SECY-98-244

October 22, 1998

FOR: The Commissioners

FROM: William D. Travers /s/
Executive Director for Operations

SUBJECT: NRC HUMAN PERFORMANCE PLAN

PURPOSE:

This memorandum informs the Commissioners of the status of the development of an agency human performance plan. A listing of the current activities specifically related to the assessment of human performance at nuclear power plants is included. However, a few activities related to human performance are not included in this plan because they are included in the PRA implementation plan or they relate to an immediate need, such as follow-up to a major operational event. This plan is a work-in-progress and, as such, includes a description of what needs to be done to complete the plan.

BACKGROUND:

In the aftermath of the accident at Three Mile Island-Unit 2 (TMI-2) in 1979, the Nuclear Regulatory Commission (NRC) established its first human factors program, based in part on recommendations from the 1979 "Report of the President's Commission on the Accident at Three Mile Island" (the Kemeny Commission report), the staff reports NUREG-0578 and NUREG-0585 from the TMI-2 Lessons Learned Task Force, and the Nuclear Regulatory Commission Special Inquiry Group 1980 report, "Three Mile Island: A Report to the Commissioners and to the Public" (the Rogovin report). These special studies identified extensive human factors deficiencies at TMI and recognized the likelihood that similar problems existed throughout the industry.

The NRC commissioned the Human Factors Society to develop a plan to assist agency management in establishing a human factors program. This report was published in 1982 as NUREG/CR-2833, "Critical Human Factors Issues in Nuclear Power Regulation and a Recommended Comprehensive Human Factors Long-Range Plan." In 1983 the NRC staff developed the agency's first human factors plan as NUREG-0985, "U.S. Nuclear Regulatory

Commission Human Factors Program Plan." Revisions to that plan were published in 1984 and 1986. In parallel with the NRC efforts, the nuclear power industry, thru the Electric Power Research Institute (EPRI), the Institute for Nuclear Power Operations (INPO), and the Nuclear Energy Institute (NEI), also established numerous programs to enhance human performance. These include: NEI's proposals for a plant performance assessment process, the accreditation of selected training programs, INPO's "Excellence in Human Performance" program, as well as EPRI's research on control room design, job aides, protective clothing, procedures, and proficiency training and testing.

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In an effort to enhance coordination among offices and to reduce the potential for duplication and overlap, a Human Factors Coordinating Committee (HFCC) was formed in 1994. That committee was composed of Branch Chiefs with human performance functional responsibilities from the Offices of Nuclear Reactor Regulation (NRR), Analysis and Evaluation of Operational Data (AEOD), Nuclear Materials Safety and Safeguards (NMSS), and Nuclear Regulatory Research (RES), along with a representative from the regions. The committee published a "Human Performance Program Plan" (HPPP) in August 1995 and revised it in July 1996. In their review of the HPPP, the Advisory Committee on Reactor Safeguards (ACRS) stated that the HPPP was more of a catalog of ongoing activities than a plan, since it did not contain a systematic process to identify and prioritize the agency's human factors activities. To address this issue and other questions raised by ACRS and the Nuclear Safety Research Review Committee (NSRRC), it was recognized that a more comprehensive plan was needed. In 1997 the staff began work on a new version of the plan and the HFCC was eliminated in favor of more traditional coordinating mechanisms.

DISCUSSION:

The attachment to this paper is the current version of the "NRC Human Performance Plan" (HPP). The HPP includes a mission statement with goals, strategies to accomplish the mission, and a listing of human performance activities grouped within each goal. The plan also describes the process that was used to prioritize the human performance activities (see Appendix B to the attached HPP). The prioritization of the activities was used as a basis for allocating resources to human performance activities in the FY 1999 and 2000 budgets. However, the plan should be considered as a work-in-progress since the prioritization process was based on qualitative safety/risk assumptions rather than quantitative risk assessments. The process used to prioritize the activities will be changed to be more risk-informed by incorporating insights from quantitative risk assessments to the extent feasible. A primary focus for the near-term work to be accomplished under the HPP will be developing these risk insights and changing the prioritization process.

The HPP currently comprises only activities in NRR, AEOD, and RES. NMSS staff with human factors expertise are currently focused on the nuclear byproduct materials risk review so there are no activities specific to human performance ongoing in NMSS at this time. NMSS intends to participate in the agency-wide coordination of human factors efforts after completion of NMSS's risk review, which is expected to be completed by the end of December 1998.

In letters to Chairman Jackson on June 12 and June 24, 1998, the ACRS commented on the HPP. Although the ACRS commented favorably on the mission statement, they stated that the plan did not describe how the mission would be achieved. They also raised concerns related to the purpose of the HPP, its risk basis, and the need for closure criteria. The ACRS is primarily concerned about the process that was used to identify and prioritize the human performance activities. The criteria used in the prioritization process included: qualitative assessment of safety/risk significance, regulatory effectiveness and efficiency, success likelihood, and resource impact. In large part, the activities were identified and prioritized based on best human factors or engineering judgment; that is, quantitative risk information was not readily available for use to identify or prioritize activities nor were closure criteria established to indicate when the work should be considered complete.

To the extent feasible, and using the best data and techniques available at that time, the staff will incorporate insights from quantitative risk assessments in a new identification and prioritization process for the next revision to the HPP. Risk-informed closure criteria for human performance activities will also be developed.

The method currently under discussion for revising the plan is based on an analysis of the influence of human performance on risk, including how human performance has affected recent events in nuclear power plants and the root causes of such performance. Accident Sequence Precursor (ASP) events from the last six years would be evaluated to determine the impact human performance had and could have had on real events. Additionally, analysis of current risk insights (from IPE's, IPEEE's, etc.) and sensitivity studies would be used to determine the risk worth of human performance in operating nuclear power plants. This work will provide the basis for the new process for identification and prioritization of human performance activities and for establishing closure criteria.

Schedule and Resources

A progress report on the development of the quantitative identification and prioritization process will be completed by the end of April 1999. The staff will seek ACRS review of this process as part of the revision to the HPP. Staff will also continue to coordinate with industry organizations which have activities in the human performance area. The resources needed to continue the development of the risk-informed identification and prioritization process will be reprogrammed from the FY 1999 resources that were originally intended for activities listed in the HPP.

William D. Travers
Executive Director for Operations

Attachment: As stated

cc w/att: SECY
OGC
OCA
OPA
CFO
CIO

ATTACHMENT

NRC Human Performance Plan
September 1998

Introduction

Successful human performance is critical for the safe and efficient operation of complex systems. This is true, not only in the nuclear industry, but in all industrial settings in which people must work with complex and sophisticated systems. Indeed the significance of human performance to system operations has assumed increasing prominence in recent years to the extent that a number of government agencies and industry groups in fields as diverse as aviation, aerospace, land and sea transportation, industrial processes, and health care have issued detailed program plans that stress the human factor in system safety. People specify, design, develop, test, evaluate, operate, upgrade, and maintain such systems, and their actions and decisions affect system safety directly and indirectly. Humans excel at certain types of behaviors and tasks and perform well in certain environments. They function less well under other situations and conditions. Likewise, hardware and software systems perform certain tasks significantly better than others. These differences must be considered in the design of systems so that humans can perform their functions safely and efficiently.

Human performance activities were introduced into the NRC and the nuclear power industry after the accident at Three Mile Island in 1979. A description of the history of these activities, including a brief description of industry activities, is at Appendix A. This Human Performance Plan (HPP) describes the activities related to human performance that are currently underway at the NRC. The risk significance and need for those activities were qualitatively assessed via the prioritization process described in Appendix B. Quantitative risk information was not readily available for use to identify or prioritize activities, nor were closure criteria established to indicate when the work should be considered complete. Also, closure criteria had not been developed which considered an acceptable level of human performance and the cost/benefit of additional research or regulatory initiatives.

The prioritization process used for this revision of the HPP included the following criteria and weighting factors: qualitative assessment of safety/risk significance and regulatory effectiveness and efficiency were the criteria, and success likelihood and resource impact were the weighting factors. In large part, the activities were developed and prioritized on the basis of best human factors or engineering judgment and the resultant ratings were assigned subjectively against the qualitative safety/risk criteria by Division Directors from the Offices of Nuclear Reactor Regulation (NRR), Analysis and Evaluation of Operational data (AEOD) and Nuclear Regulatory Research (RES), whose responsibilities encompassed human performance. The final ratings were determined by these managers through a consensus process.

It is necessary to develop quantitative risk information based on the root causes of the human contribution to operating events (e.g., procedures, training, etc.) for future versions of the HPP. Such risk information can then be used as a guide for where the NRC should focus its attention to most effectively reduce risk and to determine if new or additional research, guidance, or requirements are warranted. Such information could also be valuable in deciding which activities to modify, reduce, or terminate.

Background

In an effort to enhance coordination among NRC offices and to reduce the potential for duplication and overlap, a Human Factors Coordinating Committee was formed in 1994. That committee was comprised of Branch Chiefs with human performance functional responsibilities from NRR, AEOD, RES and the Office of Nuclear Materials Safety and Safeguards (NMSS), along with a representative from the regions. The committee published the "Human Performance Program Plan" (HPPP) in August 1995 and revised it in July 1996. The HPPP addressed the traditional areas of human factors, such as, staffing, training, human-system interface, procedures, management and organization, and communications, as well as, the areas of data collection, analysis, and inspection. In their review of the HPPP, the Advisory Committee on Reactor Safeguards (ACRS) stated that the HPPP was more of a catalog of ongoing activities than a plan, since it did not contain a systematic process to identify and prioritize the agency's human factors activities. To address this issue and other questions raised by the ACRS and the Nuclear Safety Research Review Committee (NSRRC), it was recognized that a more comprehensive plan was needed. In 1997 the staff began work on a new version of the plan and the HFCC was eliminated in favor of more traditional coordinating mechanisms. The responsibility for development of a plan was assigned to RES, because future developmental efforts were expected to involve confirmatory research. A revised plan was submitted to the Executive Director for Operations (EDO) in July 1997 as the "Human Performance and Human Reliability Implementation Plan." This plan was intended to address some of the concerns raised by the ACRS and the NSRRC, however the ACRS continued to have concerns.

In May and June of 1998, the staff presented a new version of the "NRC Human Performance Plan" to the ACRS for review and comment. This new version was developed from continued analyses of information and experience as well as coordination among the NRC offices. In its letter to Chairman Jackson on June 12, 1998, concerning the HPP and in its review and evaluation of the NRC safety research program of June 24, 1998, the ACRS raised several concerns regarding the HPP. Although the ACRS agreed with the HPP mission statement, it did not believe that the HPP include a systematic approach for achieving the mission, that is, the activities were not directly linked to mission fulfillment. Further, the ACRS did not feel that the plan was risk-informed because the plan was not based on a "high-level model" of human performance. Additionally, the ACRS commented that the HPP does not adequately define the purpose of the activities that are currently part of the human performance programs in NRR, RES, and AEOD, and that the plan was only an inventory of activities. They also stated that the plan itself lacks a purpose and any indication of whether or not the current risk-worth of human performance is too high.

Purpose

This NRC Human Performance Plan describes the current program for the assessment of human performance at nuclear power plants. The current version includes: a mission statement, strategies to accomplish the mission, and a listing of human performance activities grouped within each goal. The plan also describes the process that was used to prioritize the human performance activities (see Appendix B). However, the plan should be considered a work-in-progress since the prioritization process was based on qualitative safety/ risk assumptions rather than quantitative risk assessments. Once quantitative risk assessment insights into the issue of human performance are available, a new prioritization process will be developed. A primary focus for the work to be accomplished on the HPP will be developing these risk insights and a new prioritization process.

Mission

The mission of the NRC human performance program is to ensure effective risk-informed and performance-based regulation and oversight of human performance in the design, operation, maintenance, and decommissioning of nuclear reactor sites and other NRC-regulated facilities by (1) identifying human performance issues important to public health and safety, (2) increasing understanding of the causes and safety implications of degraded human performance, and (3) implementing the appropriate regulatory response to human performance issues.

The following strategies support accomplishing the goals included in the mission:

• Goal (1)		
	To identify human performance issues important to public health and safety.	
	Strategies	
	(1A)	Identifying and prioritizing human performance and operational issues from a variety of sources so that resources can be focused on issues that have high risk importance.
	(1B)	Evaluating changes to licensee facilities and activities that could impact human performance (such as the introduction of advanced technology into conventional control rooms or the implications of deregulation and decommissioning).
• Goal (2)		
	To increase the understanding of the causes and safety implications of degraded human performance.	
	Strategies	
	(2A)	Developing new models of human performance (e.g., ATHEANA) to support risk-informed and, where appropriate, performance-based regulation.
	(2B)	Collecting and analyzing operational and performance data to improve the assessment of human performance in risk analysis.

	• Goal (3)	
	To implement the appropriate regulatory response to human performance issues.	
	Strategies	
	(3A)	Evaluating the need to develop rules and regulatory and inspection guidance, supported by technical bases, to implement or improve regulatory responses to human performance issues.
	(3B)	Supporting inspections and event investigations when specialized expertise is needed.

The HPP currently comprises only NRC activities in NRR, AEOD, and RES. NMSS staff with human factors expertise are currently focused on the nuclear byproduct materials risk review so there are no activities specific to human performance ongoing in NMSS at this time. NMSS will participate in the agency-wide coordination of human factors efforts after completion of NMSS's risk review, which is scheduled for completion by the end of December 1998. In addition the HPP does not include certain human performance related activities that are included in the PRA Implementation Plan or which relate to an immediate need, such as follow-up to a major operational event. Further, the HPP does not address industry human performance activities. As the HPP is further developed the staff will coordinate with industry organizations to ensure that there is no unnecessary duplication of effort and that cooperative efforts will be pursued where appropriate.

Developing and Implementing Activities

The Human Performance Plan contains numerous activities in support of the mission. Overall, the agency's Strategic Plan serves as a primary driver for activities conducted within the HPP. Activities may be initiated as a result of lessons learned through experience (reactive) or efforts to anticipate future changes and challenges (proactive).

Specifically, HPP activities may be initiated as a result of several specific drivers, including the following:

(a)	lessons learned about human error from operating experience, events analyses, and risk insights. (Strategy 1A)
(b)	recognition of changes taking place in the nuclear industry and their potential impact on human performance. Such changes include, the rapid growth of high level integrated digital technologies in control rooms and local control stations; the effects of plant aging and decommissioning; and the effects of deregulation and the aging workforce. (Strategy 1B)
(c)	information obtained from experience in the nuclear industry in other countries and other industries (world-wide) in which skilled personnel operate and maintain complex human-machine systems. (Strategy 1A)

Once activities that support the mission have been identified, they can then be prioritized. The next section offers a general description of the current process that was used to prioritize HPP activities.

HPP Prioritization Process

The prioritization process that was used for this version of the HPP followed a modified Delphi technique. In this technique individual raters first independently assess and assign ratings to each item to be rated. The raters then convene to arrive at a consensus after reviewing and discussing the individual ratings. In accordance with this technique, the criteria, an algorithm, and a description of the prioritization procedure were distributed to each Office's cognizant division director along with descriptions of all program activities. Each office individually prioritized every HPP activity. Following the individual office prioritizations, the Division Directors then met to resolve differences and to reach a consensus rating.

Each rater applied weighting factors of "success likelihood" and "resource impact" to each of two criteria, "safety/risk significance" and "regulatory effectiveness and efficiency." The resultant values were used to arrive at a single prioritization score. The prioritization process is described in detail in Appendix B.

To the extent feasible, and using the best data and techniques available at that time, the insights from quantitative risk assessments will be incorporated in a new identification and prioritization process for the next revision to the HPP. Risk-informed closure criteria for human performance activities will also be developed.

Description of Human Performance Activities

The activities that have been identified as supporting the mission have been prioritized and are listed below. The activities are grouped by the goal that they support. A principle activity that will be pursued but is not included in the prioritized list is the continued development of the HPP. The primary activities related to this are the quantification of risk associated with human performance, including data collection and assessment technique development; development of a risk-informed activity identification and prioritization process; and development of closure criteria.

The outputs of HPP activities cover the broad range of NRC products, including inspection reports, generic communications, technical basis reports, regulations and regulatory guides, database analyses, trending reports, contributions to International Standards, and professional presentations and publications.

Activity		Lead Office	Prioritization Score
Goal 1)	Identifying human performance issues important to public health and safety.		
Participate in national and international standards and professional activities related to human performance and human reliability issues influencing the nuclear power industry		NRR, RES, AEOD	52
Determine potential impacts of licensee downsizing on human performance and on safe operations		RES	48
Coordinate with the research community		NRR, RES, AEOD	40
Evaluate the effects of workload transitions on crew performance, e.g., information collection and transfer, and task prioritization		RES	36
Goal 2)	Increasing understanding of the causes and consequences of degraded human performance.		
Conduct systematic analyses of operating experience data for risk-informed and performance-based regulatory activities involving human performance and human reliability		AEOD	56
Maintain a database of inspection and licensee event report findings to trend and identify significant generic issues in human performance		NRR	50
Evaluate the feasibility of using task network modeling techniques to support reviews of medical uses of radioactive materials		RES	30
Goal 3)	Implementing the appropriate regulatory response to human performance issues.		
Prepare generic communications related to human performance issues		NRR	72
Revise Regulatory Guide 1.8, "Qualification and Training of Personnel for Nuclear Power Plants" to endorse ANSI/ANS - 3.1 - 1993 with exceptions		RES	64
Develop advanced alarm systems review criteria for assessing the effect of advanced alarm system design characteristics on plant system and human performance		RES	60
Upgrade the program review model (NUREG-0711) to support review of advanced reactor digital retrofit activities that involve human performance		NRR	60
Monitor power plant technical personnel training accreditation process for compliance to 10 CFR 50.120 and 10 CFR 55 (c)(1) - (7)		NRR	60
Develop review guidance based on an assessment of the effects of computer-based procedures and soft controls on crew performance and safety		RES	56
Support the regional offices (which are responsible for conducting inspections), as needed, in operating reactor inspections and event investigations related to human performance		NRR	56
Update and revise NUREG-0700, Revision 1, "Human System Interface Design Review Guidelines" to update information, e.g., on advanced interface systems		RES	55
Conduct/support operating reactor licensing reviews involving human performance and human reliability issues		NRR	55
Develop review guidance based on an assessment of the effects of interface management tasks on crew workload and performance		RES	55
Develop review guidance based on an assessment of the effects of hybrid human system interfaces on human performance by identifying significant issues related to		RES	55

HHSIs		
Complete revision to NUREG-0800 (SRP) for Chapters 13 (Conduct of Operations) and 18 (Human Factors Engineering)	NRR	52
Develop review guidance and acceptance criteria for crediting operator actions in place of automated system or component actuations	RES	52
Improve root cause investigation methods in the Human Performance Investigation Process (HPIP)	RES	52
Provide human factors expertise to NRR/AEOD Daily Events Briefing (Morning Call)	NRR	50
Develop an inspection procedure for event-identified management and organization issues to support operating reactor review activities that involve human performance	NRR	48
Develop a control room observation protocol for observations of control room command, control, and communications	NRR	48
Monitor severe accident management training activities in accordance with NRC's Severe Accident Management Task Action Plan	NRR	47
Develop an inspection manual chapter on human performance evaluations to establish performance-based thresholds for initiating human performance related inspections	NRR	47
Review human performance issues related to USI A-46 reviews (per GL87-02) "Verification of Seismic Adequacy of Mechanical and Electrical Safety Issues" to prepare safety evaluations for multi-plant activities	NRR	40
Provide human factors expertise to NRR/AEOD Significant Events Panel	NRR	40
Support agency activities involving human performance on as needed basis	NRR, RES	40
Identify human supervisory control personnel performance assessment and fitness for duty evaluation behavioral methods, implementation strategies, and task contexts for acute fitness for duty changes	RES	36
Develop risk communication guidelines for communicating risk-informed decisions to the public and risk analyses results to decision makers	RES	30

Human Performance and Operational Experience Data and Risk

In the prioritization process described above and in Appendix B, qualitative assessments of risk were used. To most efficiently allocate NRC's resources for identifying and dealing with human performance issues, it is desirable to determine their quantitative risk significance. However, the methods and data needed to perform this quantitative assessment are not yet available. The following summarizes what has been learned from currently available human performance information. A more detailed discussion of the results of the review of existing data is provided in Appendix C.

The NRC's Human Factors Information System (HFIS) includes data collected from licensee event reports (LERs) from January 1992 through April 1998. For each reported event, one or more Human Performance Items (HPIs) are identified. The HPIs are coded according to a variety of categories, including root cause (e.g., inadequate staffing) and work type (e.g., control room operations). The 8718 HPIs included in the HFIS grouped by root cause category and work type have been reviewed. It can be seen in Table C1 that each root cause category/work type combination is well represented. Although the frequency counts for each combination cannot be used to infer risk importance, it does indicate that all root cause categories and work types are potentially important.

To determine some measure of risk significance, the staff analyzed the coverage of root cause category/work type combinations for events in HFIS for which Accident Sequence Precursor (ASP) analyses were also performed. The conditional core damage probability (CCDP) calculated for each of the 12 ASP events is greater than 10^{-5}; 5 of the events have CCDPs greater than 10^{-4}, and 1 event (the Wolf Creek reactor coolant system drain down) has a CCDP greater than 10^{-3}. All root cause categories and most work types were involved in these 12 events (see Table C2). This indicates that the issues which the HPP currently addresses are appropriate to the extent that the operational experience data and these limited risk assessments show that significant events fall within all of the categories for which there are root cause data and for most work types. More extensive quantitative risk assessments can refine the focus of future activities.

Conclusions

Review of the list of activities as prioritized indicates that current issues have the highest priorities and that the lower priorities were assigned to longer term or anticipatory issues. This could be because these issues are considered to be of high safety/risk importance or important to regulatory effectiveness or efficiency or because the costs to complete the activity is low because the work is nearly completed or the likelihood of success is high. Lower cost and greater likelihood of success help discriminate among similarly ranked activities on the safety/risk or regulatory effectiveness or efficiency criteria. In large part, the activities were developed and prioritized in accordance with best human factors or engineering judgment, and the resultant ratings have been assigned subjectively against the safety/risk criteria. These subjective judgments, though, were the result of the experience of the individuals performing the rating task and were informed by the operating experience data.

The prioritization allowed the individual Offices the opportunity to review their operating plans and funding priorities to determine if there should be any changes to current resource allocations. The nature of the prioritization scheme also allows new activities to be independently prioritized, so that they can be placed within the scope of existing activities without having to reprioritize the entire list. This version of the HPP is strongly weighted toward current and short-term activities and, using this version as a baseline, the staff can better focus on longer-term anticipatory issues in future revisions of the HPP.

As improved human reliability data become available and reliability analysis techniques mature, a new, more risk-informed prioritization process will be developed with the goal of better focusing the agency's human performance resources. The method currently under discussion for revising the plan is based an analysis of the influence of human performance on risk, including how human performance has affected recent events in nuclear power plants and the root causes of such performance. Accident Sequence Precursor (ASP) events from the last six years would be evaluated to determine the impact human performance had and could have had on real events. Additionally, analysis of current risk insights (from IPE's, IPEEE's, etc.) and sensitivity studies would be used to determine the risk worth of human performance in operating nuclear power plants. This work will provide the basis for the new process for identification and prioritization of human performance activities and for establishing closure criteria.

Appendix A

History of Human Factors at the NRC

In the aftermath of the accident at Three Mile Island-Unit 2 (TMI-2) in 1979, the USNRC established its first Human Factors program with the formation of a Division of Human Factors Safety (DHFS) in NRR and a Human Factors Branch in RES. This program was established, in part, based on recommendations from the 1979 "Report of the President's Commission on the Accident at Three Mile Island" (the Kemeny Commission report), the staff reports NUREG-0578 and NUREG-0585 from the TMI-2 Lessons Learned Task Force, and the Nuclear Regulatory Commission Special Inquiry Group 1980 report, "Three Mile Island: A Report to the Commissioners and to the Public" (the Rogovin report). These special studies identified extensive human factors deficiencies at TMI and recognized the likelihood that similar problems existed throughout the industry. The DHFS was established along the traditional organizational approaches to the human factors discipline - Human-System Interface, Procedures, Training/Qualifications/Licensing, Staffing, and Management and Organization.

NUREG-0660, "NRC Action Plan Developed as a Result of the TMI-2 Accident," May 1980, and NUREG-0737, "Clarification of the TMI Action Plan Requirements," November 1980, were developed to respond to the findings from the TMI accident and the results of the special studies referenced above. These two staff reports contained numerous Action Plan items that addressed a broad range of human factors deficiencies and followup actions for both the NRC and industry. The staff was instrumental in the development of guidance in the areas of control room design review (NUREG-0700, 1981, and NUREG-0801, 1981), emergency operating procedures (NUREG-0799, 1981, and NUREG-0899, 1982), and safety parameter display systems (NUREG-0835, 1981), all of which were promulgated through the publication of NUREG-0737, Supplement No. 1, "Clarification of TMI Action Plan Requirements - Requirements for Emergency Response Capabilities," in January 1983. Other guidance was provided in NUREG-0731, "Guidelines for Utility Management Structure and Technical Resources," 1980, and NUREG-1280, "Power Plant Staffing," 1980. Several human performance issues led to rulemaking: I0 CFR 50.54 contains requirements for minimum licensed operator staffing, 10 CFR 50.120 describes the requirements for training programs at nuclear power plants, 10 CFR Part 26 has the requirements for a Fitness-for-Duty program, 10 CFR 52.47 describes requirements for applications for standard design certification, and 10 CFR Part 55 establishes requirements for operator licensing and simulators.

The NRC commissioned the Human Factors Society to develop a plan to assist agency management in establishing a human factors program. This report was published as NUREG/CR-2833, "Critical Human Factors Issues in Nuclear Power Regulation and a Recommended Comprehensive Human Factors Long-Range Plan," in 1982. The agency adopted some of the recommendations of that report. In 1983 the NRC staff developed the agency's first human factors plan as NUREG-0985, "U.S. Nuclear Regulatory Commission Human Factors Program Plan." Revisions to that plan were published in 1984 and 1986. In each of these plans human factors functions included Staffing and Qualifications, Training, Licensing, Procedures, Man-Machine Interfaces, Management and Organization, and Human Reliability.

In 1985 the human factors research function was discontinued within the NRC. In 1987 the human factors research function was reestablished based on a recommendation in the National Research Council's 1986 report, "Revitalizing Nuclear Safety Research." Another study was commissioned at the National Academy of Sciences, National Research Council 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.

The report from that study was published as "Human Factors Research and Nuclear Safety" in 1988. The research agenda from that report included Human-System Interface Design, Personnel Subsystem (training, licensing, work scheduling), Human Performance (measurement, prediction and modeling of human error), Management and Organization, and research on the regulatory environment. In 1989 the "Human Factors Regulatory Research Program Plan," NUREG-1384, was published, in part to respond to the recommendations from the National Academy of Sciences report. This plan encompassed all the recommended agenda topics except for the regulatory environment, and also included a Reliability Assessment topic area.

In an effort to enhance coordination among NRC offices and to reduce the potential for duplication and overlap, a Human Factors Coordinating Committee was formed in 1994. That committee was composed of Branch Chiefs with human performance functional responsibilities from AEOD, NMSS, NRR, and RES, along with a representative of the regions. The committee published the "Human Performance Program Plan" (HPPP) in August 1995 and revised it in July 1996. The HPPP again addressed the traditional areas of human factors, such as, staffing, training, human-system interface, procedures, management and organization, communications, as well as the areas of data collection and analysis and inspection. In their review of the HPPP, the Advisory Committee on Reactor Safeguards (ACRS) stated that the HPPP was more of a catalog of ongoing activities than a plan, since it did not contain a systematic process to identify and prioritize the agency's human factors activities. To address this issue and other questions raised by ACRS and the Nuclear Safety Research Review Committee (NSRRC), it was recognized that a more comprehensive plan was needed. In 1997 the staff began work on a new version of the plan and the HFCC was eliminated in favor of more traditional coordinating mechanisms. The responsibility for development of a plan was assigned to RES, because future developmental efforts were expected to involve confirmatory research. The new plan was also to address the questions raised by the ACRS and the NSRRC. A revised plan was submitted to the Executive Director for Operations (EDO) in July 1997 as the "Human Performance and Human Reliability Implementation Plan." Another National Academy of Sciences report, which stressed the importance of human factors, was published in 1997. That report "Digital Instrumentation and Control Systems in Nuclear Power Plants - Safety and Reliability Issues," also included several recommendations regarding human factors and human-machine interfaces.

In May and June of 1998, the staff presented a new version of the "NRC Human Performance Plan (HPP)" to the ACRS for review and comment. This new version was developed in accordance with continued analyses of information and experience as well as coordination among the offices. In its letter to Chairman Jackson on June 12, 1998, concerning the HPP and in its review and evaluation of June 24, 1998, of the NRC safety research program, the ACRS raised several concerns regarding the HPP. Although the ACRS agreed with the HPP mission statement, it did not believe that the HPP described a systematic approach for achieving the mission. Additionally, the ACRS commented that the HPP does not adequately define the purpose of the activities that are currently part of the human performance programs in NRR, RES, and AEOD.

During this same time period the industry also pursued various human performance issues through their own organizations. The three organizations that have been most involved with human performance issues are: the Nuclear Energy Institute (NEI), the Institute for Nuclear Power Operations (INPO) and its associated National Academy for Nuclear Training, and the electric Power Research Institute (EPRI). The NEI human performance programs constitute proposals to refine NRC's regulatory programs with programs such as their plant performance assessment program. INPO has focused on the area of training, specifically through the accreditation process implemented by the National Academy for Nuclear Training. EPRI's primary focus has been on research to improve the efficiency of nuclear power plant personnel. Their programs have included guidelines for control room design, job aides for maintenance personnel and for procedure development, protective clothing for extreme environments, and proficiency training and testing. Their current program is focusing on leading indicators of human performance, cause analysis and corrective action job aides, and corrective action implementation tools.

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APPENDIX B

HPP Prioritization Process

Overview

A draft prioritization process, which incorporated criteria used in various existing agency prioritization schemes, was developed by RES human factors staff and presented at a consensus meeting of cognizant Branch Chiefs, Division Directors, and their Deputies from AEOD, NRR, and RES. As a result of that meeting, criteria were redefined, and an algorithm to be applied to the prioritization of HPP activities was developed. At a follow-up meeting, agreement was reached on the algorithm for combining the criteria and weighting factors, and the procedure to be followed in performing the prioritization.

The prioritization process uses a modified Delphi technique. In this technique individual raters first independently assess and assign ratings to each item to be rated. The raters then meet together to arrive at a consensus after reviewing and discussing the individual ratings. In accordance with this technique, the criteria, algorithm, and a description of the prioritization procedure were distributed to each office's cognizant division director along with descriptions of all program activities. Each office individually prioritized every HPP activity, with the exception of those that met the criteria for exemption described below. Following the individual office prioritizations, a meeting was held to resolve differences and to reach an agency-wide consensus.

Activities Exempt From Prioritization

Through staff and management discussions and a review of existing prioritization schemes, it was agreed that although certain activities provide insights or are related to human performance activities, they should not be included in the HPP. These are activities undertaken as a result of (a) a major operational event, which requires mandatory NRC response with qualified personnel to assess the event, evaluate its significance, and determine any actions that must be taken or (b) an immediate need to comply with statutory requirements; international agreements; a directive from the Commission, the EDO or Congress; or to respond to allegations, etc. In addition, activities prioritized as part of another agency program plan (e.g., the PRA Implementation Plan) were not included in the HPP in order to avoid any confusion that might result from multiple prioritizations in different plans.

The Prioritization Process

Each reviewer applied weighting factors of "success likelihood" and "resource impact" to each of two criteria: "safety/risk significance" and "regulatory effectiveness or efficiency." An algorithm was used as a means of combining the criteria assigned to each activity to arrive at a single prioritization score. The criteria and weighting factors are defined as:

a. Criterion - Safety/Risk Significance

The extent to which the activity should contribute to the solution of a safety problem, a better definition of the nature and extent of a potential problem, or an improvement or enhancement to safety. This criterion includes such concepts as core damage frequency, early significant release, person/rem dose, safety margins, defense in depth, and safeguards, and the implementation of such concepts to prevent harm or mitigate risk to the public. It also includes insights gained from participation in international activities. Activities under this criterion include those needed (a) for operational safety reviews, (b) to support continued safe facility operation or evaluation of necessary modifications or enhancements, (c) to support confirmatory or anticipatory research in those areas in which operating experience indicates potential problems, and (d) to support generic issue resolution and multi-facility actions.

b. Criterion - Improving Regulatory Effectiveness and Efficiency

The extent to which the activity should improve the agency's regulatory effectiveness and efficiency by improving the clarity, coherence, and consistency of risk-informed, performance-based regulation, and by ensuring that regulatory burdens are consistent with the risk. This criterion includes (a) improvements to the regulatory framework (including regulations, regulatory guides, inspection plans, codes and standards), and (b) support for generic issue resolution and multi-facility actions.

c. Weighting Factor - "Success likelihood"

The likelihood that the activity will achieve its safety, risk, or regulatory objective. This weighting factor includes outcomes and products that are (a) technically sound, (b) good public policy (i.e., they meet the principles of good regulation), (c) practical, (d) feasible to implement, and (e) timely.

d. Weighting Factor - "Resource Impact"

The amount of NRC resources required annually to undertake or complete the activity. Resource savings to the NRC from leverage gained from international activities, joint initiatives with industry, etc., were considered in this assessment. For activities conducted, in part or in whole by NRC staff, 1 staff month of effort or less was considered "low"; between 1 staff month and 1 FTE was considered "medium"; and more than 1 FTE was considered "high." For activities conducted, in part or in whole by contractors, an annualized cost of $100K or less was considered "low"; between $101K and $499K was considered "medium"; and above $500K was considered "high." If an activity required both staff and contract resources, the higher figure was used.

For every program activity to be prioritized, the reviewer followed the same five-step process:

First, a cost-benefit decision matrix (Table B1) was entered, in which the reviewer weighed the costs of the activity (the Resource Impact Weighting Factor) against the first benefit (the Safety/Risk Significance Criterion). Both cost and benefit were judged on a three-point (High-Medium-Low) scale. The resulting value, which could range from a low of 1 (High Cost-Low Benefit) to 9 (Low Cost-High Benefit) was entered into the algorithm as V^S.

Second, a cost-benefit decision matrix was again used, and the process was repeated for the Regulatory Effectiveness or Efficiency Criterion, and the resultant value was entered into the algorithm as V^R.

Table B1. Cost-Benefit Decision Matrix

			Resource Impact	
		High	**Medium**	**Low**
Safety/Risk or Regulatory Policy	**Low**	**1**	**2**	**3**
	Medium	**4**	**5**	**6**
	High	**7**	**8**	**9**

Third, the reviewer applied the success likelihood weighting factor against each of the two criteria. Hence, the reviewer estimated the "success likelihood" that the activity would achieve its Safety/Risk objective. This judgment was made along a five-point scale on which 1 represented "little, if any, likelihood that the activity would achieve its safety or risk objective"; 3 represented a 50/50 likelihood (or "don't know"); and 5 represented a high likelihood. The resultant value was entered into the algorithm as SL^S.

Fourth, the success likelihood process was repeated for its Regulatory Effectiveness or Efficiency objective, and the resultant value was entered into the matrix as SL^R.

Finally, the algorithm's mathematical operation was performed, and the activity's prioritization score (P_A) was determined.

The algorithm was: $P_A = (V^S \times SL^S) + (V^R \times SL^R)$,

where

P_A = The Prioritization Score for the Activity

V^S = The Safety/Risk Significance as weighted by Resource Impact

V^R = The Regulatory Effectiveness and Efficiency as weighted by Resource Impact

SL^S = The Success Likelihood Score for Safety/Risk Significance

SL^R = The Success Likelihood Score for Regulatory Effectiveness or Efficiency

It should be noted that for some of the activities the resource impact weighting factor had a significant effect on the prioritization of that activity when compared to activities of equal safety/risk significance because of the estimated cost (in staff time or contract dollars).

Appendix C

Human Performance Analysis

The NRC's Human Factors Information System (HFIS) includes data collected from LERs reported from January 1992 through April 1998. For each reported event, one or more Human Performance Items (HPIs) are identified. The HPIs are coded according to a variety of categories, including root cause (e.g., inadequate staffing) and work type (e.g., control room operations). The root cause categories have several subelements that help define or specify the category. For instance the training category includes no training, training less than adequate, training process problem, task qualification, individual knowledge, and simulator fidelity. The following is a description of all of the root cause categories and subcategories.

HFIS - Root Cause Categories

T Training	01 No training 02 Training LTA 03 Training process problem 04 Task qualification 05 Individual knowledge LTA 06 Simulator fidelity LTA
P Procedures and Reference Documents	11 No procedure/reference documents 12 Procedure technical content LTA 13 Procedure contains human factors deficiencies 14 Procedure/reference document development and maintenance LTA
O Organizational Issues	21 Inadequate staff 22 Poor task allocation 26 Inadequate controls/poor schedule design 27 Excessive hours worked/acute fatigue 28 Frequent use of overtime/cumulative fatigue
M Management and Supervision	31 No supervision 32 Inadequate supervision/command and control 33 Management expectations or directions LTA 34 Perceived pressure to complete task 36 Scheduling and planning LTA 37 Worker selection (unqualified worker) 40 Individual corrective action LTA 41 Action not yet started or untimely 42 No action planned 43 Operating experience review LTA 44 Corrective action program LTA 47 Root cause LTA 48 Audits or problem identification LTA
C Communication	51 Misunderstood or misinterpreted information 52 Communication not timely 53 Communication content LTA 54 No communication/information not communicated 55 Communication equipment LTA
H Human - System Interface and Environment	61 Labels LTA 62 Information organization or format LTA 63 Size, shape, or coding LTA 64 Placement or location LTA 65 Information content LTA 66 HSI does not exist/not available 67 Function LTA (accuracy/precision) 68 Too much information to effectively monitor 71 Temperature/Humidity LTA 72 Lighting LTA 73 Noise 74 Radiation 75 Work area layout or accessibility LTA] 77 Postings LTA

W Work Factors	81 Work package quality LTA 82 Briefings, preparation, turnover LTA 83 Work practice or craft skill LTA 84 Non-conservative decision-making/Questioning attitude LTA 85 Team interactions LTA 86 Work untimely 87 Willful non-conservative action 88 Tag outs LTA 89 Housekeeping LTA 91 Independent verification/plant tours LTA 92 Self-check LTA 93 Awareness or attention LTA 94 Log keeping or log review LTA

Note that any one reported event can involve multiple HPIs, each with a different root cause and a different work type. Also note that, in the HFIS, (a) a particular problem (e.g., poor communication between the control room operators and maintenance staff) can be coded as involving multiple HPIs if it involves multiple work types and (b) multiple instances of a problem type (e.g., willful nonconservative actions by control room operators) can be coded as a single HPI. From the standpoint of an event frequency analysis, therefore, these treatments can lead to problems of over counting in case (a) and undercounting in case (b).

Table C1 provides a breakdown of 8718 HPIs included in the HFIS grouped by root cause category and work type. It can be seen that each root cause category/ work type combination is well represented. Although the frequency counts for each combination cannot be used to infer risk importance (due to the above-mentioned methodology for counting HPIs as well as the lack of reactor safety consequence information in the HFIS), they do indicate that all root cause categories and work types are potentially important.

To provide some measure of risk significance, Table C2 shows the coverage of root cause category/work type combinations for the 74 HPIs included in the 12 events in HFIS for which Accident Sequence Precursor (ASP) analyses have been performed. The conditional core damage probability (CCDP) calculated for each of the 12 events is greater than 10^{-5}; 5 of the events have CCDPs greater than 10^{-4}, and 1 event (the Wolf Creek reactor coolant system drain down) has a CCDP greater than 10^{-3}. Because of the small number of HPIs only the coverage of the of root cause categories and work types are shown. It can be seen that all root cause categories and most work types were involved in these 12 events. However, once again, the information contained in HFIS does not provide a means for determining which root cause category/work type combinations are more important and which are less important. This determination requires additional review of the events to determine the role a particular HPI played in the observed scenario.

Tables C3-C5 show the results of an independent review of the 5 LERs and associated ASP analyses for which the calculated CCDP is greater than 10^{-4}. Table C3 identifies specific HPIs that strongly influenced the progression of each event. Note that positive HPIs as well as negative HPIs are identified. It appears that correction of the negative HPIs listed would have prevented or terminated the respective scenarios, and that removal of the positive HPIs would have allowed further scenario progression. Table C4 shows the coverage of HPIs grouped by work type and by the impact on three factors which affect risk: the frequency of system challenges, the degree of defense-in-depth, and the safety margins for the individual safety barriers that are intended to provide defense-in-depth. Table C5 is similar but addresses root cause categories. As in the case of Tables C1 and C2, Tables C4 and C5 show that a broad variety of root cause categories and work types can be important. Unlike Tables C1 and C2, Tables C4 and C5 show where positive HPIs as well as negative HPIs can significantly affect safety. It should be cautioned that the results shown in Tables C3-C5 are preliminary and have not been completely reconciled with the information provided in the HFIS. Nevertheless, they indicate the potential value of in-depth event reviews for qualitatively assessing the risk significance of HPI categories.

Table C1

HFIS LER Information
Root Cause Category for Types of Work Performed

From: 01/01/92 to Present
Number of LERs: 3786
Number of Human Performance Items: 8718

Root Cause Category ------------------- Work Type	Communication	Human System Interface	Management and Supervision	Procedure and Reference Doc. Dev. and Maint	Training	Work Factors	TOTAL
Administrative	68	10	125	242	59	123	**627**
Calibration	45	26	45	95	31	59	**301**
Control Room Operations	443	138	513	489	282	449	**2314**
Design	132	16	314	161	76	120	**819**

Maintenance	250	74	202	276	169	286	**1257**
Modifications	142	20	158	138	49	81	**588**
Refueling	37	6	16	26	20	18	**123**
Testing	360	154	502	672	258	538	**2484**
Troubleshooting	46	13	29	34	32	51	**205**
TOTAL	**1523**	**457**	**1904**	**2133**	**976**	**1725**	**8718**

Table C2

ASP LER Information
Root Cause Category for Types of Work Performed

From: 01/01/92 to Present
Number of ASP LERs with Human Performance Element: 12
Number of Human Performance Items: 74

Root Cause Category ------------------ Work Type	Communication	Human System Interface	Management and Supervision	Procedure and Reference Doc. Dev. and Maint	Training	Work Factors
Administrative						
Calibration						
Control Room Operations						
Design						
Maintenance						
Modifications						
Refueling						
Testing						
Troubleshooting						
Administrative						
Calibration						
Control Room Operations						
Design						
Maintenance						
Modifications						
Refueling						
Testing						
Troubleshooting						

Table C3

Important Human Performance Items for ASP Events (CCDP > 10^{-4})

Plant	CCDP	Event	Important Human Performance Items
Wolf Creek	2.0E-3	Inadvertent RCS draindown	Decision to conduct a valve stroke test Prompt recognition and response

Oconee 2	2.1E-4	LOOP, potential loss of emergency power	Lack of procedures for LOOP (Keowee) Competent action of Keowee technician
Sequoyah 2	1.8E-4	LOOP, interrupted RCP seal cooling	Understaffed main control room Prompt restoration of seal cooling
Catawba 2	1.5E-4	Potential LOSW	Poor calibration procedure Fault identified by surveillance
LaSalle 1	1.3E-4	LOOP, a few SRV failures	Inadequate preventive maintenance Appropriate event response

Table C4

Qualitative Risk Impact of Important Human Performance Items (HPIs)
ASP Events in HFIS (CCDP > 10^{-4})
Organized by Root Cause Work Type

	Frequency of Challenges			**Defense-in-Depth**			**Safety Margins**		
Work Type	Hardware-Initiated	Human-Initiated	External Event	Redundancy (Config.)	Diversity (Dependency)	Recovery Probability	Success Criteria	Equipment Unavailability	Human Error Probability
Administrative									
Calibration	Catawba 2 (procedure)								
CR Operations	Catawba 2 (surveillance)	Wolf Creek (decision)		Sequoyah 2 (under staff)		Wolf Creek (recognition) Sequoyah 2 (restoration) LaSalle1 (response)			Sequoyah 2 (understaffing)
Design									
Maintenance	LaSalle 1 (prev. maint.)								
Modifications									
Refueling									
Testing									
Trouble-shooting						Oconee 2 (planning) Oconee 2 (work skill)			

Legend:

Negative HPI
Positive HPI

Table C5

Qualitative Risk Impact of Important Human Performance Items (HPIs)
ASP Events in HFIS (CCDP > 10^{-4})
Organized by Root Cause Category

	Frequency of Challenges			Defense-in-Depth			Safety Margins		
Root Cause	Hardware-Initiated	Human-Initiated	External Event	Redundancy (Config.)	Diversity (Dependency)	Recovery Probability	Success Criteria	Equipment Unavailability	Human Error Probability
Communication									
HSI									
Management & Supervision	LaSalle 1 (prev. maint.)			Sequoyah 2 (understaffing)		Oconee 2 (planning)			Sequoyah 2 (understaffing)
						Sequoyah 2 (restoration)			
Procedures/ Ref. Docs.	Catawba 2 (procedure)								
	Catawba 2 (surveillance)								
Training		Wolf Creek (decision)				Wolf Creek (recognition) LaSalle1 (response)			
Work Factors						Oconee 2 (work skill)			

Legend:

Negative HPI
Positive HPI