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Safety-Related Operator Actions: Methodology for Developing Criteria

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This Work Performed For
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PREVIOUS DOCUMENTS IN THIS SERIES

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ABSTRACT

This report presents a methodology for developing criteria for design evaluation of safety-related actions by nuclear power plant reactor operators, and identifies a supporting data base. It is the eleventh and final NUREG/CR Report on the Safety-Related Operator Actions Program, conducted by Oak Ridge National Laboratory for the U.S. Nuclear Regulatory Commission. The operator performance data were developed from training simulator experiments involving operator responses to simulated scenarios of plant disturbances; from field data on events with similar scenarios; and from task analytic data. A conceptual model to integrate the data was developed and a computer simulation of the model was run, using the SAINT modeling language. Proposed is a quantitative predictive model of operator performance, the "Operator Personnel Performance Simulation (OPPS) Model," driven by task requirements, information presentation, and system dynamics. The model output, a probability distribution of predicted time to correctly complete safety-related operator actions, provides data for objective evaluation of quantitative design criteria.

LIST OF FIGURES

NOMENCLATURE ACRONYMS, ABBREVIATIONS, AND INITIALISMS

ANS	American Nuclear Society
ANSI	American National Standards Institute
BWR	boiling water reactor
CTE	critical task element
ECCS	emergency core cooling system
EPRI	Electric Power Research Institute
IREP	Interim Reliability Evaluation Program
JPA	job performance aid
LOCA	loss of coolant accident
MSIV	main steam isolation valve
MSRV	main steam relief valves
MW	megawatts (1,000,000 watts)
NASA	National Aeronautics and Space Administration
NPP	nuclear power plant
NRC	U.S. Nuclear Regulatory Commission
OPPS	Operator Personnel Performance Simulation
ORNL	Oak Ridge National Laboratory
PMS	performance measurement system
PRA	probabilistic risk assessment
PSF	performance shaping factor
PWR	pressurized water reactor
RCIC	reactor core isolation cooling
RHR	residual heat removal
RO	reactor operator
SAINT	Systems Analysis of Integrated Networks of Tasks
SRO	senior reactor operator
SROA	Safety Related Operator Action
TA	task analysis
THERP	Technique for Human Error Rate Prediction

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1. INTRODUCTION

There is increasing recognition on the part of reactor safety analysts of the need to include in system reliability and safety studies the effects of human interaction. NUREG/CR-0660, Task 1.D.1 (Ref. 1) calls for a human factors design review of nuclear power plant control rooms to identify and correct deficiencies which may lead to operator error. An important aspect of control room design is the allocation of safety functions between the operators and automated systems. The nuclear industry has viewed this as a plant design issue, reflected in the American National Standards Institute (ANSI) draft N660 design automation standard (Ref. 2). The desire is to quantify the impact of the operator on system performance, but the lack of a comprehensive, objective data base has been a major obstacle. Data currently available on human performance in nuclear power plant operations are based primarily on information from studies of humans in jobs other than nuclear-power-related operations (e.g., aviation or military operations) or from subjective observation (i.e., expert opinion) by nuclear industry personnel. The Safety-Related Operation Action (SROA) project at Oak Ridge National Laboratory (ORNL) has been working to develop a data base of operator performance under emergency conditions to support development of criteria for the Nuclear Regulatory Commission (NRC) to use in evaluating new plant and backfit designs involving operator action in safety systems. This report concludes the program and recommends a proposed evaluative model — the Operator Personnel Performance Simulation (OPPS) model.

1.1. SROA Project Objectives

The primary objective of the SROA project was to develop a data base of quantitative measurements of operator performance under emergency conditions in order to support development of criteria to evaluate the use of operator action as part of the design basis of a nuclear power plant. The data base will also provide input to other NRC regulatory and research efforts in such areas as operational safety, human factors, and risk assessment. A secondary objective of the project was to develop candidate criteria, based on the supporting data base, for evaluating automatic versus manual system operation during emergency events.

1.2. SROA Research Approach

The research philosophy of this project was to integrate predictive modeling and performance measurement in high-fidelity simulation; with the principal objective being the establishment of safety-related operator action criteria.

Task analyses of operating sequences (events) were conducted to delineate task requirements. These task requirements must be clearly understood to guide the development of a model of process control. The sequences were then verified by comparing them with empirical data of the same events at an operating plant, and by simulating the same operating sequences on that plant's training simulator with licensed operators acting as the control room crew. The next step was to convert this descriptive and definitive model of the operating sequence, derived from the system/task analysis into a simulation model.

1.3. OPPS Model

To be used effectively in studying operator and system performance, models cannot treat the operator in isolation of other system components. Thus, conceptual models of human perception and cognition are not sufficient in and of themselves to capture the processes by which the operator and the hardware and software components of the system interact. What is needed is an operator model that interacts with different elements of the larger system model in which it is embedded, so that the various behaviors exhibited by the operator affect system variables and vice versa. The eventual goal of modeling of SROAs is to allow *quantitative predictions* of operator and total system performance as an analyst varies the impact or level of factors which are presumed to shape the behavior of the operator, but the problem of developing a model for a NPP was beyond the scope of this study.

SROA criteria can be based on a scenario dependent model. The scenario of an operating sequence begins with the plant in normal operations. This condition is upset by a malfunction which challenges the safety limits of the plant. The operator works to support and supplement the automated plant systems in order to return the plant to a condition of stable operation. The operator actions are modeled in parallel with a representation of plant dynamics. In the current model the plant is modeled as a simple time delay representing the time from the malfunction to the time at which safety limits are exceeded if required operator actions are not successfully completed.

1.3.1. OPPS Model Structure

The model developed for the SROA criteria organizes human behavior into four phases (see Appendix A for a detailed description of the OPPS model):

1. Stimulus organization or observation
2. Hypothesis generation, identification, and interpretation
3. Option selection or task definition
4. Response execution or output actions.

These four phases are organized into three major modules with an additional "Recovery" section added in the OPPS model:

1. DETECT a disturbance
2. INTERNAL PROCESSING of information
3. OPERATIONS (of equipment)
4. ERROR RECOVERY.

Allowance is made in the OPERATIONS module for operator errors of omission and commission.

1.3.2. OPPS Model Format

The end product of the SROA project is a SAINT computer implementation of the OPPS model. (SAINT is an acronym for Systems Analysis of Integrated Networks of Tasks and is described in Appendix A.) The accompanying documentation will guide a user through the steps in the use of the OPPS model:

1. Map system design into the OPPS model using a Task Sequence Chart (TSC).
2. Identify model inputs using a Scenario Analysis Questionnaire.
3. Quantify model inputs using the instructions for running the model.
4. Run OPPS model in a computer simulation.
5. Interpret OPPS model outputs.
6. (OPTIONAL) Rerun model for graphical output.

Input Variables

The OPPS model operating instructions (in Appendix A.7) structures the collection of data necessary to run the model. This covers two classes of data:

1. Task descriptive and Performance Shaping Factor (PSF) data necessary to drive the OPPS model.
2. Data for which OPPS model defaults exist but which may be modified at the option of the user.

Output Parameters

The outputs of the OPPS model will be in the form of probability distribution for time to successful completion of operator functions involving SROAs.

1.4. Report Organization

The remainder of this report is organized as follows:

- Section 2 describes the derivation of the SROA design criteria
- Section 3 discusses models of some current measures of performance
- Section 4 discusses how to use the SROA design criteria methodology
- Section 5 presents conclusions and recommendations.

Appendices A and B present the OPPS model and supplementary material on how the criteria and the model were developed and tested.

2. DERIVATION OF SROA DESIGN CRITERIA

2.1. SROA Performance Requirements Determination

The earlier studies in this program of field-data, simulator PMS data, and the pilot task analyses reported operators' response times and recorded some errors of omission, but did not provide answers to two basic questions: "What are the required human actions/reactions?," and "What should the rest of the system be doing as the operators react with it?" Answers to these questions can be obtained from a comprehensive system analysis. Formal documentation of system analysis has not been typical practice in the nuclear industry, but is now recommended by the NRC when NPPs conduct human engineering reviews of completed control rooms and/or in defining control room design requirements (Ref. 3). Adoption of requirements for such a formal process in the design of nuclear power plants is beginning to receive more attention and consideration. The U.S. military and aerospace has for some time required application and documentation of the system engineering process, including mission requirements analysis, functional analysis, functional requirements allocation, and synthesis of all system performance and design requirements into a detailed system design. Definition of the System Engineering Process, and its sequential steps are excerpted from MIL-STD-499A (Ref. 4) in Fig. 2.1. These steps are followed, in sequence, for new designs and for re-design when functions or system elements change and a reallocation of system functions/subfunctions is indicated or contemplated. Additional definitions for application to human engineering design reviews of existing NPP control rooms and for systems/operations design analysis techniques useful in defining control room design requirements are given in Section 1 and Appendix B of Ref. 3.

When evaluating existing systems, performance requirements and/or allocations are often not known, and/or there is no system documentation (such as system and subsystem functional performance specifications and drawings) which document how the functions were allocated between the system elements (hardware, computer programs, procedural data, facilities, and personnel). For these systems a sort of "reverse engineering analysis" must be done in order to determine what each system element should do to properly perform the function being investigated. This method is called a "system/task analysis." It analyzes each task, clusters of tasks, and functions from which the tasks were assigned in the functional system/subsystem context to determine the assigned responsibilities, roles, and performance requirements of each system element, i.e., equipment (hardware), facilities, people, and data (procedures and software).

2.2. SROA Task Analyses

Two SROA pilot task analysis studies (Refs. 5 and 6) were used: (1) to demonstrate the use of task analysis techniques on selected abnormal/emergency operation events; (2) to investigate the use of simulator data obtained from an automated Performance Measurement System (PMS) to supplement and validate traditional task analytic data; and (3) to demonstrate sample applications of task analytic data to address questions pertinent to

10.2 System Engineering Process.

10.2.1 Mission Requirements Analysis. Impacts of the stated system operational characteristics, mission objectives, threat, environmental factors, minimum acceptable system functional requirements, technical performance, and system figure(s) of merit as stipulated, proposed, or directed for change shall be analyzed during the conduct of the contract. These impacts shall be examined continually for validity, consistency, desirability, and attainability with respect to current technology, physical resources, human performance capabilities, life cycle costs, or other constraints. The output of this analysis will either verify the existing requirements or develop new requirements which are more appropriate for the mission.

10.2.2 Functional Analysis. System functions and sub-functions shall be progressively identified and analyzed as the basis for identifying alternatives for meeting system performance and design requirements. System functions as used above include the mission, test, production, deployment, and support functions. All contractually specified modes of operational usage and support shall be considered in the analysis. System functions and sub-functions shall be developed in an iterative process based on the results of the mission analysis, the derived system performance requirements, and the synthesis of lower-level system elements. Performance requirements shall be established for each function and sub-function identified. When time is critical to a performance requirement, a time line analysis shall be made.

10.2.3 Allocation. Each function and sub-function shall be allocated a set of performance and design requirements. These requirements shall be derived concurrently with the development of functions, time-line analyses, synthesis of system design, and evaluation performed through trade-off studies and system/cost effectiveness analysis. Time requirements which are prerequisites for a function or set of functions affecting mission success, safety, and availability shall be derived. The derived requirements shall be stated in sufficient detail for allocation to hardware, computer programs, procedural data, facilities, and personnel. When necessary, special skills or peculiar requirements will be identified. Allocated requirements shall be traceable through the analysis by which they were derived to the system requirement they are designed to fulfill.

10.2.4 Synthesis. Sufficient preliminary design shall be accomplished to confirm and assure completeness of the performance and design requirements allocated for detail design. The performance, configuration, and arrangement of a chosen system and its elements and the technique for their test, support, and operation shall be portrayed in a suitable form such as a set of schematic diagrams, physical and mathematical models, computer simulations, layouts, detailed drawings, and similar engineering graphics. These portrayals shall illustrate intra- and inter-system and item interfaces, permit traceability between the elements at various levels of system detail, and provide means for complete and comprehensive change control. This portrayal shall be the basic source of data for developing, updating, and completing (a) the system, configuration item, and critical item specifications; (b) interface control documentation; (c) consolidated facility requirements; (d) content of procedural handbooks, placards, and similar forms of instructional data; (e) task loading of personnel; (f) operational computer programs; (g) specification trees; and (h) dependent elements of work breakdown structures.

Fig. 2.1. System Engineering Process Definitions from MIL-STD-499A (from Ref. 4).

nuclear power plant operational safety, e.g., layout of the control room, staffing and training requirements, operating procedures, interpersonal communications, and job performance aids.

In developing the OPPS model, the concepts of a system/task analysis were applied to define system requirements (including operator performance requirements) and to document the operating sequence that was used to develop a standard scenario of an actual field event that had occurred at an operating BWR. The event was then replicated in that plant's training simulator, using an experienced operating crew, in order to observe and record operator's individual and crew performance. Performance was then compared to the required performance (obtained from the front-end task analysis) and to the field performance records. Thus the simulated performance would provide input data to the OPPS model to test the model's ability to predict operator actions in the field.

The plan for selecting and documenting this operating sequence is included in Appendix B, SROA Field Data Collection Plan. Copies of the forms created by this task analysis are included in Appendix B.

The task analysis data were the most useful data in developing the OPPS network because they provided sequencing of task elements and the timing of these sequences, which were used to quantify the model.

2.3. Simulator Data

Three series of experiments were performed in 1981 and 1982: one for Boiling Water Reactors (BWRs) (Ref. 7), and two for Pressurized Water Reactors (PWRs) (Ref. 8 and 9). All studies evaluated simulated malfunction sequences by collecting operator response data using Performance Measurement System (PMS) software (Refs. 10 and 11) which recorded control manipulations and plant parameters. An observer was also on hand to record other information concerning operator behavior. These data were analyzed to extract operator response times and error rate information. Demographic and subjective data were collected and analyzed to evaluate the possible effects of performance shaping factors on operator performance.

The observation of operator responses to simulated scenarios in those studies provided the basis for the SROA model structure. Observation of problems experienced by the operators helped identify these model inputs which were believed to most influence operator performance. These studies also provided information for SROA model quantification. Data provided by these studies were used for time distributions and error probabilities in the SROA model.

The FY1983 simulator data, from the BWR operating sequence verification runs, were analyzed to establish the standardized performance requirements limits and the observed performance measures. These performance criteria and measures were then used to test the OPPS model and to provide a data base for use in future experiments in a separate research project initiated in FY 1983, FIN No. B0821. This project will use training simulators in presenting standardized operating sequences to varied groups of NPP control room operators. Operators with various backgrounds will be used and varying sequences will be chosen in order to determine the effects of selected internal and/or external performance shaping factors on individual operator and crew performance.

2.4. Field Data

Collection of PWR/BWR field data was performed in 1980 and 1981 by the Memphis State University Center for Nuclear Studies, and these data were compared to simulator data by General Physics Corporation (Ref. 12). The performance measure used for these field data was the time required for operators to initiate the first correct manual action in response to an abnormal or emergency event.

When the simulator performance data were analyzed and compared to field event data, the investigators concluded that time alone is an unsatisfactory measure of the acceptability of assigning tasks to operators.

The system/task analysis approach was used to identify the total involvement of the operators with the other NPP system elements. Each operating sequence being investigated was documented to reveal how the requirements of the function (i.e., "mitigate consequences of an accident and restore plant to safe condition") had been (in the existing design) allocated to the operators, other personnel and other system elements. These sequences/scenarios were broken down into tasks, and the tasks into task elements, where the assignments to specific operators and/or to specific plant equipment, facilities, procedures, and software were recorded. The results of the analyses were documented first in a pre-fill analysis and the data sheets were completed after verification with plant operations personnel and simulated runs in the plant's training simulator. Description of this process is contained in Appendix B.

Data from field studies were used to test the OPPS model. Model predictions of operator response time for a BWR relief valve failure were compared to field data on that event. The general agreement obtained between the field data and model predictions tends to confirm the reasonableness and utility of the model, but more extensive demonstrations are required.

2.5. SROA Design Criteria Data Base

The efforts and reports cited in Sections 2.1 through 2.4 have provided the data base for the identification, quantification, and prediction of NPP control room operator's performance on safety-related events, for the operating sequences and the plants covered in this program. As additional events (operating sequences) are analyzed and quantified, and field data from other plants are collected, they can be added to the data base, to provide historical data on operator response times and errors, and to provide input to probabilistic prediction models, e.g., the OPPS model.

3. SOME CURRENT MODELS OF HUMAN PERFORMANCE MEASURES

Development of reliable and useful operator performance measures is at the heart of many of the issues currently being addressed in studies of human performance: human reliability, personnel qualifications, operator licensing, training, control room design, procedures, job aids, evaluation of performance, and allocation of functions/tasks to humans and other system elements. Each study requires that the criteria for system/human performance requirements be defined, and that the techniques and standards for measurement be specified. This section reviews some methods and models relevant to development of the OPPS model and discusses how they were used to define the model's structure.

3.1. ANSI-N660 — A Time Standard

One criterion upon which the nuclear industry can make design/retrofit decisions is the ANSI N660 Standard (Ref. 2). The current draft of the N660 Standard defines performance as a function of time.

The N660 draft states that each safety related action required to initiate or adjust a safety system for which a required operator action is contemplated shall be evaluated in terms of two time tests. If both time tests, as well as certain other requirements of the standard are satisfied, the designer may assume that adequate time will exist for a qualified operator to perform the required safety related action. The time intervals defined below are illustrated in Fig. 3.1.

The performance criterion inherent in the N660 Standard are used to specify time requirements (assuming an acceptable level of reliability) which include the effects of the severity and frequency of the event conditions. The standard was designed to parallel accident conditions 2, 3, and 4 on the rationale that the rare, severe events (condition 4), yield higher stress and the operators, being less familiar with their procedures, will require more time for a given degree of reliability. Condition 2 events are expected to occur annually, with lower stress and require a shorter time for the operators to respond. Condition 3 time values are roughly interpolated between those two extremes.

To apply the standard, the designer determines the interval from the time an event occurs (T_O in Fig. 3.1) until the consequences of that event result in some design limit being exceeded (T_1). From this interval he subtracts the equipment and process delay times of the safety system under consideration. This determines the maximum permissible delay in activating the safety system. From the "front end" of the event time line he subtracts the interval between initiation of the event and the activation of the first alarm to the operator. The time remaining is the time available for the operator to take whatever corrective action is required. If there is sufficient time available, the designer may allocate some or all of the safety functions to the operators. If there is not sufficient time, the safety function is to be automated. The two time tests are used to determine if the time available for the operator to take action is "sufficient."

The N660 approach ignores many aspects of operator performance; e.g., how well an operator can keep a parameter in a normal band and how reliable an operator is in regard to

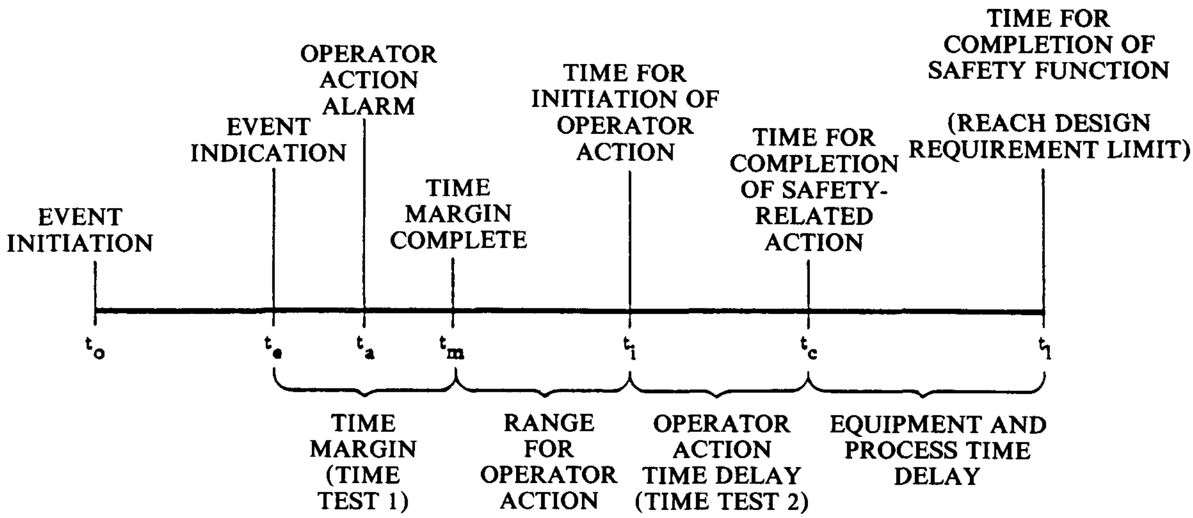


Fig. 3.1. Time Intervals for ANSI N660 Criteria.

errors and control of the plant are just a few of the many possible performance measures. We consider this approach inadequate, by assuming reliability to be a function of time alone. Many factors in addition to time affect operator performance reliability. Insufficient time may guarantee unreliable operation, but sufficient time alone will not guarantee reliable operation.

The model implicit in the N660 standard was discussed in NUREG/CR-0901 (Ref. 13). Haas and Bott discussed four phases of the "model" and presented results of a survey of operators opinions on these four phases, which are quoted below:

1. "Shock - initial period of reaction to a highly stressful situation during which no positive action is taken.
2. Diagnosis - operator assesses available information, identifies event that has occurred and plans his corrective actions.
3. Immediate Action - first corrective action taken as soon as possible after initiation of the event.
4. Subsequent Action - additional corrective action taken over a longer period to time, presumably under a reduced stress level because immediate corrective action has brought the reactor to a recognizably safe condition."

These four phases can be categorized into two areas describing the operator's behavior as consisting of two distinct phases labeled "cognitive" and "motor." The cognitive phase includes a period of inability to respond following an alarm signal (or cue), time for verification of automatic action, time for diagnosis of the situation, and time for planning of corrective action. The diagnosis is assumed to consist of identification of the accident event in relation to various pre-defined, analyzed scenarios for which procedures have been written, using "event-based" procedures common at the time the standard was drafted. Planning consisted primarily of reading the appropriate procedures. The "motor" phase consists of manual actions required by procedures, and good operating principles.

3.2. Human Reliability Models

The use of reliability analysis to evaluate risks of NPP operation is gaining wide acceptance. Increased work in this area by the NRC in the Interim Reliability Evaluation Program (IREP) has refined the use of Probabilistic Risk Assessment (PRA) techniques. The contribution of operator reliability to overall system reliability is recognized as important, and sometimes even dominant.

3.2.1. Technique for Human Error Rate Prediction (THERP)

Developed by Swain and his colleagues at Sandia National Laboratories (Ref. 14), THERP is a procedure for calculating the probability of successfully completing a task composed of chains of discrete actions. The approach is similar to that used in conventional reliability analysis, wherein a probability tree diagram is constructed, with branches depicting different events and outcomes; see Fig. 3.2. Values assigned to all events with the exception of the first are conditional probabilities. The probability of success on a given task is defined as the sum of the individual conditional probabilities for successfully executing each control action.

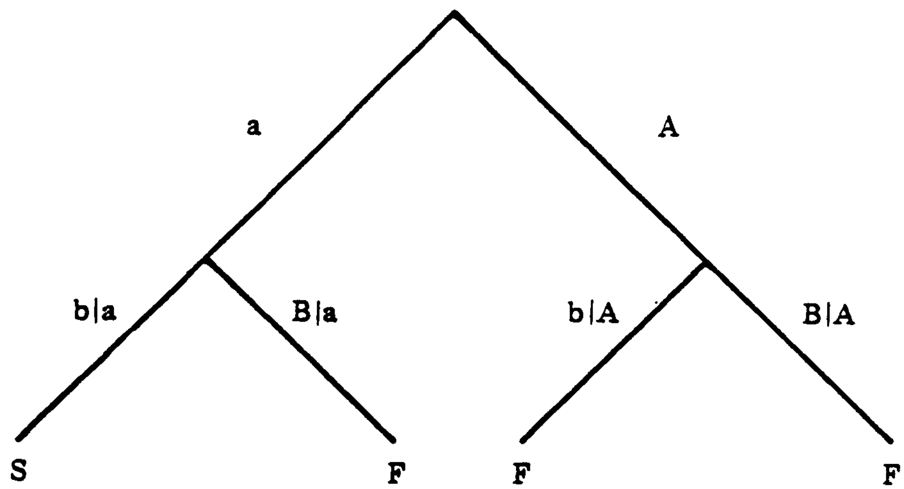
There are two problems with this method which limit its usefulness for the development of SROA design evaluation criteria.

1. The model focuses primarily on *observable* aspects of human performance, in which the operator activates, positions, moves, removes, or adjusts controls.
2. There is no provision for estimating time to complete tasks in mitigating an event.

3.2.2. Other Human Reliability Analysis (HRA) Developed by NRC

Considerable human reliability technology development and application has been undertaken in NRC sponsored research. Some of the HRA research products which are applicable to operator performance modeling include:

1. Operator Action Tree/Time Reliability Correlation, NUREG/CR-3010 (Ref. 15)
2. Maintenance Personnel Performance Simulation (MAPPS), NUREG/CR-2669 (Ref. 16)
3. Modeling of Multiple Sequential Failures During Testing, Maintenance and Calibration, NUREG/CR-2211 (Ref. 17)



a = probability of successful performance of Subtask 1

A = probability of unsuccessful performance of Subtask 1

$b|a$ = probability of successful performance of Subtask 2 given a

$B|a$ = probability of unsuccessful performance of Subtask 2 given a

$b|a$ = probability of successful performance of Subtask 2 given A

$B|A$ = probability of unsuccessful performance of Subtask 2 given A

$$Pr[S] = a(b|a)$$

$$Pr[F] = 1 - a(b|a) = a(B|a) + A(b|A) + A(B|A)$$

Fig. 3.2. THERP Fault-Tree Approach to Calculate Probabilities of Complete-Path Success (Pr [S]) and Failure (Pr [F]).

3.3. Example of Models of Human Decision Making

3.3.1. Rasmussen Model

A complement to the framework of the N660 standard is a descriptive model of the way that decisions are made. Rasmussen (Ref. 18) distinguishes three levels of performance which can be categorized in terms of the extent to which higher-order mental functions control behavior. Figure 3.3 is a schematic of the Rasmussen conceptualization of information processing. The three levels of performance are distinguished by the extent of cognitive involvement in the sequence leading from receipt of information to the execution of control actions. *Knowledge-based* is the highest level of performance in this concept. At this level, actions must be planned from analysis, and decisions are based on knowledge of the functional and physical properties of the system and the priorities of the various goals. Knowledge-based behavior (measured as performance) is required for those situations which are unplanned (and not predicted, therefore no rules or procedures exist), and occur rarely.

Rule-based performance is the most common in the operation of nuclear power plants. The decision process is one of selecting procedures based on plant state or intermediate, short-cut paths, such as initiating a task merely in light of present system state and remembered procedures. *Skill-based* performance involves the execution of a predetermined pattern of control actions whose coordination is overlearned to the point of automation. Manual control of NPP water levels falls in this area.

Rasmussen (Ref. 19) developed a model of decision making behaviors. A diagram of this model is in Fig. 3.4. Sections of this model were used for the internal processing sections of the OPPS model.

3.3.2. Models Developed or Sponsored by NRC

There are other concepts, models, methods, or techniques which should be considered applicable to the modeling of NPP operator performance. Some approaches of immediate interest are available through other NRC sponsored research in the man-machine interface and human reliability program elements of the NRC human factors program.

3.3.2.1. Man-Machine Interface

Relevant man-machine interface projects have been undertaken with NRC sponsorship. The projects of immediate relevance to OPPS are:

1. FIN NO. B0438, "Operational Aids for Reactor Operators" is being researched by ORNL and Search Technology, Inc. A gross level model of operator decision making being used in this project is provided in Fig. 3.5. This model should be compared with the OPPS model concepts relevant to operator decision making, and any advantages offered should be incorporated in future improvements of the OPPS model.

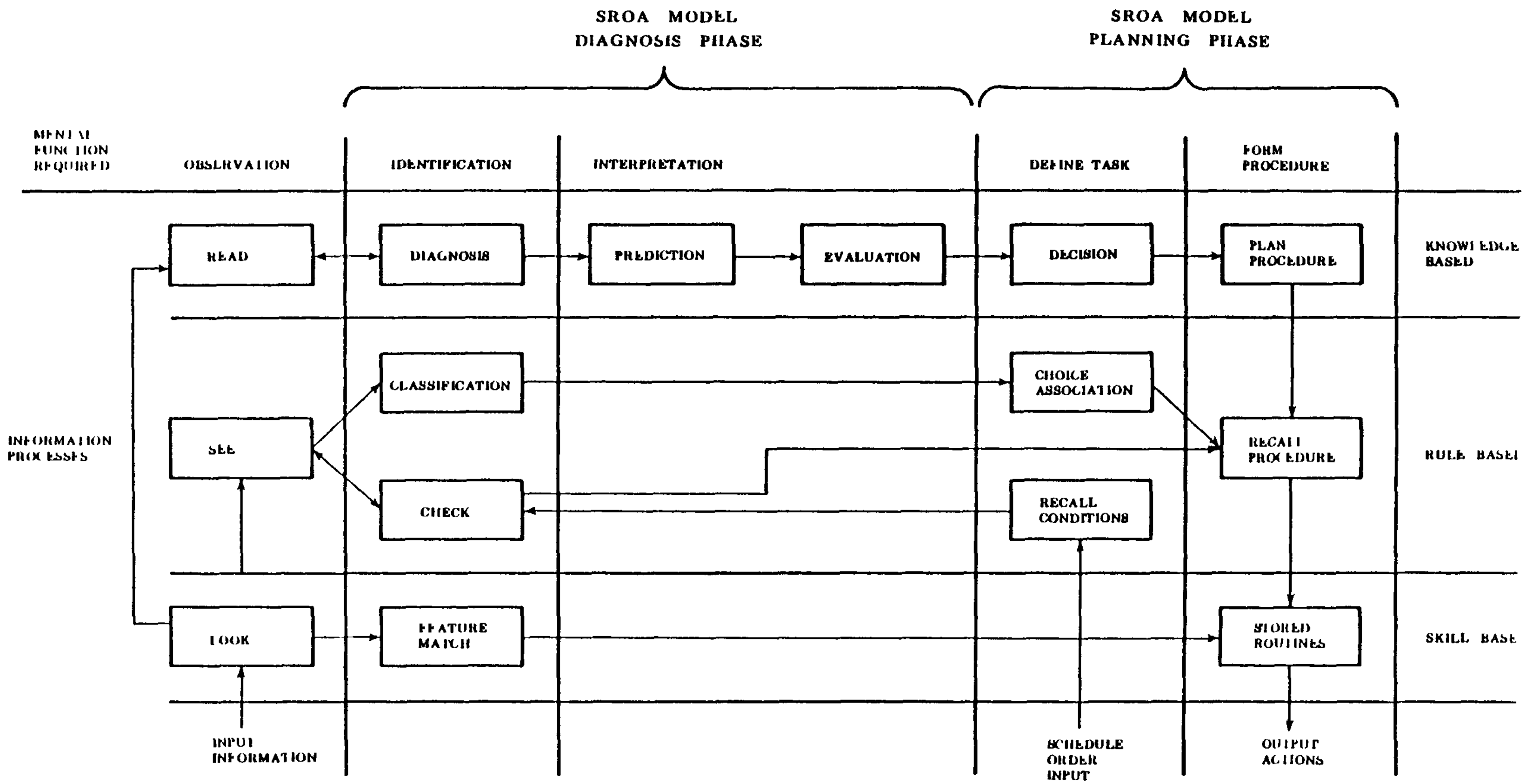


Fig. 3.3. Rasmussen Conceptualization of Behavior, Adapted to SROA. From Ref. 18.

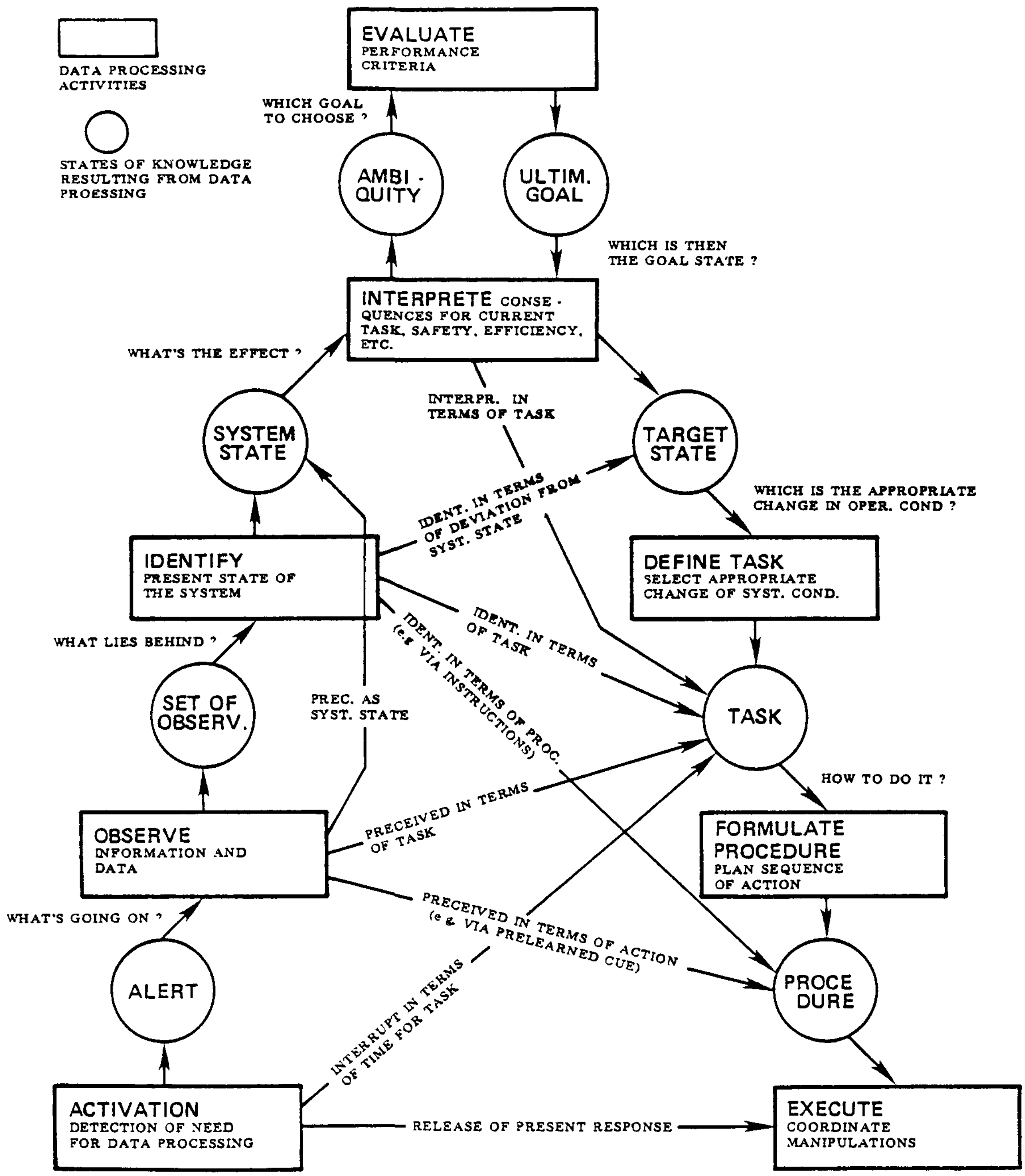


Fig. 3.4. Schematic Conceptualization of the Rasmussen Model (from Ref. 19).

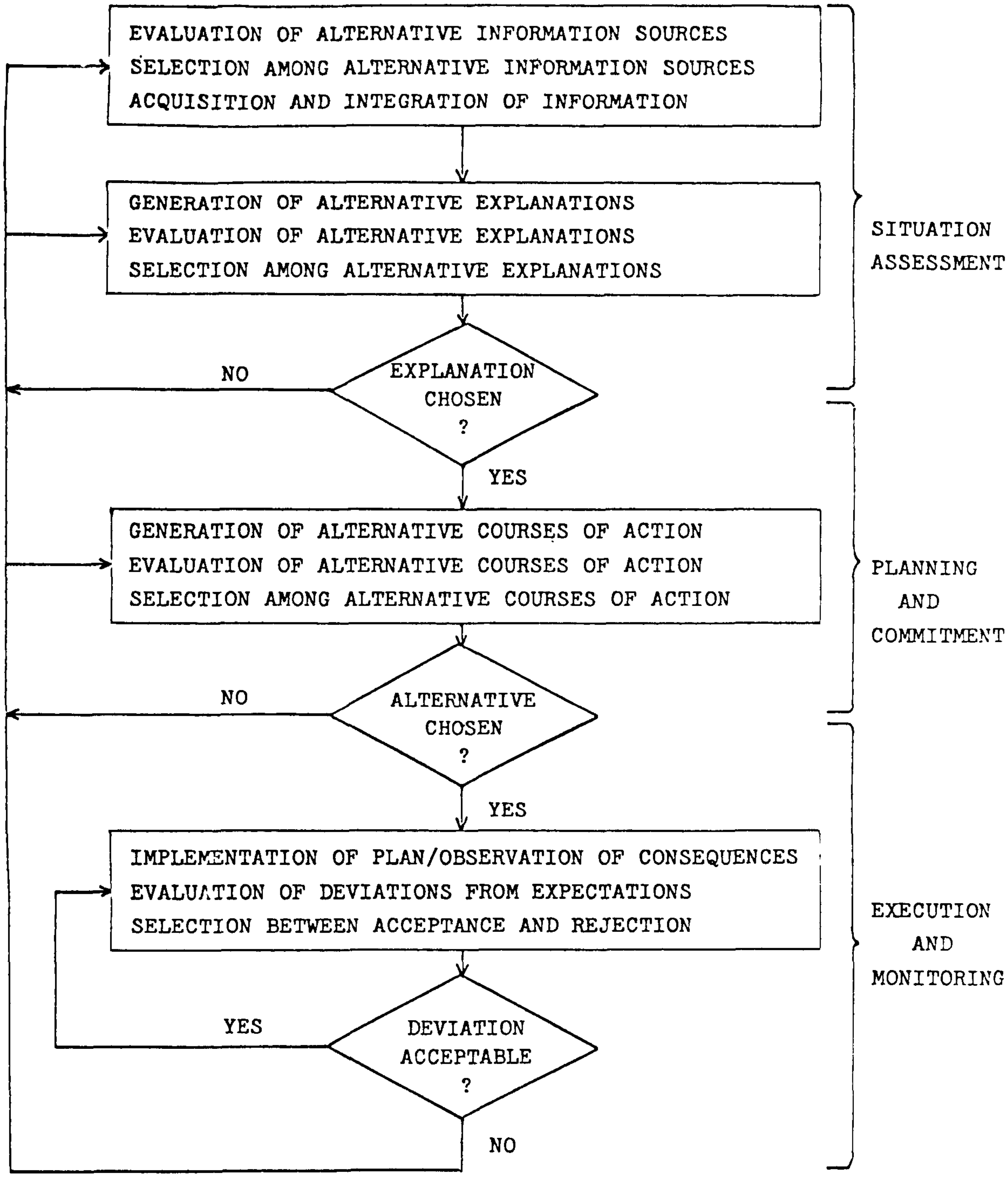


Fig. 3.5. Operator Decision Making Tasks.

From: W.B. Rouse and S.H. Rouse, A Framework for Research on Adaptive Decision Aids. Norcross, Georgia: Search Technology, Inc., Report 83-1, April 1983.

2. The task analyses methods developed under this SROA project, discussed in paragraph 2.2, were expanded in scope and depth by the NRC control room crew task analysis project (Ref. 20). These procedures and data forms were used to define the tasks and task elements which were inputs to the OPPS model. A description of these efforts is in Appendix B.

3.4. Derivation of the Operator Personnel Performance Simulation (OPPS) Model

The proposed OPPS model incorporates only the parts of the Rasmussen model that are applicable to the internal processes of the operator during an accident. Figure 3.4 illustrates the model from Reference 19. Figure 3.6 shows its use in the OPPS model. (The alert/activation nodes are incorporated in a detection phase in the OPPS model.)

The interpretation nodes were not used because development of a cognitive model was beyond the scope of this program. It is assumed that the operator functions by rule and skill more than by interpretive knowledge, especially in scenarios that might be analyzed using the OPPS model. Currently the nuclear industry is implementing symptom-based procedures, which terminate the diagnosis phase following confirmation of the system disturbance and classification of the "symptoms" of the disturbance as seen in key system parameters. This tends to replace the higher level knowledge-based behavior (trying to determine the cause of the disturbance) with rule-based behavior. The symptom-based procedures are designed as rules to direct operator action based on the symptoms of the disturbance. Also, the industry's expanded use of full-scope simulators in the training of NPP operators, and research to extend the capabilities of simulators will permit the trainees to experience a wider range of possible operating sequences, normal, abnormal, and emergency — and therefore to establish rules for successful performance and reduce the likelihood of an unforeseen event.

The reduction to time distributions of data on operator simulator performance (Ref. 10 and 11), on which a probability or reliability cut-off could be specified, suggested the combination of time and reliability as measures of operator performance. The candidate OPPS model was developed to predict probability distributions of time for correct completion of required safety-related operator actions (SROA). The probability of incorrect action, or failure to complete the actions in a specified time are also model outputs. The model combines performance measures of the nuclear industry's work on time based standards (Ref. 2) with more recent work on operator reliability (Ref. 21). The resulting composite measure can be useful to a system designer in achieving a required system reliability within design time limits. The reliability format may also be useful to a regulatory agencies, to specify cut-off criteria in design evaluation.

The details of the OPPS model, and how it was implemented in SAINT computer simulation are included in Appendix A, "The Operator Personnel Performance Simulation (OPPS) Model."

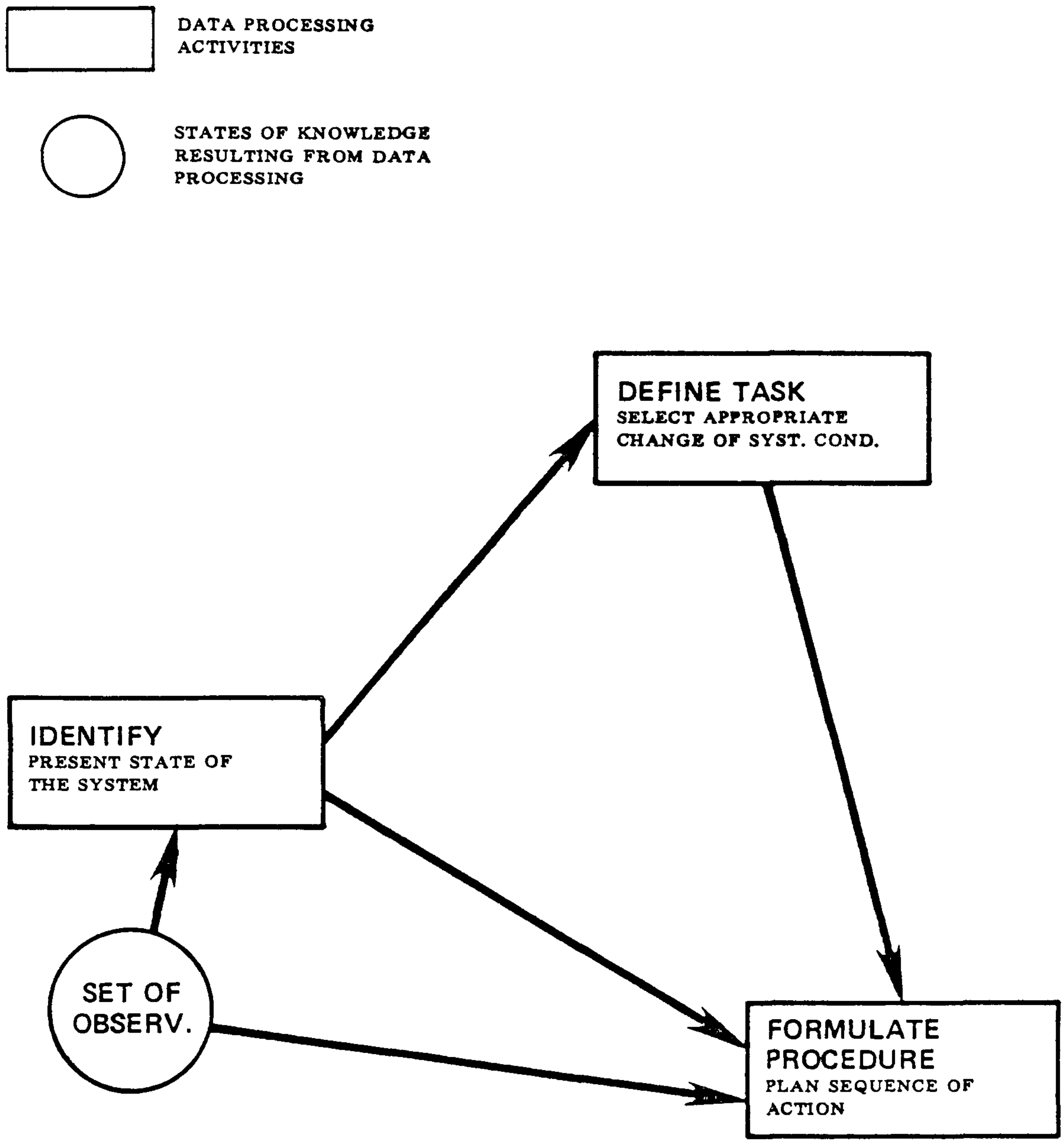


Fig. 3.6. Rasmussen's States of Knowledge and Data Processing Activities Used in OPPS Model.

4. HOW TO USE THE SROA DESIGN CRITERIA METHODOLOGY AND THE OPPS MODEL

The methods described in Section 2 can be used to identify the functions and system/human performance requirements to be allocated in new design (or redesign) and for the assignment of tasks to people and the other system elements. Here is the sequence of steps to be followed:

1. Each candidate function/subfunction being considered (e.g., the SROA: "Mitigate consequences of a main steam relief valve failed open.") would be analyzed and documented as an operating sequence.
2. For existing plants an analysis should be done to define how the design of the NPP, as revealed in the technical data (engineering drawings, functional and technical specifications, safety analysis reports, etc.) and in the procedures, has dictated the operation of the plant, and the allocation of functions among its system elements.
3. Relevant operating histories, from the same plant or similar plants, should be used to check the system/task data.
4. Simulate to provide the verification of the tasks and task elements and allow recording of precise time lines using the plant's training simulator and the PMS.
5. The OPPS model can then be used to test the proposed or existing operating sequence scenario, and to predict the reliability and variability of human performance.

With a valid, predictive model, a candidate SROA design scenario can be task analyzed and the model used to predict system/operator performance. The model outputs can provide the format for definition of SROA criteria. Comparing predicted system performance with SROA criteria leads to design approval if the SROA criteria are met. If SROA performance requirements are not met by the proposed design, feedback of organizational changes to modify performance shaping factors, or of design changes to modify the scenario task requirement, will be needed. Predicted performance of the modified system can then be evaluated for the optimal allocation of the required functions and tasks and the desired human reliability until the SROA criteria are satisfied, as shown in Fig. 4.1.

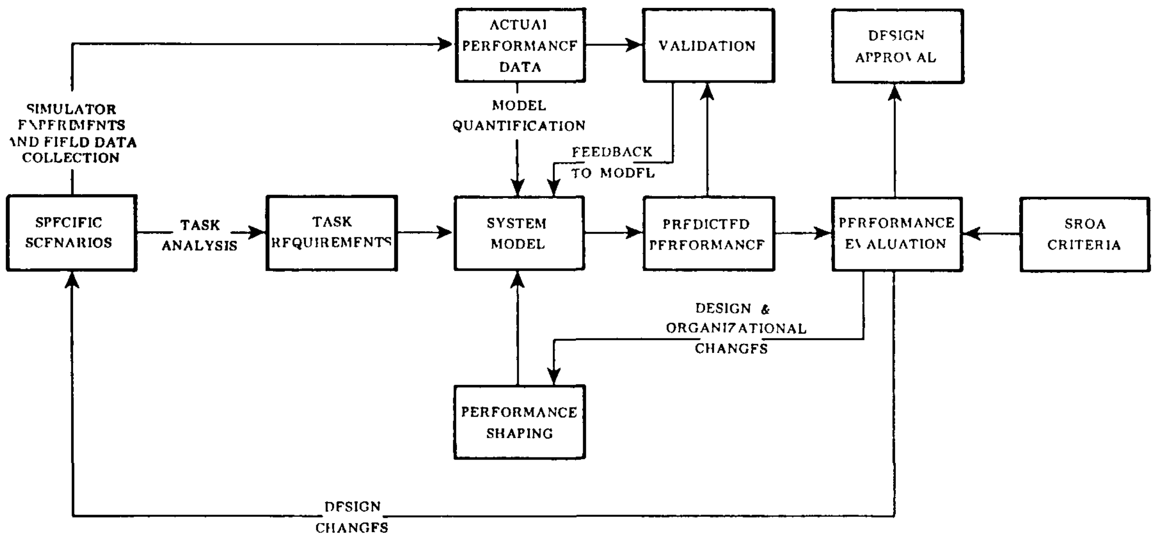


Fig. 4.1. Steps in SROA Research Leading to Design Approval.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Performance Measures

Operator response time alone is an inadequate performance measure on which to base SROA design evaluation criteria. Performance is a broad and complex issue. No single measure is likely to be adequate to capture all important facets of performance. Operator response time, procedural accuracy, and process control actions are possible criteria that may be used to judge operator performance for Safety-Related Operator Actions. A complete model to incorporate system dynamics and operator process control measures was beyond the scope of this project. Time and reliability were the performance measures developed for the OPPS model. This combination builds on previous industry work on time standards (Ref. 2), and incorporates reliability in a format compatible with Probabilistic Risk Assessment (PRA) (Refs. 14 and 21).

5.2. SROA Criteria

The use of the system/task analysis approach to structure the operating sequences and to determine the operator's and the system's performance requirements for each task and task element; the verifying of the functional allocation of the NPP system functional requirements to each system element by comparison with the actual field data of the events; and the verification runs in the training simulator, provide the system/operators performance data required to evaluate the times and actions required for any safety-related operator action. To predict other events for which there are no field data and/or to evaluate proposed designs and changes, the analyses phases and the simulator verification runs will furnish system/human performance criteria and measures which can be put into the OPPS model to obtain predictions of reliability. The OPPS model provides a visible, standardized, objective basis for establishment of such criteria. The OPPS model and methodology predict operator/system performance in the form of time-reliability distributions. Various event scenarios can be analyzed using the OPPS model, and cut-off criteria can be established at whatever level of reliability is needed to meet safety goals.

5.3. OPPS Model

Available conceptual and predictive models of operator behavior were reviewed and a hybrid model was adopted for the development of SROA design evaluation criteria. The OPPS model was represented in SAINT networks and quantified using simulator, field, and task analytic data. The OPPS model is described in Appendix A.

5.4. Data Base

Quantification of the OPPS model drew on data from all previous work reported in this project (Refs. 5—9, 12 and 13), as well as industry standards work (Ref. 2), and NRC work on operator reliability (Refs. 14 and 21—23). The values judged to be the most appropriate and reliable were selected for the quantification of each model element. Appendix A details the selection of data for model quantification. Appendix B contains the SROA field data collection plan, and samples of the task analysis data for the MSRV operating sequence.

5.5. Research Needs

The methodology for determining SROA criteria and the OPPS model presented are significant advances in predicting and measuring human performance. However, certain areas may benefit from additional research and development.

5.5.1. The OPPS Model

1. The model should be iterated for each task in the operating sequence(s).
2. The system model should be refined to include system dynamics and should be made fully interactive with all nodes of the operator model.
3. The operator cognitive model in the ANALYZE and PLAN modules needs refinement and more reliable quantification.
4. Error modes and probabilities should be incorporated in the ANALYZE and PLAN modules.
5. The crew structure in NPP control room operations should be incorporated in the model.
6. The effects of individual and administrative performance shaping factors on operator performance should be incorporated in the model.
7. The OPPS model should be subjected to a thorough validation test prior to regulatory application.
8. More research on development of performance measures is needed for refinement and more reliable quantification.

5.5.2. Human Factors Data Base

A unified Human Factors Data Base should be developed for model quantification to support design and regulatory activity.

5.6. Recommendations

1. Efforts to develop an operator performance prediction model should be continued with emphasis on iteration of each crew member for each task, and the interaction of the human element with the other system elements on each task. Along with the refinement of the human/system dynamic interactions, the effects of the system's and the individual's performance shaping factors on system/crew/individual performance should be determined and incorporated into the model.

2. A Human Factors Data Bank should be developed to provide a repository for data needed by the NRC in the Human Factors Research Program. This data bank should contain, as a minimum, the sort of information about operator actions generated in this program, i.e., system/task analysis data, field event data, simulated performance criteria and measures, and recorded and predicted human reliability data. As other normal, abnormal, and emergency events are analyzed and verified, their operating sequence scenarios and OPPS model inputs should be added to the data bank. The human factors data should be retrievable for future and continuing research and/or reporting. The data bank should be integrated with all other NRC efforts to obtain and categorize human factors data, in particular the Human Reliability Data Bank for Nuclear Power Plant operations, as described in NUREG/CR-2744 (Refs. 24 and 25).

3. A data bank of operating sequences (documented by scenarios with performance requirements, individual's task requirements, and performance measures) could aid in development of simulator licensing examinations.

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APPENDICES

APPENDIX A

THE OPERATOR PERSONNEL PERFORMANCE SIMULATION (OPPS) MODEL

APPENDIX B

SAFETY-RELATED OPERATOR ACTIONS (SROA) FIELD DATA COLLECTION PLAN

LIST OF FIGURES

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APPENDIX A

Section A.1

OPPS MODEL DEVELOPMENT

A.1 OPPS Model Development

Modeling of NPP operators' performance should be considered within the context of a systems approach to the design and evaluation of NPPs. To be used effectively in studying operator and system performance, models cannot treat the operator in isolation of other system components. Thus, conceptual models of human perception and cognition are not sufficient in and of themselves to capture the processes by which the operator and the hardware and software components of the system interact. What is needed is an operator model that interacts with different elements of the larger system model in which it is embedded, so that the various behaviors exhibited by the operator affect system variables and vice versa. The eventual goal of modeling of SROA's is to allow quantitative predictions of operator and total system performance as an analyst varies the impact or level of factors which are presumed to shape the behavior of the operator.

Developing a model for a NPP was beyond the scope of this study. The scope of this study is to concentrate on the operators' safety-related actions; therefore, a simple time delay is used to represent plant dynamics. This node model of the plant can be expanded at a later date.

A.1.1 OPPS Model Structure

The model developed for the SROA criteria draws heavily on prior modeling work by Rasmussen (Refs. 1, 2). Both organize human behavior into phases roughly described as:

(1) Stimulus organization or observation
(2) Hypothesis generation, identification, and interpretation
(3) Option selection or task definition
(4) Response execution or output actions

These four phases are organized into three major modules with an additional "Recovery" section added in the OPPS model:

(1) DETECT a disturbance
(2) INTERNAL PROCESSING of information
(3) OPERATIONS (of equipment)
(4) ERROR RECOVERY

In recognition of the fallibility of human performance, allowance is made in the OPERATIONS module for operator errors of omission and commission (Ref. 3). However, our research program has shown that operators exhibit a high error rate countered by a high recovery rate. The composite of these effects is observed in field data (Ref. 4).

A.1.2 OPPS Model Format

The end product of the SROA project is a SAINT computer implementation of the OPPS model. SAINT is an acronym for Systems Analysis of Integrated Networks of Tasks and is described in Section A.2.1 The accompanying documentation will guide a user through the steps in the use of the OPPS model:

(1) Map system design into the OPPS model using a Task Sequence Chart (TSC).
(2) Identify model inputs using Scenario Analysis Questionnaire.
(3) Quantify model inputs using the instructions for running the model.
(4) Run OPPS model in a computer simulation.
(5) Interpret OPPS model outputs.
(6) (OPTIONAL) Rerun model for graphical output.

A.1.2.1. Input Variables

The OPPS model operating instructions in A.7 structures the collection of data necessary to run the model. This covers two classes of data.

(1) Task descriptive and Performance Shaping Factor (PSF) data necessary to drive the OPPS model.
(2) Data for which OPPS model defaults exist but which may be modified at the option of the user.

Table A-1 shows examples of both types of model inputs. The complete procedure for defining model inputs is presented in Section A-7.

A.1.2.2 Output Parameters

The outputs of the OPPS model will be in the form of probability distribution for time to successful completion of operator functions involving SROAs. Figure A-1 illustrates the type of output.

Table A-1 Example OPPS Model Inputs

1.	THE TIME TO ALARM CONDITION (TIME, t , OR DISTRIBUTION)
2.	THE TIME TO SAFETY FUNCTION DEGRADE
3.	THE NUMBER OF MANIPULATIONS REQUIRED
4.	THE ERROR PROBABILITIES -DEFAULT OR ENTER
5.	THE RECOVERY PROBABILITIES - DEFAULT OR ENTER
6.	THE NUMBER OF PROCEDURES USED
7.	IS SCENARIO USED IN TRAINING? (YES OR NO)

SAINT SIMULATION PROJECT 1 BY MSRV
DATE 5/ 18/ 1983
STATISTICS TASK SUMMARY REPORT

AVERAGES OF THE STATISTICS COLLECTED FOR 2000 ITERATIONS

TASK NUMBER	TASK LABEL	STAT TYPE	COLCT POINT	AVERAGE	STD DEV	NO. ITER	MINIMUM	MAXIMUM
				--------STATISTICS ON THE AVERAGE VALUE PER ITERATION---------				
41	STOP	FIR	STA	0.1280E 04	0.9027E 02	2000	0.1012E 04	0.1462E 04
10	FIRSTRT	FIR	STA	0.7300E 03	0.5108E 02	2000	0.6304E 03	0.9450E 03
22	OPERWIN	NUM	COM	0.8920E 00	0.3105E 00	2000	0.0	0.1000E 01
33	S/SWIN	NUM	COM	0.1080E 00	0.3105E 00	2000	0.0	0.1000E 01
14	COMMIT	NUM	COM	0.0	0.0	2000	0.0	0.0
13	OMMIT	NUM	COM	0.2550E 00	0.4951E 00	2000	0.0	0.3000E 01

HISTOGRAM OF THE AVERAGE FIR STA STATISTIC FOR TASK 41 (STOP)

OBSV FREQ	RELA FREQ	CUML FREQ	UPPER CELL LIMIT	0 20 40 60 80 100
0	0.0	0.0	0.1000E 04	+
1	0.000	0.000	0.1020E 04	+
0	0.0	0.000	0.1040E 04	+
1	0.000	0.001	0.1060E 04	+
9	0.004	0.005	0.1080E 04	+
7	0.003	0.009	0.1100E 04	+
27	0.013	0.022	0.1120E 04	+*
43	0.021	0.044	0.1140E 04	+*
66	0.033	0.077	0.1160E 04	+**
105	0.052	0.129	0.1180E 04	+***
112	0.056	0.185	0.1200E 04	+***
159	0.079	0.265	0.1220E 04	+****
170	0.085	0.350	0.1240E 04	+****
179	0.089	0.439	0.1260E 04	+****
158	0.079	0.518	0.1280E 04	+****
146	0.073	0.591	0.1300E 04	+****
159	0.079	0.671	0.1320E 04	+****
130	0.065	0.736	0.1340E 04	+***
116	0.058	0.794	0.1360E 04	+***
82	0.041	0.835	0.1380E 04	+**
100	0.050	0.885	0.1400E 04	+**
105	0.052	0.937	0.1420E 04	+***
87	0.043	0.981	0.1440E 04	+**
28	0.014	0.995	0.1460E 04	+*
10	0.005	1.000	0.1480E 04	+
0	0.0	1.000	0.1500E 04	+
0	0.0	1.000	0.1520E 04	+
0	0.0	1.000	INF	+

2000				0 20 40 60 80 100

HISTOGRAM OF THE AVERAGE FIR STA STATISTIC FOR TASK 10 (FIRSTRT)

OBSV FREQ	RELA FREQ	CUML FREQ	UPPER CELL LIMIT	0 20 40 60 80 100
0	0.0	0.0	0.6000E 03	+
0	0.0	0.0	0.6100E 03	+
0	0.0	0.0	0.6200E 03	+
0	0.0	0.0	0.6300E 03	+
8	0.004	0.004	0.6400E 03	+
48	0.024	0.028	0.6500E 03	+*
61	0.030	0.058	0.6600E 03	+**
86	0.043	0.101	0.6700E 03	+**
121	0.060	0.162	0.6800E 03	+***
150	0.075	0.237	0.6900E 03	+****
151	0.075	0.312	0.7000E 03	+****
152	0.076	0.388	0.7100E 03	+****
155	0.077	0.466	0.7200E 03	+****
153	0.076	0.542	0.7300E 03	+****
129	0.064	0.607	0.7400E 03	+***
121	0.060	0.667	0.7500E 03	+***
134	0.067	0.734	0.7600E 03	+***
98	0.049	0.783	0.7700E 03	+**
111	0.055	0.839	0.7800E 03	+***
82	0.041	0.880	0.7900E 03	+**
51	0.025	0.905	0.8000E 03	+*
55	0.027	0.933	0.8100E 03	+*
37	0.018	0.951	0.8200E 03	+*
31	0.015	0.967	0.8300E 03	+*
19	0.009	0.976	0.8400E 03	+
15	0.007	0.983	0.8500E 03	+
3	0.006	0.990	0.8600E 03	+
5	0.002	0.992	0.8700E 03	+
6	0.003	0.995	0.8800E 03	+
5	0.003	0.998	0.8900E 03	+
0	0.0	0.998	0.9000E 03	+
1	0.000	0.999	0.9100E 03	+
1	0.000	0.999	0.9200E 03	+
0	0.0	0.999	0.9300E 03	+
0	0.0	0.999	0.9400E 03	+
1	0.000	1.000	0.9500E 03	+
0	0.0	1.000	0.9600E 03	+
0	0.0	1.000	0.9700E 03	+
0	0.0	1.000	0.9800E 03	+
0	0.0	1.000	0.9900E 03	+
0	0.0	1.000	0.1000E 04	+
0	0.0	1.000	INF	+

2000				0 20 40 60 80 100

Figure A-1 OPPS Model output (SAINT Simulation).

APPENDIX A

Section A.2

PROPOSED OPPS MODEL

A.2 Proposed OPPS Model

SROA criteria can be based on a scenario dependent model. The scenario of an operating sequence begins with the plant in normal operations. This condition is upset by a malfunction which challenges the safety limits of the plant. The operator works to support and supplement the automated plant systems in order to return the plant to a condition of stable operation. The operator actions are modeled in parallel with a representation of plant dynamics. In the current model the plant is modeled as a simple time delay representing the time from the malfunction to the time at which safety limits are exceeded if required operator actions are not successfully completed.

A.2.1 Modeling With SAINT

Systems Analysis of Integrated Networks of Tasks (SAINT) is explained by Seifert (Ref. 5). It is not a model, but rather a computer simulation language for modeling and analyzing man-machine systems. SAINT provides both the structural framework for quantitative implementation of any conceptual models and the means of implementing the model into digital computer Monte Carlo simulation. SAINT evolved from two separate technologies: task analysis and the Monte Carlo simulation of operator performance developed by Siegel and Wolf (Ref. 6). A system is represented in SAINT symbology as a network of nodes. Each node represents a task element and the various task characteristics (e.g., time of performance, priority, and requirements) attributed to it. Branches between nodes indicate relationships and task flow through the network.

The OPPS Model developed in this project was input into a SAINT network shown graphically in Section A.3. The specific rules governing the network structure are contained in the SAINT Users Manual (Ref. 7). The branching between nodes may be represented conditionally, probabilistically, or deterministically. By combinations of these branches, driven by model user input variables, the SAINT network of the OPPS Model is tailored to a specific design evaluation problem.

For each SAINT node representing operator action, a time distribution is assigned. These distributions were developed from simulator and task analysis data on operator time responses in dealing with plant disturbances. The use of Monte Carlo simulation to randomly compute time for each node, and sum total time through all operator action nodes yields a probability distribution of time to complete required safety-related operator actions. This time is compared to the system dynamics, which limit time available for successful functioning of the system, and yield a probability distribution of time for successful functioning of the system.

A.2.2 Model Structure

The OPPS Model has been developed to have the operator treat a disturbance in four phases. Each of these phases is briefly described here, with further explanation in Section A-6.

OPPS Model Phases:

(1) DETECT a disturbance
(2) INTERNAL PROCESSING of information
(3) OPERATIONS (of equipment)
(4) ERROR RECOVERY

Figure A-2 shows the general structure of the model. Figure A-3 shows the OPPS model detail. Two parallel branches model operator actions and plant dynamics respectively. The two branches are not interactive in the current model.

A.2.2.1 DETECT Phase

The operator detects the disturbance either prior to alarm annunciation or afterwards. The model selection between the two mechanisms is dependent upon the time from disturbance initiation to alarm annunciation, the indication or instrumentation upon which the operator would key his detection, and a probability of detection prior to the audible alarm.

Pre-alarm detection behavior has been noted in previous research (Ref. 8) when the time between the start of a malfunction and the alarm is greater than a few seconds. Detection seems to be related to the type of indication available to the operator prior to the alarm. If the indication which deviates because of the malfunction is used by the operator to derive an overall measure of plant performance, we call this a "high level" indication. High level indications are described further in Section A.5.1. If one of these indications is affected by a plant malfunction, there is a small but finite probability of pre-alarm detection. Also, if the disturbance develops very slowly, so that pre-alarm indication is available on instrumentation that is logged and reviewed periodically, there is a higher probability of pre-alarm detection.

Normally, detection occurs when an alarm is annunciated. Detection of a disturbance following an audible alarm, with a flashing legend light is essentially instantaneous. No time delay is used to model this behavior, since it would be in the range of milliseconds. Based on observations made during previous simulator experiments, no provision for errors in detection are modeled. The DETECT Phase of the OPPS model is represented in flow chart form in Figure A-4.

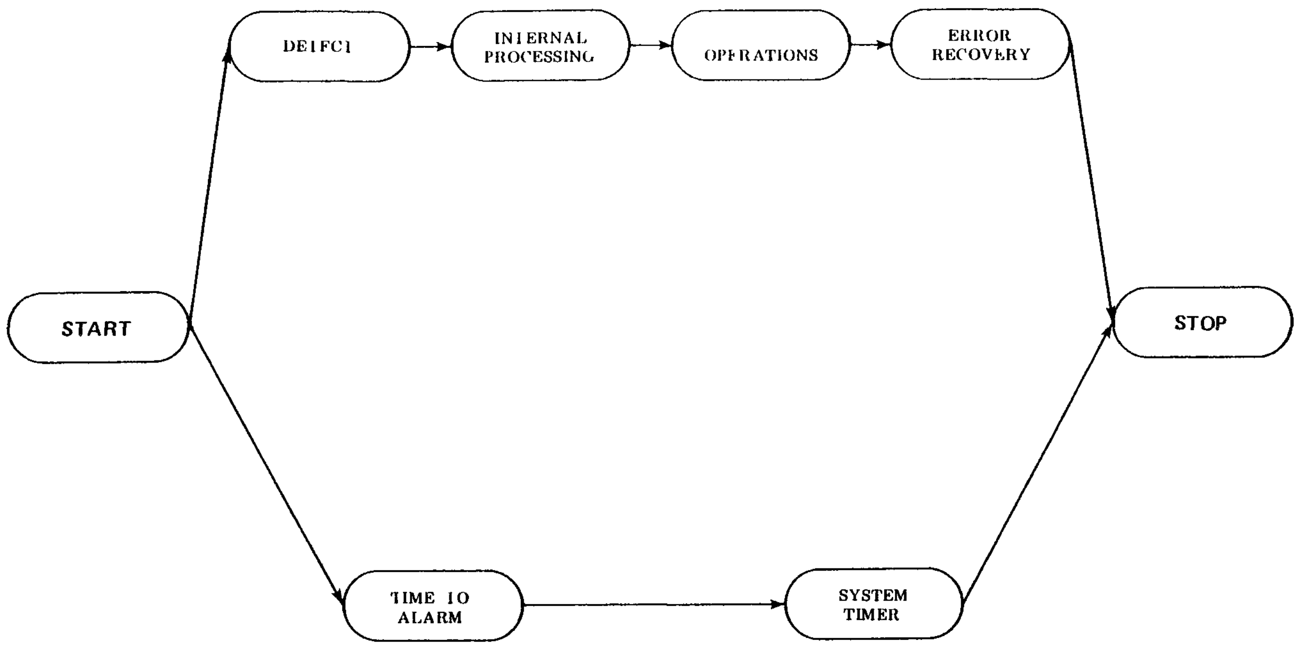

Figure A-2 General structure of OPPS model.

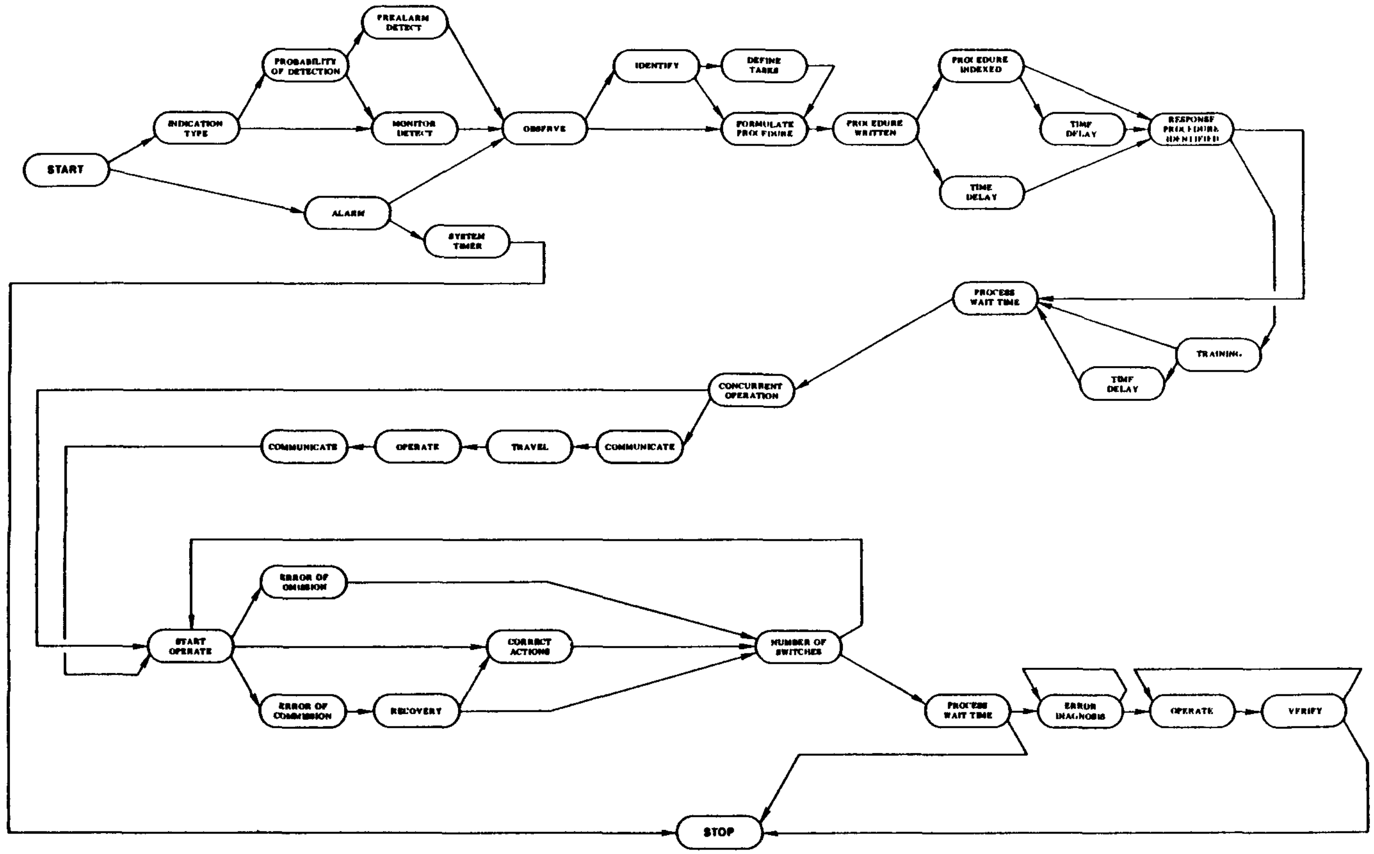

Figure A-3 OPPS Model - Detail

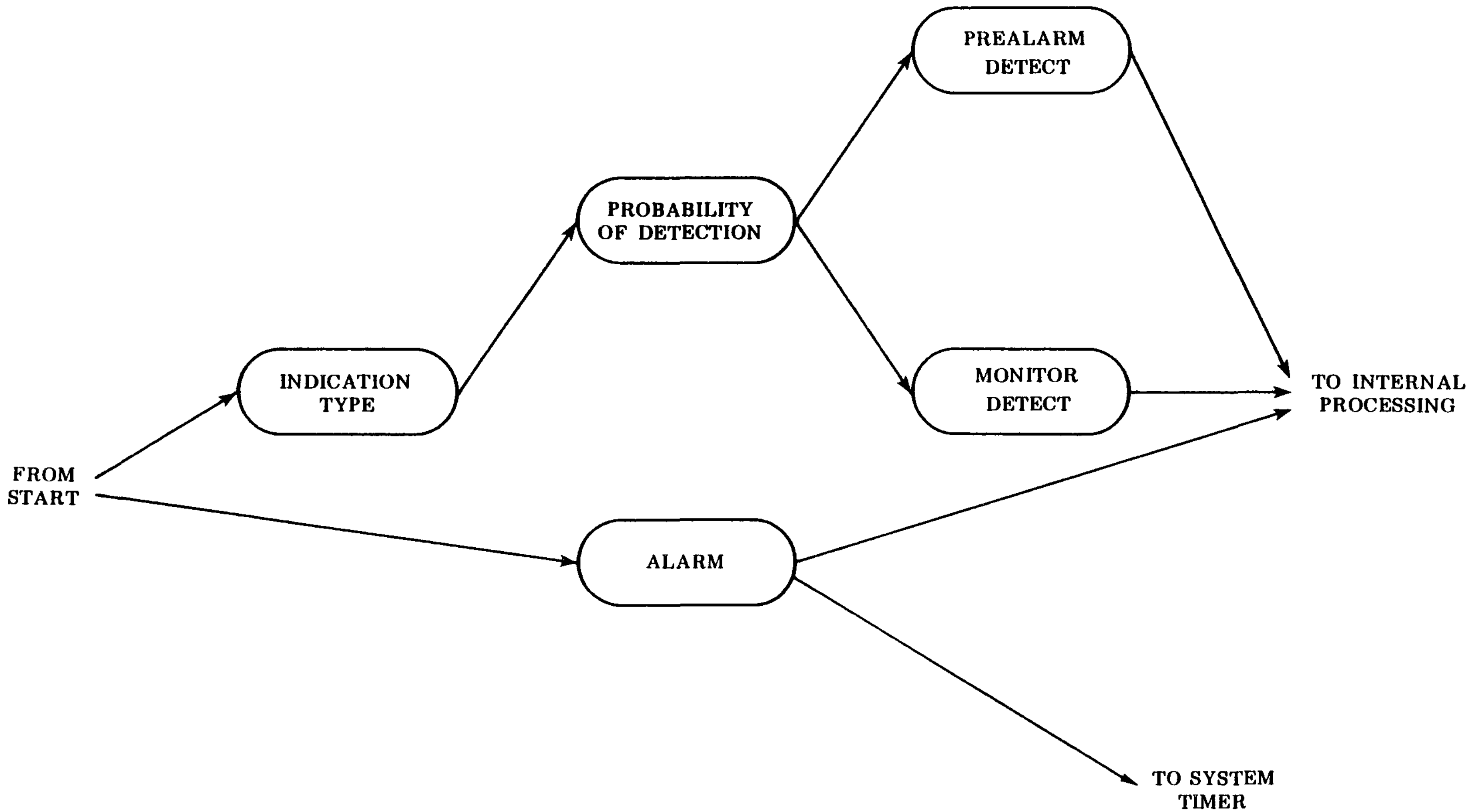

Figure A-4 Structure of DETECT phase of OPPS model.

A.2.2.2 INTERNAL PROCESSING Phase

After a malfunction has been detected the cognitive processes of the operator are considered (Figure A-5). The model behind this process is based on the Rasmussen model of human decision sequence (Ref. 2).

The **OBSERVE** node is the first encountered after the detect phase. It represents the time taken to gather data for diagnoses of the alarms. If this data points to a specific malfunction for which specific training has been conducted, the model activates the **FORMULATE PROCEDURE** node which is expanded in Figure A-6 and will be discussed later. If the data suggests a more general disturbance, then the **IDENTIFY** node is called. The **IDENTIFY** node represents the time needed by the operator to verify and classify plant indications of the disturbance and diagnose the nature and severity of the problem. Following disturbance identification, two paths are available. The first path leads to the **DEFINE TASK** node. **DEFINE TASK** is performed when the root cause of a problem must be identified in order to select plant procedures for response to the malfunction. If symptoms were identified and the malfunction can be combatted from these symptoms, the model goes to the **FORMULATE PROCEDURE** node. The quantification of time distributions for these behaviors was provided by task analysis data. No errors in cognitive behavior are modeled due to the complexity of cognitive errors. However, treatment of decision errors is needed to make the OPPS model more useful in PRA studies.

The **FORMULATE PROCEDURE** node takes an average time to read the procedures and incorporates performance shaping factors (PSF) for procedures to predict the total time spent on procedures formulation. The PSFs used are:

(1) Written Procedures
(2) Indexed Procedures
(3) Response Procedure Specified From Analysis Procedure
(4) Procedures Used In Training

The PSFs are utilized to impose on the operator a fixed time delay of 1 minute for not having a written procedure, not having indexed procedures, not specifying a response procedure in the analysis procedure, or not using the procedure in training. The model thus allows from one to five minutes for procedures formulation.

A.2.2.3 OPERATIONS Phase

The first branch in the operations module is to determine if auxiliary operator actions (remote to the control room) are required. Figure A-7 illustrates this section of the **OPERATIONS** phase. Possible alternative branching in this module is decided by the following questions:

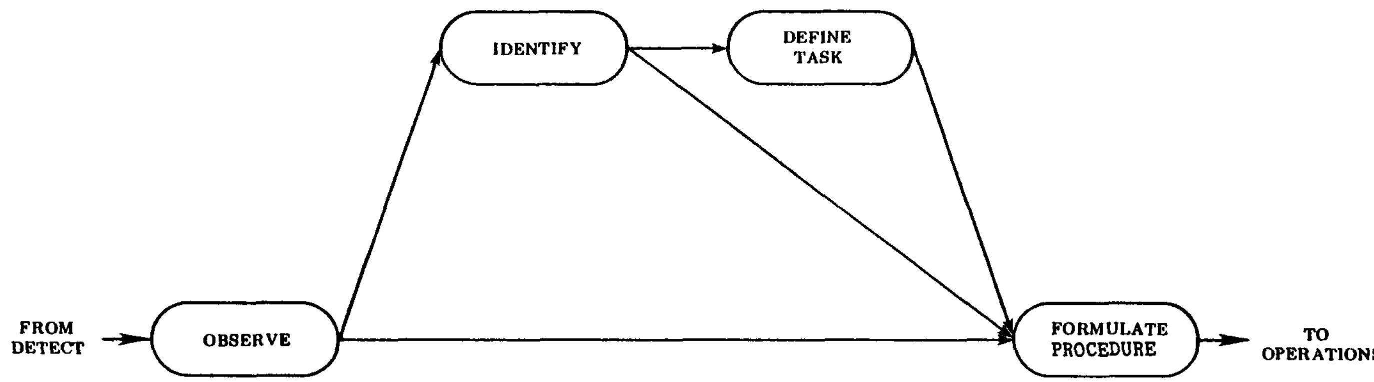

Figure A-5 Internal process phase from the OPPS model.

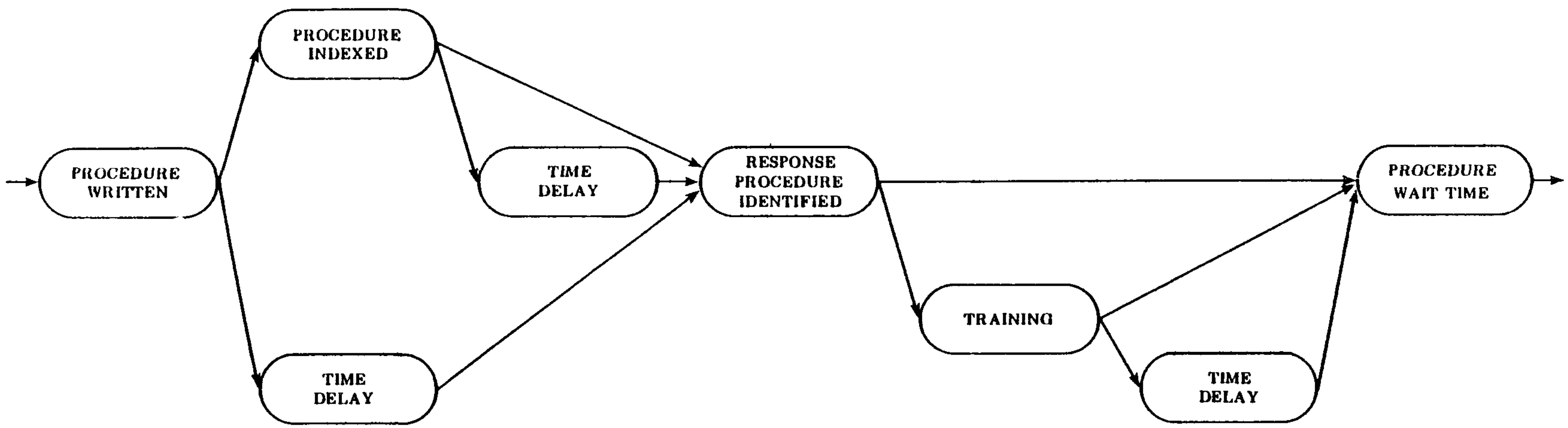

Figure A-6 Expansion of **FORMULATE PROCEDURE** node.

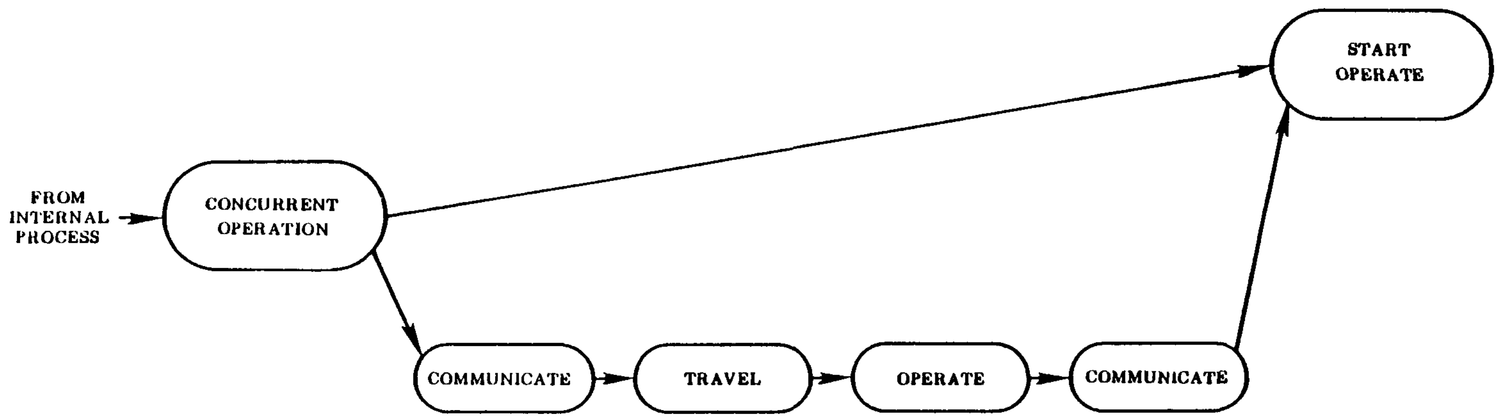

Figure A-7 Remote operations section of **OPERATIONS** phase.

(1) Are auxiliary operator/remote actions required?

(2) Are these actions concurrent or consecutive with control room operations?

If auxiliary actions are required and they cannot be performed concurrent to control room actions, then an estimated time to **COMMUNICATE**, **TRAVEL** to the remote work station, **OPERATE** equipment and **COMMUNICATE** the results to the control room operator is added to the total time in the OPPS model for operator performance time. No provision is made in the current model for errors by auxiliary operators.

The control room operations phase of the model is illustrated in Figure A-8. This is a simplified composite of the operator model in the N660 standard (Ref. 9) and the human error model used in THERP (Ref. 10). The operate module is a loop which iterates until each required SROA is completed (or missed). This model assumes a procedure directed sequence of operator actions: rule based behavior in the Rasmussen model (Refs. 1 & 2).

Operator error is incorporated in the model. For each action, an **ERROR OF OMISSION** (skipping the action), or **ERROR OF COMMISSION** (doing something else in error) is possible. Based on simulator data showing a high rate of immediate recovery for errors or commission, an immediate **RECOVERY** step is built into the model following that type of error. Data for branching probabilities as well as time distributions for the nodes come from previous simulator experiments (Ref. 3, 8).

The model simulates the operator progressing through the required sequence of actions. The operations module is finished when the count loop is complete. At this stage the sequence may still contain uncorrected errors.

To allow for hardware delay time built into the safety systems, an additional **PROCESS WAIT TIME** node is added to the exit of this module, shown in Figure A-9. This is to account for delays in the execution of the task sequence caused by such factors as valve cycle time in critical path operations.

A.2.2.4 Recovery Phase

Following the completion of the **OPERATIONS** Phase there may be uncorrected errors which prevent successful system functioning. The **ERROR RECOVERY** Phase of the model, shown in Figure A-9, provides for the probabilistic detection of these errors in the **ERROR DIATNOSIS** node provided enough time is available. If an error is detected, the model assumes all errors will be detected due to the alerted condition of the operator. Detected errors are assumed to be corrected in the model without further error in an **OPERATE/VERIFY** loop.

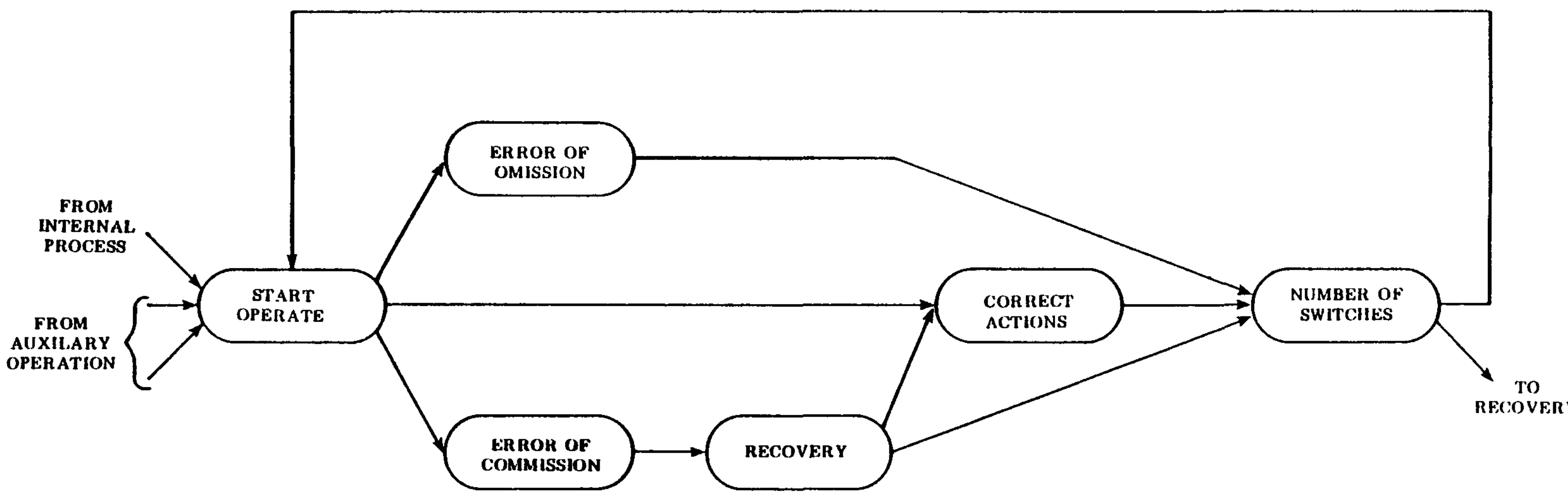

Figure A-8 **OPERATIONS** phase of the OPPS model.

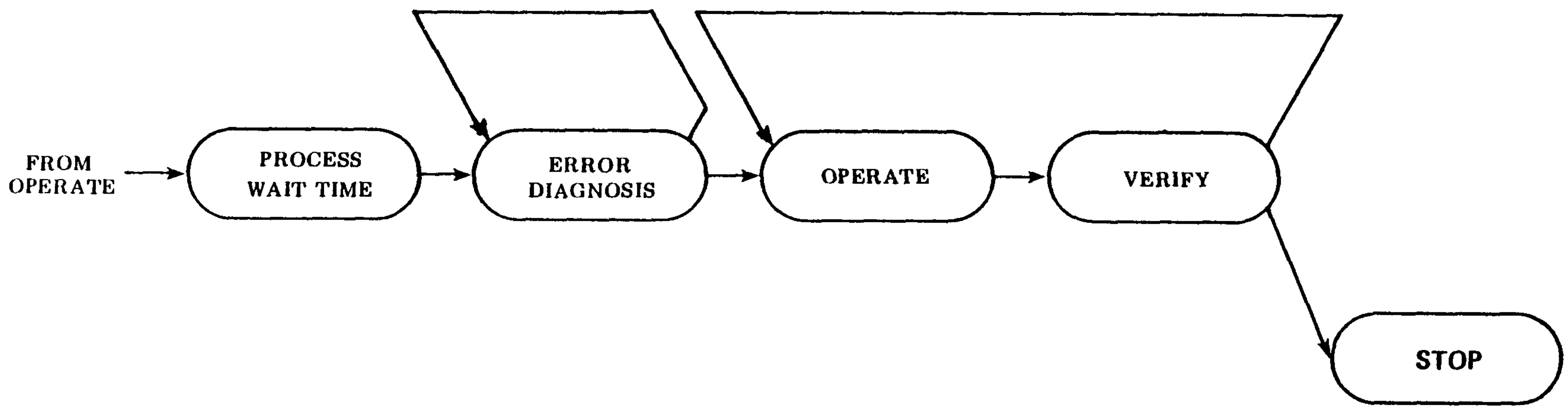

Figure A-9 OPPS Model: **ERROR RECOVERY** Phase.

A.2.3 Model Quantification

During the SROA project, a data base on operator performance to support both the structure and the quantification of the OPPS model was assembled. These data were collected on plant specific disturbances. The data had to be reduced to extract information about specific task elements or "building blocks" of operator performance which in composite form the operator response. The OPPS model provided the structure for identifying and extracting the appropriate data. Section A.4 details the development of data sets for each element in the OPPS model.

A.2.3.1 Operator Response Time

Data on operator response times were obtained primarily from the task analysis of simulator scenarios in this project. The use of the Berliner verb categorization (Ref. 11) for defining behavior elements was the principal tool in the extraction of time response data from the task analysis studies. The Berliner categorization was used in analyzing the PWR (Ref. 12), BWR (Ref. 8), and NRC (Ref. 13) crew task analysis data bases. Through the use of the Berliner Classification of Behaviors, time or duration was determined for processes, activities, and specific behaviors. The Berliner terms, shown in Table A-2, code behavior at a very specific level of detail, e.g., communications within view versus communications outside the control room.

The major data reduction technique was the use of sorts by Berliner code, start time, and stop time. Using these three data, it was possible to develop distribution statistics for the duration of, or the time spent at a particular Berliner code (on a particular kind of task element). These distributions were used to quantify elements in the OPPS model. Table A-3 illustrates some of these data used in the OPPS Model. Section A.3 shows the specific application of task analysis data to OPPS model quantification.

Table A-2 Current classification of behaviors adapted from Berliner (Reference 20)

Processes	Activities	Specific Behaviors
1. Perceptual	1.1 Searching for and Receiving Information	1.1.1 Inspects 1.1.2 Observes 1.1.3 Reads 1.1.4 Receives
	1.2 Identifying Objects, Actions, Events	1.2.1 Identifies 1.2.2 Locates
2. Cognitive	2.1 Information Processing	2.1.1 Calculates 2.1.2 Interpolates 2.1.3 Tabulates
	2.2 Problem Solving and Decision Making	2.2.1 Analyzes 2.2.2 Calculates 2.2.3 Chooses 2.2.4 Compares 2.2.5 Plans 2.2.6 Verifies
3. Communication	 3.1 Within View 3.2 Not Within View 3.3 Outside Control Room	3.-.1 Answers 3.-.2 Communicates 3.-.3 Directs 3.-.4 Informs 3.-.5 Instructs 3.-.6 Requests 3.-.7 Records
4. Motor	4.1 Simple/Discrete	4.1.1 Activates 4.1.3 Positions 4.1.2 Moves 4.1.4 Removes
	4.2 Complex/Continuous	4.2.1 Adjusts 4.2.2 Balances 4.2.3 Touches

A.2.3.2 Operator Reliability

In order to incorporate operator reliability in the OPPS Model, general values for the Human Error Probability (HEP) for specific error types was needed. The THERP technique, discussed in Section 3 was incorporated in a general form. The data used were drawn from the work by Swain and Guttman assembled in NUREG-1278 (Ref. 10). These data were augmented by error data from simulator experiments in the SROA project and special simulator experiments conducted for Sandia National Laboratories (Ref. 3) to evaluate HEPs for NPP operational tasks.

Table A-3 Distribution sets used for the OPPS Model Network (units in seconds).

Verb Set	Type of Distribution	Mean	Standard Deviation	Minimum Value	Maximum Value
1. Observe, Store	Normal	13.35	12.3	1.15	45.0
2. Read	Normal	1.51	1.06	0.76	2.5
3. Locate, Identify	Normal	3.83	3.83	0.07	12.0
4. Calculate, Verify, Evaluate	Normal	26.59	13.88	5.0	55.0
5. Recall	Normal	11.90	2.03	0.30	67.0
6. Predict, Plan, Decision, Choice, Condition	Normal	32.7	15.26	8.0	60.0

APPENDIX A

Section A.3

OPPS MODEL - QUANTITATIVE DATA SOURCES

Table A-4

BRANCHING PROBABILITIES

From	TO	VALUE	Data Source
1. Probability of Detection	a) Pre-alarm Detect	.0001*	Default (user input)
	b) Monitor Detect	.9999*	
2. Start Operate	a) Omission	.0341*	NUREG/CR-3309 (Ref.3)
	b) Correct Action	.96274*	
	c) Commission	.00316*	
3. Commission Recovery	a) Commission Counter	.133	NUREG/CR-3309 (Ref. 3)
	b) Correct Action	.867	
4. Recovery Diagnose/ Plan	a) Recovery Diagnose/Plan	Decreasing from .99 by .05	NUREG/CR-1278 (Ref. 10)

*Default value

Table A-5

TIME DISTRIBUTION

Saint Node	Data Source	Distribution Set (SEC) $\bar{X}$	s	min.	max.
Pre-Alarm Detection	Task Analysis*	60	0	60	60
System Timer	User Input	N/A			
Alarm	User Input	N/A			
Monitor Detect	User Input	N/A			
Observe	Task Analysis	16.5	7.6	4	73
Identify	Task Analysis	31.6	3.2	26.4	37.84
Define Task	Task Analysis	3.8	3.8	.07	12.3
Formulate Procedure	Task Analysis	10	2.5	5.9	14.1
Time Delays	Author**	60	0	60	60
Procedure Wait	User Input	N/A			
Communicate	Author**	180	0	180	180
Travel	Author**	300	0	300	300
Aux Operate	Author**	11.9	20.3	1	70
Commission	Task Analysis	11.9	20.3	1	70
Operate	Task Analysis	11.9	20.3	1	70
Process Time Wait	User Input	N/A			
Recovery Diagnose/Plan	Task Analysis***	48.1	20.75	31	110
Operate	Task Analysis	11	9.20	31	70

*Task Analysis References 12 and 8.
**Author assigned defaults.
***Sum of Distribution 5 and 6 $\bar{X}$ and s.

APPENDIX A

Section A.4

OPPS MODEL - SCENARIO ANALYSIS QUESTIONNAIRE

The scenario is ____________________

The OPPS is ____________________

OPPS Scenario Analysis Questionnaire

Prealarm Phase

1. What is the probability of detecting the malfunction prior to the annunciator (default .0001) __________

2. What is the average time from disturbance initiation to alarm annunciation (conventional audible alert and light box)? (range 0 to xxxx seconds) ______ sec.

3. Is the pre-alarm indication of the disturbance a high level indication monitored continuously (e.g. MWe output)? Y or N

4. Is the pre-alarm indication logged or reviewed periodically? Y or N

   If yes at what frequency (i.e. hourly, daily, etc.)? __________

Diagnosis Phase

5. Is the alarm annunciator legend associated with a specific condition or does it identify a general disturbance requiring more complex analysis?

   general or specific

6. How many indications are specified in procedures to diagnose the disturbance? ________ #

7. Is the diagnosis terminated at the symptom level, or extended to the root cause?

   symptom or root cause

Planning Phase

8. Are the procedures written? Y or N

9. Are procedures indexed? Y or N

10. Are the procedures memorized as part of the immediate actions of a sequence? Y or N

11. Is the scenario used in training? Y or N

12. How many procedures are used? ________ #

Operations Phase

13. What is the aggregate time delay before the procedure or procedure steps can begin? ______ sec.

14. How many operations are performed by control room operators? ________ #

15. Are switch operations to be performed remote from the main control room? Y or N

16. Are remote operator actions performed concurrently with the control room operator's actions? Y or N

17. How many operations are performed by remote operators? ________ #

18. What is the aggregate equipment delay time embedded in the procedure. ______ sec.

19. What is the expected average commission error probability? (default .00316 or enter #) __________

20. What is the expected average omission probability (default .0341 or enter #) __________

Process

21. What is the average time delay from alarm condition to violation of safety limits (i.e. before which the operators must complete their action)? ______ sec.

    Note:
    This limit should be based on estimates which take into account the variables of the scenario being evaluated.

FOR USE WITH SAINT

```
*P.:*
//BEKSAINT JOB (21722,I8),'SAVE6522,72 BIN C',TIME=(1,30),MSGCLASS=A
/*JOBPARM LINES=10,CARDS=1000
/*ROUTE  PRINT RMT45
// EXEC FORTHCLG,PARM.FORT=MAP,PARM.LKED='OVLY,LIST',LIB=FORT,
// GOSIZE=384K
//FORT.SYSIN DD *
```

*** * * USER FUNCTIONS GO HERE * * ***

```
//LKED.HEXLIB DD DSN=TZA.SAINT.HEX1,DISP=(OLD,KEEP),UNIT=3330-1,
// VOL=SER=ZX4444
//LKED.SYSIN DD *
      ENTRY MAIN
      INCLUDE HEXLIB
      OVERLAY ALPHA
      INSERT ATASS,BETAXF,BUILD,CNCVT,CONDIT,CVT,DATIN,DET,DFAUS,DFAUT
      INSERT DISTR,DMODS,DSWT,ECHO,ECHOS,ERRIN,GEN,GTCHAR,IMODFN,INIT
      INSERT INITS,IRATT,ISATT,MAP,MODFN,MONIT,LPACK,LLABL,MSWT
      INSERT MTASK,NMOD,PERTXF,PLOTS,PNABA,POP,OUTPT,PROB,RCLEAR,REG
      INSERT SGEN,SSTAT,STATT,TASK,TCLEAR,UCOLL,UHSTO,UINPT
      INSERT UPLTS,UTIME,UVAR,VAR
      OVERLAY ALPHA
      INSERT ATSET,COLST,ENDIT,FILEM,GASP,GETIA,GETPR,GETRA,GETSA
      INSERT GETTC,HISTO,MODRF,NFIND,PRIOR,PUTIA,PUTPR,PUTRA,PUTSA
      INSERT PUTTC,QRANK,RMOVE,RPLOT,SCHAT,SCHED,SCOND,SSAVE
      INSERT TIMEQ,TMARK,UPDATE,USERF
      OVERLAY ALPHA
      INSERT SUMRY,UOTPT
//GO.FT07F001  DD  DUMMY
//GO.FT01F001 DD DSN=&&TAPE1,UNIT=SYSDA,
//  DISP=(NEW,DELETE),DCB=(LRECL=136,BLKSIZE=3724,RECFM=VBS),
//  SPACE=(2400,136)
//GO.FT02F001 DD DSN=&&TAPE2,UNIT=SYSDA,
//  DISP=(NEW,DELETE),DCB=(LRECL=136,BLKSIZE=3724,RECFM=VBS),
//  SPACE=(2400,136)
//GO.FT03F001 DD DSN=&&TAPE3,UNIT=SYSDA,
//  DISP=(NEW,DELETE),DCB=(LRECL=136,BLKSIZE=3724,RECFM=VBS),
//  SPACE=(2400,136)
//GO.FT04F001 DD DSN=&&TAPE4,UNIT=SYSDA,
//  DISP=(NEW,DELETE),DCB=(LRECL=136,BLKSIZE=3724,RECFM=VBS),
//  SPACE=(2400,136)
//GO.FT08F001  DD  UNIT=SYSDA,SPACE=(CYL,(1,1))
//GO.FT09F001 DD DSN=&&TAPE9,UNIT=SYSDA,
//  DISP=(NEW,DELETE),DCB=(LRECL=136,BLKSIZE=3724,RECFM=VBS),
//  SPACE=(2400,136)
//GO.FT05F001  DD *
```

OPPS Model SAINT Code

```
GEN,SROA0,5,18,1983,1,2000,1,98529994,,Y
POP,,,9,10,,,,2*
OUT,1,1,,,,,,,,,,,,Y,N,Y*
DIS,1,CO,.15*
DIS,2,CO,.85*
DIS,3,CO,1380.*
DIS,4,NO,16.5,4.,73.,17.59*
DIS,5,NO,31.62,26.4,36.84,3.16*
DIS,6,NO,3.83,.07,12.,3.83*
DIS,7,NO,10.,5.86,14.14,2.51*
DIS,8,NO,11.9,1.0,70.,20.3*
DIS,9,NO,48.12,31.03,110.01,20.75*
DIS,10,CO,.5*
DIS,11,CO,60.*
DIS,12,CO,.6*
ISA,1,DS,1,2,DS,2*
ATA,1,,,,1,SC,0*
PRO,5,,,6,.9999,15,.0001*
TAS,6,LOGREAD,1,,SC,3600*
ATA,23,,,,2,SC,0,SA,,10,SC,20*
ATA,24,,,,3,SC,1*
ATA,27,,,,4,SC,1*
ATA,28,,,,5,SC,1*
ATA,30,,,,6,SC,1*
ATA,39,,,,7,SC,1*
ATA,31,,,,8,SC,1*
ATA,32,,,,9,SC,1*
TAS,36,AUXOPER,1,,UF,9*
ATA,17,STA,SA,,6,UF,6,SA,,9,SC,14*
TAS,31,WAIT1,1,,SC,832*
TAS,18,WAIT2,1,,SC,70*
STA,1,M*
STA,41,,,FIR,STA,20,1000.,20.*
STA,10,,,FIR,STA,30,850.,10.*
STA,22,,,NUM,COM*
STA,33,,,NUM,COM*
STA,14,,,NUM,COM*
STA,13,,,NUM,COM*
TAS,1,START,0,,SC,0,,,SO*
DET,1,2,3*
TAS,2,INDTYPE,1,,DS,12,,0*
CFI,2,5,ALV,,1,IA,,6*
TAS,3,ALARM,1,,DS,10,,2*
TCL,3,6,23,15,23,2,23,5,23*
DET,3,4*
TAS,4,SYSTIME,1,,DS,3*
DET,4,33*
TAS,5,PROBDET,1,,DS,12*
```

OPPS Model SAINT Code (Continued)

```
DET,6,23*
TAS,15,PREDET,1,,DS,11*
DET,15,23*
TAS,23,OBSERVE,1,,UF,8*
CFI,23,24,ALV,,2,IA,,26*
TAS,24,IDENTIFY,1,,DS,5
CFI,24,25,ALV,,3,IA,,26*
TAS,25,DEFTASK,1,,DS,6*
DET,25,26*
TAS,26,FORMATPR,1,,UF,10*
DET,26,27*
TAS,27,PROWRITE,1,,SC,0*
CFI,27,29,ALV,,4,IA,,28*
TAS,28,INDEXED,1,,SC,0*
CFI,28,38,ALV,,5,IA,,30*
TAS,29,DELAY1,1,,SC,60*
DET,29,30*
TAS,38,DELAY2,1,,SC,60*
DET,38,30*
TAS,30,RESPRO,1,,SC,0*
CFI,30,39,ALV,,6,IA,,31*
TAS,39,TRAINING,1,,SC,0*
CFI,39,40,ALV,,7,IA,,31*
TAS,40,DELAY3,1,,SC,60*
DET,40,31*
CFI,31,32,ALV,,8,IA,,16*
TAS,32,CONCUR,1,,SC,0*
CFI,32,34,ALV,,9,IA,,16*
TAS,34,COMM,1,,SC,180*
DET,34,35*
TAS,35,TRAVEL,1,,SC,300*
DET,35,36*
DET,36,37*
TAS,37,COMM,1,,SC,180*
DET,37,16*
TAS,7,ERROMIS,1,1,SC,0*
DET,7,11*
TAS,8,ERRCOMM,1,1,DS,8*
DET,8,12*
TAS,12,RECOVER2,1,1,SC,0*
PRO,12,,,9,.867,14,.133*
TAS,9,OPERATE,1,1,DS,8*
DET,9,10*
ATA,9,,SA,,3,UF,3*
TAS,10,FIRSTRT,1,1*
DET,10,17*
TAS,11,RECOVER,1,1,*
PRO,11,,,9,.00001,13,.99999*
TAS,13,OMIT,1,1,SC,0*
DET,13,17*
```

OPPS Model SAINT Code (Continued)

```
ATA,13,,SA,,5,UF,5*
TAS,14,COMIT,1,1,SC,0*
DET,14,17*
ATA,14,,SA,,4,UF,4*
TAS,16,DUMOPER,1,1*
PRO,16,,,7,0.0341,8,0.00316,9,0.96274*
TAS,17,DUMFIN1,1,1*
CFI,17,18,AGV,14,6,SA,,16*
CFI,18,22,ALV,,7,SA,,19*
ATA,18,STA,SA,,7,UF,2*
TAS,19,DIAGPLAN,1,1,DS,9*
PRO,19,SA,,20,1.,19,2.*
ATA,19,STA,SA,,1,UF,1,SA,,2,UF,11*
TAS,20,OPERATE,1,1,DS,8*
DET,20,21*
TAS,21,VERIFY,1,1*
CFI,21,22,AGA,7,8,SA,,20*
ATA,21,STA,SA,,8,UF,7*
TAS,22,OPERWIN,1*
DET,22,41*
TAS,33,SYSWIN,1*
DET,33,41*
TAS,41,STOP,1,,,,,SI*
FIN*
*
```

Function USERF:

```
      FUNCTION USERF(IP)
      GO TO (100,200,300,400,500,600,700,800,900,1000,1100),IP
100   CALL GETSA(1,VALUE)
      USERF=VALUE+.05
      RETURN
200   CALL GETSA(4,VALUE)
      X=VALUE
      CALL GETSA(5,VALUE)
      Y=VALUE
      USERF=X+Y
      RETURN
300   CALL GETSA(3,VALUE)
      USERF=VALUE+1
      RETURN
400   CALL GETSA(4,VALUE)
      USERF=VALUE+1
      RETURN
500   CALL GETSA(5,VALUE)
      USERF=VALUE+1
      RETURN
600   CALL GETSA(6,VALUE)
      USERF=VALUE+1
      RETURN
700   CALL GETSA(7,VALUE)
      USERF=VALUE+1
      RETURN
800   X=RNORM(4)
      USERF= X * 2
      RETURN
900   X=RNORM(8)
      USERF=X*10
      RETURN
1000  X=RNORM(7)
      USERF=X*2
      RETURN
1100  CALL GETSA(2,VALUE)
      USERF=VALUE-.05
      RETURN
      END
```

APPENDIX A

Section A.5

OPPS MODEL DESCRIPTION

The OPPS model is used to predict operator and system response performance for a malfunction scenario requiring safety-related operator actions. The performance measures the model predicts are:

(1) Error rates for switch manipulations (omission and commission)
(2) Percentage of error-free manipulation sequences finished prior to system time completion
(3) A time distribution for time to completion of the sequence modeled.

It is assumed the operator goes through the four phases for successful system operation listed below:

(1) Detection of a disturbance
(2) Internal processing of information
(3) Operation of equipment
(4) Recovery of errors

These phases of behavior are expanded into many nodes representing individual behaviors.

A.5.1. Detection of a Disturbance

The model begins with a dummy node labeled **START.** A dummy node is used when branching or statistics are needed but no time distribution or attribute assignments are made. This node causes the model iteration to begin. When this node is completed, two other nodes are started. These are the **ALARM** and the **INDICATION TYPE** nodes. The **INDICATION TYPE** node is used to represent the performance shaping factor (PSF) of indication cues to the operator that a malfunction is occurring prior to alarm annunciation. To allow the alarm branch to stop the pre-alarm detection branch, a 0.6 second time delay is included in the **INDICATION TYPE** node (a SAINT coding expedient).

A high level indication is one an operator can use to measure plant status by. High level indications effect the branching from this node. Table A-6 is a list of candidate high level indications derived from subject matter experts' opinions. If a user of the model inputs to the **INDICATION TYPE** node a high level indicator as the cue the model branches to a **PROBABILITY OF DETECTION** node, else the model branches to the **MONITOR DETECT** node. The **PROBABILITY OF DETECTION** node is a dummy node which takes a user input for the probability of pre-alarm detection and branches according to that input. If the chance of detection is low then the model will branch to the **MONITOR DETECT** node. This node uses a time distribution which represents the time between the official logging of indications during normal plant operations. This time is usually hourly or per shift (6 or 8 hours).

Table A-6

High Level Plant Indications
for Pre-Alarm Disturbance Detection in the
OPPS Model

PWR Parameters

1. Rx Power
2. PZR Level
3. PZR Pressure
4. T_{ave}
5. S/G Level
6. S/G Pressure
7. Feedwater Flow
8. Steam Flow
9. Generator Output (MW)
10. Rod Position

BWR Parameters

1. Rx Level
2. Rx Pressure
3. Rx Core Flow
4. Rx Recirculation Flow
5. Rx Feedwater Flow
6. Steam Flow
7. Generator Output

If there is a high probability of pre-alarm detection then the branch to **PRE-ALARM DETECT** node is taken. The **PRE-ALARM DETECT** represents the average time to malfunction detection as derived from the previous Oak Ridge National Laboratory experiments (Refs. 14 and 15). The branching from pre-alarm phase is always to the **OBSERVE** node.

The **ALARM** node runs in parallel with the modules mentioned above. The user of the model inputs the time distribution for time from malfunction initiation to alarm annunciation. If this time is less than the detection phase then when the **ALARM** is complete the pre-alarm phase is canceled and the **OBSERVE** and **SYSTEM TIMER** nodes are started. If the alarm time is longer than the pre-alarm detect time then the model signals **OBSERVE** prior to the alarming of the malfunction. The **SYSTEM TIMER** node represents the time from alarm annunciation until a plant system violates safety limits. The value for this time is a user input and is added to the time for the alarm node for comparison of operator time at the end of the model.

A.5.2 Internal Processing

The Internal Processing Phase of the model starts with the **OBSERVE** node which represents an operators collective observations during the course of the scenario. A time value taken from a time distribution is multiplied by a constant which represents the number of indications specified in a procedure gives the duration of this node. The distribution comes from the ORNL task analysis studies (Ref. 12 and 8) and represent the average time spent observing. In addition to the user input of number of indications used, the user must also input information on the scenario for this node to function. The user must determine whether the alarm annunciator legend is associated with a specific condition or identifies a more general disturbance. The model branches in response to this user input. If a specific condition is identified then the path to formulate procedures is taken. If a general disturbance is indicated then the branch to **IDENTIFY** is taken. The **IDENTIFY** node is given a time value from a distribution from the ORNL task analysis studies (Ref. 8 and 12) which represents the average time to identify deviations in parameters. This node also deals with the diagnosis of an event. If the diagnosis can be terminated at the symptom level then the operator model branches to the **PROCEDURE WRITTEN** node. If the diagnosis extends to the root cause then the **DEFINE TASK** branch is taken. **DEFINE TASK** represents the time it takes the operator to determine possible causes of a malfunction after indication data has been gathered. The cognitive phase is completed with the **PROCEDURE WRITTEN** node. This node represents the time it takes to reference and read the required procedures. The number of procedures is a user input. Following this node is a group of nodes representing procedural PSFs. These nodes represent desired PSFs for a procedure and if not present in a procedure a time penalty is given to the operator. The user inputs the answers to the questions about PSFs.

The questions about PSFs are listed below, **TIME DELAY** is imposed only when the answers to the questions are "No."

Questions	Nodes Affected
1. Are the procedures written?	**PROCEDURE WRITTEN**
2. Are procedures indexed?	**PROCEDURE INDEXED**
3. Are the procedures memorized as part of the immediate actions for a sequence?	**RESPONSE PROCEDURE IDENTIFIED**
4. Is the scenario used in training?	**TRAINING**

At the end of these PSFs the aggregate **TIME DELAY** before the procedure/procedure-steps can begin is taken into account by the **PROCEDURE WAIT TIME** node. The branching out of this node takes one of two paths depending on the answer to a user input. The user must determine if switch operations remote to the main control room are performed.

Possible alternatives branching in the **CONCURRENT OPERATION** module are decided by the following questions:

(1) Are auxiliary/remote actions required?
(2) Are these actions concurrent with control room operations or consecutive?

If auxiliary actions are required and they cannot be performed concurrent with control room actions, then an estimated time to **COMMUNICATE**, **TRAVEL** to the remote work station, **OPERATE** equipment and **COMMUNICATE** the results to the control room operator is added to the model.

The auxiliary operations phase leads into the **START OPERATE** node. This is a dummy node used to allow the probabilistic branching to either the **CORRECT ACTION**, **ERROR OF OMISSION**, or **ERROR OF COMMISSION** node. The **OPERATE** Phase uses probabilistic branching for reaching the action nodes (omission and commission, as well as correct actions) and for the **RECOVERY** nodes. The values for these probabilities come from the Sandia National Labs draft report (Ref. 10) on error rates. Of the three branches the model can take when the **START OPERATE** node is finished, **CORRECT ACTION** is the first discussed. This branch has the highest probability of being taken (P = 0.963).

The **CORRECT ACTION** node, as do all the action or operate nodes has a time value taken from a distribution set developed from the ORNL task analysis studies (Refs. 12 and 8). The model in turn branches to the **FIRST RESPONSE TIME** node. This is a dummy node used to collect a time statistic for the very first correct response time for the iteration.

The **ERROR OF OMISSION** branch is taken next most often (P = 0.0341) and represents a procedural step forgotten or overlooked. This node branches to the **NUMBER OF SWITCHES** node which counts operator actions. Omission errors are counted by a dummy node.

The **ERROR OF COMMISSION** node is treated the same as the omission section of the operations phase. The chance of taking the Commission branch is .316 percent (P = 0.00316). The **RECOVERY** for commission can occur immediately following the error, and usually does. The recovery rate is set at 86.7% (P = .867) (Ref. 3). A counter is also included for the number of commission errors.

All three operate branches come together in the **NUMBER OF SWITCHES** module. This node takes as a user input the number switches to be manipulated and causes the iteration of the Operate Phase until the number of **CORRECT ACTIONS, ERROR OF OMISSIONS,** or **ERRORS OF COMMISSION** summed equals the expected number of manipulations. The safety-related operator actions may not be complete, due to unrecovered errors, but the normal **OPERATIONS** Phase is over. The number of unrecovered errors is saved for use in the **ERROR RECOVERY** Phase.

The next node encountered in the model is the second **PROCESS WAIT TIME** node which accounts for the aggregate equipment delay time embedded in the procedure. This is a user input. Coming out of this node the model branches to an Error Recovery Phase if errors were committed during the Operate Phase, if not the branching goes to the statistics section of the model. Following the completion of the Operations Phase, uncorrected errors are given a chance of being corrected while in the **ERROR DIAGNOSIS** node. This node iterates increasing the probability of error correction with each loop in the same way as described by Swain and Guttman (Ref. 10). When the module is finally complete all errors are assumed to be corrected in the model without further error in an **OPERATE/VERIFY** loop.

The final phase of the model are the two statistics nodes labeled **OPERATOR WIN** and **SYSTEM WIN.** These nodes give the percentage of times the operator part of the model finished before the system design time limit providing a measure of system reliability.

APPENDIX A

Section A.6

OPPS OPERATING INSTRUCTIONS

A.6 Operating Instructions

The purpose of this section is to describe to the user the values to be changed to customize the OPPS model to individual purposes. Several editors could be used to edit the SAINT code for the OPPS model. The purpose of this appendix is not to explain an editor but to describe how the model is altered for various inputs. The explanation will consist of the question from the OPPS Scenario Analysis Questionnaire (A-4), the default line to be edited, and what editing is required to incorporate the Questionnaire data in the model.

A.6.1 Prealarm Phase

1. The question is:

   What is the probability of detecting the malfunction prior to the annunciator? ________

   The default line is:

   ```
   10000   PRO,5,,,6,.9999,15,.0001*
   ```

   The probability is the "R_1" variable from the question and value "R_2" is one minus "R_1." Either one of these numbers can not be zero, and must be in decimal notation.

   10000 PRO,5,,,6,.R_2,15,.R_1*

2. The question is:

   What is the average time from disturbance initiation to alarm annunciation (conventional audible alert and light box)? (range 0 to xxxx seconds) ____sec.

   The default line is:

   ```
   09500   DIS,10,CO,.5*
   ```

   The value "R" is changed to a real number and input.

   ```
   09500   DIS,10,CO,.R*
   ```

3. The question is:

   Is the pre-alarm indication of the disturbance a high level indication monitored continuously (e.g. MWe output)? Y or N

   The default line is:

   ```
   09900   ATA,1,,,,1,SC,0*
   ```

   The value of yes is 0; the value of no is 1 (Y = 0, N = 1). The variable "I" is changed accordingly. "I" is an INTERGER.

   ```
   9900   ATA,1,,,,1,SC,I*
   ```

4. The question is:

Is the pre-alarm indication logged or reviewed periodically?

Y or N

If yes, at what frequency (i.e. hourly, daily, etc.)? ________

The default line is:

10100 TAS,6,LOGREAD,1,,SC,3600*

The answer to the first part of question 4 only has input to line 10100 if the answer is no. If the answer is yes the time in part 2 of the question is converted into seconds and then input into position "I." If the answer was no then zero is input into "I."

10100 TAS,6,LOGREAD,1,,SC,I*

A.6.2 Diagnosis Phase

5. The question is:

Is the alarm annunciator legend associated with a specific condition or does it identify a general disturbance requiring more complex analysis?

general or specific

The default line is:

10200 ATA,23,,,,2,SC,0,SA,,10,SC,20*

If the selection of general of general is made, the variable "I_1" is equal to 0. Specific is input as a 1.

10200 ATA,23,,,,2,SC,I_1,SA,,10,SC,20*

6. The question is:

How many indications are specified in procedures to diagnose the disturbance? ________#

The INTERGER specified is input into the "I_2" position on line 10200.

10200 ATA,23,,,,2,SC,I_1,SA,,10,SC,I_2*

7. The question is:

Is the diagnosis terminated at the symptom level, or extended to the root cause? symptom or root cause

The default line is:

10300 ATA,24,,,,3,SC,1*

The INTERGER (I) is specififed as 1 if the symptom level is chosen or 0 if the root cause branch is taken.

```
10300    ATA,24,,,,3,SC,I*
```

A.6.3 Planning Phase

8. The question is:

   Are the procedures written: Y or N

   The default line is:

   ```
   10400    ATA,27,,,,4,SC,1*
   ```

   If the answer to the question is yes, the value for "I" is 1. An answer of no requires a 0 to be put into the variable "I."

   ```
   10400    ATA,27,,,,4,SC,I*
   ```

9. The question is:

   Are procedures indexed? Y or N

   The default line is:

   ```
   10500    ATA,28,,,,5,SC,1*
   ```

   If the answer to the question is yes, the value for "I" is 1. If the answer is no, then the variable "I" is 0.

   ```
   10500    ATA,28,,,,5,SC,I*
   ```

10. The question is:

    Are the procedures memorized as part of the immediate actions for a sequence? Y or N

    The default line is:

    ```
    10600    ATA,30,,,,6,SC,1*
    ```

    The instructions for the previous two questions hold true for this one.

    ```
    10600    ATA,30,,,,6,SC,I*
    ```

11. The question is:

    Is the scenario used in training? Y or N

    The default line is:

    ```
    10700    ATA,39,,,,7,SC,1*
    ```

The instructions for the previous three questions hold true for this one.

```
10700    ATA,39,,,,7,SC,I*
```

12. The question is:

    How many procedures are used? __________

    The default line is:

    ```
    3400    USERF=X*2
    ```

    The value for the number of procedures (I) is input into this line.

    ```
    3400    USERF=X*I
    ```

A.6.4 Operations Phase

13. The question is:

    What is the aggregate time delay before the procedure or procedure steps can begin? ______ sec.

    The default line is:

    ```
    11200    TAS,31,WAIT1,1,,SC,832*
    ```

    The time in seconds is input to the variable "I."

    ```
    11200    TAS,31,WAIT1,1,,SC,I*
    ```

14. The question is:

    How many operations are performed by control room operators? __________

    The default lines are:

    ```
    11100    ATA,17,STA,SA,,6,UF,6,SA,,9,SC,14*
    18800    CFI,17,18,AGV,14,6,SA,,16*
    ```

    The variable "I" is equal to 1 minus the number of operations (i.e. switch manipulations) made by operators (example: If the answer is 15, the I = 15 -1 or 14.

    ```
    11100    ATA,17,STA,SA,,6,UF,6,SA,,9,SC,I*
    18800    CFI,17,18,AGV,I,6,SA,,16*
    ```

15. The question is:

    Are switch operations to be performed remote from the main control room?

    Y or N

    The default line is:

    ```
    10800    ATA,31,,,,8,SC,1*
    ```

The value of "I" is 1 if the answer to the question is yes, and 0 if the answer is no.

```
10800   ATA,31,,,,8,SC,I*
```

16. The question is:

    Are remote operator actions performed concurrently with the control room operator's actions?

    Y or N

    The default line is:

    ```
    10900   ATA,32,,,,9,SC,1*
    ```

    The instructions for the last question hold true for this question.

    ```
    10900   ATA,32,,,,9,SC,I*
    ```

17. The question is:

    How many operations are performed by remote operators?

    ________#

    The default line is:

    ```
    3700   USERF=X*10
    ```

    The answer to the question is input into the variable "I."

    ```
    3700   USERF=X*I
    ```

18. The question is:

    What is the aggregate equipment delay time embedded in the procedure? ________sec.

    The default line is:

    ```
    11300   TAS,18,WAIT2,1,1,SC,70*
    ```

    The time in seconds is input into the variable "I."

    ```
    11300   TAS,18,WAIT2,1,1,SC,I*
    ```

19. The questions are:

    What is the expected average commission error probability? (default .00316 or enter #) ________

    What is the expected average omission probability? (default .0341 or enter #) ________

    The default line is:

    ```
    18500   PRO,16,,,7,0.0341,8,0.00316,0.96274
    ```

The error of commission is variable R_1.

The error of omission is variable R_2.

Variable R_3 is probability of correct operation. All variables are real numbers and $R_1 + R_2 + R_3 = 1.0$ and is in decimal notation.

18600 PRO,16,,,7,R_2,8,R_1,9,R_3*

A.6.5 Process

20. The question is:

What is the average time delay from alarm condition to violation of safety limits (i.e. before which the operators must complete their action)?

_____ sec.

The default line is:

```
8800  DIS,3,CO,1380.*
```

The variable "R" is the number of seconds from alarm to violation of safety limits. "R" is a real number.

```
8800  DIS,3,CO,R*
```

APPENDIX A

Section A.7

OPPS MODEL TEST

A.7 OPPS Model Test

A.7.1 Scenario

In order to test the OPPS model and demonstrate its use, an example scenario was analyzed and modeled. The OPPS model output was then compared to available field data from similar scenarios. The scenario examined was the failure open of a Main Steam Relief Valve (MSRV) on a BWR nuclear power plant. A complete description of the scenario is given in the Operating Sequence Overview in Appendix B.

A.7.2 Scenario Analysis

The test scenario was task analyzed by the methodology of the NRC Crew Task Analysis method (Ref. 13). From that data, the OPPS Scenario Analysis Questionnaire (Figure A-10) was prepared to determine the inputs to the OPPS model.

A.7.3 OPPS Model Output

The OPPS model was edited to match the scenario being analyzed. The model program was then run to predict operator/system performance in the scenario being analyzed.

The tabular output of the OPPS model is shown in Figure A-11. It is a summary report of system performance over all Monte Carlo iterations of the model simulation. The number of iterations is given in the heading. Scenario statistics are presented in the following fields:

TASK NUMBER - an arbitrary number identifying the SAINT node.

TASK LABEL - the name of the SAINT node.

STAT TYPE - the type of statistic collected

FIR - FIRST

NUM - NUMBER

COLLT POINT - the collection point for the data in the SAINT model.

STA - START OF NODE

COM - COMPLETION OF NODE

STATISTICS

AVERAGE - mean value, or point value

STD DEV - standard deviation

NO. ITERATIONS - number of iterations

MINIMUM - minimum value of the parameter

MAXIMUM - maximum value of the parameter

The scenario is MSRV Fails

The SROA is Scram Reactor

OPPS Scenario Analysis Questionnaire

Prealarm Phase

1. What is the probability of detecting the malfunction prior to the annunciator (default .0001) .4

2. What is the average time from disturbance initiation to alarm annunciation (conventional audible alert and light box)? (range 0 to xxxx seconds) 37.7 sec.

3. Is the pre-alarm indication of the disturbance a high level indication monitored continuously (e.g. MWe output)? (Y) or N

4. Is the pre-alarm indication logged or reviewed periodically? (Y) or N

   If yes at what frequency (i.e. hourly, daily, etc.)? hourly

Diagnosis Phase

5. Is the alarm annunciator legend associated with a specific condition or does it identify a general disturbance requiring more complex analysis?

   general or (specific)

6. How many indications are specified in procedures to diagnose the disturbance? 6 #

7. Is the diagnosis terminated at the symptom level, or extended to the root cause?

   symptom or (root cause)

Planning Phase

8. Are the procedures written? (Y) or N

9. Are procedures indexed? (Y) or N

10. Are the procedures memorized as part of the immediate actions for a sequence? (Y) or N

11. Is the scenario used in training? (Y) or N

12. How many procedures are used? 3 #

Figure A-10 OPPS Scenario Analysis Questionnaire for SRV Fails

Operations Phase

13. What is the aggregate time delay before the procedure or procedure steps can begin? 600 sec.

14. How many operations are performed by control room operators? 26 #

15. Are switch operations to be performed remote from the main control room? Y or (N)

16. Are remote operator actions performed concurrently with the control room operator's actions? Y or (N)

17. How many operations are performed by remote operators? 10 #

18. What is the aggregate equipment delay time embedded in the procedure. 300 sec.

19. What is the expected average commission error probability? (default .00316 or enter #) Default

20. What is the expected average omission probability (default .0341 or enter #) Default

Process

21. What is the average time delay from alarm condition to violation of safety limits (i.e. before which the operators must complete their action)? 1980 sec.

Note:
This limit should be based on estimates which take into account the variables of the scenario being evaluated.

Figure A-10 OPPS Scenario Analysis Questionnaire for SRV Fails (cont'd)

STATISTICS TASK SUMMARY REPORT

AVERAGES OF THE STATISTICS COLLECTED FOR 1000 ITERATIONS

TASK NUMBER	TASK LABEL	STAT TYPE	COLCT POINT	--------STATISTICS ON THE AVERAGE VALUE PER ITERATION---------				
				AVERAGE	STD DEV	NO. ITER	MINIMUM	MAXIMUM
41	STOP	FIR	STA	0.1475E 04	0.1343E 03	1000	0.1159E 04	0.2017E 04
10	FIRSTRT	FIR	STA	0.7283E 03	0.4831E 02	1000	0.6304E 03	0.8819E 03
22	OPERWIN	NUM	COM	0.9990E 00	0.3163E-01	1000	0.0	0.1000E 01
33	SYSWIN	NUM	COM	0.1000E-02	0.3162E-01	1000	0.0	0.1000E 01
14	COMIT	NUM	COM	0.6000E-02	0.7727E-01	1000	0.0	0.1000E 01
13	OMIT	NUM	COM	0.4280E 00	0.6459E 00	1000	0.0	0.4000E 01

Figure A-11 OPPS Model Test Tabular Output

A.7.4 Test Results - from Figure A-11

STOP represents the predicted task completion time for the operator model. The mean value was 1475 seconds with a standard deviation of 134 seconds. The shortest completion time was 1159 seconds, the longest - 2017 seconds.

FIRSTRT represents the time to the first operational response predicted for the operator. The average was 728 seconds with a standard deviation of 48 seconds. The quickest response predicted was 630 seconds, the longest - 881 seconds.

OPERWIN represents the rate of successful completion of the operators action before the system time limit. The probability for successful completion of operator actions in this test was predicted as 99.9%. Since success is defined as binary the maximum occurrence in any iteration is 1. The standard deviation is a meaningless artifice of the SAINT program.

SYSWIN represents the predicted rate at which the operators will fail to complete safety-related operator actions within the plant design limits. In this test that rate was 00.1%. As with OPERWIN, the maximum occurrence per iteration is 1 and the standard deviation is meaningless.

COMMIT gives the predicted number of commission errors by the operators, .006 in this test. The minimum and maximum number of commission errors in an iteration were 0 and 1.

OMIT gives the predicted number of omission errors for iteration. The average was .428 with a standard deviation of .645. The minimum predicted was 0, the maximum 4.

Graphic output of the OPPS model for the test scenario is shown in Figure A-12. These plots show the predicted relative and cumulative distribution of simulation completion and first operator response time for the OPPS test sequence modeled.

```
     ***HISTOGRAM OF THE AVERAGE FIR STA STATISTIC FOR TASK   41 (STOP    )***

OBSV   RELA     CUML         UPPER
FREQ   FREQ     FREQ      CELL LIMIT     0        20        40        60        80       100
                                         +    +    +    +    +    +    +    +    +    +    +
   0   0.0      0.0       0.1140E 04     +                                                 +
   2   0.002    0.002     0.1200E 04     +                                                 +
  17   0.017    0.019     0.1260E 04     +*                                                +
  74   0.074    0.093     0.1320E 04     +****C                                            +
 145   0.145    0.238     0.1380E 04     +*******    C                                     +
 190   0.190    0.428     0.1440E 04     +*********           C                            +
 196   0.196    0.624     0.1500E 04     +**********                    C                  +
 156   0.156    0.780     0.1560E 04     +********                              C          +
  84   0.084    0.864     0.1620E 04     +****                                      C      +
  57   0.057    0.921     0.1680E 04     +***                                          C   +
  33   0.033    0.954     0.1740E 04     +**                                             C +
  21   0.021    0.975     0.1800E 04     +*                                               C+
  12   0.012    0.987     0.1860E 04     +*                                               C+
   8   0.008    0.995     0.1920E 04     +                                                 C
   4   0.004    0.999     0.1980E 04     +                                                 C
   1   0.001    1.000     0.2040E 04     +                                                 C
   0   0.0      1.000     0.2100E 04     +                                                 C
   0   0.0      1.000     0.2160E 04     +                                                 C
   0   0.0      1.000        INF         +                                                 C
 ---                                     +    +    +    +    +    +    +    +    +    +    +
1000                                     0        20        40        60        80       100
```

Figure A-12 OPPS Model Test Graphic Output

The column headings present:

- OBSV FREQ - observed frequency of predicted task times.
- RELA FREQ - relative frequency of predicted time response in each time interval, expressed as a fraction of 1.
- CUML FREQ - the cumulative frequence of predicted time response at all times less than or equal to the specified time interval.
- UPPER CELL - the maximum task time for the interval and cumulative task
- LIMIT completion frequencies shown. Time is in seconds.
- SCALE - a scale from 0 to 100% shows the interval (*) and cumulative (c) probability distribution of task times predicted by the model.

A.7.5 Test/Field Data Comparison

The predicted time distribution for operators to complete the safety-related operator actions in the test sequence were extracted from Figure A-12 and presented in a log-normal/probability plot in Figure A-13.

Field data from other occurrences of BWR MSRV failure are shown in Table A-7. These data were adjusted by adding 5 minutes to match the test scenario description. The field data are plotted on Figure A-13 for comparison to the OPPS model prediction. The medians of the two distributions are approximately equal; however, the field data are much more variable than the model prediction. This is consistent with previous findings that field data are more variable than simulator data (Ref. 12). The OPPS test scenario models a particular set of task requirements and performance shaping factors (PSFs) as detailed in the OPPS Scenario Analysis Questionnaire. The field data represent a variety of task requirements and PSFs which differ in unknown ways from the test scenario. These differences are reflected in the greater variability of the field data.

The OPPS model was able to closely match the mean of field data available for the test scenario. The field data were more variable than the OPPS model prediction as might be expected (Ref. 16). It is important to note that no data from the test scenario was used in the development of the OPPS model, so this represents an independent test.

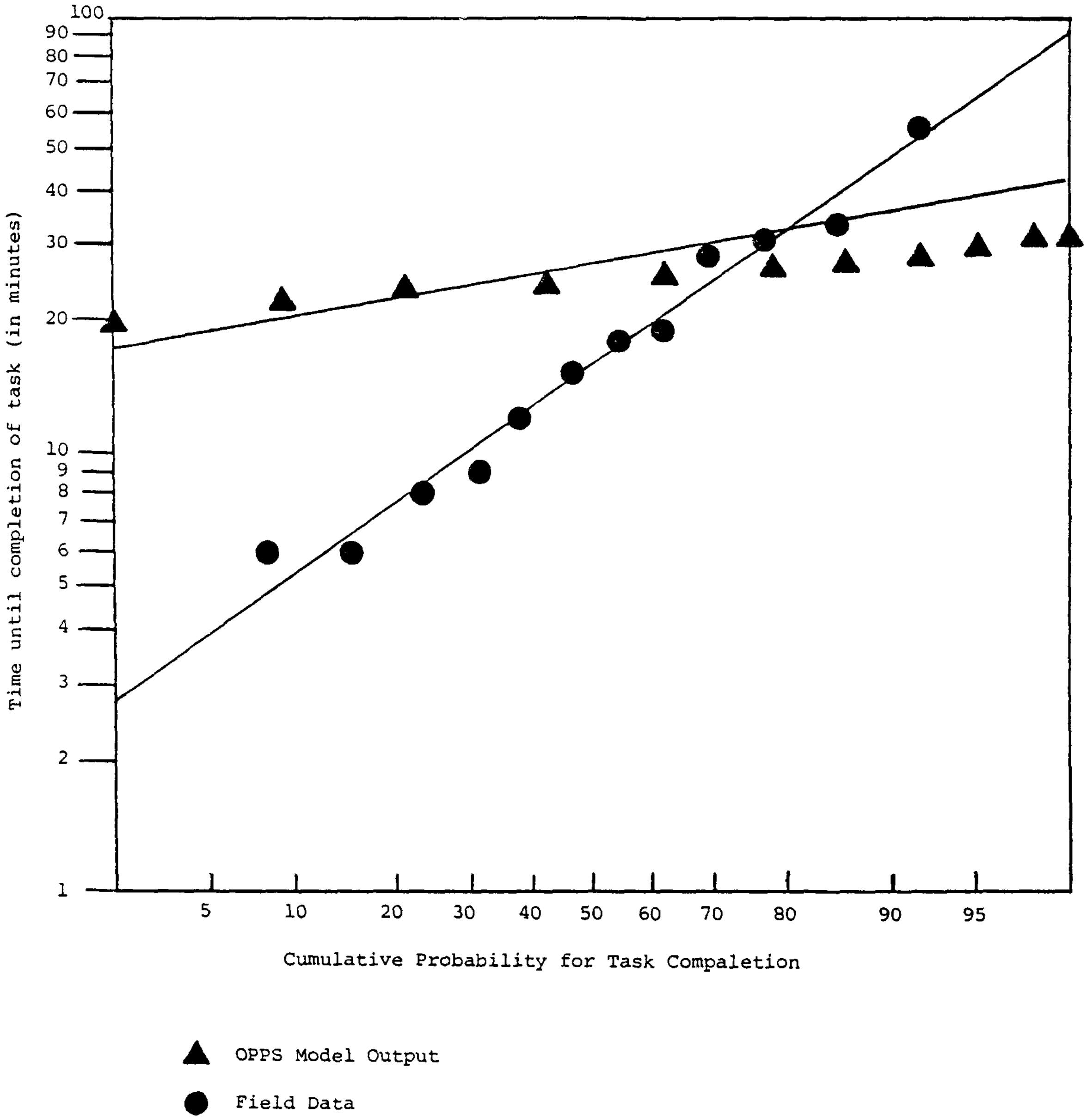

Figure A-13 Comparison of OPPS Model Test Scenario to Field Data

Table A-7

Field Data of Operators' Time to Scram Reactor Following Main Steam Relief Valve Failure

INCIDENT #	SCRAM TIME (MINUTES)	SCRAM TIME (+5 MINUTES)*
1	25	30
2	28	33
3	13	18
4	14	19
5	10	15
6	50	55
7	3	8
8	1	6
9	1	6
10	4	9
11	7	12

* Unpublished data from work on Reference 16. Adjusted by +5 minutes to match the test scenario.

APPENDIX A

Section A.8

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A.8 REFERENCES

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APPENDIX B

Section B.1

INTRODUCTION

B.1 Introduction

B.1.1 Background

Increased concern for the human element in nuclear power plant (NPP) safety has raised many questions which can be addressed by human factors studies. NUREG/CR-0660, Task 1.D.1 calls for a human factors design review of nuclear power plant control rooms to identify and correct deficiencies which may lead to operator error. An important aspect of control room design is the allocation of safety functions between the operators and automated systems. The nuclear industry has viewed this as a plant design issue, reflected in the American National Standards Institute (ANSI) draft N660 design automation standard. The Safety Related Operator Action (SROA) program at Oak Ridge National Laboratory (ORNL) has been working to develop a data base on operator performance under emergency conditions to support development of criteria for the Nuclear Regulatory Commission (NRC) to use in evaluating new plant and backfit designs involving operator action in safety systems.

B.1.2 Objectives of the SROA Program

The primary objective of the SROA program is to develop a data base on operator performance under emergency conditions in order to support development of criteria to evaluate the use of operator action as part of the design basis of a nuclear power plant. The data base will also provide input to other NRC regulatory and research efforts in the areas of operational safety, human factors, and risk assessment. The secondary objective of the program is to develop candidate criteria, based on the supporting data base, for evaluating automatic versus manual system operation during emergency events.

With a predictive model, a candidate SROA design scenario can be task analyzed, then the model used to predict system/operator performance. Comparing predicted performance with SROA criteria leads to design approval if the SROA criteria are met. If not, feedback of organizational changes to modify performance shaping factors, or of design changes to modify the operator task requirements, will be needed. Predicted performance of the modified system can then be evaluated, until the SROA criteria are met.

B.1.3 SROA Research Approach

The research philosophy of this project is to integrate predictive modeling and performance measurement in high-fidelity simulators, with the principal objective being the establishment of safety-related operator action criteria. In the research program to develop SROA criteria and a supporting model, task analyses were conducted to determine particular task requirements. These task requirements must be clearly understood to guide the development of a comprehensive systems-oriented model of process control.

B.1.4 SROA Model

The SROA design evaluation criteria will be based on a predictive model of system/operator performance. Outputs of the model will be predictions of time and reliability for the operators to function successfully. Some model inputs or task requirements can be derived from scenario task analysis data on the Task Sequence Chart, based on data obtained from actual plant events. However, additional plant specific information is required

The SROA model must be quantitative and valid. The first requires quantitative data for the construction of the model. The second requires a successful comparison of model predictions to actual operating events - i.e., to what degree does the model prediction agree with historical data on actual events. The SROA program has produced data from both simulator and field studies for model quantification, but to use the same data for model validation would not provide an independent trial of the model. The final field data collection will provide data for model verification with a reference plant event. The test of the model will then be independent of the data used in its development.

B.1.5 Purpose of the Plan

The purpose of this data collection plan is to outline the methods to be used in gathering data on control room operator actions in response to a plant transient. The data collected will then be used to verify the SROA model and will be analyzed and used to compare field and simulator operator performance data, and to develop standardized operating sequences which will be included in SROA design criteria.

APPENDIX B

Section B.2

METHODOLOGY

B.2 Methodology

B.2.1 Field Data Collection Approach

Detailed procedures for data collection describe how the data collection team will acquire task data. The product of data collection will consist of complete documentation of the operating sequence for one selected abnormal event which has occurred in an operating nuclear power plant (NPP). Collection of the data will be performed in two phases. During Phase I, information will be extracted from plant-specific materials gathered for a desk-top (pre-fill) task analysis. The methodology and forms developed by GP/Biotechnology for the NRC Crew Task Analysis Program will be adapted for use in the data collection. In addition, we will collect amplifying data on-site to verify the pre-filled data by examining additional plant records. Phase II will consist of on-site simulator observation and data collection which will be used to verify the SROA model prediction.

B.2.1.1 Selection of the Event

The event to be studied in this experiment must meet certain criteria to be suitable for study. The event should have occurred at some time in the operating history of the subject plant and must be reproducible on the plant specific simulator. Also, the event must have some time constraints that force the operator to take a safety-related action before a safety limit or Technical Specification limit is exceeded.

An event that meets these criteria is an inadvertent opening of a main steam safety-relief valve (MSRV). The subject plant has experienced three occurrences of this event, and it is easily simulated. Another feature of this event is that it requires no assistance from plant equipment (auxiliary) operators, only control room operators.

Of the three in-plant occurrences of this event, one is especially well suited for data collection. The actual event occurred while the plant was operating at 90% power. The MSRV opened for no apparent reason, but reclosed when the control switch was cycled. After a five minute interval, the valve opened again, and would not reclose. The operators were forced to manually scram the reactor when the suppression pool temperature reached 110^{o}F. The continued blowdown following the scram resulted in high drywell pressure seven minutes following the scram. The scenario ended with cooldown rate under control, and reactor level being maintained by the condensate system and Reactor Core Isolation Cooling system (RCIC).

B.2.1.2 Data Collection Team Structure

The procedures developed for use during data collection are intended to guide the activities of the Data Collection Team. The team composition consists of a team leader, task analyst, subject matter expert (SME), and an audiovisual expert. The leader or the analyst will be a human factors specialist. Duties and responsibilities of the team members are delineated in subsequent sections, as applicable.

B.2.2 Phase I Data Collection

The first data collection activity will be a preliminary desk-top (pre-fill) task analysis of selected written materials. Table B-1 lists data sources which may be helpful during the pre-fill analysis.

Table B-1 Written sources of data

- o Training materials
- o Procedures (administrative, operating, emergency, communications)
- o Results of any task analyses that may have been performed for development of upgraded, diagnostically-oriented emergency procedures
- o Technical Specifications
- o Control room and panel layout drawings
- o Instrumentation and control schematics
- o Systems descriptions
- o Emergency plan and implementing procedures
- o Final Safety Analysis Report (FSAR)
- o Piping and instrumentation drawings
- o Control room operators' log book
- o Supervisor's log book

The primary purpose of this activity is to provide guidance for preparing detailed descriptions of the operating sequence and for performing initial quality control checks. The secondary purposes are to familiarize the data collection team with the expected response of the plant and control room crew members and to fill in the data forms as much as possible in advance. This will increase on-site efficiency and minimize time demands on plant personnel.

B.2.2.1 Data Collection Documentation

Four documents, titled the Operating Sequence Overview (OSO), the Task Sequence Chart (TSC), and the Activity Cluster Chart (ACC) and the Task Data Form (TDF) will be prepared using plant technical and historical data. The Task Data Form (TDF), will be used during simulator data collection and will be discussed separately in Section B.2.3.1. These documents comprise the detailed description of the operating sequence. In addition, they are also important tools to be used by the data collection team upon arrival on-site. The forms for an individual operating sequence comprise a "batch," and are appended to a Data Review Sheet (DRS), which is the record of preparation and quality control review of the documents. Detailed procedures for preparation of the forms are discussed in the following sections.

B.2.2.1.1 Operating Sequence Overview (OSO)

An Operating Sequence Overview, based upon the brief description of the sequence will be prepared for the operating sequence. The OSO is designed to be a general "roadmap" for preparing the Task Sequence Chart. To fulfill this function the OSO should be as brief (no more than one page in length) and as general as possible, and will be written by members of the data collection team. Team members will determine the specific plant conditions at the beginning and end of the sequence. The operations expert will provide information about the expected progression of the sequence, as well as the list of major systems involved.

The Operating Sequence Overview will be written prior to development of the Task Charts for the sequence, but will be subject to change as the work progresses.

Team members will include the following information in the Operating Sequence Overview (Figure B-1):

> **Initial Conditions** - This paragraph should include plant status (e.g., full power), status of major components that will be affected by events (e.g., steam jet air ejectors operating in Train A), and any off-normal system status. Unless otherwise specified, all systems should be assumed to be operating normally.
>
> **Sequence Initiator** - The cue or condition starting the sequence should be indicated. This may be an administrative directive or a specific incident (e.g., the alarm for the open MSRV).
>
> **Expected Progression of Action** - The progression should be written in narrative form. It should not contain detailed procedures, nor should it be written at the level of the individual tasks. It should not focus just on the operator but on the operator-plant relationship (plant factors requiring operator action and plant response to operator action). The progression must indicate participation of other crew members in the sequence where relevant.
>
> Where the sequence in question can be done in alternative ways at operator option, this narrative should specify the way that it is to be accomplished. Assumptions should be made and stated about any variable physical plant actions which can affect the

Operating Sequence Overview

Plant Name: Operator Function/Subfunction: generate power

NSSS Type: W-PWR Operating Sequence ID: -
C.R. Type: Multiple

Operating Sequence: Shutdown from Minimum Load to Hot Standby

Initial Conditions The plant has been operating at full power for several months. Shutdown for refueling purposes has begun. A previous shift has started the shutdown by reducing power to minimum load (15% power) and satisfying the following prerequisites for shutdown to hot standby: (1) reactor power is less than 20%, (2) Reactor Coolant System T_{ave} is maintained at the programmed value; (3) both source range NI's are in operatipn; and (4) the load dispatcher has been notified of the impending shutdown. Two out of three condensate pumps are running.

Sequence Initiator - The incoming shift receives the order to continue the shutdown.

Expected Progression of Action - To achieve a hot standby condition, the crew will transfer electrical power from operating supply to shutdown supply; shutdown the turbine, and shutdown the reactor, while maintaining reactor coolant system temperature using the steam dumps in the pressure control mode.

Final Conditions - The plant is stabilized in a hot standby condition (Mode 3, as designed in Technical Specifications). Reactor Coolant System T_{ave} = 547^{o}F; Reactor Coolant System pressure = 2,235 psig; K_{eff} = .99; steam generator level = 33%; and control banks are inserted.

Major Systems - Systems involved in this operating sequence are: 500 KV, 4 KV, Steam Dump Control System, Rod Control System, Turbine Control System, Condensate System, Nuclear Instrumentation System, Reactor Protection System, Auxiliary Feedwater System, and Main Feedwater System.

Figure B-1 Example of An Operating Sequence Overview performance or outcome of the sequence (e.g., detailed plant parameters or plant response characteristics which would affect the sequence).

Final Conditions - This paragraph should include plant status (e.g., hot standby) and any changes in system/component status as a result of the sequence.

Major Systems - A list of major systems involved in the sequence should be included.

B.2.2.1.2 Task Sequence Charts (TSC)

The ORNL TCS's are a modification of the Crew Task Analysis Task Sequence Charts and will be prepared for the operating sequence, based on the events described in the Operating Sequence Overview. Figure B-2 shows an example of a Task Sequence Chart.

The Task Sequence Chart is designed to show the sequence of tasks and their corresponding cues within the operating sequence. It will be prepared during pre-fill for the sequence, but may require revision to reflect changes made during the on-site verification.

Information included in the heading of a Task Sequence Chart should be:

- o Plant Name
- o Operating Sequence
- o Operator Function/Subfunction
- o Operating Sequence ID

Detailed instructions for completion of the entries comprising the body of the form are as follows:

Task Sequence Number - The sequential number assigned to the task representing the order in which the task occurred during the operating sequence.

Task - The task title, which describes the activity or related activities being performed should be carefully structured. Team members should keep in mind the definition of task, and the specific characteristics of a task.

The analysts, with input from the operations expert, will determine what activities the task is composed of and structure a task statement to describe those activities. The task title will be written as an imperative statement of the action to be accomplished (e.g., start a reactor feedwater pump; shutdown a station diesel generator).

TASK SEQUENCE CHART — ORNL*

Page ___ of ___

Plant Name:

Operating Sequence:

Operator Function/subfunction:

Operating Sequence ID:

Task Seq. No.	Task	Cue	Procedure Name & Number	Plant Specific System Name	INPO System Name & No.	Performance Requirement (PR)			PR Source
						H/W	Reg.	Op.	

*Modified From NUREG/CR-3371

Figure B-2 Task Sequence Chart (ORNL).

Cue - A cue should be identified for each task. The cue can be described as the "green light" for the task. It is the message (from plant information or instruction) that the operator must receive and process before he can begin the task. In the case where the team is identifying a specific plant parameter that will lead to the pre-determined end-of-sequence, this should be identified as a cue.

Some examples of types of cues are as follows:

- o Procedural - this cue refers to the written procedure the operator is using at the time, which directs the sequence of his action.

- o Operating practice - this cue refers to other guidance the operator may be using (e.g. standing orders, plant directives, engineering practices), but which are not identified in the procedure in use.

- o Specific indications - these cues may include plant parameters, alarms, indicating lights, etc., and should be identified as specifically as possible (Turbine load = 150 MWe or Rx water level low alarm).

- o Plant or equipment status - these cues may include equipment running or tripped, lineup completed, etc., and should be identified as specifically as possible (Reactor Feedwater Pump tripped, Diesel started and loaded).

Procedure - Specific procedure numbers, titles and paragraph numbers should be included where they are applicable. This is included to assist in the preparation for the walk-through/talk-through.

System - The plant-specific system that the operator acts upon/interacts with in performing the task will be identified. A system can be defined as an integral part of a nuclear plant comprised of electrical, electronic, or mechanical components that may be operated as a separate entity to perform a particular function. The systems will be identified from a plant-specific operational systems list. For most tasks, actions will be limited to one system; however in the case of interdependent systems, the team may decide to include both systems (e.g., reactor protection system and ex-core nuclear instrumentation system).

INPO Systems - The INPO generic system name and number that corresponds to the plant-specific system will be identified, if available.

Performance Requirement (PR) - This field will be used to document system/operator performance requirements. The field is divided into three categories; Hardware (H/W), Regulatory (REG) and operational (OP). The hardware category uses PRs from engineering analysis of equipment limitations (strength, melting point, etc.). The regulatory performance requirements are defined by the legal and license limits as dictated in Tech. Specs., FSAR, CFR, etc. Operational PRs are determined from procedures and good operating practices. A determination will be made during pre-fill as to which category the task action will be assigned, if any. For example: If the operator is required to stop a pump taking suction on a tank holding "x" gallons of water and the pump is rated at "y" gallons per minute, he must stop the pump in "z" minutes to prevent equipment damage. This time would be entered in the H/W category. This area will be verified during Phase II.

PR Source - This field will list the source used during PR identification, and entrys will be "Plant Design," "Procedure," or "Tech. Spec."

B.2.2.1.3 Activity Cluster Charts (ACC)

An Activity Cluster Chart will be prepared for the operating sequence. The Activity Cluster Chart is a descriptive link between plant states and crew task interactions with the plant that identifies sets of operator activities (both physical and mental) that underlie and determine the specific elements of physical task behavior.

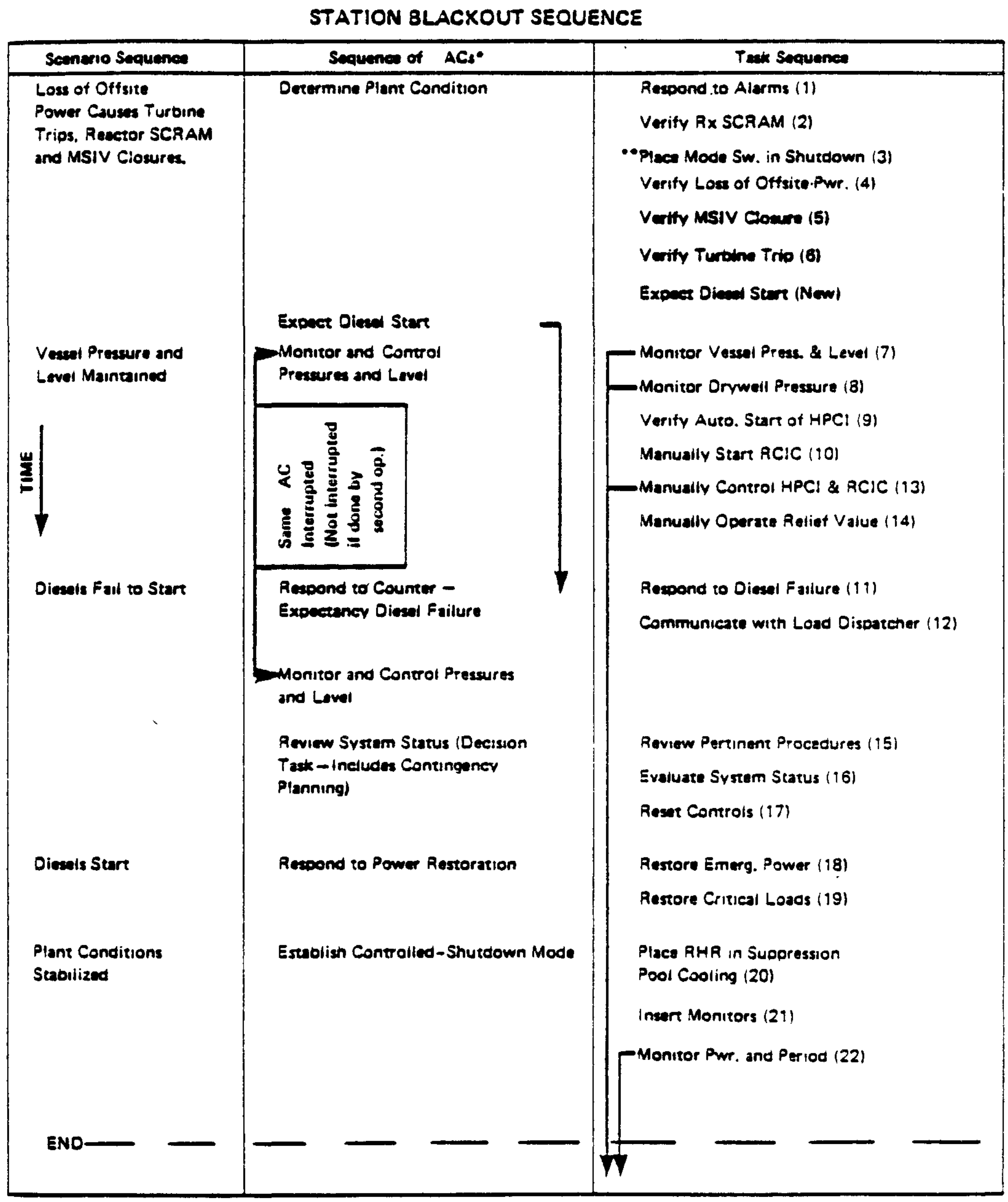
The Activity Cluster Chart will contain the following information:

- o statement of each activity cluster in the operating sequence, listed in the order in which they occur
- o each event described in the operating sequence overview related to each activity cluster
- o tasks contained in each activity cluster

An Activity Cluster Chart is designed to:

- o indicate the general focus of operator behavior (both physical and mental) in various portions of an operating sequence
- o provide a structured account of the physical crew tasks and behavioral elements associated with an activity cluster
- o indicate criticality in sequence of activity clusters even though the sequence of tasks and elements within a cluster is not critical

Activity Cluster Charts will be prepared by members of the Data Collection Team, using a three-column format, as shown in Figure B-3. Team members will determine the tasks to be included within each



* AC = Activity Cluster

**In itself is not a verification task, but placed here because performed routinely during SCRAM verification).

Figure B-3 Sample Activity Cluster Chart activity cluster and structure an activity cluster statement descriptive of the set controlling these tasks. Activity cluster statements should be written to relate to events (either stated or implied) in the Operating Sequence Overview and also relate to specific tasks to be identified in the Task Sequence Chart.

B.2.2.1.4 Data Review Sheet (DRS)

Each Operating Sequence Overview, Task Sequence Chart, and Activity Cluster Chart will undergo review prior to use on-site. During preparation of the OSO, TSC, and ACC, the draft forms will be appended to a Data Review Sheet, shown in Figure B-4. The heading information will be completed, noting operating sequence and plant name and the names of those data collection team members who participated in the preparation of the forms and dates of preparation. All forms will be retained with the DRS.

Each prefilled data form will undergo a Subject Matter Expert (SME) and task analyst review prior to its use on site. The data collection team members will be available to respond to questions from the reviewers during the review.

The SME review will be performed in order to detect obvious errors in the flow of task action. The plant documentation available to the data collection team will be used as a basis for the SME review. Perceived errors will be noted and discussed with the data collection team and changes made where appropriate.

The pre-fill will be reviewed to ensure internal consistency by a task analyst. Each data form will be reviewed to ensure compliance prior to use of the pre-filled form on site.

The review of all documents within the batch will be recorded on the Data Review Sheet. The SME and task analyst reviewers will initial the "Reviewed by" box and note the date of the review for the OSO and TSC in the "Post Prefill (A-4)" column. The Team Leader will initial the "Revisions" column and provide the date to indicte that all revisions resulting from the review have been completed.

B.2.2.2 On-Site Field Data Verification

Upon completion of pre-fill, the data collection team will travel to the site where field data verification will take place. One plant will be visited, with a BWR nuclear steam supply system. The purpose of this visit will be to obtain amplifying information in order to accurately reconstruct the actual plant event to be simulated during Phase II, and update the pre-filled task analysis forms discussed in Section B.2.2.1. The general sequence of events and actions can be verified from the control room and shift foreman's log books. Strip charts, alarm typer printouts, maintenance requests, and scram reports can provide additional information related to the times when certain operator actions and plant responses occurred. The pre-filled data collection forms will be reviewed and corrected to reflect actual plant and operator response to the event.

DATA REVIEW SHEET

Operating Sequence: ______________________ Plant Name: ______________

Prepared by: ____

Date: __________ OSO: __________ ACC: __________ TSC: __________ TDF: ______.

A-4 Checklist Date: ______________ C-1 Checklist Date: ______________

	POST PREFILL (A-4)		PLANT REVIEW (B-5)		FINAL REVIEW (C-1)	
OPERATING SEQUENCE OVERVIEW	Reviewed by		Reviewed by		Reviewed by	X
	Date		Date		Date	X
	Revisions*		Revisions	X	Revisions	X
	Date		Date	X	Date	X
ACTIVITY CLUSTER CHART	Reviewed by		Reviewed by		Reviewed by	X
	Date		Date		Date	X
	Revisions		Revisions	X	Revisions	X
	Date		Date	X	Date	X
TASK SEQUENCE CHART	Reviewed by		Reviewed by		Reviewed by	X
	Date		Date		Date	X
	Revisions		Revisions	X	Revisions	X
	Date		Date	X	Date	X
TASK DATA FORMS	Reviewed by		Reviewed by		Reviewed by	
	Date		Date		Date	
	Revisions		Revisions	X	Revisions	X
	Date		Date	X	Date	X

*The data collection team leader is responsible for insuring that all revisions are incorporated on the forms. The team leader should initial this block when all revisions are complete.

Figure B-4 Data Review Sheet

B.2.3 Phase II. On-Site Simulator Data Collection

The site visit will require support including personnel assigned to assist the study team, equipment and materials, and facilities for data collection activities. Support needed from the utility company include the following:

- Two experienced individuals, licensed to operate the plant at the SRO level and knowledgeable of the specific control room and plant design, to participate in review of desk-top analysis, and talk-throughs of operational sequences. (one half day)

- Three licensed operators (1 SRO, 2 ROs) to operate the simulator during the scenario data collection. (one half day)

Facilities which the data collection team will require include the following:

- Access to a small conference room or other working space for review of desk-top task analysis with plant personnel

- Access to telephones

- Access to plant records

- Access to the plant simulator for one half day

B.2.3.1 Task Data Form (TDF)

As mentioned in Section B.2.2.1, the Task Data form will be completed during Phase II. This form is based on the task element level and requires detailed inputs which are initially derived from plant data. It is pre-filled using the verified descriptive data obtained during Phase I, and completed using the observations and videotapes obtained during the simulator runs.

Materials and documents which will be needed include results from preceding project activities (Phase I) and documentation received from the plants.

Input from preceding project activities include:

- Operating Sequence Overview (OSO)

- Task Sequence Chart (TSC)

- Activity Cluster Chart (ACC)

- Data Review Sheet (DRS)

The Task Data Form (Figure B-5) comprises the primary data collection record and will be revised and validated during subsequent steps in the data collection process. The instructions in this procedure describe the initial work in preparing the TDF at the home office prior to simulator data collection.

The form is divided into three parts. The headings include Plant Identification and Task Identification. The main body of the form comprises the Description of Task Action information.

The Task Data Form will be completed for each task listed on the TSC. One or more sequentially numbered pages are required to complete the description of the task.

Plant and Task Identification entries are pre-filled to the extent possible by the data collection team prior to the site visit using the OSO, ACC, TSC, and plant documents. The task description will be completed to the extent possible.

There will be some legitimate blank fields on all forms at the end of pre-fill. Legitimate blanks are identified in the following discussion of specific fields. Sources of entries for each field are also identified.

B.2.3.1.1 Plant Identification

Items include the following:

- Plant Name: Name of the plant where data collection occurs.

- Unit Number: The number of the unit for multiple unit sites.

- NSSS Vendor: The vendor of the nuclear steam supply system and type (PWR or BWR).

- A-E: The architect-engineer firm which designed the plant.

- TG Vendor: The vendor of the turbine-generator to which the unit supplies steam.

- CR Type: Single or multi-unit control room. The control room is multi-unit if the control rooms of two units are open to each other.

- OL Date: The year in which the unit was (or expects to be) granted an operating license. All estimated dates will be followed by "EST."

TASK DATA FORM (DESCRIPTIVE)

Page No. ______

PLANT IDENTIFICATION

Plant Name ______

Unit Number ______

NSSS Vendor ______

A E ______

TG Vendor ______

CR Type ______

OL Date ______

TASK IDENTIFICATION

Operating Sequence ______

Operating Sequence ID ______

Operator Function ______

Operator Sub function ______

Comments ______

CUE ______

Task Statement ______

Task Purpose ______

INPO Task Code ______

Task Sequence No ______

Task Duration ______

Procedures ______

Data Collected at ______

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INPO EQUIV		RESPOND	RLOC	CONTENT

Figure B-5 Task Data Form (Descriptive)

B.2.3.1.2 Task Identification

Items include:

- Operating Sequence: The title of the sequence in which the task occurs (source: OSO).

- Operating Sequence ID: The number assigned to the operating sequence (source: OSO).

- Operator Function: The applicable category of operator performance which the operating sequence supports (source: OSO).

- Operator Sub-function: The applicable sub-category of operator performance which the operating sequence supports (source: OSO).

- Comments: Any additional notes which the Data Collection Team considers to be important, relative to the task.

- Cue: The input (e.g., a system indication, order, procedural step) that tells the crew member to initiate the task (source: TSC).

- Task Statement: An imperative statement that summarizes the task action (e.g., start a reactor feedwater pump; shutdown a station diesel generator) (source: TSC).

- Task Purpose: The reason for which the crew member performs the specific task. All elements of the task support this purpose. The purpose explains why the crew member interacts with the plant systems.

- INPO Task Code: The code number assigned to the equivalent or related task(s) in INPO's job-task analysis. This item will be left blank if INPO has not identified an equivalent or substantially related task (source: TSC).

- Task Sequence Number: A number indicating an acceptable order of performance of the task in relation to the other tasks in the sequence (source: TSC).

- Task Duration: An estimate of the total elapsed time typically required to complete the task. This will not be pre-filled. Task duration will be measured during site data collection as the elapsed time from the start of the first element assocaited with the task until the start of the last element.

- Procedures: The identifying title, number and paragraph number of the plant procedure(s) applicable to the task.

Procedures will be identified in the desk top analysis. Additional procedures may be found to be applicable during the site visit. There may be no applicable procedures for some tasks. (source: TSC)

- Data Collected at: Identification of the location where the data describing task action was actually collected. This will not be pre-filled. Acceptable entries are "control room" or "simulator."

B.2.3.1.3 Description of Task Action

The Task Data Form will present information describing the observed activities of each control room crew member at the task element level. Each entry on the lower portion of the form, reading across the form, constitutes a task element.

During pre-fill, the data collection team will analyze the operating procedures in use at the plant, and design documentation to develop a preliminary estimate of the flow of action during performance of the task. The SME will play a key role in the pre-fill of the description of task action. The data collection team will pre-fill those entries where expert judgement coupled with a review of plant documentation provides a reasonable basis for the entry. (These entries are preliminary as all entries will be reviewed and verified on-site.) Once completed, an entry can be read as a complete, or model, sentence.

B.2.3.1.3.1 Discussion of Model Sentence and Content

The approach to task data collection employs a concept termed "Model Sentence." The TDF is designed to capture the essential components of each task element in a manner such that data in one or more fields can be extracted from a computerized data base without losing the capability to describe the task element in narrative form. Each task element within the task will be described according to the model sentence. Therefore, each line of entries across the data form may be read as a model sentence. Lists of acceptable entries for data fields which comprise the task element have been developed in some cases as an additional method for ensuring consistency in data collection. Figure B-6 provides a menu of acceptable entries.

The form of the Model Sentence is as follows:

> In order to (task purpose: a summary of why the task is done) the subject (the individual who performs the action(s) of the task), at (panel or other workstation ID), performs the following task behavior(s) (verb) addressing (object of action), by means of (source of information, mechanism of action).

- "In order to" clause: This is the Task Purpose recorded in the Task Identification part of the form. All elements within the task share the Task Purpose.

- "Subject": This is the individual who performs the task element. The subject is initially understood to be "crew member." The job category to which the task is assigned at the particular plant will be identified on site. A specific job category may be entered in the pre-fill if it is reasonably certain. The field designator on the form is JOBCAT. Acceptable entries are listed in Figure B-6.

- "At": Location is identified by a panel name or other work station identifier. It is the location of the entry in the means of action column. The field designator on the form is LOC.

- "Performs what task behavior": This is a verb which describes the crew member behavior. Verbs will be selected from the Berliner classification. The field designator on the form is VERB. Acceptable entries are included in Figure B-6. Definitions of the verbs are included in Figure B-7.

- "Object of Action": The object is the component or parameter or other condition to which the task behavior is directed. The object is not the control room interface, which is frequently the means of action when the crew member interacts with control room instrumentation. Identification of the object will generally have two parts: (1) identification of the specific component, parameter, and state of the parameter and (2) identification of the related plant system of which it is part.

The object of action may be identified by the component or parameter or by both component and parameter. Field designators on the TDF are COMPONENT and PARAMETER. Examples of the use of these fields are:

"RO positions feedwater valve . . ."
"RO observes reactor water level . . ."

In some cases, additional information is required to describe the object of action. When the means of action (see MEANS, below) is a display and there is an entry in the parameter field, an entry may be made in the state field.

The second part of object of action includes the plant system with which the crew member interacts.

The plant systems addressed in each task are initially recorded on the TSC. In some cases the team may find in analyzing a task into elements that systems not recorded on the TSC are involved. Plant specific nomenclature should be used.

When the plant system is identified as part of the object of action, the INPO generic equivalent should be determined from the sytems translation and also recorded on the Task Data Form. The field designators on the Task Data Form are PLANT SYSTEM and INPO EQUIV.

DESCRIPTION OF TASK ACTION													
Who Takes Action	Location of Means of Action	Behavior		Object Action						Means of Action	Communication Link		
JOBCAT	LOC	TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INPO EQUIVALENT	MEANS	RESPONDENT	RLOC	CONTENT
Choose one of the following: RO 1 RO 2 RO 3 SRO 1 SRO 2 (Shift Supervisor) SS (Shift Superintendent) STA (Shift Technical Advisor) SM (Station (Plant) Manager)	Place where object of action is located (Panel Number or Other Workstation Identifier)	The elapsed time in the sequence at which an element is initiated by a member of the crew Not pre filled Determined on site Where multiple elements are concurrent assign them all the same start time	Verb representing crew behavior From modified Berliner classification Inspects Observes Reads Monitors Scans Detects Identifies Locates Interpolates Verifies Remembers Calculates Chooses Compares Plans Decides Diagnoses Moves Holds Pushes/Pulls Positions Adjusts Types Answers Informs Requests Records Directs Receives	Choose one word from one of the following groups Mechanical Group Accumulators Blowers/Fans Boilers Compressors Condenser Containment Penetrations Control Rods Demineralizers Filters/Strainers Heat Exchangers Main Stream Line Pumps Reactor Stack Tanks Turbine Valve Operators Valves Electrical Group Batteries Circuit Closure Devices Circuit Breakers Switchgear Electrical Conductors Electrical Distribution Buses Generators Turbine Diesel Interlock Motors Rectifiers Transformers Instrumentation & Controls (I&C) Equipment Computer Sensors/Control Instruments Controller Master Controller Sensors	Choose one word from one of the following groups Mechanical Group Differential Pressure Flow Humidity Level Position Pressure Speed Temperature Time Vacuum Vibration Electrical Group Current Frequency Power Resistance VARS Voltage Radiation Group Dose Rate Radioactivity Reactor Group Delta Flux Neutron Flux Startup Rate Control Mode Group Automatic Close Manual Off On Open Setpoint In Input Signal Out Output Signal Operability Reset Silence Trend Test Chemistry Group Concentration of Gas Concentration of Solids Conductivity Plant Status Trip System Activation System Isolation	When the means of action is a display and there is an entry in the parameter field an entry may be made in the state field selected from the list below depending on the type of display Two position (binary) display on off in out open close fast slow Continuous Display increasing decreasing steady	Open will usually be a procedure or job performance aid (JPA)	Generally from TSC Local Plant Nomenclature From Plant Procedures & Panel Nomenclature	INPO Generic Equivalent From translation list written prior to plant visit and used during pre fill of Task Data Form	This is the operator plant interface a control display or others Control Group Continuously variable controls Discrete controls Display Group Annunciators Indicator lights Meters/recorders Computer Recorders Counters CRTs Other Group Verbal communications Printed material Safety equipment Communication equipment: — Conventional powered telephone system (CPTS) — Sound powered telephone system (SPTS) — Walkie talkie radio transceivers (WTRT) Page party announcing system (PPAS)	Job category of person communicated with: RO 1 RO 2 RO 3 SRO 1 SRO 2 (Shift Supervisor) SS (Shift Superintendent) STA Shift Technical Advisor SM (Station (Plant) Manager) Load Dispatcher Health Physics Team PEO (Plant Equipment Operator) NRC HQ Bethesda NRC Regional Office County Civil Defense Local PD Sheriff State Energy Management Agency State Nuclear Energy Div	Location of party communicated with: On site Control room Off site	Open-Ended

For Parameter it is often necessary to identify the associated component

Model Sentence – Description of Task Action

In order to *(the reason why the task is being performed (1))* subject *(the individual who performs the action(s) of the task/subtask (2))* at *(panel or other workstation ID (3))* performs the following task behavior(s) *(verb) (4)* addressing *(object or behavior (5))* by means of *(source of information, mechanism of action*

Figure B-6 Standard Data Base Entries for Task Data Form (Descriptive)

PROCESSES	ACTIVITIES	SPECIFIC BEHAVIORS	DEFINITIONS
1 Perceptual	1.1 Searching for and Receiving Information	1.1.1 Inspects	To examine carefully, or to view closely with critical appraisal.
		1.1.2 Observes	To attend visually to the presence or current status of an object, indication, or event.
		1.1.3 Reads	To examine visually information which is presented symbolically.
		1.1.4 Monitors	To keep track of over time
		1.1.5 Scans	To quickly examine displays or other information sources to obtain a general impression.
		1.1.6 Detects	To become aware of the presence or absence of a physical stimulus.
	1.2 Identifying Objects, Actions, Events	1.2.1 Identifies	To recognize the nature of an object or indication according to implicit or predetermined characteristics.
		1.2.2 Locates	To seek out and determine the site or place of an object.
2. Cognitive	2.1 Information Processing	2.1.1 Interpolates	To determine or estimate intermediate values from two given values.
		2.1.2 Verifies	To confirm.
		2.1.3 Remembers	To retain information (short-term memory) or to recall information (long-term memory) for consideration.
	2.2 Problem Solving and Decision Making	2.2.1 Calculates	To determine by mathematical processes.
		2.2.2 Chooses	To select after consideration of alternatives.
		2.2.3 Compares	To examine the characteristics or qualities of two or more objects or concepts for the purpose of discovering similarities or differences.
		2.2.4 Plans	To devise or formulate a program of future or contingency activity.
		2.2.5 Decides	To come to a conclusion based on available information.
		2.2.6 Diagnoses	To recognize or determine the nature or cause of a condition by consideration of signs or symptoms or by the execution of appropriate tests.
3 Motor	3.1 Simple/Discrete	3.1.1 Moves	To change the location of an object.
		3.1.2 Holds	To apply continuous pressure to a control
		3.1.3 Pushs/Pulls	To exert force away from/toward the actor's body.
	3.2 Complex/Continuous	3.2.1 Positions	To operate a control which has discrete states.
		3.2.2 Adjusts	To operate a continuous control
		3.2.3 Types	To operate a keyboard.
4 Communication		4.0.1 Answers	To respond to a request for information.
		4.0.2 Informs	To impart information.
		4.0.3 Requests	To ask for information.
		4.0.4 Records	To document something, as in writing.
		4.0.5 Directs	To ask for action.
		4.0.6 Receives	To be given written or verbal information.

Source. Berliner, et al., 1964 (Modified).

Figure B-7 Standardized List of Action Verbs for Use at the Task Element Level

When the object of action is not related to control room instrumentation, it will be identified in the OTHER OBJECT field. Applicable procedures and other job performance aids (JPAs) available to guide that task performance are examples. Procedure numbers will already be recorded in the task identification part of the form. JPAs, will be identified on-site.

- "Means": This is the item with which the crew member actually interfaces. In process control tasks, the interface will not be with the plant equipment addressed. There is an intermediary, a control, display, or person. Means may include other tools/materials--what the crew member uses to perform the behavior. The definition of means will be categorical--a type (e.g., electric switch, meter, CRT) or, if the means of control or information source or recipient is a person, the means will be a mode of communication (e.g., voice communication, standard telephone, page-party system, etc.). The field designator on the task data form is means. The entry will be the applicable word from the pre-defined list presented in Figure B-7.

When communications are involved (i.e., if the source or recipient of information, or the agent of control, is another person), the job category and location of the other party in the communication will be recorded. These items will be determined on-site.

A communication will be included as an element if it is essential to performance of another task element. A communication may be essential because:

- It is the initiating cue for performance of an element--an order given or received

- It provides task input or feedback information without which another task or element cannot be performed. (This includes communication with people off-site; e.g., informing load dispatcher of plant status because load dispatcher must know this to do his tasks.)

Communications will not be noted during pre-fill, except where the expected communication is obvious. A communication will be recorded as an element within the task it supports. Data recorded describing the communication will include JOBCAT, LOC, BEHAVIOR, MEANS, and COMMUNICATION LINK fields. There are three entries in the Communication Link Field. These include RESPOND, the job category of the person communicated with; RLOC, the location of the respondent; and CONTENT, a brief summary of the message. CONTENT is a free form entry.

- "Miscellaneous Field": One data field appears on the descriptive part of the form which is not part of the model sentence. This is the time field identified as TIME on the

TDF. The time of interest is the start time for each crew member task element. The time will be recorded during review of videotapes made during the site data collection.

Before simulator data collection begins, the pre-filled TDF will be reviewed by plant personnel. This review will verify the accuracy of the data and make any changes that are necessary. Acceptance of the pre-filled data will be recorded on the DRS.

B.2.4 Control Room Operating Crew

Collection of the simulator data will be performed in a dedicated exercise with licensed operators. The test subjects will represent the typical level of experience normally found in the control room including the same number of personnel present during the actual event. The control room crew for this experiment will consist of 3 persons: one Senior Reactor Operator (SRO), to play the role of shift supervisor, and two Reactor Operators (ROs), to play the roles of reactor operator and balance of plant (BOP) operator. The shift supervisor is responsible for directing the actions of reactor operator and BOP operator. The supervisor will reference the procedures and evaluate plant conditions to make decisions for response to the casualty. The reactor operator is responsible for actions that concern reactor control, reactor instrumentation and the reactor recirculation system. The BOP operator is responsible for actions concerning a large number of systems, both normal and emergency.

B.2.4.1 Data Collection

Each simulator sequence being recorded will have a Human Factors Specialist and a Subject Matter Expert observing and recording the operating crew performance. Any changes required to the TDF should be noted on the form at that time.

The operators will respond to the event on three runs. Each simulator run will be recorded by the Performance Measurement System (PMS) and videotaped with two cameras, concentrating on the reactor operator and BOP operator. Figure B-8 shows the camera layout which will be used. The communications between all three operators will be recorded on one audio channel. The other audio channel will be used to overdub perceptual and cognitive tasks as the operators view the videotape.

The first run conducted will be a "cold" exercise (i.e. operators have not been informed of the event). The scenario will then be repeated twice, ensuring that the operators correct any errors committed on the first run. The runs will be conducted in approximately ten minute blocks. The operators will overdub each ten minute block, immediately after completion of that block, while their thoughts are fresh in their minds. The two benchmark runs will be used for comparison to the field data, and for completing the TDF.

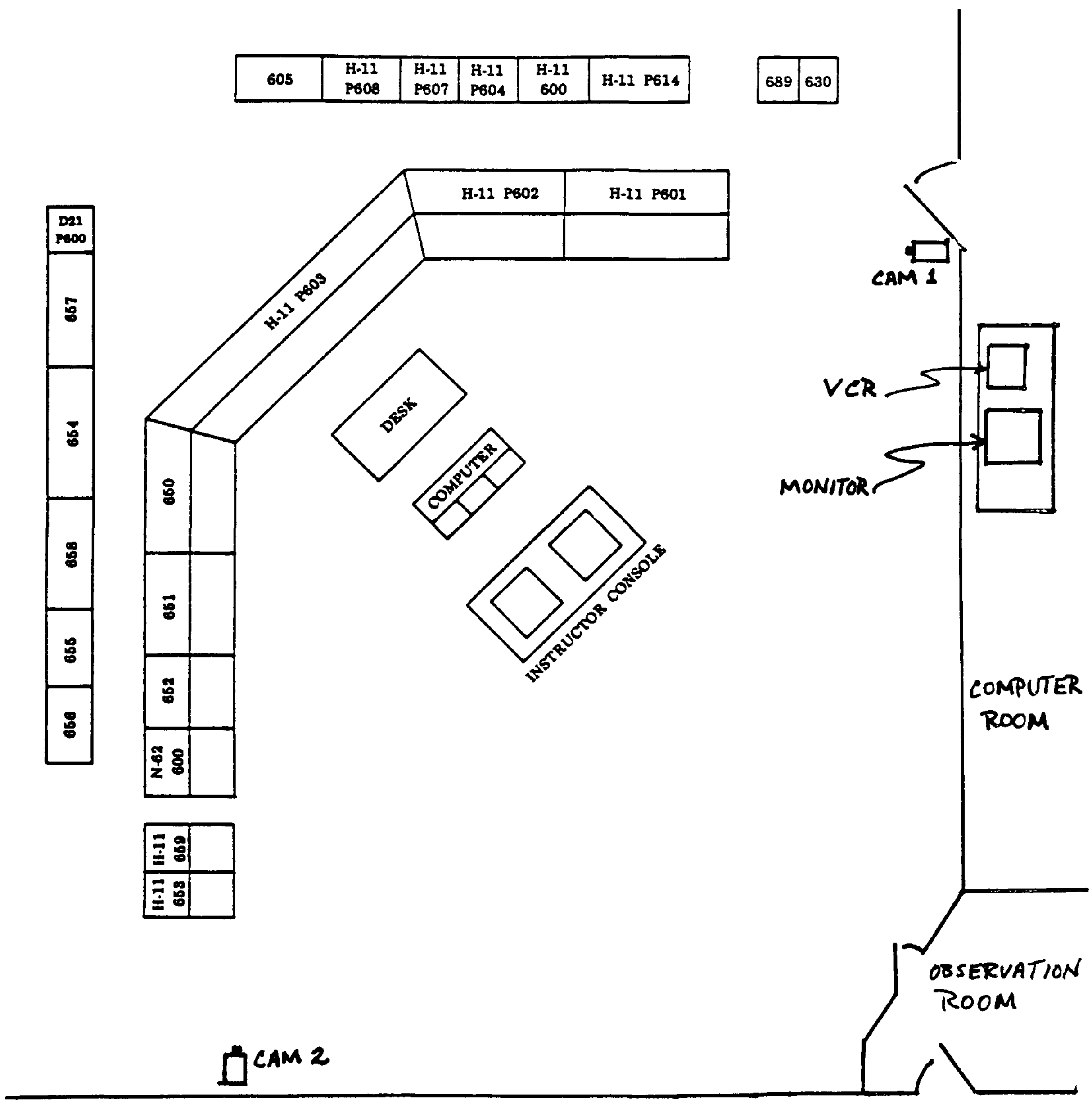


Figure B-8 Video Camera Layout for Simulator Runs

B.2.5 Task Analysis

Following completion of data collection, a task analysis of the videotaped simulator exercises will be performed to complete/verify the TDF. Videotapes will be supplemented by PMS data to assist in measurement and recording of the observed demonstrated performance of each crew member during the simulated operating sequence. All agreements and disagreements between observer TDFs, videotapes, and PMS will be noted and analyzed.

APPENDIX B

Section B.3

DATA USES

B.3 Data Uses

B.3.1 SROA Use of Data

The data collected in this simulator exercise will have two SROA uses. First, the data will be used as one input into the SROA model. (Additional plant-specific information is required). The SAINT model will then be run to predict operator/system performance. The second use will be a comparison of field and simulator data on operator/system performance with the predicted performance from the SROA model. This comparison will verify the accuracy of the model for predicting performance for the event. Copies of the completed data forms will be included in the criteria for SROA final report.

B.3.2 Other Data Uses

The scenario videotape and PMS records will be analyzed for the 1983 simulator research program using the Task Data Form (TDF) and other forms from the NRC Crew Task Analysis project. This will provide a detailed benchmark run for evaluation of repetitions of the scenario during training. The benchmark run and supplemental training runs will provide an extensive data base for calibration of the simulator data with field data.

APPENDIX B

Section B.4

SAMPLES OF TASK ANALYSIS DATA

(a) Operating Sequence Overview
(b) Task Sequence Chart — ORNL
(c) Task Data Forms, Tasks 1,2,3,17,18,32,33

Operating Sequence Overview

Plant:

Operator Function/Subfunction: Supervise and Control/Restore Plant to Safe Condition

NSSS Type: GE/BWR

Operating Sequence ID: 27

C.R. Type: Multiple

Operating Sequence: Respond to inadvertent open of a safety relief valve.

Initial Conditions: The plant is operating at 90% power. The midnight shift has just reported and verified that all systems are operating normally: (1) Both recirculation pumps in operation; (2) Both feedwater pumps, all condensate pumps, and all condensate booster pumps are in service; (3) All Emergency Core Cooling Systems (ECCS) and Reactor Core Isolation Cooling (RCIC) are in standby.

Sequence Initiaton: One main steam relief valve (MSRV) fails open below its pressure setpoint. The operator succeeds in closing the valve, but it later reopens.

Expected Progression of Action: Once the operator has identified the malfunction, the Residual Heat Removal (RHR) system is placed in the suppression pool (torus) cooling mode to remove the heat from the relief valve discharge. The control switch for the failed valve is cycled, and the valve closes. After five minutes safety relief valves reopen, and attempts to close it fail. The operators manually scram the reactor, and trip the main turbine when it is evident the failed valves will not close. Following the scram, the other loop of RHR is placed in torus cooling mode, and the condensate system is aligned to maintain reactor level.

Final Conditions: The plant continues the depressurization through the open relief valve. Reactor water level has stabilized. Both feedwater pumps have been removed from service, two condensate and condensate booster pumps have been tripped, and both recirculation pumps have tripped. Plant is stable in hot shutdown. (Mode 3 per Technical Specifications.)

Major Systems: The major systems involved in the transient are: (1) Main Steam; (2) Condensate and Feedwater; (3) Residual Heat Removal and RHR Service Water; (4) Standby Gas Treatment; (5) Reactor Core Isolation Cooling.

TASK SEQUENCE CHART — ORNL*

plant name:

operator function/subfunction: Supervise and Control Plant Functions

operating sequence: Main Safety Relief Valve (MSRV) Fails Open

operating sequence id: 27

Task Seq. No.	Task/Purpose	Cue	Procedure Name & Number	Plant Specific System Name	INPO System Name & No.	Performance Requirement (PR)			PR Source
						H/W	Admin.	Op.	
1	Recognize possible MSRV failure/To identify plant condition	SF/FF mis-match Decreasing MWe Annunciator	ARP-2225 Safety/Blow-down valve trouble	Main Steam (MS)	105				
2	Verify MSRV has failed/To determine appropriate actions	SF/FF mis-match Annunciator Dec MWe	NOP-1907 Failure of relief valves	(MS)	105				
3	Cycle failed MSRV/To attempt to reseat the valve	Operating Practices	NOP-1907	(MS)	105			Attempt to close Failed valve to avoid manual scram	Training
4	Monitor plant parameter/ To determine condition of plant	Operating Practices							
5	Inform supervisor of plant status/To provide information	Procedure	NOP-1907					Commun-ication Manage-ment	Procedure

*Modified From NUREG/CR-3371

TASK SEQUENCE CHART — ORNL*

plant name:

operator function/subfunction: Supervise and Control Plant Functions

operating sequence: Main Safety Relief Valve (MSRV) Fails Open

operating sequence id: 27

Task Seq. No.	Task/Purpose	Cue	Procedure Name & Number	Plant Specific System Name	INPO System Name & No.	Performance Requirement (PR)			PR Source
						H/W	Admin.	Op.	
6	Monitor torus indication/ To determine proximity to tech. spec. limit	Procedures	NOP-1907	RHR	5				
7	Read tech. specs./To determine plant status in relationship to capabilities	Operating Practices							
8	Initiate corrective maintenance action/To correct malfunctioning equipment	Tech. Specs.							
9	Verify plant is in a stable condition/To ensure plant is safe	Operating Practices							
10	Reset controls/To return plant to proper lineup	Operating Practices							

*Modified From NUREG/CR-3371

TASK SEQUENCE CHART — ORNL*

plant name:

operator function/subfunction: Supervise and Control Plant Functions

operating sequence: Main Safety Relief Valve (MSRV) Fails Open

operating sequence id: 27

Task Seq. No.	Task/Purpose	Cue	Procedure Name & Number	Plant Specific System Name	INPO System Name & No.	Performance Requirement (PR)			PR Source
						H/W	Admin.	Op.	
11	Recognize possible MSRV failure/To identify plant condition	SF/FF mis-match Decreasing MWe annunciator	ARP-2225 Safety Blow-down valve trouble	(MS)	105				
12	Verify MSRV has failed/To determine appropriate actions	SF/FF mis-match Annunciator Dec MWe	NOP-1907 Failure of relief valves	(MS)	105				
13	Cycle failed MSRV/To attempt to reseat the valve	Operating Practices		(MS)	105			Attempt to close failed valve to avoid manual Scram	Training
14	Manually SCRAM the reactor/To reduce heat generation	Procedure	ARP-2001 NOP-1907	Reactor protection system (RPS)	12			Evident the valves will not close	Procedure
15	Trip the main turbine/ To prevent reverse power	Procedures	ARP-2001	Turbine generator (TG)	45	Prior to Reverse Power			Procedure and Generator Technical Manual

*Modified From NUREG/CR-3371

TASK SEQUENCE CHART — ORNL*

plant name:

operator function/subfunction: Supervise and Control Plant Functions

operating sequence: Main Safety Relief Valve (MSRV) Fails Open

operating sequence id: 27

Task Seq. No.	Task/Purpose	Cue	Procedure Name & Number	Plant Specific System Name	INPO System Name & No.	Performance Requirement (PR)			PR Source
						H/W	Admin.	Op.	
16	Operate MSRV's/To equalize heat load in the torus	Procedures	NOP-1907	(MS)	105				
17	Operate Feedwater system/ To maintain reactor vessel	Procedures	NOP-1285 Feedwater System		94			Maintain Rx Level Between +32" and +42"	Procedure
18	Inform supervisor of plant status/To provide information on plant	Procedure	NOP-1907						
19	Insert source and intermediate range monitor/To monitor reactor power	Procedure	ARP-2001	Nuclear Instrumentation (NI)	15			Monitor Core Flux Decrease	Procedure
20	Monitor reactor pressure and level/Determine plant condition	Operating Practices						Monitor Cool-down rate	Tech. Spec.

*Modified From NUREG/CR-3371

TASK SEQUENCE CHART — ORNL*

plant name:

operator function/subfunction: Supervise and Control Plant Functions

operating sequence: Main Safety Relief Valve (MSRV) Fails Open

operating sequence id: 27

Task Seq. No.	Task/Purpose	Cue	Procedure Name & Number	Plant Specific System Name	INPO System Name & No.	Performance Requirement (PR)			PR Source
						H/W	Admin.	Op.	
21	Inform load dispatcher of plant status/To provide information to offsite personnel	Procedure						Provide Information on plant status	Procedure
22	Attempt to close stuck open MSRV's/To control cooldown rate	Operating Practices		(MS)	105				
23	Operate reactor recirculation system/To match interlocks	Operating Practices		Reactor Recirculation (RR)	96				
24	Align feedwater system for start-up configuration/ To prevent vessel overfeed	Procedure	NOP-1285	Feedwater (FW)					
25	Initiate Torus cooling/ To lower suppression pool water temperature	Procedures		RHR RHRSW	5 113			Establish Sufficient Cooling Water	Procedure

*Modified From NUREG/CR-3371

TASK SEQUENCE CHART — ORNL*

plant name:

operator function/subfunction: Supervise and Control Plant Functions

operating sequence: Main Safety Relief Valve (MSRV) Fails Open

operating sequence id: 27

Task Seq. No.	Task/Purpose	Cue	Procedure Name & Number	Plant Specific System Name	INPO System Name & No.	Performance Requirement (PR)			PR Source
						H/W	Admin.	Op.	
26	Verify insertion of control rods/To ensure heat production is stopped	Procedure							
27	Reset the SCRAM/To clear interlocks to stop water driving into SCRAM discharge volume	Procedure		RPS	R				
28	Declare alert status/To inform site personnel of plant status	Procedure	NOP-4400 Notification of an unusual event					Initiate Notification	Procedure
29	Align steam jet air ejector for operation of mechanical vacuum pump/ To maintain condenser vacuum	Operating Practices		SJAE	56				
30	Align control board devices/To return control to position consistent with operating state	Operating Practices		ACED	62			Ensure Continuity of Elec. power	Procedure

*Modified From NUREG/CR-3371

TASK SEQUENCE CHART — ORNL*

plant name:

operator function/subfunction: Supervise and Control Plant Functions

operating sequence: Main Safety Relief Valve (MSRV) Fails Open

operating sequence id: 27

Task Seq. No.	Task/Purpose	Cue	Procedure Name & Number	Plant Specific System Name	INPO System Name & No.	Performance Requirement (PR)			PR Source
						H/W	Admin.	Op.	
31	Align Torus to radwaste/ To decrease torus level	Operating Practices		RHR	5				
32	Start-up reactor water clean-up system/To return plant to normal configuration	Operating Practices		RWCU	95				
33	Reset drywell and equipment drain isolation/ To allow water to drain			Radwaste drains	107				

*Modified From NUREG/CR-3371

TASK DATA FORM (DESCRIPTIVE)

Page No 1

PLANT IDENTIFICATION

Plant Name

Unit Number

NSSS Vendor General Electric

A E

TG Vendor

CR Type Conventional

OL Date

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub function Mitigate Consequences of an Accident

Comments

CUE Steam flow/feed flow mismatch Annunciator, Decreasing MWe

Task Statement Recognize possible SRV failure

Task Purpose To identify plant condition

INPO Task Code CRO-1-E, SRO-4.46

Task Sequence No 1

Task Duration 7 seconds

Procedures ARP-2225 Safety/Blowdown Valve Trouble

Data Collected at

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV	MEANS	RESPOND	RLOC	CONTENT
RO2	30	1:32-1:34	Observes	Valve (SRV)	Pressure	ON		Main Steam (MS)	105	Annunciator			
RO1	30	1:34-1:37	Observes	Valve	Pressure	ON		Main Steam	105	Annunciator			
SRO-2	30	1:36	Observes	Valve	Pressure	ON		Main Steam	105	Annunciator			
RO2	29	1:35-1:36	Observes	Valve		OPEN		Main Steam	105	Indicating light (II)			
RO2	29	1:37	Decides				SRV "A" has failed open						
RO2	00	1:37-1:38	Informs							Verbal	CR Crew	CR	SRV "A" open

TASK DATA FORM (DESCRIPTIVE)

PLANT IDENTIFICATION

Plant Name ____

Unit Number ____

NSSS Vendor General Electric

A E ____

TG Vendor ____

CR Type Conventional

OL Date ____

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub function Mitigate Consequences of an Accident

Comments ____

CUE Annunciator: Dec. MWe & SF/FF

Task Statement Verify SRV has failed

Task Purpose To determine appropriate actions

INPO Task Code SRO.4.46. CRO-1-E

Task Sequence No 2

Task Duration 32 seconds

Procedures NOP-1907 Failure of relief valves to operate

Data Collected at ____

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV	MEANS	RESPOND	RLOC	CONTENT
RO2	29	1:39-1:40	Observes	Turbine Generator	Power	Dec.		Turbine Generator (TG)	45	Digital Display (D.D.)			
SRO2	00	1:40-1:41	Informs							Verbal	CR Crew	CR	I'll get the procedures
RO1	30	1:40-1:42	Observes	Valve operator (SRV)		Off		Main Steam	105	Indicating Light			
SRO2	33-2	1:44-1:53	Locates				Procedure HNP-1907						
SRO2	33-2	1:53-2:10	Reads				Procedure HNP-1907						

TASK DATA FORM (DESCRIPTIVE)

Page No. 1

PLANT IDENTIFICATION

Plant Name

Unit Number

NSSS Vendor General Electric

A-E

TG Vendor

CR Type Conventional

OL Date

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments

CUE Operating practices

Task Statement Cycle failed SRV

Task Purpose To attempt to reseat the valve

INPO Task Code CRO-105.4-0

Task Sequence No. 3

Task Duration 27 seconds

Procedures

Data Collected at:

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV.		RESPOND.	RLOC	CONTENT
RO-2	29	1:43-1:46	Observes	Turbine Generator	Power	Steady		Turbine Generator	45	Digital Display			
RO-2	30	1:46	Positions	Valve (SRV)		Open		Main Steam	105	Discrete Control (DC)			
RO-2	30	1:46-1:47	Observes	Valve Operator		On		Main Steam	105	Indicating Light			
RO-2	29	1:47	Observes	Turbine Generator	Power	Steady		Turbine Generator	45	Digital Display			
RO-2	30	1:48	Positions	Valve (SRV)		Auto		Main Steam	105	Discrete Control			
RO-2	29	1:48-1:49	Observes	Turbine Generator	Power	Steady		Turbine Generator	45	Digital Display			
RO-2	30	1:49	Observes	Valve Operator		On		Main Steam	105	Indicating Light			

TASK DATA FORM (DESCRIPTIVE)

Page No. 2

PLANT IDENTIFICATION

Plant Name ______

Unit Number ______

NSSS Vendor General Electric

A E ______

TCI Vendor ______

CR Type Conventional

OL Date ______

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments ______

CUE Operating practices

Task Statement Cycle failed SRV

Task Purpose To attempt to reseat the valve

INPO Task Code CRO-105.4-0

Task Sequence No. 3

Task Duration 27 seconds

Procedures ______

Data Collected at: ______

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INPO EQUIV.		RESPOND	RLOC	CONTENT
RO-2	30	1:51-1:54	Positions	Sensor (SRV/DISCHG)	Pressure	Reset		Main Steam	105	Discrete Control			
RO-2	30	1:51-1:54	Observes	Valve operator		OFF		Main Steam	105	Indicating Light			
RO-2	30	1:52	Positions	Sensor (SRV/DISCHG)	Pressure	Normal		Main Steam	105	Discrete Control			
RO-2	00	1:53	Informs							Verbal	CR Crew	CR	Cycled & Reset
RO-2	30	1:54	Observes	Valve operator		On		Main Steam	105	Indicating Light			
RO-2	30	1:55	Decides	Valve (SRV)		Open		Main Steam	105	Indicating Light			
RO-2	00	1:56-1:59	Informs							Verbal	CR Crew	CR	Valve didn't close

TASK DATA FORM (DESCRIPTIVE)

Page No. 3

PLANT IDENTIFICATION

Plant Name ________

Unit Number ________

NSSS Vendor General Electric

A E ________

TG Vendor ________

CR Type Conventional

OL Date ________

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments ________

CUE Operating Practices

Task Statement Cycle failed SRV

Task Purpose To attempt to reseat the valve

INPO Task Code CRO-105.4-0

Task Sequence No. 3

Task Duration 27 seconds

Procedures ________

Data Collected at: ________

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV.		RESPOND.	RLOC	CONTENT
RO-2	30	1:59	Positions	Valve (SRV)		Open		Main Steam	105	Discrete Control			
RO-1	29	1:58	Remembers	Turbine Generator	Power		Response to pressure	Turbine Generator	45	Digital Display			
RO-1	29	1:59-2:03	Observes	Turbine Generator	Power	Steady		Turbine Generator	45	Digital Display			
RO-2	30	2:01	Positions	Valve (SRV)		Auto		Main Steam	105	Discrete Control			
RO-2	30	2:01	Observes	Valve operator		On		Main Steam	105	Indicating Light			
RO-2	30	2:02	Positions	Sensor (SRV/DSCHG)	Pressure	Reset		Main Steam	105	Discrete Control			
RO-2	30	2:02	Observes	Valve operator		OFF		Main Steam	105	Indicating Light			
RO-2	30	2:03	Positions	Sensor (SRV/DISCHG)	Pressure	Normal		Main Steam	105	Discrete Control			

TASK DATA FORM (DESCRIPTIVE)

PLANT IDENTIFICATION

Plant Name ______

Unit Number ______

NSSS Vendor General Electric

A E ______

TG Vendor ______

CR Type Conventional

OL Date ______

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments ______

CUE Operating Practices

Task Statement Cycle failed SRV

Task Purpose To attempt to reseat the valve

INPO Task Code CRO-105.4-0

Task Sequence No. 3

Task Duration 27 seconds

Procedures ______

Data Collected at: ______

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV.		RESPOND.	RLOC	CONTENT
RO-2	30	2:03	Observes	Turbine Generator	Power	INC.		Turbine Generator	45	Digital Display			
RO-2	00	2:05	Informs							Verbal	CR Crew	CR	MWe increasing
RO-2	30	2:06-2:07	Verifys	Sensor (SRV/DISCHG)	Pressure	Reset		Main Steam	105	Indicating Light			
RO-2	30	2:07	Decides	Valve (SRV)		Closed		Main Steam	105	Indicating Light			
RO-2	00	2:08-2:09	Requests							Verbal	RO-1	CR	Is pressure staying down

TASK DATA FORM (DESCRIPTIVE)

Page No. 1

PLANT IDENTIFICATION

Plant Name ______

Unit Number ______

NSSS Vendor General Electric

A-E ______

TG Vendor ______

CR Type Conventional

OL Date ______

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments ______

CUE Procedure ARP-2001

Task Statement Operate feedwater system

Task Purpose To maintain reactor vessel

INPO Task Code CRO-94.6,94.4-0

Task Sequence No. 17

Task Duration 7:35

Procedures Feedwater system

NOP-1285

Data Collected at: ______

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV	MEANS	RESPOND.	RLOC	CONTENT
RO-1	29	8:33-8:49	Observes	Reactor	Level	Dec		Feedwater	94	Recorder			
RO-1	28	8:35	Chooses	Valve (Turbine/Trip)				Feedwater	94	Discrete Control			
RO-1	29	8:57	Monitors	Reactor	Level	Inc		Feedwater	94	Recorder			
RO-1	28	8:58	Locate	Valve (Turbine/Trip)				Feedwater	94	Discrete Control			
RO-1	28	9:08	Observe	Reactor	Level	Valve		Feedwater	94	Meter			
RO-1	00	9:12	Informs							Verbal	CR Crew	CR	Level is increasing
RO-1	29	9:12	Decides	Valve (Turbine/ Trip)				Feedwater	94	Discrete Control			
RO-1	29	9:13	Positions	Valve (Turbine/ Trip)		Trip	"B" Pump	Feedwater	94	Discrete Control			

TASK DATA FORM (DESCRIPTIVE)

PLANT IDENTIFICATION

Plant Name

Unit Number

NSSS Vendor General Electric

A E

TG Vendor

CR Type Conventional

OL Date

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub function Mitigate Consequences of an Accident

Comments

CUE Procedure ARP-2001

Task Statement Operate feedwater system

Task Purpose To maintain reactor vessel

INPO Task Code CRO-94.6.94.4-0

Task Sequence No. 17

Task Duration 7:35

Procedures Feedwater system NOP-1285

Data Collected at:

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV		RESPOND	RLOC	CONTENT
RO-1	28	9:15	Observes	Pump (Reactor)	Speed	Dec,		Feedwater	94	Meter			
RO-1	29	9:16	Observes	Controller (Pump)	Speed	Valve		Feedwater	94	Continuous Variable Control (CVC)			
RO-1	00	9:17	Informs							Verbal	CR Crew	CR	"B" Feedwater pump is tripped
RO-1	29	9:18	Positions	Controller (Pump)	Speed	Manual	Pump "B" Controller	Feedwater	94	Discrete Control			
RO-1	29	9:19	Positions	Controller (Pump)	Speed	Manual	Master	Feedwater	94	Discrete Control			
RO-1	29	9:19-9:25	Adjust	Controller (Pump)	Speed	Dec,	RFP "B" Demand sig	Feedwater	94	CVC			

TASK DATA FORM (DESCRIPTIVE)

PLANT IDENTIFICATION

Plant Name ____

Unit Number ____

NSSS Vendor General Electric

A E ____

TG Vendor ____

CR Type Conventional

OL Date ____

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub function Mitigate Consequences of an Accident

Comments ____

CUE Procedure ARP-2001

Task Statement Operate feedwater system

Task Purpose To maintain reactor vessel

INPO Task Code CRO-94.6.94.4-O

Task Sequence No 17

Task Duration 7:35

Procedures Feedwater system NOP-1285

Data Collected at ____

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV	MEANS	RESPOND	RLOC	CONTENT
RO-1	28	9:36-9:37	Observes	Pump (Reactor)	Speed	Dec	RFP "B" Demand sig	Feedwater	94	Meter			
RO-1	28	9:37	Locates	Valve (Turbine/ Trip)				Feedwater	94	Discrete Control			
RO-1	29	9:45-10:17	Adjusts	Pump (Reactor)	Speed	Dec	Master	Feedwater	94	CVC			
RO-1	28	9:53-10:07	Observes	Pump (Reactor)	Speed	Dec		Feedwater	94	Meter			
RO-1	28	10:07-10:08	Observes	Pump (Reactor/ DISCHG)	Pressure	Dec		Feedwater	94	Recorder			
RO-1	00	10:07-10:09	Informs							Verbal	RO-2	CR	Should be within capabilities of the booster pump

TASK DATA FORM (DESCRIPTIVE)

PLANT IDENTIFICATION

Plant Name ______

Unit Number ______

NSSS Vendor General Electric

A E ______

TG Vendor ______

CR Type Conventional

OL Date ______

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub function Mitigate Consequences of an Accident

Comments ______

CUE Procedure ARP-2001

Task Statement Operate feedwater system

Task Purpose To maintain reactor vessel

INPO Task Code CRO-94.6.94.4-0

Task Sequence No 17

Task Duration 7:35

Procedures Feedwater system NOP-1285

Data Collected at: ______

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior TIME	Behavior VERB	Object of Action COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV	Means of Action MEANS	Communication Link RESPOND	RLOC	CONTENT
RO-1	00	10:10-10:13	Requests							Verbal	RO-2	CR	Can second feedwater pump be removed from area
SRO-2	00	10:14	Requests							Verbal	RO-1	CR	Do you have level under control
RO-1	00	10:15	Informs							Verbal	SRO-2	CR	Status of level is 40 inches & inc
RO-2	00	10:16	Informs							Verbal	RO-1	CR	OK to trip RFP
RO-1	00	10:17	Informs							Verbal	CR Crew	CR	Tripping "A" RFP
RO-1	29	10:18	Positions	Valve (Turbine/Trip)		Trip		Feedwater	94	Discrete Control			

TASK DATA FORM (DESCRIPTIVE)

Page No. 5

PLANT IDENTIFICATION

Plant Name ______

Unit Number ______

NSSS Vendor General Electric

A-E ______

TG Vendor ______

CR Type Conventional

OL Date ______

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments ______

CUE Procedure ARP-2001

Task Statement Operate feedwater system

Task Purpose To maintain reactor vessel

INPO Task Code CRO-94.6.94.4-O

Task Sequence No. 17

Task Duration 7:35

Procedures Feedwater system

NOP-1285

Data Collected at: ______

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV.	MEANS	RESPOND.	RLOC	CONTENT
RO-1	28	10:20-10:21	Observes	Pump (Booster)		On		Feedwater	94	Indicating Light			
RO-1	28	10:22	Positions	Pump (Booster)		Trip		Feedwater	94	Discrete Control			
RO-1	29	10:24-10:26	Adjusts	Pump (Reactor)	Speed	Dec		Feedwater	94	CVC			
RO-1	30	11:01-11:03	Observes	Reactor	Level	Inc		Feedwater	94	Meter			
RO-1	00	11:02	Informs							Verbal	CR Crew	CR	Level is at 580 inches
SRO-2	29	11:03	Observes	Reactor	Level	Inc		Feedwater	94	Meter			
SRO-2	00	11:03	Request							Verbal	RO-1	CR	What is of the feedwater system

TASK DATA FORM (DESCRIPTIVE)

Page No. 6

PLANT IDENTIFICATION

Plant Name

Unit Number

NSSS Vendor General Electric

A-E

TG Vendor

CR Type Conventional

OL Date

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments

CUE Procedures ARP-2001

Task Statement Operate feedwater system

Task Purpose To maintain reactor vessel

INPO Task Code CRO-94.6.94.4-O

Task Sequence No. 17

Task Duration 7:35

Procedures Feedwater system NOP-1285

Data Collected at:

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV.		RESPOND	RLOC	CONTENT
RO-1	00	11:05	Informs							Verbal	SRO-2	CR	One booster pump is tripped
SRO-2	00	11:09	Informs							Verbal	RO-1	CR	Level is 72 inches
RO-1	29	11:15	Informs							Verbal	SRO-2	CR	I will remove additional booster pump
RO-1	29	11:16-11:17	Positions	Pump (Booster)		Trip		Feedwater	94	Discrete Control			
RO-1	29	11:16-11:17	Observes	Pump (Booster)		OFF		Feedwater	94	Indicating Light			
RO-1	28	11:35-11:39	Observes	System	Pressure	Trend		Feedwater	94	Recorder			
RO-1	00	11:43	Informs							Verbal	CR Crew	CR	Reactor pressure is 200 lbs.

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TASK DATA FORM (DESCRIPTIVE)

Page No 7

PLANT IDENTIFICATION	TASK IDENTIFICATION	
Plant Name	Operating Sequence Main Steam Relief Valve Fails Open	Task Statement Operate feedwater system
Unit Number	Operating Sequence ID 27	Task Purpose To maintain reactor vessel
NSSS Vendor General Electric	Operator Function Supervise and Control Plant Functions	INPO Task Code CRO-94 6,94 4-0
A E	Operator Sub function Mitigate Consequences of an Accident	Task Sequence No 17
TG Vendor	Comments	Task Duration 7:35
CR Type Conventional		Procedures Feedwater system
OL Date		NOP-1285
	CUE Procedure ARP-2001	Data Collected at.

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV		RESPOND	REOC	CONTENT
RO-1	30	11:50	Observes	Reactor	Level	Valve		Feedwater	94	Meter			
RO-1	00	11:50	Informs							Verbal	CR Crew	CR	Reactor level is 588 inches
RO-1	28	14:03	Positions	Pump		On		Feedwater	94	Discrete Control			
RO-1	28	14:03	Observes	Pump				Feedwater	94	Indicating Light			
SRO-2	00	14:29	Requests							Verbal	RO-1	CR	Is the 110 valve closed
RO-1	00	14:30-14:36	Informs							Verbal	SRO-2	CR	110 is Closed--125 & 115 are open

TASK DATA FORM (DESCRIPTIVE)

Page No. 8

PLANT IDENTIFICATION

Plant Name ______

Unit Number ______

NSSS Vendor General Electric

A-E ______

TG Vendor ______

CR Type Conventional

OL Date ______

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments ______

CUE Procedure ARP-2001

Task Statement Operate feedwater system

Task Purpose To maintain reactor vessel

INPO Task Code CRO-94.6.94.4-0

Task Sequence No. 17

Task Duration 7:35

Procedures Feedwater system NOP-1285

Data Collected at: ______

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV.		RESPOND.	RLOC	CONTENT
RO-1	29	15:17	Positions				Made switch to single	Feedwater	94	Discrete control			
RO-1	00	16:06	Requests							Verbal	SRO-2	CR	What is pressure
SRO-2	00	16:08	Informs							Verbal	RO-1	CR	Pressure is 40 lbs.

TASK DATA FORM (DESCRIPTIVE)

Page No. 1

PLANT IDENTIFICATION

Plant Name

Unit Number

NSSS Vendor General Electric

A E

TG Vendor

CR Type Conventional

OL Date

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub function Mitigate Consequences of an Accident

Comments

CUE Procedure

Task Statement Inform supervisor of plant status

Task Purpose To provide information on plant

INPO Task Code SRO-3.44

Task Sequence No 18.

Task Duration :37

Procedures NOP-1907

Data Collected at:

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV		RESPOND	RLOC	CONTENT
SS	00	8:46-9:22	Informs							PPAS	SS	On-site	Plant is SCRAMED with two SRV's stuck open

TASK DATA FORM (DESCRIPTIVE)

Page No. 1

PLANT IDENTIFICATION		TASK IDENTIFICATION			
Plant Name		Operating Sequence	Main Steam Relief Valve Fails Open	Task Statement	Start up Reactor Water Clean-up System
Unit Number		Operating Sequence ID	27	Task Purpose	To return plant to normal configuration
NSSS Vendor	General Electric	Operator Function	Supervise and Control Plant Functions	INPO Task Code	CRO-95.1-0
A-E		Operator Sub-function	Mitigate Consequences of an Accident	Task Sequence No.	32
TG Vendor		Comments		Task Duration	1:34
CR Type	Conventional			Procedures	
OL Date					
		CUE	Operating Practices	Data Collected at:	

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV.	MEANS	RESPOND.	RLOC	CONTENT
SRO-2	30	16:35	Decides				Place RWCU in service						
RO-1	00	16:35	Request							Verbal	SRO-2	CR	Do you want RWCU on?
SRO-2	00	16:36	Informs							Verbal	RO-1	CR	Yes
SRO-2	00	16:59	Informs							Verbal	CR Crew	CR	He will open the 4 valve to cleanup
SRO-2	21	16:59 17:13	Positions	Valve		Open		RWCU	95	DC			
RO-2	00	17:02	Informs							Verbal	RO1	CR	Open RWCW Isol. Valve

TASK DATA FORM (DESCRIPTIVE)

Page No. 2

PLANT IDENTIFICATION

Plant Name ______

Unit Number ______

NSSS Vendor General Electric

A-E ______

TG Vendor ______

CR Type Conventional

OL Date ______

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments ______

CUE Operating Practices

Task Statement Start up Reactor Water Clean-up System

Task Purpose To return plant to normal configuration

INPO Task Code CRO-95.1-0

Task Sequence No. 32

Task Duration 1:34

Procedures ______

Data Collected at: ______

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action MEANS	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV		RESPOND.	RLOC	CONTENT
RO-1	30	17:03-17:24	Positions	Valve (Isol)		OPEN		RWCU		Discrete Control			
RO-1	00	17:08-17:09	Requests							Verbal	SRO-2	CR	Do you want the valve opened fast?
SRO-2	30	17:14	Observes	Valve				RWCU	95	IL			
RO-2	30	17:27-17:51	Positions	Valve(Isol) (Suction)		OPEN		RWCU	95	DC			
RO-1	00	17:28	Requests							Verbal	RO-2	CR	Hold this valve for me.
RO-2	30	17:29-17:49	Positions (Isol) (Suction)	Valve		OPEN		RWCU	95	DC			

TASK DATA FORM (DESCRIPTIVE)

Page No. 3

PLANT IDENTIFICATION

Plant Name ______

Unit Number ______

NSSS Vendor General Electric

A-E ______

TG Vendor ______

CR Type Conventional

OL Date ______

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments ______

CUE Operating Practices

Task Statement Start up Reactor Water Clean-up System

Task Purpose To return plant to normal configuration

INPO Task Code CRO-95.1-0

Task Sequence No. 32

Task Duration 1:34

Procedures ______

Data Collected at: ______

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV.	MEANS	RESPOND.	RLOC	CONTENT
SRO-2	30	17:37 17:48	Scans				System Status	RWCU	95				
RO-2	30	17:56	Positions	Pump		Start		RWCU	95	DC			
RO-2	30	17:56	Observes	Pump		ON		RWCU	95	IL			
RO-2	30	17:58 18:09	Observes	Valve	Position	Open		RWCU	95	IL			
RO-1	00	18:02	Asks							Verbal	RO2	CR	Is cleanup back on?
RO-2	00	18:07	Informs							Verbal	CR Crew	CR	Clean-up is on

TASK DATA FORM (DESCRIPTIVE)

Page No. 1

PLANT IDENTIFICATION

Plant Name ___

Unit Number ___

NSSS Vendor General Electric

A-E ___

TH Vendor ___

CR Type Conventional

OL Date ___

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments ___

CUE ___

Task Statement Reset Drywell & Equipment Drain Isolation

Task Purpose To allow water to drain

INPO Task Code CRO-107.3-0

Task Sequence No. 33

Task Duration :16 secs

Procedures ___

Data Collected at: ___

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV.	MEANS	RESPOND	RLOC	CONTENT
SRO-2	30	16:37	Positions	Valve (Drywell/ Equipment)		CLOSE		Rad Waste Drains	107	Discrete Control			
SRO-2	30	16:38	Positions	Valve (Drywell/ Floor)		CLOSE		Rad Waste Drains	107	DC			
SRO-2	30	16:39	Positions	Valve (Drywell/ Equipment)		CLOSE		Rad Waste Drains	107	DC			
SRO-2	30	16:40	Positions	Valve (Drywell/ Floor)		CLOSE		Rad Waste Drains	107	DC			
RO-2	21	16:42	Positions				Group Isolation Reset	Rad Waste Drains	107	DC			

TASK DATA FORM (DESCRIPTIVE)

PLANT IDENTIFICATION

Plant Name ______

Unit Number ______

NSSS Vendor General Electric

A-E ______

TG Vendor ______

CR Type Conventional

OL Date ______

TASK IDENTIFICATION

Operating Sequence Main Steam Relief Valve Fails Open

Operating Sequence ID 27

Operator Function Supervise and Control Plant Functions

Operator Sub-function Mitigate Consequences of an Accident

Comments ______

CUE ______

Task Statement Reset Drywell & Equipment Drain Isolation

Task Purpose To allow water to drain

INPO Task Code CRO-107.3-0

Task Sequence No. 33

Task Duration :16 secs

Procedures ______

Data Collected at: ______

Who Takes Action JOBCAT	Location of Means of Action LOC	Behavior		Object of Action						Means of Action	Communication Link		
		TIME	VERB	COMPONENT	PARAMETER	STATE	OTHER OBJECT	PLANT SYSTEM	INFO EQUIV.	MEANS	RESPOND	RLOC	CONTENT
RO-2	21	16:42	Positions				Group Isolation Reset	Rad Waste Drains	107	Discrete Control			
SRO-2	21	16:43	Positions				Reset DW Sump Inboard Isolation	Rad Waste Drains	107	Discrete Control			
SRO-2	21	16:43	Positions				Reset DW Sump Inboard Isolation	Rad Waste Drains	107	DC			
SRO-2	21	16:51	Positions	Valve (DW/Equipment)		OPEN		Rad Waste Drains	107	DC			
SRO-2	21	16:52	Positions	Valve (DW/Floor)		OPEN		Rad Waste Drains	107	DC			

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16 ABSTRACT *(200 words or less)*

This report presents a methodology for developing criteria for design evaluation of safety-related actions by nuclear power plant reactor operators, and identifies a supporting data base. It is the eleventh and final NUREG/CR Report on the Safety-Related Operator Actions Program, conducted by Oak Ridge National Laboratory for the U.S. Nuclear Regulatory Commission. The operator performance data were developed from training simulator experiments involving operator responses to simulated scenarios of plant disturbances; from field data on events with similar scenarios; and from task analytic data. A conceptual model to integrate the data was developed and a computer simulation of the model was run, using the SAINT modeling language. Proposed is a quantitative predictive model of operator performance, the "Operator Personnel Performance Simulation (OPPS) Model," driven by task requirements, information presentation, and system dynamics. The model output, a probability distribution of predicted time to correctly complete safety-related operator actions, provides data for objective evaluation of quantitative design criteria.

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