the way out and similarly, any change in regulations has an impact all the way in, both on the choice of hardware, the design of hardware, the nature of training, the nature of licensing and morale.

It may very well be that morale is one of the most important ones. It is these sort of considerations that made us broaden the scope of human factors.

It is also important to realize that with any complex system, if you make a change in it for the better to remove a defect of some kind, you do not end up with the system you had before minus the defect.

The easiest way to see this is to look at the notorious problem of trying to relieve traffic congestion in cities by building beltways around them. In a naive sense, people think that if you build a freeway around a city, it will reduce the amount of traffic because they will take to the freeway.

Without exception, it increases the amount of traffic entering the city and causes worse congestion and the reason is that what you are faced with now is not the old system minus the roads you have altered but a totally new system which will then find its own equilibrium.

And when you are dealing with very fine complex systems like this, what appears to be a relatively minor change to the control room design, let's say, may very well have impacts all the way out and a relatively minor change in regulation or management may have an impact all the way in. It is essential that research should be seen in that context.

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[SLIDE.]

DR. MORAY: And indeed, people who write research reports should be encouraged to report in that context. We recommend, I think, I hope it comes through clearly that when somebody submits a report after doing a contract, they should be asked to say not merely what their conclusions are about the particular work they have done but what impact that is likely to have at all the other levels with which their research has not been primarily concerned.

[Commissioner Bernthal enters the meeting.]

DR. MORAY: We would like to see a broadening of the people who are involved in planning, conducting and evaluating the research program. In this, we agree with the Frosch Report

and indeed we found sympathy with a lot of their recommendations.

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[SLIDE.]

DR. MORAY: In particular, we would like to see peer review both of proposed research and of the draft reports. The reason for this is that at the moment we feel that the staff of the NRC who are concerned with human factors are grossly overburdened because of their small numbers.

The total output in the area of human factors which NRC has sponsored is really quite commendable. It is about 125 reports since 1979. That is a very considerable amount of research.

We feel that the quality of the research could be improved by the use of peer review. It would be possible we are sure to recruit on an ad hoc basis people from universities, from consulting companies and from the industry to vet both request for proposals, the proposals themselves and the draft reports so that when the reports are finally published, they will be of the highest possible quality.

There are some reports, NRC reports in these areas, which have some strange contents which I have tried to read almost all of the ones that have come out since 1980 and I would emphasize that it is not in my opinion the fault of the staff in RES that these -- here and there, there are strange

contents of the reports.

I can see no way given the staffing levels that the people in RES could possibly have monitored all the reports in detail and indeed, that is one reason why I think that the NRC has made use of the national laboratories.

Now the national laboratories have played a very important role in that respect but it does, of course, lead to a dilution of funds through successive creaming off of overheads as you go through a series of organizations and we would like to see the NRC more directly manage its own program, I think, in this.

You would closer to the work that you, yourselves, are interested in. By using peer reviews, you could probably off load some of the work. Ultimately, the reports are clearly your responsibility and therefore, they should be monitored for quality by yourselves.

We also would like to see in this respect closer cooperation between the RES branch of NRC and other bodies that do research or which don't do research, for example, INPO. INPO by its charter and its definition is not a research organization. Nonetheless, it has a very important role to play as a broker, I think, between the results of research and their application.

EPRI, Electric Power Research Institute, has an excellent research program and that is, the Edison Institute

and there are a number of other bodies. We would like to see cooperation as far as possible between research in NRC and research done by these other bodies.

It would be cost effective and it would also, we think, encourage the industry as reflected in its membership of these organizations to see activities undertaken by NRC as supportive of better and safer operation by the industry rather than always seeing NRC as an antagonist which I am afraid it seems to be the case.

I have talked to people connected with the nuclear industry in Canada, Great Britain, the Nordic countries, France and Italy and without exception they are sad, shall I put it that way, sad to see the degree of antagonism between industry and regulation in the states and feel that it is, well, there is always such antagonism and indeed probably must be in order to ensure good regulation, there is a feeling that it is higher here than almost anywhere else possibly in the world.

We feel that cooperation in research is an area where something could be done to reduce the tension while in no way reducing the rigors of regulation and it would also lead to, I think, as I said before cost benefit activities.

There are a lot of very bright people in universities and in other places who would be willing to undertake research in nuclear engineering departments, in psychology departments, in mechanical and industrial engineering departments and they

should be tapped directly as well as through the national laboratories.

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[SLIDE.]

DR. MCRAY: We are sensitive to the fact that some of these suggestions may be difficult. We also are aware that one of the major problems in all industries towards the adoption of human factors results is that the laboratory studies done by human factors people seem very remote from the actual industrial day-to-day experience.

It is very often the case in university human factors research, not always but very often, that the experimental rigor is the prime criterion for good research and that means over simplifying the research and that the results which come out are not convincing.

If you are trying to tell a utility that on the basis of this research, it should go off and spend a substantial amount of money in order to improve things that they look at the research and they do not find it entirely convincing.

Now it is very difficult for people who are professionally qualified in human factors to get access to research facilities which bear at least a face validity to the kind of control rooms and systems which occur in real industry. It would be very nice if those of us who wished to do research in this area would be able to go to nuclear simulators but if

you approach any utility and ask if there is any possibility of using their simulator, one is almost always told that it is up and running for training and licensing pretty well 24 hours a day.

There simply isn't spare time and also there is, I think, an understandable unwillingness on the part of some to let relatively unqualified university people play around with their simulators which is understandable.

Now we feel that one of the things that NRC somehow should do is to provide a bridge or provide access to research facilities, to research simulators or training simulators which would allow research to take place in situations which are convincing to the industry.

It is all too easy to say that you don't have to believe these results because, "Look, they weren't done in a nuclear power station so why should we bother to take any notice."

If one could undertake research on medium or high fidelity simulators it would certainly improve the quality of research and the plausibility and credibility of the research and bearing in mind the whole time that the aim of this research is not the self-aggrandizement of the researcher or even indeed the acquisition of more and greater pure knowledge, but knowledge which should be directly applicable to the improvement of safety in the operation of nuclear facilities.

It must be applied research and the more closely the situation in which the research is done is identifiable as the real world, the more likely it is that the client industry will both take the research seriously and indeed be able to see how to use it cost effectively. So we would recommend the promotion of joint activities on a scale greater than those done in the past.

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[SLIDE.]

DR. MORAY: There has been talk in the past of a possible research facility at one of the national laboratories which would include a simulator of a power plant control room and we would like, I think, to put forward for your consideration the possibility of something like a national research center.

There are problems with such an idea. The cost is coming down day-by-day because of the increase in the power of computers and hardware. There would be, I think, problems in deciding how to staff it and how to fund it although one would assume that if it were successful, it would to some extent attract funds from industry and, of course, there is always the problem that you would have to some extent a generic facility which some people would regard as not really like their particular one.

But nonetheless, we don't see really any way in which

we can let people or give people access to facilities where research can be done on the scale unless something like this is done given the intensity of the use of existing simulators for training and licensing. So we think that should be a consideration.

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[SLIDE.]

DR. MORAY: We feel very strongly that as we said at the beginning there must be some kind of public commitment to the research if you are going to attract the people you need to do what is very difficult research.

In this respect we feel that it is important that a program be mounted for a considerable time. It is not the case that you can solve the human factors problems and then it will be done once and for all.

We are now entering a period when although there are no new plants being ordered, there is life extension work going on and there is re-fitting and we are getting to a point where some of the equipment in the earlier plants is having to be replaced and in many cases the people who built the original equipment are no longer there or the particular items of equipment are not there.

Clearly, there is going to be new equipment put in. There is going to be some kind of computerization even if only decision aids and things of that kind and that means that there

is going to be a steady, ongoing need for human factors research to make sure that the changes in the plants match the requirements of the human personnel.

We feel that there has been in the past a tension between the regulatory branch and the research branch at NRC. Naturally enough, the regulatory people frequently find an urgent need for information on some particular topic. The research branch has tended to look at longer term research efforts in several cases, many cases.

To give you an example to which I will return in another section, any day now somebody is going to come along and say, "We want to put an artificial intelligence SPDS system into a plant." There are companies in the computer business who are ready to sell these things.

At that point, a decision is going to have to be made as to whether this is acceptable from a regulatory standpoint and the regulatory branch is going to want to know whether it is safe from a human factors standpoint.

We feel that the Research branch cannot do high quality research if it is constantly having to interrupt its program to support the urgent short term needs of the regulatory branch and we would like to suggest that to some extent these are separated, that what we came to call in our panel, "responsive research," that is research which is responsive to a particularly urgent question should be done

through the regulatory side; whereas, the longer view basic research on human factors should be done by the Research branch.

We feel that it is more important that there be continuity on the Research branch than that the financial effort be enormous. Good research can't be done by sudden injections of one shot funds to solve a particular piece of work which then may be halted which something else is done and started up again.

Apart from anything else, you are not going to get outside contractors to be prepared to work under those conditions. I have heard from several consulting companies who were involved in the earlier phase saying that they are probably not going to bid on any future work because they found it so difficult to carry out the work before.

That is a bad situation because you are in danger of losing high quality people who could do the work. So we would rather see a relatively small but prolonged program than a massive short one and we believe that to be an extremely important recommendation.

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[SLIDE.]

DR. MORAY: Although we were asked to talk primarily about the needs for research, we would like to draw your attention to the fact that there is really a distinction to be

made between the need for new research and the need for transfer of existing knowledge.

There is a very large amount of well-established human factors knowledge which is available. The reason it is not used is that engineers are not compelled to take human factors courses when they are at universities and so they seldom if ever come across this particular approach to design.

There is much information which could be used and isn't. The most obvious example which comes to my mind is the work on shift work. One of your own reports, NUREGs, recorded an astonishing variety of patterns of shift work in the nuclear industry almost as if people had chosen one from every conceivable pattern that the human wit could think of.

There is a well-established body of knowledge about good and bad shift schedules. That does not need much research. What it needs is some mechanism of transferring the knowledge from the data base to use a fashionable word to those who actually are going to use it and we feel that there should be an attempt to improve the transfer.

Even EPRI says that it is not happy about the transfer of its own research findings to the industry and I think they do a rather better job perhaps than the NRC. There are two places; one is that we need to establish transfer of information from existing human factors knowledge to the nuclear industry and the other, we need to somehow improve the

transfer of knowledge from NURECs, contract work, EPRI back into the industry where it should be used.

We would like to see an attempt to do this again as a cooperative undertaking. It would not in any way again reduce the rigors of regulation and would certainly help to produce a climate where people felt that research sponsored by NRC was helping them rather than threatening them.

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[SLIDE.]

DR. MORAY: We would like to see NRC, for example, publish an annual review of human factors research relevant to the nuclear power industry. This is not to be confused with the annual report which NRC currently puts out its own program because that is clearly a document for internal consumption.

If you read through it, it tells you what research is being done inside the NRC but it does not provide enough information or any indication of how it could be useful to me if I am a utility manager trying to decide how to improve my plant.

We are not even concerned here with only looking at research done in the context of the nuclear industry. We are thinking of an annual review or maybe bi-annual which would provide a channel for the latest research across the field of human factors which is seen to be of use to the nuclear industry in particular regardless of where it comes from. It

might come from aerospace. It might come from military. It might come from industrial research. It might come from basic research in universities.

At the moment we were someone startled when we asked for a list of all the human factors work that had been done by the NRC, 125 reports at least, to find that NRC doesn't actually have as far as we can find out any kind of data base retrival system whereby you can actually look up things from your own reports under such titles and we feel that that at least would help people to be aware of what work you have done.

[SLIDE.]

DR. MORAY: Nowadays, electronic data bases for bibliographic searches are not very difficult or indeed expensive to set up. If I want to look up relevant research, I have a great deal of trouble now.

I have my own library of your reports but the fact remains that if a utility wanted to look for data on some particular problem which you have contracted and which you have published, they would find it quite difficult to find it. There is no easy way to search your own records and we would like to see something done first about that.

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DR. MORAY: Secondly, to broaden that to a data base which would include work done by EPRI, perhaps by INPO and

utilities and universities to make it really accessible so that this data can be used. If it is not accessible, people won't use it. That is quite clear.

COMMISSIONER BERNTHAL: It might make you feel either better or worse to know that this agency is not unaware of that problem. We have been floundering around with it for about, certainly as long as I have been here. I think we are making progress finally.

DR. MORAY: It makes me feel better.

[Laughter.]

DR. MORAY: Definitely.

COMMISSIONER BERNTHAL: But you are absolutely right.

DR. MORAY: Next slide, please.

[SLIDE.]

DR. MORAY: In fact, we will go straight on to the one after that as well because we were just saying here that we would like that.

[SLIDE.]

DR. MORAY: Turning now to the actual recommendations for research areas, we did start by asking whether NRC should support research at all, whether it is a job of a regulatory agency to do so and we said, "Yes, there is no doubt about it."

The other avenues of research, EPRI, INPO, Edison Institute and others, do not have the vested interest in continuous support of human factors research for the nuclear

industry that you have and we feel the only way to guarantee continuous support is for NRC to do it.

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DR. MORAY: We decided that there were three main areas. There are some research topics which may have a critical impact on safety and must be addressed immediately. In some areas, research is needed as a basis for evaluation. I will return to that in a minute and in some areas, a research topic is not going to have an immediate pay off in a year or two but is part of a building block for a long term program. The particular thing we had in mind there is probably research on human error.

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DR. MORAY: And we want to emphasize very strongly, I think it is not written quite as heavily in black and white in the report as we should have written it, that in all cases when we talk about research we are aiming at research at management, maintenance and other ancillary workers and not just control room operators.

It is very easy to drop into the habit of thinking that it is only control room operators. We think it is very important to keep it broad.

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DR. MORAY: We nominated about five areas. In the human-system interface design, control room work, probably the highest priority topic is automation and computer-based job performance aids.

As I mentioned before, there are companies who are about to sell or try to sell computerized SPDS systems, computerized EOPs, decision aids. The use of AI, artificial intelligence, is getting to the point where it can have an impact on the industry.

We firmly recommend that NRC do not get into the business of doing research on AI, on artificial intelligence. If I may put in a private opinion at the moment, I regard that as one of the blackest of black holes of funding that has been seen in many a year.

The important thing for NRC to do is to do research on how to evaluate artificial intelligence and expert systems. At the moment, there is no well understood methodology for telling whether you have a good one or a bad one. The characteristic evaluation of an expert system is that it appears to behave like a human expert.

The whole point in the nuclear control room context is that we want to go beyond the human expert. If the system is only as good as a human, you have perfectly good humans there already and it is not well understood how one evaluates

artificial intelligence and expert systems and indeed, computer automated systems in general.

That is where we think you should put the effort in this area, not in constructing them or doing experimental research on their properties.

COMMISSIONER BERNTHAL: Pardon me, but did you find in your studies that there was a consensus today at least in the industry for the need to move aggressively to the kind of automated systems interfacing that you are talking about here?

I ask that question because as recently as a very few years ago, I think not today, but there wasn't even a consensus on this Commission that it was a good idea to move toward an automated rather than a human dominated system.

DR. MORAY: We believe that there are certainly situations and ways in which computer aided decision systems would help humans to make decisions. We did not find, we have no evidence that there is an overwhelming urge by the industry to put them in.

COMMISSIONER BERNTHAL: That's right.

DR. MORAY: But as in many industries in this country, what happens tend to be technology driven. Once you have vendors who have systems of this kind and they are selling very aggressively their products, you are going to get requests about whether or not they can be used and the evaluation of those systems is not going to be easy.

To show that they work from a computer point of view is not enough. We know that people get lost in hierarchical data bases. That is empirically established. How to tell whether you have a system which is good for people to use is very difficult and is not fully understood. That is what I am saying.

I don't think you can stop people wanting to put them in because not the utilities but the computer industry is going to develop them and try to market them and at that point, somebody is going to ask whether or not they can put them in. You have to know how to assess them.

COMMISSIONER BERNTHAL: But in some cases, I think, the first step, the first threshold had not even been reached of agreeing that it was a good idea at all in principle to move in that direction.

DR. MORAY: That might be a good research topic.

COMMISSIONER BERNTHAL: Yes.

DR. MORAY: Essentially what one wants -- one doesn't want to suppress innovation but one wants to make sure that you have innovation with safety and that is largely a matter of assessment and evaluation.

There are some other topics. EOP design still has quite a lot to be done on it, I think. But basically, you will find other topics mentioned in the report.

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DR. MORAY: I am going to skim the most important items here because the others are in the report and I want to leave time for you to ask me questions.

In the personnel subsystem, we felt there are three areas. Now the last of these, shift scheduling and vigilance, is probably a case where there is little need for research other than in the research on how to get the knowledge transferred to the industry.

Obviously, with things like the Peach Bottom problem, vigilance and shift work is a serious human factors problem but there is a lot of information out there which could be tapped if industry chose to make use of it, if they knew about it. It is not entirely their fault.

We feel that there is still room for improvements in licensing examinations, in research to establish which aspects of licensing examinations do, in fact, correlate with performance indicators and subsequent good operating habits and we feel that it is also important still to continue with research into training because when a person is trained, their skill will not be maintained unless they are retrained at intervals.

The airlines do this regularly and the best way to use simulators and the best way to re-train, the correct interval, the best interval to do this are subjects for

research. We do not know for sure what they are.

It may very well be that part task simulators on PCs could play a very important role as well as full scale high fidelity simulators. This is the kind of thing and different styles of training, embedded training, exploratory training as it is called. There is a lot of research here that could be done to significantly improve operator performance, we think.

Related to this is the question which I know is one that is a matter of grave concern and that is over the degrees for operating staff, academic qualifications. Clearly, if such degrees are to be mandated, it is very important to know what kind of degree curriculum and what kind of training should be involved.

There is remarkably little evidence, well the evidence that we have is that it is extraordinarily difficult to get a transfer of skill from academic and theoretical knowledge to operating knowledge and trouble-shooting.

In the empirical studies of which there are few, about eight or nine that I know of in process, related to process industries, none of them have shown significant transfer as a result of exposure to theoretical training.

But the studies are all flawed. They are short. The particular kind of theoretical training was probably not sufficient to bring it about and the truth of the matter is that we do not at the moment know how you should train somebody

with theory in order to get it to transfer to skill and that is clearly an important and urgent topic for research.

How to do the research, I think, is fairly straight forward but it needs to be done because otherwise, as one of your own NUREGs again says, when you look at the syllabuses that people who have taken degreed courses go through, they are not clearly what is wanted in order to upgrade the operating and trouble-shooting skills.

They are designed almost always for people who are going to be nuclear engineers and not nuclear operators and as I say, this is a field where there is a major lack of information about how to do it well and we strongly recommend research in that area.

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DR. MORAY: On the subject of human error research, again we have a strong recommendation here which is linked to probabilistic risk assessment. We strongly recommend that no more research be done along the current lines for estimating the probability of human error for human error reliability in PRA.

At the moment as things stand, I think it is the largest single area of research supported so far has been in human error and PRA. The problem is that what the research has done is provide increasingly sophisticated ways to get expert

to give you their subjective estimates about the probability of human error.

In order to know whether those estimates are valid, you need empirical data on how often errors do, in fact, happen, but if you had the empirical data you wouldn't need the subjective estimates.

The kind of research that is needed to improve our understanding of human error is empirical data now, data banks, not improved ways of getting experts to guess at what the numbers are.

Furthermore, we think that while we understand the reason for the reason for the emphasis on PRA and human error reliability, we would like to suggest that there is a more important way of looking at human error. At best, knowing the probability of human error tells you how often a person will make an error of a particular kind.

That is not actually the important thing to know. The important thing to know is which error is this particular person about to make now. If you can understand the causal mechanisms of human error, then you can do something to stop it or alleviate it or to support the person.

Merely knowing that the probability is that he will make this error once in every 5,000 times that he performs the action is not actually useful except for licensing. From the point of view of management of safety. what you need is to

understand the cognitive mechanisms which give rise to errors when humans do things. That is what we mean by causal errors.

[SLIDE.]

DR. MORAY: More particularly, we suggest that you should regard error estimates as a way of coupling research into error management using feedback. In any engineering system, you normally use errors to derive a control signal to control a system.

We feel that if you find using PRA techniques as an area where people are likely to make errors, that is a sign that something needs to be changed in the design of the system in order to reduce the error and that is the classical negative feedback control of errors which leads to reduction of errors.

You don't normally just measure the error. You do something about it. Now we feel that it is of fundamental importance to realize that what we need to understand is why and when errors occur, of how they occur, so that they can be prevented or mitigated not simply to know the descriptive frequency with which they occur over a long period.

This a new field. Research has begun intensively if only about the last seven or eight years. It is difficult. We are beginning to see how to do it and it is clearly the case that if you have research that tells you how to stop an error or manage it, that is more valuable than knowing how often it is going to occur.

We, therefore, strongly recommend research on causal models of human error and no more research on how to get expert estimates of the frequency of human error.

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DR. MORAY: We also recommend that there should be research in the fields of organization and management. We would like to see research on the impact of regulations on the practice of management.

We have heard from utility people that some of the managers who we think were telling the truth feel that they are spending so much time meeting regulations that they haven't got time to manage the plant and I am sure that you have heard complaints directly from the utilities in this area. There are disciplines which have studied the impact of regulatory style on management.

Clearly, what you need do to is to find how to produce regulations which encourage efficient management of the plant at the same time as satisfying the regulatory requirements.

We also feel that there is resistance on the part of utility management quite widely to change and that research should be done on how you create a climate of reliability, a culture of reliability in which the entire plant from management down are dedicated to safety and reliability.

There has been research done in the military. There has been research done in other industries and we would like to see that done in the nuclear area. In many respects morale is clearly critical. Good management can create good morale and get surprisingly good performance out of people with surprisingly bad equipment in many cases.

We had a letter which is not included in the report from some operators who said, "Above all please, for God's sake, do something about shift work. It is terrible. We all hate it. When we complained, our managers just said, 'Shift work is part of your job, get used to it.'" That is not good management and it is not management which is going to produce high quality performance on the part of the operating staff. There is clearly need for management research. There is a well understood methodology.

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DR. MORAY: Finally, we come to perhaps a delicate topic and one in which we are aware that perhaps we are asking you to go out outside your own mandate from Congress. We feel that regulation after all is an activity of humans for humans and by humans and is, in fact, human factors and we would like to see research done to try to discover the best style of regulation.

Is there a mix of self-regulation and top-down

regulation which is likely to be more effective and safer than the traditional one? At least, the human factors design principles should apply to the regulations which come out so that they are clear and unambiguous.

We think there is room here for improving regulation, the way regulation is done, and that this probably would pay off in better compliance and a better relationship between utilities and the NRC.

We are aware that this may not be possible within your mandate and we would like to make these suggestions. We would like you to regard these suggestions as support for anything which you wish to do in this area and not as a criticism, but as something which you can show to other people and say, "If you wish to, the Academy Report has also said this is worth looking at."

Finally, because regulation is going to performance regulation very often, it seems to be this change in philosophy, that we would like to see research on what are the performance measurement indicators, how do you tell that a plant is being run well and that is not an easy topic and certainly needs research.

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DR. MORAY: The conclusions are that we think that it is certainly desirable and important and possible to mount a

renewed human factors research program. We say here particularly something which I would like to draw your attention to, and that is, we wish to say that we think that human factors should be organized as a branch at NRC.

At the moment, it is being guided under reliability broadly speaking. It has never had a branch head of its own. We have no criticism of the way in which the people who are currently responsible for the program are carrying out their work, but the fact remains that I find it doubtful that if you had a human factors branch, you would invite it to look after thermal hydraulics and it is a field of professional expertise which those who have not worked in it do not know and do not understand its methodology.

Perhaps more importantly, as we understand it is only at the level of the branch, an independent branch, that the budget for research is secure for research on human factors. Human factors is not the same as PRA and reliability research.

It is something quite different and with the best rule in the world, we do not feel confident that if it is being run by a branch head with primary responsibilities in another area when the crunch comes that the budget for research in human factors is going to be safe.

We are not and let me say this very, very explicitly, we are not trying to write ourselves jobs either for the members of the panel as individuals nor for our profession. We

have no objection to the person being an engineer who has gained considerable experience over several years in human factors work in one of the national laboratories or indeed somebody from NRC itself.

We are not saying that you must rush out and hire lots and lots of quotes, "human factors" people, all of whom have Masters or Ph.D.'s in Human Factors from University departments but we are saying that we do not feel confident that without a human factors program at the level of a branch that the program will be secure, continuous and of a quality which will meet your needs.

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DR. MORAY: However, if you adopt at least some of the recommendations which we are putting in this report, we do think that you will have taken the steps necessary to provide leadership in the critical area of human factors. Further steps will have to be taken as this unfolds.

We hope that it will develop cooperation between NRC, the industry and others and let me say finally that the feeling of the panel, of my panel, was that we felt very strongly that we were not out to criticize past or present programs. We felt that the existence of a nuclear industry in this country is contingent on it being shown to be safe.

Given the known rate of human error in all

industries, there is no reason to think that it is lower in nuclear than any other industry or for that matter, higher and that it is of the utmost importance to start up research again in the area of human factors for nuclear safety for the benefit of society, the safety of society, and the future of the industry including the design of the next generation of reactors.

We hope that you will find the work we have done helpful to you and we will be happy to be at your disposal to answer any questions either now or on other occasions. Thank you very much for your patience.

CHAIRMAN ZECH: Thank you very much, Dr. Moray. Questions from my fellow Commissioners, Commissioner Roberts?

COMMISSIONER ROBERTS: No, not at this time.

CHAIRMAN ZECH: Commissioner Bernthal.

COMMISSIONER BERNTHAL: Well, I apologize that I was late getting here. The Chairman is getting used to it, I am afraid lately. We are now out here instead of downtown and when I have to go downtown, it is very hard to get back at two o'clock but I think I got the broad gist of what I missed here.

I have a few comments and then some questions. One of the things as you pointed out has been facing the Commission and continues to is the issue of degreed operators and I would appreciate any further comment you care to make in any detail you have time to make today but the one thing that I would

appreciate your thoughts on is the question of whether it is even practical to expect to be able to analyze the transfer as you put it of an education or a degree, the transfer of that knowledge, to operations and trouble-shooting as you put it.

It is unclear to me that that would be possible even in principle and I don't think that is the intent or the idea broadly speaking of education and certainly not in my mind at least of education as it might apply to a nuclear power plant operator.

Rather, you hope that the pool of talent is upgraded somewhat by requiring a degree and that the degree then leads to better training, that is, a better recipient for training and from thence to a better operator, a better trouble shooter.

Would you care to comment on that because that seems to me at least to be the philosophy behind asking for a degree from every operator eventually?

DR. MORAY: Well, as you know throughout the world the pattern of practice in this regard is very varied.

COMMISSIONER BERNTHAL: It is.

DR. MORAY: The academic educational backgrounds vary from country to country enormously. I think it is a mistake to think that it is the fact that people have degrees by themselves is going to change anything. This is one of the cases where a systems viewpoint is most important.

Certainly, I think all of us would assume that

somebody who has a greater knowledge of a discipline must be able to exercise his knowledge and skills, put them to use, in a better way than someone who hasn't. That in some sense must be true.

The problem is that the exact way in which it transfers, how that knowledge is useful, is not well understood. I would hope in the interest of efficiency that one would go further than your view. I mean the reason that I would want somebody to be degreed would be that I knew, I felt very strongly that as a result of that training, I could definitely show that on all the tasks I might want him to do he would be better whether it is controlling, fault management, STA, whatever it may be.

Now the problem is that how he is going to be able to use his knowledge is going to interact very strongly with a number of other things. For example, in France the equivalent of the STA, the safety engineer, is degreed but more importantly he has the ultimate responsibility in the control room.

If he says, "This is an emergency, we go to the emergency procedures," you go. Here the STA gives advice if called upon and we know that the role of the STA has turned out to be very difficult because he has the academic training but the operators frequently regard him as somebody who doesn't operate and therefore is not somebody who has the same skills

they have.

So I think you have to see it, the whole point of going for it is that it is worth having in the sense that it improves the operation of the power plant and that is why. If that is not what you are going for then it is clearly not worth bothering about because I don't think that just having gone through a degree is going to necessarily gain you much.

For one thing, it is fairly widely believed that people with degrees, university degrees, for example, don't like shift work and if all you are doing is turning your operating staff into people who are going to be more resentful of shift work than they were before, you are going to lose them to other industries or lose them to other jobs.

So what you need is an understanding of exactly what kind of training you should have at that level which will support the activities which you know from doing a job in task analysis are those which are critical for the safe management of the station.

COMMISSIONER BERNTHAL: You seem to be using the term, "degrees," and I will call it, education interchangeably with training though and that, it seems to me, exactly the point, that those in my mind at least are not at all the same thing, that you get an education so you learn fundamentally how to think and you have demonstrated the ability to absorb knowledge and the ability to absorb training, if you will, and

one hopes then that with that first of all demonstration and secondly with whatever you might have learned by way of thought processes that you are going to be trained better and therefore, ultimately operate better.

DR. MORAY: Well, I would like to go further than hoping it. I would like to systematically design the training and the education in such a way as to guarantee it.

COMMISSIONER BERNTHAL: But the training is what i am emphasizing and the education, I think, you will never be able to demonstrate that education except perhaps the point you mention that education might be detrimental to your affection for shift work but on the other hand, you have also mentioned that we ought to do something about the antipathy toward shift work.

DR. MORAY: Well, as a matter of fact, this brings me to the other question you asked me, is it possible to conceive of doing this kind of research and the answer to that is yes. I have colleagues at Illinois in the aerospace area who are doing precisely this kind of research now and I have myself, in fact, begun to do research on exactly this issue.

It is not terribly difficult to see how to do the research if you are human factors professional. It is actually fairly straight forward. It just hasn't been done.

COMMISSIONER BERNTHAL: The research on what?

DR. MORAY: On how to ensure that knowledge -- to do

research on how you ensure that theoretical knowledge leads to an improvement in skill. Certainly knowledge and skill are two different things.

COMMISSIONER BERNTHAL: Right.

DR. MORAY: And the transfer between them is not fully understood but it is very easy to do research to improve our knowledge of that and I would strongly argue for that. Yes, methodologically, it is not very difficult.

COMMISSIONER BERNTHAL: Well, it is a very important issue as you point out. I also was particularly interested in your comments on the approach to human error and what we should study; that is, the cause of human error rather than the statistics of human error, I guess, and in that regard I don't know whether you care to comment but it is worth noting maybe that every serious accident, truly serious accident, the most serious accidents we have had in this business have occurred between twelve midnight and six a.m. There must be a message there. Even the Chernobyl event occurred in the wee hours of the morning and maybe you have a comment.

DR. MORAY: Well, the numbers of really serious accidents is rather small.

COMMISSIONER BERNTHAL: That's right.

DR. MORAY: But it is undoubtedly true what you say and this is a case where the main factors, I think, are thoroughly well understood and documented in introductory

textbooks on human factors which students get in their introductory courses.

If you look at the history of accident research, the two that spring to mind is a Swedish study in driving trucks and an enormous study lasting over something like 30 years on people reading meters in the gas industry including, I think, something like 150,000 data points which is quite a study and they all show this huge rise in errors in the early hours of the morning apparently due to biological rhythms. That is absolutely perfectly well understood.

Moreover, we know quite a bit about how that interacts with shift work which is the important thing. I mean, you are always going to get a rise in errors in the small hours of the morning. The question is, how can you reduce that and to what level can you reduce it and can you build systems which will absorb the errors even if the errors are made.

COMMISSIONER BERNTHAL: I am not sure how much time we have but would you care to offer a clue on some of the things you do know about how shift work influences errors in the wee hours of the morning?

DR. MORAY: Yes. Well, one obvious one, it is fairly clear now that if you are working eight-hour shifts and you rotate forward, morning, evening, night, you will get a much better adaptation than if you rotate backwards.

It is generally agreed that because of the extreme

resistance in the biological rhythms tc changing phase, at the moment it is considered the best thing to do is to have sort of two days on and then change shifts.

Don't put people on nights for a week because it takes about three or four days, three or four 24-hour periods to begin to seriously shift the biological clock around the phase and b. that time the week is virtually over and just as they are beginning to adjust, you take them off again.

There is argument about this but the most commonly accepted view at the moment is you rotate rapidly and just on very sh:.t, two days on nights and then off again.

COMMISSIONER BERNTHAL: There is certainly nobody that I am aware of in the industry doing that.

DR. MORAY: Oh, there are.

COMMISSIONER BERNTHAL: Are there some?

DR. MORAY: Yes. You will find it in your report. Some of them are.

COMMISSIONER BERNTHAL: All right, but most are not.

DR. MORAY: And as I say, it looks rather like a random selection from all possible permutations.

COMMISSIONER BERNTHAL: Most are not, I think. I am not aware of any that do that.

DR. MORAY: Yes. Well, as you know, there are 12 hour shifts coming in in various places.

COMMISSIONER BERNTHAL: That's right. Do you have

any comment on that?

DR. MORAY: I have just been reviewing the literature on that. It is very thin literature. What I can say is at the moment empirically, there is no evidence that 12 hour shifts increase the occurrence of accidents or incidents although operators say that they think that they are getting more fatigued.

On the other hand, they all appear to like it so much that it is probably more than offset by the social thing. Now the problem is, there are some significant problems. If I was to run a 12 hour shift, overtime becomes extremely important. A 12 hour shift, there doesn't seem to be any shift.

Somewhere between 12 and 16, you are almost certainly beginning to get severe fatigue setting in so I would be very careful about allowing overtime. I would be very careful about apparent 12 hour shifts with say two hours driving on either end to get home, you know, things like that. Twelve is, I think, the evidence at the moment is that 12's are all right, somewhat to my surprise.

COMMISSIONER BERNTHAL: Well, I think the argument we have had is that whatever disadvantages there may be in the boredom factor or the fatigue factor gets offset by the smaller number of turnovers in 12 hours.

DR. MORAY: That appears to be the case, yes, and better communications.

COMMISSIONER BERNTHAL: Yes. You also raised the issue of a central research facility that I gather you feel should involve a simulator primarily so the human factors researchers could have access to a simulator.

I have two questions. One, how much does it matter that there is a vast array of different control rooms in this country so you really would have a lot of different simulators or are they all generically okay for the human factors research worker and secondly, as a rather pointed question, whether you have thought about the possibility, maybe we ought to think about the possibility, that the Tennessee Valley Authority would be an appropriate entity being as it is a government agency to step forward and take the lead in an area like that.

DR. MORAY: What we recommend is that steps should be taken to help those who wish to do research in quasi-realistic settings to get access to the facilities to do so. We mentioned one possibility of a national facility because there was talk about this a few years ago. I think Oak Ridge was discussing the possibility.

Now I don't know what has happened to that suggestion but it is not that so much, it is the question as to how we are going to get people able to do research in a setting which will be acceptable to the utility if the results of the research show that they are going to have to make a considerable investment.

They are more likely to accept it, I think, and also the results are more likely to be genuine. I mean, if you take somebody and stick him in a lab for two or three hours and run then even on a simulation of some kind of plant as I do, you don't see the behavior that you get with people running eight hour shifts several days on end.

Particularly, for example, if you take something like a new display design, say computer generated displays, SPDS, whatever it may be, to evaluate that is really quite difficult because the people, operators who have experience of previous systems may well take some time to adjust to the new one and the immediate impact of working with a new system may be rather poor behavior because they are simply not used to it. They don't know how to look at it. They don't know how to call it up. They don't know how to manage it.

Now it will take certainly somewhere between ten and 100 hours for people to get used to a new display and probably considerably longer to get up to the level of skill which they will show after say a year or two unless you have a strikingly better display in which case the operators will tell you instantly.

So what I am arguing for is access to research facilities where research can be done in a realistic way not with artificial subjects people coming in for an hour or two, not with undergraduates, not on an over-simplified PC desk top

graphics but on something which at least has a generic similarity to real control rooms. Holden in Norway has this kind of facility and do sponsor and I know you have relations with Holden.

They are not easy to use. That kind of research, that kind of quasi-field research is very difficult to manage and very difficult to design but I think there is a case for it. I would be quite happy if TVA were the people.

We are not telling you to spend all your money to go out and build one or even recommending it, I beg your pardon, I shouldn't say telling but we are just saying that we feel it is important that that quality of research should be available, access to those research facilities should be available.

COMMISSIONER BERNTHAL: There are two kinds of things really that you are talking about it seems to me. One, the fact that we have many different control rooms doesn't matter. It sounds like in one case you are talking about testing the efficacy of new hardware, for example, whereas you also seem to touch on another area of research which would be observation of the human performance on whatever the plant or the simulator might be and one wonders whether you might not even be able to carry that out within operating nuclear power plants.

DR. MORAY: Well, if I wanted to do research on fault management, for example, what happens when an incident occurs and people are faced -- one thing we feel very strongly about

is that research needs to be done on fault diagnosis for beyond design basis faults and that is a difficult thing. How do you train people for things you don't know are going to happen, the unknown fault?

We believe there probably are generic ways of doing that. If I wanted to carry out research on how people do fault management, I don't think that I, let alone the utility or you, gentlemen, would be very keen on my doing it in a plant.

COMMISSIONER BERNTHAL: No, I agree.

DR. MORAY: A simulator, yes, and certainly the exact way in which somebody manages an incident is going to depend on the exact physical system in the end. There are plants or there were before the DCRDRs were done where a display was over there and the control was over there and although the EOPs may be written quite correctly, "Do this," you can't actually do it without arms twice as long or eyes on storks.

Now generic research on say the logical processes, the thinking processes, underlying diagnosis can be done without having a simulator which matches any one particular plant. The transfer of the particular plant can be done on a relatively small scale bit of research for that transfer situation.

COMMISSIONER BERNTHAL: Yes. The case that I really had in mind if a utility were willing for carrying out at power plants is like the instance you mentioned or the case you

mentioned where you were trying to assess performance over a long period of time, over shift times, and you can't do that in two hours on a simulator.

DR. MORAY: That you can do, yes. No, that you can do.

COMMISSIONER BERNTHAL: That sort of thing it seems to me if the utilities would cooperate observers in the control room shouldn't be disruptive.

DR. MORAY: Indeed.

COMMISSIONER BERNTHAL: One other question and then I give someone else a crack here, did you involve NASA, I am sure you did at one level or another, but how much did you involve NASA in your study? That is, NASA was at one time viewed as something of a leader in this area. I don't know whether they are still viewed as being a leader. I would hope they are. Might the NRC have a good deal to learn from NASA in these areas?

DR. MORAY: You mean in the generic areas of human factors?

COMMISSIONER BERNTHAL: Yes.

DR. MORAY: Oh, yes.

COMMISSIONER BERNTHAL: Human factors research and understanding.

DR. MORAY: Yes, certainly. We didn't go and talk to NASA particularly because several people on the panel including

myself have done research for NASA as contractors. We are all very familiar with the research they do and indeed with many of the people who do it.

From inside the panel, that was part, I think, of our background expertise as to why we were chosen to be on the panel. Certainly, military, NASA, there are lots of people who do good work.

COMMISSIONER BERNTHAL: And, again, it would be your judgment that we have not had very good technology transfer if you will from those agencies?

DR. MORAY: That's right, yes.

COMMISSIONER BERNTHAL: I agree. That is all for now. Thank you.

CHAIRMAN ZECH: Commissioner Carr.

COMMISSIONER CARR: Have you asked anybody for time on a simulator at a utility?

DR. MORAY: I have. I have asked a couple.

COMMISSIONER CARR: I am surprised that you can't have it. They don't run that often.

DR. MORAY: Well, they told me that they are running them day and night and they are too busy.

COMMISSIONER BERNTHAL: Yes, I question that, too. I think you are quite right, Ken.

COMMISSIONER CARR: Maybe it is how we ask but how much time are you talking about that you would need, s

months?

DR. MORAY: Depending upon the study, it might be anything from a few days, a few hours a day, to a few hours a day for a quite long period, six months or something. I can't say that. You can't say that out of the context of a particular investigation any more than you can in any other science.

COMMISSIONER CARR: That seems like that could be overcome reasonably easily.

DR. MORAY: Yes. I think, you see in the report we asked for your role, NRC's role as a sort of broker between the research community and the utilities or INPO or anybody because I find it very difficult to believe that these things are running seven days a week, 24 hours a day.

COMMISSIONER CARR: We have simulators that we control.

DR. MORAY: Yes, I agree.

COMMISSIONER CARR: I think that is a problem that we can overcome. Would you expand a little bit on the principal human factors research areas that could significantly improve maintenance?

DR. MORAY: There is a large body -- a lot of it is again technology transfer. There is, for example, an excellent publication by EPRI on design for maintainability. I would start by trying to make sure that that was understood although

it is a little late now because --

COMMISSIONER CARR: I started to say if there are 104 of them out there already designed --

DR. MORAY: That's right and they have been designed in a way which makes maintenance very difficult. A lot of it is technology transfer because we know about labeling. We know about how to write operations procedures. The EPRI study way back in the late 1970's has a picture, a photograph, of a maintenance man sitting on the floor with a manual which says, "This photograph records the only occasion on which we saw a maintenance person using procedures." Now when that is said, there is something wrong.

COMMISSIONER CARR: So you don't think research is really necessary in this area?

DR. MORAY: I think research is necessary to make sure that what is known about how to train, how to write operating procedures, maintenance manuals and so on, that that knowledge is put to use.

COMMISSIONER CARR: But there it is a matter of just taking it and using it.

DR. MORAY: Yes. I would start certainly by looking at the transfer of training issue and there are some problems. For example, the wrong unit/wrong train fault which is very, very common. We were told by your people that this is the single most common maintenance error.

Now that may simply be due to poor design in the sense of incompatible labeling with the position of the equipment. I mean there are cases where the label is up here on top of one thing and the actual thing to which it refers is side by side. Those are simple. You need a human factors audit.

So I would certainly start by looking at transfer of training and human factors audits for maintainability and then I would start looking to see what else I need to do in the way of better training, licensing even of maintenance and the design of communications between the maintenance people and the control room, things of this kind because I think there are things there.

COMMISSIONER CARR: When you say "licensing," you mean licensing maintenance personnel, have a minimum qualification?

DR. MORAY: Yes. It worries me that very often maintenance is contracted by companies as so I have been told and once you start doing that --

COMMISSIONER CARR: Very often.

DR. MORAY: -- you don't really know where they are coming from. Considering the importance of maintenance in keeping the plant in a safe state, one really feels that there ought to be some pretty strong constraints on licensing or qualifications or minimum qualifications and some kind of

monitoring system.

It is interesting that if you go in the next generation of reactors to increasing automation, you are faced with a fact that a fully automated plant, probably the only people who can cause human error is to have a day-to-day impact are maintenance personnel and not operators.

The more sophisticated and automated a plant becomes, the more the weak link becomes maintenance and not operation and unless you also upgrade maintenance as you invent and design more sophisticated plants, you are going to be left with a plant that is actually weaker than it was when it was manually controlled. There is room there for some prospective research.

COMMISSIONER CARR: Thank you.

CHAIRMAN ZECH: Commissioner Rogers.

COMMISSIONER ROGERS: Yes. In many of these areas that you have touched on as high priority areas, some of them really relate to old problems that have been around for a long time in industry and in management situations and have you in setting up your priority system, did you try to include the measurability of results as a way of ascertaining what can be measured and what can't be measured in terms of effectiveness of research?

Some of these areas strike me as very difficult and they have been around for a long time, things that relate to

management effectiveness and they are difficult to measure. There are so many elements that relate to individuals rather than their training and education.

It seems to be that one of the biggest problems in the whole human factors area once you get out of things like man-machine interfaces is to develop measurables, something that you can measure that you have done something, that it all seems very plausible and it all seems very reasonable but has it really made a difference and I wonder if you could comment a little bit about the relationship between setting a set of research priorities and being ale to measure results of having done that research.

DR. MORAY: Yes, certainly. At one stage we had a shopping list of about 40 recommendations which we felt would not be terribly useful to you and we tried to narrow them down and make them more generic rather than giving great detail. We did not include anything on that list which we felt we could not ourselves measure were we given the opportunity.

We had several people on the panel, LaPorte, Shikiar and one or two others, who have experience in doing research in management and organization for the military and for other industries and although it is not my particular area of expertise, I am a human machine system person, those people have in their careers certainly been involved in objective measurement.

I think one important thin is to realize that there are different things that one means by measurement. To the engineer, if it is not measurable to two places of decimals and highly repeatable, that is sometimes thought as not being measurement.

In many cases, it is sufficient to use a weaker form of measurement such as better than, greater than, less than It would, for example, I think be quite satisfactory if somebody came and said, "Look, I want to institute this change in the utility and I am not sure how much better it is going to make things but all the research that we have done guarantees that it won't make them worse," that that would be sufficient grounds for saying, "Go ahead."

Certainly, I think everybody would agree that the further you move towards a societal and a social and the organizational aspects, the further you get away from the kind of measurement in degrees Celsius or BTUs or whatever it may towards ordinal measurement to use the formal term, greater than/less than.

But it doesn't mean they can't be measured and depending upon what kind of answer you require, you can certainly establish the appropriate measurement. You may not be able to say that it will go up by 22 percent. Indeed, that may be undesirable.

For example, one has to be very careful. I once got

involved in some work on the 12 hour shift a few years ago and the question was, would it increase error and for various reasons at that time we came to the conclusion that the best estimate ten years ago or so, eight years ago, was that it would probably double the number of errors but doubling it from 10 to the minus 6 to two ten to the minus six, right, is one thing. Doubling it from ten to 20 is something quite else and expressing things in percentages may be actually grossly misleading.

One can go for over precision or precision of the wrong kind so my general answer is yes. If we didn't believe that we could measure it, we would not have put it in the report although in one or two areas, such as performance indicators, we say that research is required to establish what would be satisfactory measurement scales because at the moment they don't exist.

COMMISSIONER CARR: Can I piggy-back on that particular part because you said that you need to do research on how can you tell if a plant is running well.

DR. MORAY: Yes.

COMMISSIONER CARR: How would you approach that?

DR. MORAY: I would want, I think, some kind of clearly some kind of composite measure. The fact that it is producing electricity with 90 percent availability is not in itself an adequate criteria.

COMMISSIONER CARR: No. It could be doing that with everybody out of the plant perhaps.

DR. MORAY: That's right, and that is clearly one thing one would want to look at the number of incidents, LER reports, the particular details inside them. When we want to go in and certainly do some field studies, monitoring people, seeing how they behave, looking at logs, looking at -- I would want to interview the people and find out what they were prepared to tell me about their working conditions and so forth.

It is not easy. I mean we feel that one of the problems about performance measurement indicators is that it is not at all clear at present.

COMMISSIONER CARR: I guess it is not clear to me how research could solve it.

DR. MORAY: No. The idea for the research would be systematically to look for evidence of, for example, one thing which I did one day while we were doing this report was to go through the availability figures for the last three or four years for different plants and see to what extent they are correlated on a year-to-year bass because one might have expected certain plants to be inherently good and certain plants to be inherently bad.

In fact, the variability is fairly remarkable over the years. If you have plants which are closely similar in

design and age and everything else and yet they vary greatly in performance in terms of output and availability, then one starts to look for other things such as management.

But I think what we felt was that we knew that people were talking about moving towards performance based regulations and we, ourselves, were uncertain as to what that measurement would be.

COMMISSIONER CARR: But best it be an empirical look.

DR. MORAY: Oh, I think so, yes, and possibly a conceptual one. But the point is rather than arbitrarily guessing what such measures should be, we are saying as with everything, it is worthwhile spending some money on research in advance of deciding how to do things and if the answer comes up, nobody knows, then that may give you pause about changing things anyway.

COMMISSIONER CARR: Thank you.

CHAIRMAN ZECH: Commissioner Rogers, do you have anything further?

COMMISSIONER ROGERS: Just that in conducting research in this area, do you have any comments on how to bring the systems approach, overall systems approach, to the research itself? We always try to break things down into manageable problems that we can deal with one by one but if what we are really interested in here as an organization is the improvement of overall safety, we are interested in the total system.

We are interested in the total performance of the system not maximizing one element of it possibly to the detriment of another element but really maximizing the overall performance and safety of the system.

Do you see any simple way to impose that point of view on the choice of topics and priorities within the research program itself? Obviously, if it is a very small program then that is not such a big problem but if one is looking at a variety of possible activities in research and human factors, could you comment in some way on how one relates the individual topical areas which very often tend to be those things that people think they know how to do rather than the things that actually have to be done.

DR. MORAY: Yes.

COMMISSIONER ROGERS: How to relate a choice of research topical areas to overall improvement in safety, not just in one area but overall improvement in safety. Have you tried to come to grips with that in some way?

DR. MORAY: I think clearly one is not going to do monstrous experiments in which everything is varied simultaneously. You may remember that I mentioned the fact that we would like to see emphasis put in the RFPs, in the proposals for research, on the people carrying it out should take a systems viewpoint.

If you take as an example, let's say, computerization

of emergency operating procedures, now one can certainly do the sort of piecemeal research. One can stick EOPs in a computer and see how easy they are to use. Let's suppose that one can and I think regard this as a very open question myself, get a satisfactory format for them.

Now this opens up other questions. I think I would expect the person who does that report, I would require him to write his best estimate of other areas in which this might have an impact. Does it have an impact on manning? Does it have an impact on the -- can it be expected rather to have an impact on the social organization in the control room? Is it likely to have an impact to do with time of day? Is it likely to have an impact on training?

Now I think some of these can probably be answered on he basis of existing knowledge. In others, the reports of a contract simply on computerization of EOPs would have at the bottom, the best estimate is that the following three questions are raised to which at least a small contract should be given to follow it up.

And you can take that and now you have at least one thing. You know this particular piece of equipment works. Now let's try it with instead of having the full team of operators in the control room, one of them falls sick and now you have one fewer. Can you still use them? Take that as a sort of cut. What impact will it have in incorporating the STA into

the decision making and those are probably relatively simple experiments.

Now the further away you get, the more remote and uncertain becomes the extrapolation from the fact of this work in this situation to what will happen in extremely varied situations but I think that I would start by insisting both in the proposal and in the final report that the people undertaking the work must somehow or other write into their report their systems orientation.

Maybe they will have to go and hire other people. Maybe they will have to as part of their research team, they will have to hire somebody in organizational behavior for a day and say, "Look, check over this thing and we want to see if anything in this reminds you of something where you think there may be difficulty" and then that has to be incorporated into the report.

I don't see much more than that because it may differ from every different research topic.

COMMISSIONER ROGERS: Of course, it has more and more become common not in ordinary research but certainly in educational research to look at outcomes as a requirement for part of the completion of the project is a longitudinal study of what the impact is.

DR. MORAY: Yes.

COMMISSIONER ROGERS: I think maybe some of those

concepts could be taken over here.

DR. MORAY: Certainly, yes, and I think, we also mention in the report the importance of interdisciplinary teams. It is very unlikely that you can get a really generalizable result if I do the work by myself. I have been trained in human factors and my work in the industrial engineering department and my background is psychology but I would certainly expect that I would have to team up with nuclear engineers either in the university or outside to make sure that the way that I perceive the problem is correct because I have not worked as an operator and in order to ensure that my vision of the actual implications of what I am working on is correct I must have interdisciplinary contacts and I think that again should be insisted on in the research designs.

COMMISSIONER ROGERS: Just one other thing and I don't want to really prolong this by going off in another direction but I wonder if and you touched on this question of training versus education and the difference between them.

DR. MORAY: Yes.

COMMISSIONER ROGERS: I wonder if you are familiar with the Education for Capability Program that has been tried in Great Britain and promoted somewhat by the Royal Society of Arts and whether there have been any studies of really the effectiveness of that point of view of whether it is really just philosophy or whether, in fact, there is some basis --

DR. MORAY: I am afraid I am not familiar with the results of that program, no. It is a difficult area.

COMMISSIONER ROGERS: It really has been in the polytechnics. It has not been at the university and it tries to deal with that question of how do you meld education and effectiveness which they call capability as distinct from education.

Well, I would just like to say that we all are very grateful to the enormous effort and time that I am sure that the committee has put into this sort of thing and we are very pleased to have the results of your fine work.

DR. MORAY: Thank you.

COMMISSIONER ROGERS: That is all I have.

CHAIRMAN ZECH: Dr. Moray, you have made a very strong recommendation, your first recommendation, for increased human factors research and financing and increased staff and so on and we will certainly take that into consideration and I would ask the staff when you talk to us on the 31st of May to give us your thoughts on that, too.

But Dr. Moray, what I wonder is in your review of this program which obviously you have gone into in some detail, could you give us a specific research topic if you will or going along with your strong recommendation, what would you think would be the highest priority of the human factors research program that we should undertake in order to perhaps

get the most benefit for our safety responsibilities?

DR. MORAY: I think if you are looking for a fairly short term one, probably something in the area of the introduction of computer aiding in the control room because we know that people are going to want to introduce it.

CHAIRMAN ZECH: Well, that was my next question. The control room itself, now let me get right to it. Is that what you would say we should undertake, a computer aiding of the control room operators?

DR. MORAY: No. I think you should support research on how to assess the quality of any such systems which are offered to the nuclear industry for use.

CHAIRMAN ZECH: We have computers in the control rooms as you know.

DR. MORAY: No. I am thinking of computer aided decision aids, particularly.

CHAIRMAN ZECH: I see.

DR. MORAY: Computer aided SPDS's which involve new displays, quasi-artificial intelligence, expert systems as they are sometimes called.

CHAIRMAN ZECH: Converting to the emergency operating procedures or something like that?

DR. MORAY: Yes. I would take that as a short term one because we know that any day now if you haven't had it already, you are going to get a letter from somebody saying,

"We would like to implement this, may we?"

CHAIRMAN ZECH: How about a long term one?

DR. MORAY: The causal models of human error. If you understand that, you will understand most of your problems. I say that with a smile but it is possible to do research in that area. It is very curious. Up until about seven years ago --

CHAIRMAN ZECH: I think the research would be probably interesting. It would tell us that we as you pointed out too, I think, most of our problems are caused by human error or human error relates to those problems in a very high percentage of cases but what would the research show you other than that? What would it show you that you can do about it?

DR. MORAY: Right. The research would show you the particular conditions of work, the conditions of the way problems are presented, the effects of displays and controls, the effect of training on pre-disposing a person so to process information in his mind that he comes to the conclusion which leads him to take the wrong action. It is pre-disposing causes for incorrectly acting in the light of the situation in which he finds himself at a particular instant.

Now I am not saying that it can be done like that because there is some evidence that some errors are caused by random processes in the brain, literally random in the sense of random distribution. Others are certainly caused where the patterns are related to understandable things, time of day,

lighting, lay-out, ambiguities in EOPs.

But the important thing is if one could understand the pre-disposing factors in how people process information, the cognitive activities of humans that lead to the wrong outcome given data entering the brain, one would be in a strong position to design better displays, design better EOPs, determine training, all sorts of things like that and identify potential moments when there might be an error but that is a long term one.

CHAIRMAN ZECH: You brought up a degreed operator. We have talked about that a little here, too. It is of interest to me as many know but education and training are different.

DR. MORAY: Yes.

CHAIRMAN ZECH: My view of getting a more educated operator is based, I think, on at least my own view that further education brings on or at least simulates intellectual curiosity. It makes you interested in things perhaps you haven't been involved in before. It kind of stretches your brain a little bit. It increases your logic process and it has a self-esteem type, self-confidence perhaps even, and a willingness to accept additional knowledge. It stimulates more knowledge.

Those are all things it seems to me that a person takes advantage of his God given faculties and perhaps not

necessarily but perhaps makes him into a broader individual. It doesn't necessarily make him a better operator. I am convinced of that but it could contribute to a better interest perhaps in some of the things that are going on.

But as much as anything in my view, it takes those people who we have in the control room who although we do have a number of college graduates most are high school graduates and my perception and my experience in visiting the plants around the country is that most of the people in management positions have degrees and here we have a wealth of talent at least in my view in our operators in our country that are not used, are not given the developmental possibilities to move up in the utilities and thereby bring their operational experience up into the higher management positions.

If, indeed, most utilities do have a requirement or at least if it is not a written requirement, it is an unwritten requirement for degrees in their higher management positions, it seems to me that we are just not taking advantage of the tremendous amount of talent we have and the side benefit, of course, is bringing people with more operational experience up into the senior management positions.

That is as much my interest in getting degreed operators as anything and I think the overall effect would be more professionalism not only in the control room but in the whole of the utility organization and those are just some of my

thoughts on it.

Let me just say, Dr. Moray, and to your colleagues here with you and others who were on the panel with you how much we really do appreciate what you have contributed to this Commission.

We will certainly take your recommendations and review them very seriously. We will be interested in the staff's presentation here in a couple of weeks on the same subject and I would ask the staff to comment on all the recommendations during their presentation and to give us any other views that you may have, Eric.

I personally think that we can do more in the field of human factors and should do more. I think there is a pay back in safety and, of course, that is our business and so I would hope that this presentation and the work you have done is going to lead us in that direction of seeing what we can do to prevent human error, to see what we can do to make the job of not only the control room operators as you, Dr. Moray, correctly pointed out.

We are talking about maintenance people and auxiliary technicians and all kinds of people in those power plants but what we need to do in a human factors sort of way make their job more sensible, more logical and as a result help them to operate more safely.

So I think there is a pay back here and I hope we can

take advantage of the work you have done and we thank you very, very much for a fine presentation.

DR. MORAY: Thank you very much, Mr. Chairman.

CHAIRMAN ZECH: Any further comments?

[No response.]

CHAIRMAN ZECH: If there are no further comments, thank you very much. We stand adjourned.

[Whereupon, the Commission meeting was adjourned at 3:55 o'clock p.m., to reconvene at the Call of the Chair.]

CERTIFICATE OF TRANSCRIBER

This is to certify that the attached events of a meeting of the U.S. Nuclear Regulatory Commission entitled: Briefing on NAS Human Factor Recommendations

TITLE OF MEETING: Briefing on NAS Human Factor Recommendations
PLACE OF MEETING: Washington, D.C.
DATE OF MEETING: Thursday, May 19, 1988

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.

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Ann Riley & Associates, Ltd.

5/19/88

SCHEDULING NOTES

TITLE: BRIEFING ON NAS HUMAN FACTOR RECOMMENDATIONS

SCHEDULED: 2:00 P.M., THURSDAY, MAY 19, 1988 (OPEN)

DURATION: APPROX 1-1/2 HRS

PARTICIPANTS: NRC — 5 MINS

- ERIC BECKJORD, RES

NATIONAL RESEARCH COUNCIL — 45 MINS

- DR. NEVILLE P. MORAY, CHAIRMAN
  PANEL ON HUMAN FACTORS RESEARCH NEEDS IN
  NUCLEAR REGULATORY RESEARCH
  COMMITTEE ON HUMAN FACTORS
  COMMISSION ON BEHAVIORAL AND SOCIAL
  SCIENCES AND EDUCATION

OTHER ATTENDEES

- DR. P. BRETT HAMMOND
  ASSOCIATE EXECUTIVE DIRECTOR
  COMMISSION ON BEHAVIORAL AND SOCIAL
  SCIENCES AND EDUCATION

- DR. HAROLD P. VAN COTT, STUDY DIRECTOR
  COMMITTEE ON HUMAN FACTORS AND
  PANEL ON HUMAN FACTORS RESEARCH NEEDS IN
  NUCLEAR REGULATORY RESEARCH
  COMMISSION ON BEHAVIORAL AND SOCIAL
  SCIENCES AND EDUCATION

HUMAN FACTORS RESEARCH AND NUCLEAR SAFETY

PANEL ON HUMAN FACTORS RESEARCH NEEDS IN NUCLEAR REGULATORY RESEARCH

COMMITTEE ON HUMAN FACTORS

COMMISSION ON BEHAVIORAL AND SOCIAL SCIENCES AND EDUCATION

NATIONAL RESEARCH COUNCIL

THE PANEL'S CHARGE

"[to] identify study areas in the current and recent programs that may have received inadequate attention and to provide guidance to the Office of Nuclear Regulatory Research, the Nuclear Regulatory Commission (NRC), and other research and development agencies in government, private industry, and universities regarding an appropriate research program in human factors to enhance the safe operation of nuclear power plants."

OVERVIEW

STARTED: January 1, 1986

COMPLETED: February 29, 1988

APPROACH:

* SEVEN PANEL MEETINGS

- BRIEFINGS BY:

  Argonne National Laboratory
  Department of Energy
  Electric Power Research Institute
  Hanford Engineering Development Laboratory
  Institute of Nuclear Power Operation
  Nuclear Regulatory Commission
  Westinghouse

- VISITS TO:

  Electric Power Research Institute

  Three Mile Island

- REVIEW OF NRC AND OTHER RELATED PUBLICATIONS

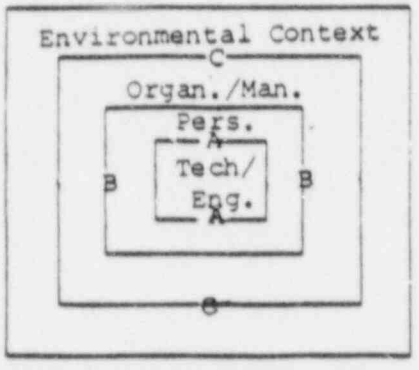
RECOMMENDATION 1: COMMITMENT TO HUMAN FACTORS RESEARCH

The panel recommends that the NRC make a firm public commitment to applied behavioral and social science (human factors safety) research. This would require a decision to increase staffing and financial support.

RECOMMENDATION 2: ADOPTING A SYSTEMS-ORIENTED APPROACH

The panel recommends that the NRC's research program maintain a broad perspective. The operator/maintainer -plant interface is extremely important.

However, other factors arising from the way in which a plant is organized, staffed, managed, and regulated and the way it interacts with other elements of the industry can also affect human performance, induce human error, and increase the level of risk of a plant.



Components of a Integrative System Safety Analysis

RECOMMENDATION 3: PEER REVIEW AND ENHANCED ACCESS TO NUCLEAR POWER RESEARCH FACILITIES AND PERSONNEL

The panel recommends that the NRC involve a diverse group of researchers in planning, conducting, and evaluating its research program.

In addition, peer review of proposals and of draft reports by behavioral science experts is needed to ensure the quality of sponsored research.

One of the barriers to effective human factors research has been the failure to provide behavioral science researchers access to realistic settings, to facilities such as simulators, and to people such as experienced operators.

While the panel recognizes the practical difficulties involved, we strongly urge the NRC and the nuclear industry to take significant steps that enhance researchers' access to these facilities and people.

One step towards achieving this goal would be to create a national research facility for the study of human factors in nuclear power systems.

RECOMMENDATION 4: CONTINUITY IN THE RESEARCH PROGRAM

To be effective, a research program must operate coherently for an extended period rather than change in response to each new, immediate, external demand.

RECOMMENDATION 5: TRANSFER OF KNOWLEDGE

The panel recommends that the NRC take advantage of existing research in the behavioral and social sciences by increasing the transfer of knowledge to the nuclear industry.

To this end, the panel recommends that the NRC publish an annual review of the human factors research relevant to the nuclear power industry.

RECOMMENDATION 6: DISSEMINATION OF NUCLEAR INDUSTRY HUMAN FACTORS RESEARCH

Several problems exist in the usability and transfer of human factors research reports prepared by the nuclear industry that should be addressed.

We are not aware that any central bibliographic data base or search service exists to abstract, index, and make available bibliographic or full text information, including NRC human factors publications.

As a first step the panel recommends the development of a bibliographic system for NRC-supported human factors reports.

RECOMMENDATION 7:
A HUMAN FACTORS RESEARCH AGENDA

BASIS FOR DETERMINING RESEARCH PRIORITIES:

-Some research topics may have a critical impact on safety and thus must be addressed.

-In some areas research is needed as a basis for evaluation.

-A particular research topic may be an essential building block for a long-term program.

NOTE: In all cases research should be aimed at management, maintenance, and other ancillary workers, as well as control room operators.

1) HUMAN-SYSTEM INTERFACE DESIGN

Highest priority topic:

- Automation and computer-based job performance aids

2) PERSONNEL SUBSYSTEM

Higher priority topics:

- Maintenance and enhancement of operational skill
- Improvements in licensing examinations
- Shift Scheduling and Vigilance

3) HUMAN PERFORMANCE

Higher priority topic:

- Causal models of human error, especially for situations with unplanned elements

CONTROL OF HUMAN ERROR

Concentrate Research on Causal, not Descriptive, Models

Couple Research to Reliability and Risk Analysis using Error Data as Feedback

The Human Element in PRA does not Require more Research

4) MANAGEMENT AND ORGANIZATION

High priority topics:

- The impact of regulations on the practice of management
- Organizational design and a culture of reliability

5) THE REGULATORY ENVIRONMENT

Higher priority topics:

- The appropriate mix of government regulation and industry self-regulation
- Developing and tracking a wide array of performance indicators

CONCLUSIONS

If a new human factors research program is implemented in 1988, receives strong support, is managed by a qualified HF specialist, is staffed by a multi-disciplinary team, and is organized as an independent branch, then...

the initial steps of leadership required of the NRC in this critical area will have been taken. Further steps will be taken as the NRC and the industry review and implement the recommendations made by the panel.

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Meeting Title: Briefing on NRC Human Factors Recommendations

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