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Maintenance Personnel Performance Simulation (MAPPS) Model: Users' Manual

Felix F. Kopstein
J. Jay Wolf

Prepared for the
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MAINTENANCE PERSONNEL PERFORMANCE SIMULATION (MAPPS) MODEL: USERS' MANUAL

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FOREWORD

Over the past four years, the U.S. Nuclear Regulatory Commission (NRC) has sponsored a comprehensive research program focused on the modeling of human behavioral activities during nuclear power plant maintenance. The purpose of these efforts was to provide to the NRC a model capable of estimating maintainer reliability information for use within probabilistic risk assessment studies.

The Maintenance Personnel Performance Simulation (MAPPS) model was developed by the Oak Ridge National Laboratory in joint effort with Applied Technical Associates, Inc. Its development and subsequent evaluation is well documented in a set of nine NUREG/CR's which includes this current report (NUREG/CR-3634, User's Manual) and the following eight reports:

- NUREG/CR-2670, *Job Analysis of Maintenance Mechanic Position for the Nuclear Power Plant Maintenance Reliability Model.*
- NUREG/CR-2668, *Job Analysis of the Maintenance Supervisor and Instrument and Control Supervisor Positions for the Nuclear Power Plant Maintenance Personnel Reliability Model.*
- NUREG/CR-3274, *Job Analysis of the Instrument and Control Technician Position for the Nuclear Power Plant Maintenance Personnel Reliability Model.*
- NUREG/CR-3275, *Front-End Analysis for the Nuclear Power Plant Maintenance Personnel Reliability Model.*
- NUREG/CR-3626, Vol. 1, *Maintenance Personnel Performance Simulation (MAPPS) Model: Summary Description.*
- NUREG/CR-3626, Vol. 2, *Maintenance Personnel Performance Simulation (MAPPS) Model: Description of Model Content, Structure, and Sensitivity Testing.*
- NUREG/CR-4104, *Maintenance Personnel Performance Simulation (MAPPS) Model: Field Evaluation/Validation.*

These reports reflect the research efforts that were on-going through the four major phases of this program, i.e., the front-end analysis, model development, model evaluation/validation, and model dissemination phases.

This report (MAPPS User's Manual) is the last report to be published from this program and provides detailed guidelines for utilization of the MAPPS model. Although the model has been developed to be highly user-friendly and provides interactive means for controlling and running of the model, the user's manual is provided as a guide for the user in the event clarification or direction is required. The user will find that in general the model requires primarily user input that is self explanatory. Once initial familiarization with the model has been achieved by the user, the amount of interaction between the user's manual and the computer model will be minimal. It is suggested however that even the experienced user keep the user's manual handy for quick reference.

With the formal turnover of the MAPPS model to the NRC in September of 1985 for establishment on the National Institute of Health's computer system, and with the publication of this user's manual, the final efforts within this program have been successfully completed.

H. E. Knee, ORNL, Principal Investigator
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LIST OF ABBREVIATIONS

A & E	Architectural and Engineering firm
BWR	Boiling Water Reactor
HTGR	High Temperature Gas Reactor
I & C	Instrumentation and Control
MOV	Motor Operated Valve
NPP	Nuclear Power Plant
NRC	U.S. Nuclear Regulatory Commission
PM	Preventative Maintenance
PRA	Probabilistic Risk Assessment
PWR	Pressurized Water Reactor
S/QC	Supervisor/Quality Control

GLOSSARY

Abilities	the combination of native aptitudes and acquired competence for performing a set of maintenance activities, or the degree of capability for accomplishing the subtask comprising a task
Aspiration	in effect, the motivation to set standards for one's performance and to meet them; often these standards are incremented or decremented as the level of aspiration changes in consequence of experienced successes or failures
Ability Difference Stress	elicited by too great a disparity between the demands of a subtask and the ability levels of assigned personnel
Communication Stress	elicited by loss of effective communication
Current Ability	the level of capability (intellective and/or perceptual-motor) possessed by a maintainer at any moment subsequent to the start of task execution: this level declines progressively under the influence of fatigue and ambient temperature
Decision Making	in this context, the psychological processes (judgements) underlying a choice among possible courses of action
Default Value	an average or routine value of some parameter supplied by MAPPS when the user does not indicate another value
Initial Ability	the level of capability (intellective and/or perceptual-motor) possessed by a maintainer at the start of task execution
Input Parameter	the value of a variable at the start of a given simulation; input parameters specify the initial state of maintainers and of the task environment
Intellective Ability	the degree of capability possessed by a maintainer for analyzing, planning, problem solving, and thinking in the course of task or subtask performance
Job Analysis	the process of determining the set of tasks normally performed by the incumbent of a particular job title
Modules	in this context, the various calculational procedures internal to MAPPS that determine progressively the assorted values assumed by variables in a simulation, e.g., ability difference effects on subtask outcomes
Monte Carlo Approach	in this context, variability of certain values internal to the simulation is achieved by randomly selecting them from statistical distributions based on pseudo-random numbers generated by the computer

Organizational Climate	the aggregate effect of certain organizational factors such as leadership, policy, values, economic, and social influences on work performance; can be favorable, indifferent, or unfavorable
Parameter	a specific value assigned to a variable (see, also, Input Parameter)
Perceptual-Motor Ability	the degree of capability possessed by a maintainer for performing physical and manipulative activity
Radiation Stress	elicited by the anticipation of exposure to radiation or by awareness of actual exposure to it
Stress	a complex psychophysiological response to conditions in the external or internal environments; the source of stress (stressor, stress stimulus) imposes requirements for personal resources to an extent that makes it impossible to maintain a steady state (see, also, Time Stress, Ability Difference Stress, Communication Stress, and Radiation Stress)
Subtask	subtask one of a set of human activities which, in aggregate, constitute a task; in the present context, analogous to a step within a maintenance procedure
Success Probability	in this context, the *a priori* probability that a given *subtask* will be successfully complete (see, also, Success Proportion)
Success Proportion	the proportion of successful *iterations* (repetitive simulations of a given task) out of the total number of iterations specified for a given simulation run (see, also, Success Probability)
Task	a coherent set of human activities designed to accomplish some specified objective(s); in the present context, analogous to a maintenance procedure
Task Analysis	the process of determining the set of subtasks and their permissible order(s) for accomplishing the specified objectives of a given task
Time Stress	elicited by pressure to complete a task within time constraints

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ACKNOWLEDGEMENTS

Since the initiation of this program at the Oak Ridge National Laboratory (ORNL) in early FY-1981, a number of individuals have been involved with and have contributed significantly to the development of the Maintenance Personnel Performance Simulation (MAPPS) model.

The three primary individuals responsible for the research and subsequent development of the MAPPS model are Dr. James Jenkins of the Nuclear Regulatory Commission (NRC), Dr. Paul M. Haas of ORNL, and the late Dr. A. I. Siegel. It was through their efforts that realization of the need for research within the maintenance area was turned into a reality through the development of MAPPS. Their inspiration, guidance, and critical review were necessary ingredients for success within this program.

The NRC monitor for the MAPPS program for more than the past three years has been Dr. Thomas G. Ryan. His critical review and keen insight for the promotion of MAPPS was invaluable to the program. Prior to Dr. Ryan, both Mr. Ellis Merschoff and Mr. James Pittman acted as NRC monitors during the first eighteen months of this program. Other NRC contributors include Dr. Charles Overbey, Mr. Fred Manning, Dr. Dan Jones, Mr. James Norberg, Mr. Jim Shephard, and Ms. Emily Robinson.

In addition to the late Dr. A. I. Siegel, the principle technical developers of the MAPPS model were Dr. J. J. Wolf of Applied Technical Associates (ATA), Dr. F. F. Kopstein (ATA), and Dr. W. D. Bartter. The model was programmed by Mr. D. Mayberry, Mr. J. Corliss, and Mr. F. Madden. Dr. P. Federman performed required task analyses and conducted sensitivity testing of the model.

At ORNL, Mr. J. Manneschmidt provided necessary computer science support, and Dr. P. A. Krois provided critical technical reviews of the program materials. Mr. J. J. Manning assisted in gathering front-end analysis data and participated in the field validation of the model. Mrs. Katie Ingersoll, Mrs. L. S. Abbott, and Ms. Cheryl Buford dedicated countless hours in the preparation of the numerous NUREG/CR's published during this program.

Other individuals who provided valuable input to this program were: Dr. David Meister (Navy Personnel Research and Development Center), Dr. William B. Askren (U.S. Air Force Human Resource Laboratory), Dr. B. J. Garrick (Pickard, Lowe and Garrick, Inc.), Dr. Tony Hinson (Institute for Nuclear Power Operations), and Mr. Robert McDermand (EBASCO Services, Inc.). Their critical review of front-end analysis work and planned development efforts during the first MAPPS peer review group meeting in December 1982, provided significant feedback to the project team concerning the direction of the program.

Participants in the second MAPPS peer review group meeting (December, 1983) provided valuable guidance concerning the then upcoming MAPPS evaluation and validation efforts. The participants were: Mr. Fred Manning (NRC), Mr. James Pittman (NRC), Mr. James Baker (U.S. Army Research Institute), Mr. R. Yerbich (Experimental Breeder

Reactor-II/Argonne National Laboratory), Mr. R. E. Cyr (Public Service of New Hampshire, Seabrook Station), and Mr. W. G. Helsel (General Electric).

Lastly, it should be noted that a number of individuals from the NRC, various nuclear facilities, and architectural and engineering firms provided voluntary, cooperative input to this program. The success of the program has to a great extent been due to their willingness to complete questionnaires, subject themselves to interviews, participate in subject matter expert meetings, and to act as subjects for evaluation/validation efforts.

The efforts of all those cited herein and of the numerous individuals that have contributed but are not explicitely mentioned have greatly been appreciated. The MAPPS model is a significant accomplishment for the NRC, the nuclear industry, and the human factors community. Its success is a reflection of the efforts of all of those that have contributed.

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Reliability and Human Factors Group
Oak Ridge National Laboratory

September, 1985

EXECUTIVE SUMMARY

This document serves as the users' manual for the *MA*intenance *P*ersonnel *P*erformance *S*imulation (MAPPS) model. MAPPS is a generalized, stochastic computer simulation model which simulates the performance of maintenance personnel in nuclear power plants. The model considers workplace, maintenance technician, motivational, human factors, and task-oriented variables to yield predictive information about the effects of these variables on successful maintenance task performance. As such, MAPPS is believed to represent a fundamental probabilistic risk assessment (PRA) analytic tool. Moreover, it serves the needs of nuclear power plant maintenance management for maintenance operations analysis, and the needs of architectural and engineering firms for maintenance system design evaluation. This manual deals only with the procedural aspects of operating the MAPPS computer program. A complete description of the content and logic of the MAPPS model is contained in the two-volume NUREG/CR-3626.

The first section of the present report describes the use of the MAPPS model within the nuclear power plant context. This section also presents the principal potential uses of the model and the major types of information that can be helpful to its various types of users in making decisions. Section 2.0 provides an overview of MAPPS utilization and explains the process of planning and executing simulation runs. Data input requirements are outlined, and the various data types are explained. Also, the model's data outputs are illustrated. Section 3.0 provides the detailed guidance to users for interacting with MAPPS via a terminal. It explains the procedures for controlling all aspects of a simulation.

1.0 INTRODUCTION

1.1 The MAPPS Model

1.1.1 Overview

The *MA*intenance *P*ersonnel *P*erformance *S*imulation (MAPPS) model was developed to provide the U.S. Nuclear Regulatory Commission (NRC) and associated nuclear power scientists, engineers, architects, and plant operators with a tool for human factors design, test and evaluation relative to nuclear power plant maintenance. A principal focus of the model is to provide maintenance-oriented human performance reliability data for probabilistic risk assessment (PRA) purposes.

MAPPS is a task-oriented, computer-based model for simulating nuclear power plant maintenance activities. It includes environmental, motivational, task, and organizational variables which influence personnel performance reliability and yields information such as predicted errors, personnel requirements, areas of maintainer stress and fatigue, performance time, and required maintainer ability levels for any corrective or preventive maintenance action in nuclear power plants.

MAPPS is the result of a multiyear research program. A complete description of all aspects of this program, as well as detailed information concerning the logic embedded in the model, can be found in the following documents: *Maintenance Personnel Performance Simulation (MAPPS) Model: Summary Description* (Ref. 1), *Maintenance Personnel Performance Simulation (MAPPS) Model: Description of Model Content, Structure, and Sensitivity Testing* (Ref. 2), and *Maintenance Personnel Performance Simulation Model (MAPPS): Field Evaluation/Validation* (Ref. 3).

1.1.2 Model Content

The primary purpose of the MAPPS model is to allow quantitative analysis of the effects of varying a set of conditions represented by model inputs on a second set of conditions or analytic results. The input conditions can be varied one at a time, or in any combination, by the user at a computer terminal. The analytic results are provided at various levels of detail, as selected by the user. Generally, all the results are available in summary form. A user can design his numerical experiments consisting of one or more runs* and be presented with data representing all elements of results from which he can develop relationships, gain interdependency insights, develop hypotheses and draw conclusions about various aspects of nuclear power plant maintenance.

For the maintenance task to be simulated, input data of three types — variable (parameter), task, and subtask — are entered by the analyst. Variables represent the conditions under which the simulated maintenance team is to work and the characteristics of selected maintenance technicians. The model allows for the simulation of up to four different

*A run is composed of multiple iterations (simulations) of a task.

maintenance job specialties — Instrumentation and Control (I & C) Technician, Maintenance Mechanic, Electrician, Supervisor/Quality Control — plus a Control Room Operator. Within MAPPS, "Control Room Operator" is used generically to refer to any person (not a particular specialty) who may collaborate remotely with a maintenance team in response to some request by the team. Task information represents a set of data relative to the task as a whole while subtask information describes the characteristics of each subtask involved in task completion.

Acting on these data, the model sequentially simulates the performance of each subtask involved in total task completion. Within the logic, the following concepts are included during the simulation of each subtask:

- The difference between the intellective and perceptual-motor abilities required for subtask completion and the actual abilities of the maintenance technicians simulated,
- Technician fatigue,
- Time stress,
- Performance decrement due to high environmental temperature,
- Stress induced by faulty communication,
- Fatigue relief due to rest breaks,
- Presence of radiation,
- Technician level of aspiration,
- Quality of written procedures for supporting performance,
- Supervisor's expectations about the quality of performance,
- Equipment accessibility at the worksite,
- Wearing of protective clothing,
- Time since the various team members last performed the task,
- Organizational climate,
- Whether or not the actual manning is greater or less than the required manning.

These interact within the MAPPS model in accordance with the flow logic which includes stochastic features to account for intra- and interindividual, situational, and contextual differences.

Depending on the result of the simulation of any subtask and the input data, the model either proceeds to the simulation of the next subtask, repeats the simulation of the subtask for up to three successive attempts, loops ahead or back in the subtask sequence, or branches to a new subtask sequence. Provisions are incorporated within the simulation for the simulated maintenance team to skip a subtask when the stress level is high and subtask completion is not essential for task completion.

This procedure continues serially for each subtask in the task completion sequence until the last subtask in the task sequence has been addressed by the simulated maintenance team. The model then simulates the performance of the task again and continues with resimulations until the specified number of full task simulations has been completed. Up to 100 iterative simulations may be specified. This reiteration is necessary because a number of simulations is required to adequately smooth the random effects introduced into each individual task simulation (iteration).

During the course of the simulation, a variety of data are compiled. These data are grouped into four categories (Subtask, Shift/Change, Iteration, and Run) and displayed in summary table form. Because not all categories of available output data will usually be wanted by the analyst, the analyst is provided with the capability for selecting any output option category mix which meets the analyst's requirements.

1.1.3 Decision Making and Trouble Shooting

Because of their special importance to nuclear power plants in general and their specific relevance to maintenance, the MAPPS model contains two special subroutines — decision making and trouble-shooting. These are included to allow special consideration of subtasks which are preponderantly cognitive in nature as opposed to normal action maintenance subtasks which incorporate a considerable perceptual-motor loading. Trouble-shooting refers to the process of diagnosing the cause of a malfunction and decision making refers to the process of selecting among alternative courses of action. When one or the other of these types of subtask is reached during the simulation of the subtask sequence, a unique processing is instituted according to a logic especially developed for these subtask types. The basis for these logics, the logics, and their implementation within the MAPPS model is fully presented in Ref. 2.

1.1.4 Emergency Events

The MAPPS model also allows for the superimposition of emergency events on the normal subtask sequence in order to allow the analyst to determine the effects on maintenance task performance of an outside emergency which occurs during the performance of a given maintenance action. If an emergency is to be considered during the simulated task performance, an input indicator is set by the analyst along with the mean duration of the emergency. MAPPS then automatically enters the emergency into the subtask sequence and the simulation accounts for the effects of the emergency on the performance of the primary maintenance task.

1.1.5 Applicability

MAPPS is a general, stochastic, subtask-driven computer simulation model believed to be applicable to any type of nuclear power plant. The model provides the capability to simulate:

- corrective as well as preventive maintenance tasks
- contractor as well as "in-house" maintenance
- maintenance conducted by personnel with any combination of skills and job titles who are working under any conditions usually encountered
- special subtask types (decision making and troubleshooting as well as normal actions subtasks.

The model also allows for:

- customized task analysis data for each simulated maintenance task
- calculated (not input) values for average subtask durations and success probabilities
- using default data when selected inputs are not provided by the user
- partial use of a Monte Carlo approach for most functions — to introduce chance elements
- replacement (rotation) of maintenance personnel
- operating via interactive computer terminal; providing results at the terminal and on a local or a remote computer line printer
- generating a variety of selectable output options at various levels of detail.

MAPPS allows the analyst to vary systematically, individually, and in combination, a variety of conditions (task variables, technician ability level variables, environmental and situational variables, and human factors variables) to yield subtask, shift, iteration, and summary data. These data show the effects of the variations introduced by the analyst on the simulated task performance and can provide, at least in part, a basis for trade-offs, regulatory decisions, and augmenting PRA analyses.

1.1.6 Model Uses

Figure 1.1 depicts the relationship of MAPPS to the commercial nuclear power industry. Three user groups are included: U.S. Nuclear Regulatory Commission (NRC) personnel, nuclear power plant architects and engineers, and nuclear power plant maintenance management. As shown in Figure 1.1, each user group has its own unique goals. The MAPPS model was designed to depict faithfully the crucial aspects of nuclear power plant maintenance so that the needs of all these users may be served.

Across the differing preoccupations of the different user groups, however, a set of primary uses can be enumerated. These primary uses are outlined below. Only the primary uses are shown, because *all* potential applications of MAPPS cannot be foreseen.

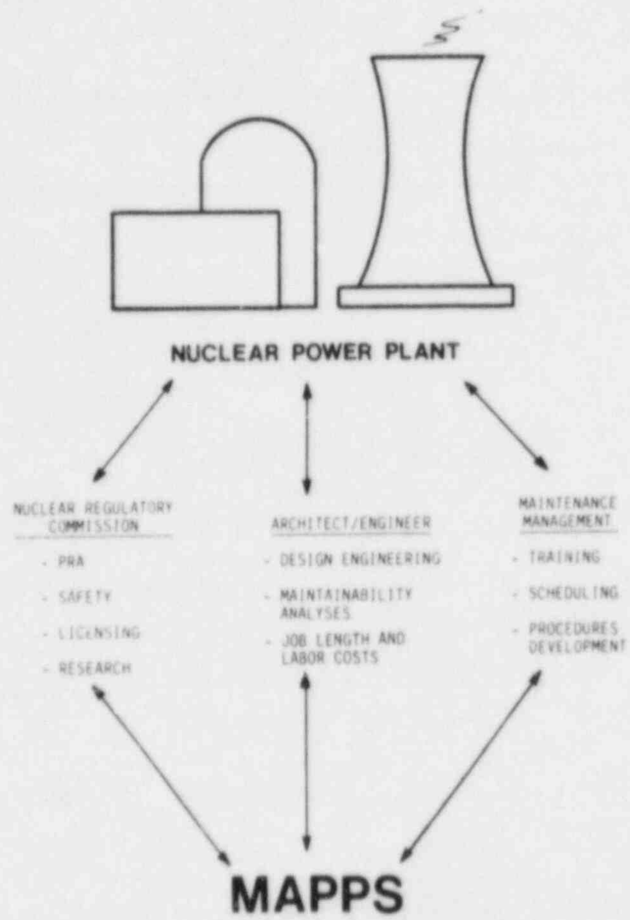


Fig. 1.1. The Use of MAPPS.

Primary Uses

Reliability/Risk/Safety Assessment

- Estimate human reliability in existing maintenance activities
- Estimate human reliability in proposed maintenance activities prior to implementation
- Identify "error-likely" situations
- Estimate improvements in human reliability due to modifications in equipment, procedures, training, etc.
- Identify and estimate the effects of critical human variables, e.g., fatigue, stress, experience, etc.
- Estimation of accumulated personnel radiation dose

Maintenance System Design Evaluation

- Estimate the effectiveness (e.g., mean-time-to-repair) of existing systems
- Identify potential maintainability problems in existing systems
- Integrate human engineering and personnel-equipment designs into maintenance system designs
- Identify personnel requirements (selection and training)
- Develop and evaluate maintenance procedures

Maintenance Operations Analysis

- Comparison and optimization of maintenance strategies
- Optimization of team assignments (type and number of maintainers)
- Maintenance planning/scheduling

Human Factors Data Store

- Contribute human factors data and information for maintenance to a human factors data store

Questions about Maintenance Task Characteristics

- What is the likelihood that an error will be made during the performance of a particular maintenance task?
- On which subtasks are maintainers likely to fail?
- How effectively will the maintenance task be performed?
- What is the probability of undetected errors occurring in particular subtasks (work-steps)?
- Which tasks require a high level of human abilities or competence?
- How many maintenance technicians should be assigned to a particular task under some given circumstances?
- What is the expected duration of a task under varying conditions (i.e., best case, worst case, intermediate)?

Questions about Maintainer Characteristics

- How is error probability affected by personal factors such as motivation and ability levels?
- What is the stress on the maintainer during task performance?

- To what extent does stress affect performance?
- When should personnel rotation take place because of maintainer fatigue and its effect on error?
- How much practice is required to maintain satisfactory competence?
- What is the optimum maintenance team composition?
- How much time will various teams of maintainers take to accomplish specified tasks?
- For given teams, what are the expected proportions of successful and unsuccessful performance of a given maintenance task?

Questions about Environment Characteristics

- How is error probability affected by environmental factors such as heat, noise, and requirements for protective clothing?
- How will work space and accessibility affect maintenance performance?

For any category of user, and for the various sorts of primary uses, MAPPS can help to find answers to the kinds of questions exemplified below.

1.1.7 A Very Simple Illustration of MAPPS Use

While Sections 2.0 and 3.0 (pages 9 and 34) of this Manual provide far more detailed descriptions of MAPPS procedures, an introductory thumbnail sketch of MAPPS use is given here.

For this illustration, it will be assumed that the data describing the task in question (Task "TIQ") have been previously obtained and stored in the pertinent MAPPS files. For present purposes, let it be assumed that the issue under consideration is the respective lengths of time required to complete Task TIQ (the task durations) by two different maintenance teams respectively of low (LO) and high (HI) ability levels or competence. MAPPS enables the analyst/user to make two successive simulation runs that differ only in the ability levels/competence of the simulated maintenance teams (i.e., the personnel performing Task TIQ) and to examine the respective, resulting task durations.

The user will begin by specifying first, for example, a maintenance team of "LO" ability. He does this by setting the appropriate Input Parameters to values corresponding with low ability levels. (The specifics are described in succeeding sections). Other Input Parameters are set to reflect as accurately as possible the circumstances and conditions under which this task is expected to be performed. Having done so, the user will cause the simulation run to proceed. He will obtain from the computer, a substantial set of data descriptive of the performance of Task TIQ under the specified circumstances by the LO Team. Included among these data will be the predicted task duration.

Next, the user will change the Input Parameters so as to reflect a maintenance team of high ability/competence (HI Team). All other circumstances and conditions will be kept constant. Again, the user will cause the simulation run to proceed. Once more the data output from this second simulation run will be produced by the computer, and this will again include the task duration.

The analyst/user is now in a position to compare the respective, predicted times taken to perform Task TIQ by the LO and the HI ability maintenance teams.

2.0 PLANNING AND EXECUTING SIMULATION RUNS

2.1 Using MAPPS

The global elements involved in the use of the MAPPS model are illustrated in Figure 2.1. MAPPS is resident in a computer accessible by the user, who interacts with MAPPS through the standard computer media: display, keyboard, and printer. The user enters or modifies input data and controls model runs through the keyboard. Model output is displayed on a screen and/or printed depending on the user's equipment and output option(s) selected.

Figure 2.2 provides a greater degree of detail with respect to the use of MAPPS within a problem-solving context. The process begins with a user requiring data. The data could be with reference to performance reliability, error analysis, task duration, and so forth. The absence of these data leads the user to design either a single MAPPS run or a set of MAPPS runs, depending on the nature of the problem. Following problem development, the user determines whether or not the maintenance task of interest is located in the MAPPS library. MAPPS has the capability of storing information for 200 tasks. In the event that the task of interest is not in the library, the required input data are collected using a task analysis technique. When all data relating to the task have been entered into MAPPS, the user initiates model runs. Following MAPPS execution, the user either modifies some aspect of the input data and makes subsequent model runs or is satisfied with the information obtained and terminates the repeated cycle of model runs. The initial problem will determine the number and nature of the required model runs.

An expanded version of the user's interaction with the MAPPS model is given in Figure 2.3. This figure shows that the procedures of MAPPS use differ slightly between old and new tasks. As described earlier, the simulation of any task requires that data be entered into the model. In Figure 2.3, the legend "new task" refers to the initial entry of data into the model. The user begins with task data, entering information such as task name. This action automatically enters the task into the library of stored tasks. The user next enters subtask data, i.e., information such as accessibility and subtask duration. Finally, the user enters parameter data, which include the major factors influencing task performance. Following the entry of all of the required data, the model is in a state to begin simulating task performance (i.e., make model runs). The procedure for model use is simplified for old tasks, i.e., tasks already stored in the library. For the simulation of these tasks, the user need only modify the parameters to suit his purposes.

The remainder of this section describes what the user must do to plan and execute simulation runs. In the next section the specific procedures and actions are prescribed in full detail. Readers may wish to consult the glossary (see page ix) for explanations of unfamiliar terms.

2.2 Developing a Simulation Run Based on an "Old" Task

In Figure 2.2 it is evident that the steps a user must go through in executing a simulation run are contingent on whether or not the task in question has been stored in the Task

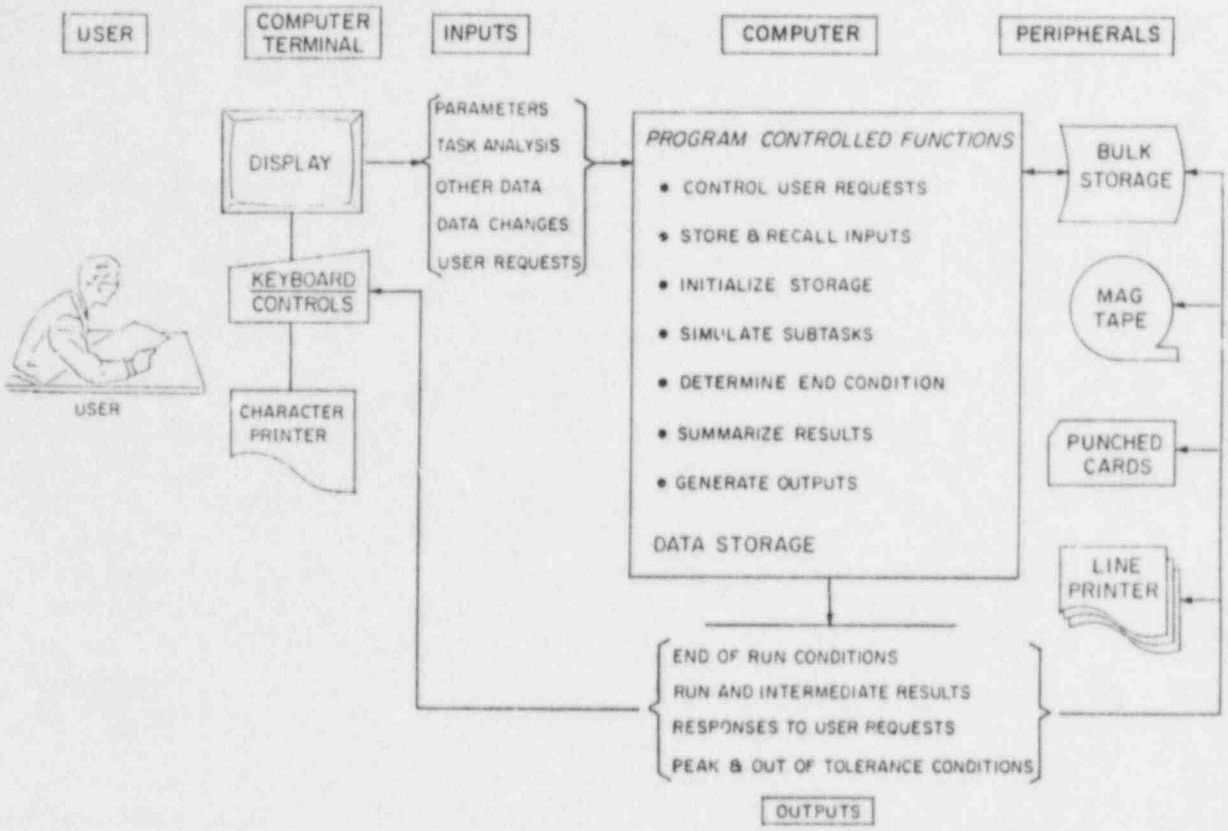


Fig. 2.1. Global Elements of Model.

Library, i.e., whether it is an "old" task or a "new" task. In the latter case, task analyses must be performed, and the task and subtask information must first be entered into the MAPPS Task Library. Therefore, the first example to be outlined here is based on an "old" task. This involves fewer steps and will be easier to grasp for the novice user. Later, an example of a "new" task will be given.

2.2.1 Developing the Problem

Regardless of which task is to be simulated and what information is to be obtained, it is first necessary to define the problem to be solved or the question(s) the simulation will help to answer. Only by first defining the problem is it possible to determine which input parameters are to be varied, which output indices will be principally examined, how many simulation runs will be required, etc. Exactly what is meant by "defining the problem" will become evident from the example below.

Example I: Source Range Channel N31 Calibration

Background

During a scheduled outage at the XYZ power plant, fragments of the control rod drive mechanism are detected in the reactor vessel. The entire core is defueled

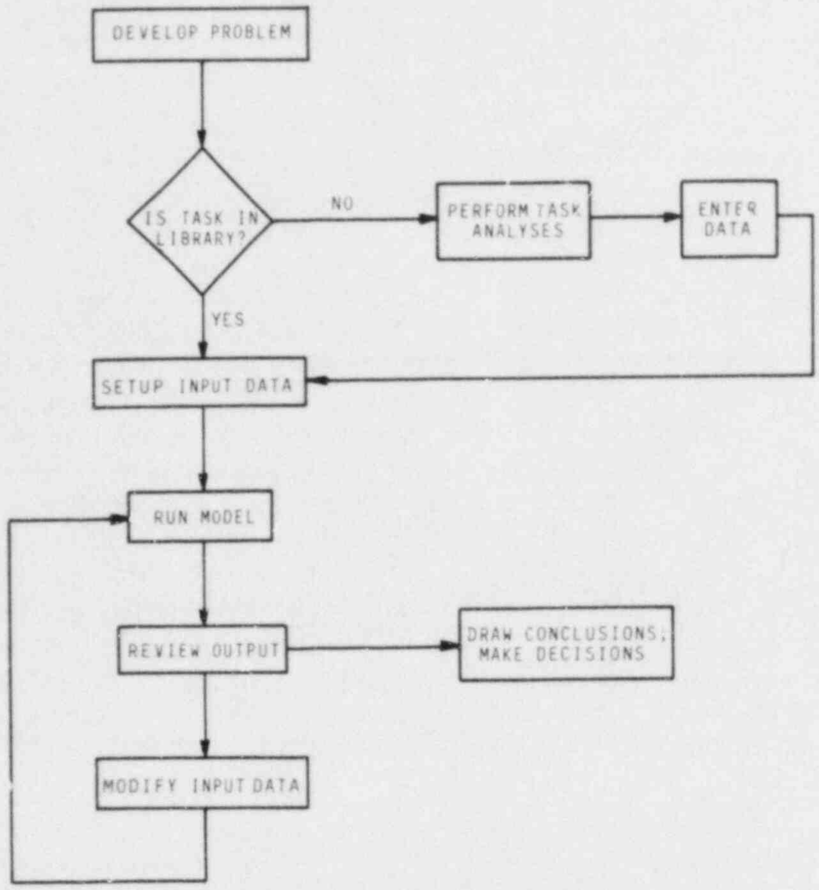


Fig. 2.2. Steps of MAPPS Use.

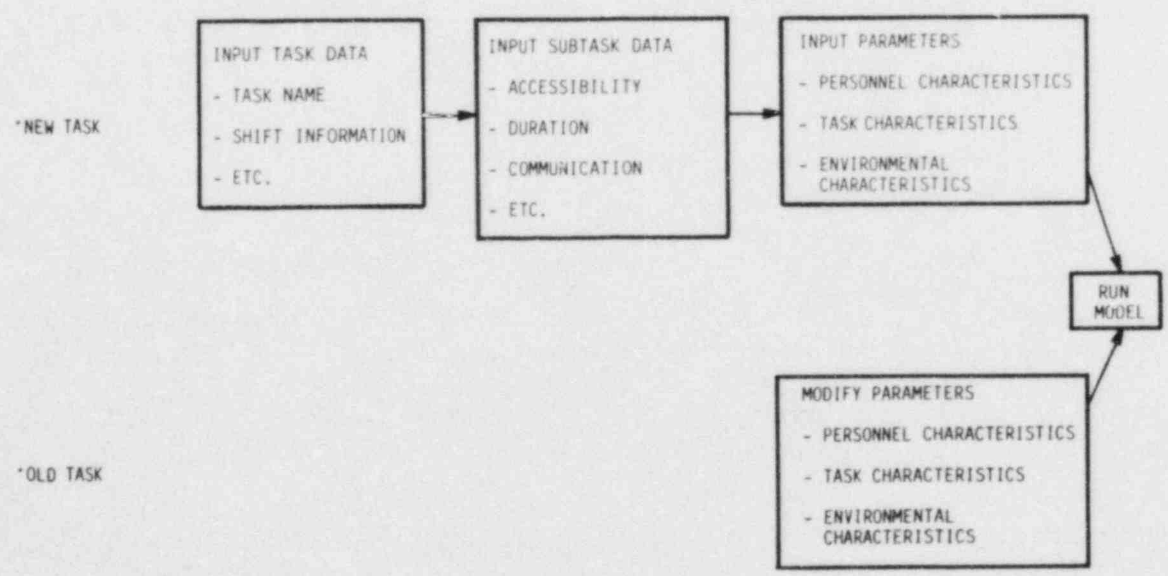


Fig. 2.3. Detailed Sequence of MAPPS Use.

for a fuel inspection and removal of the metal fragments. At this time, the Manipulator Bridge Load Cell Overload Limit fails. Two teams are assigned to troubleshoot and repair the "Bridge." Each team consists of three technicians. Team 1 has three contractor technicians; team 2 has two contractor technicians and one in-house technician. The teams follow a 12-hours-on, 12-hours-off schedule. The problem is corrected after 36 hours.

Six hours after this repair is completed, an underwater camera malfunction is reported. The problem is a cracked viewing window. Approximately 20 hours are spent in camera repair, requiring an additional four in-house Instrumentation and Control (I&C) technicians to alternate work shifts repairing the camera (i.e., two from the day shift and two from the night shift). In addition to these two major I&C involvements, the I&C department is providing backup support and setting cameras and videotape recorders. These activities require one I&C technician for six hours during each shift.

Three days after the start of the "Bridge" repair, the Source Range Channel Indicator N31 is reported to be giving out-of-tolerance readings. At this point, there is no indication that the fault is in the containment area. The repair must be accomplished as soon as possible because many of the plant personnel cannot continue with their work until the source range repair is completed.

Problem

Ordinarily, the best troubleshooter would be assigned to the task. However, the best troubleshooter was assigned to work on both the Manipulator Bridge Load Cell Overload Limit and the camera failures. He seems moderately fatigued and is approaching his quarterly radiation limit. There are eight other technicians available for assignment — three contractor and five in-house technicians. Although no one is thoroughly familiar with the ability levels of the contractor personnel, it is assumed that they are of "average" ability, as are the five in-house technicians available for assignment.

The available options are:

a. Assign only the best troubleshooter to the task.

b. Assign the best troubleshooter along with another in-house or contractor technician.

c. Assign two less experienced technicians.

In order to help reach a decision, a set of MAPPS runs is implemented and the results are reviewed from the points of view of performance adequacy and task completion time.

2.2.2 Planning the Analysis

To assess the potential differences in maintenance performance quality resulting from the three options, it is necessary to simulate each of the conditions in question. Differences in

initial conditions exist, first of all, in the manning of the task, or the team composition: single maintainer versus two maintainers. Second, the "personnel quality" or ability levels of the potential individual maintainers differ: high versus average ability (competence). Last, the high ability maintainer is further characterized by fatigue (i.e., amount of prior work) and by having absorbed a substantial amount of prior radiation. The three simulation runs will have to be differentiated by the appropriate combination of independent variables (input parameters). A plausible arrangement corresponding to options a, b, and c in the example is outlined below.

	Option		
	a	b	c
Simulation Run Number	1	2	3
Team Size	1	2	2
Ability Levels (Intellective and Perceptual-Motor)			
Maintainer No. 1	5	5	3
Maintainer No. 2	-	3	3
Prior Work (Fatigue)			
Maintainer No. 1	8	8	0*
Maintainer No. 2	-	0*	0*
Prior Radiation			
Maintainer No. 1	2000	2000	0*
Maintainer No. 2	-	0*	0*

Values followed by an asterisk are default values. Possibly, default values might also be accepted for all other input parameters. However, an appropriate time limit might be set for task accomplishment, since urgency is implied in the case scenario.

For the initial analysis of the stated options it seems likely that run summaries can provide adequate information. If necessary, analyses can be extended to the Iteration, Shift, and Subtask levels in subsequent simulation runs. For initial analytic purposes, also, the options can probably be assessed mainly in terms of their effects on these run indices: Success Proportion, Performance, Task Duration, and Total Errors. Stable values might be expected if 50 iterations (repetitive task simulations) are specified for each simulation run.

For the moment, these references to output options, etc. may seem confusing. However, they will become clear as the example is developed further. Also, in Section 3.0 (p. 34) of this Manual detailed explanations are given.

2.2.3 Is the Task in the Task Library

To find out whether the Task and Subtask Data are already stored in the Task Library the user now calls up the Initial Menu (see next Section (p. 35) of the Manual for details) and, in response to it, enters "L." The "L" is the code for the Task Library, and the appropriate display will appear next. Its examination (again, see next Section (p. 37) for

details) will establish that the "Source Range Channel N31 Calibration" task data are resident in the Task Library. In other words, it is possible to proceed directly to setting up the Input Parameters.

It is noted that the options in the problem statement require three separate simulation runs. Thus the parameters will have to be modified three times so as to fit the circumstances of each separate simulation. Of course, the procedures will be analogous in each run.

2.2.4 A Detour: The Scaling of Input Data

2.2.4.1 Input Data and Their Scales

While the specific and detailed procedures for entering all requisite input data, including Input Parameters, are explained in Section 3.0 (p. 34) of this Manual, a preliminary explanation of these data and of the scales underlying each is given here. It will be advisable for users to study the data types and their scales here so as to become able to apply them during actual data inputing operations. In this way, also, the rationales for default (i.e., MAPPS supplied) values may be understood.

2.2.4.2 Input Data Types

Required input data differ in several ways. They may describe characteristics (attributes) of the simulated maintainers and conditions of task performance (Input Parameters); they may specify certain variables of the overall task to be simulated (Task Data); or they may specify the particulars of each subtask or procedural step within the overall task (Subtask Data). Appendix A defines 28 types of subtasks.

For some variables in any of these data categories (Input Parameters, Task Data, Subtask Data) the underlying scales are direct and transparent, because they are nominal or reflect some physical continuum. For example, the maintainer characteristic "Time Before" refers to the time (in months) that has elapsed since the given maintainer last performed this task. As another example, "Temperature" refers to the temperature in degrees Fahrenheit of the work place. Thus it is only necessary to stipulate the actual or assumed number of months since the given maintainer last performed "this" task, or the ambient temperature. Should the desired value be greater or less than the maximum or minimum value of the permissible range of the given variable, the upper or lower extreme value of the range should be specified.

Note that a given simulation may represent an actual or hypothetical situation. In the former case the *known data values* should be entered, while in the latter case the *appropriate assumed values* should be used.

So long as data values are hypothetical they represent a judgment or rating by the user. The user estimates what the appropriate applicable values should be. When input data values are to represent known empirical values, however, a scale conversion (i.e., empirical measurement to MAPPS scale) may be necessary. In either case, an understanding of the origin and nature of MAPPS' data scales is desirable.

2.2.4.3 Rationales of Scales

The typology of scales underlying MAPPS input data also encompasses another dimension. It will be seen in Tables 2.1, 2.2, and 2.3 that judgmental or rating scales are, for the most part, either of a 1 – 7 or of a 0 – 1 type. Data types and scales were established in surveys of nuclear power plant (NPP) maintenance experts prior to MAPPS' design and development, and survey results determined distributions along these scales in MAPPS.

The 1 – 7 scales apply to Perceptual-Motor (P-M) and to Intellective (I) abilities. Empirical data obtained from NPP maintenance personnel indicated that the average (mean) value of this scale is 5.0 with a standard deviation (sigma) of 1.5. Thus, empirical scale values may be converted to z-scores, and the corresponding MAPPS scale value (with up to two decimals) may be determined. When the choice of an ability value is hypothetical and is to be arbitrarily stipulated, the following anchor and guide points for judgments can be used:

Scale Value	Degree of Capability Possessed by Maintainer	Interpretation
1	Virtually none	Totally inexperienced novice
2	Very slight	Marginally able/competent maintainer
3	Slight	Maintainer of very poor ability/competence
4	Moderate	Maintainer of poor ability/competence
5	Average	Maintainer of fair or average ability/ competence
6	Superior	Maintainer of high ability/competence
7	Very superior	Maintainer of very high ability/competence

It should be noted that, in MAPPS, Perceptual-Motor as well as Intellective Abilities represent the combination of native aptitudes and acquired abilities (competence).

The 0 – 1 scales represent the continuum from null to unity. For example, the probability that maintenance procedures will be used during the performance of a given task ranges from a certainty that they will *not* be used (0) to a certainty that they will be used (1.0). With respect to individuals' motivation or desire to do well (Aspiration), the lower extreme (0) represents "none" or "no desire," and the upper extreme (1.0) a total, consuming motivation. The continuum between the extremes — whatever it may represent — can be divided into a positive or affirmative proportion and a negative proportion, e.g., 0.75 that maintenance procedures will be used, and 0.25 that they will *not* be used. Judgments (ratings) should consider both directions, but must be reconciled so that their sum does not exceed unity; of course, the 1.0 – p value serves only to balance the rating, remains conceptual only, and is not entered into MAPPS.

When actually estimating (judging, rating), e.g., the probability that procedures will be used in a given maintenance task, users might envision the continuum between 0 and 1.00 as shown here:

0 0.50 1.00

Table 2.1. Maintainer and Task Parameters

Menu Name	Range (Units)	Default	Description/Use
			Maintainer Parameters
Maintainer Type	NA*	NA	E=Electrician; M=Mechanic; O=Operator,** I=I&C Technician; Q=QC/Supervisor.
Time Before	0-36(Months)	0.0	Time elapsed since last performance of this task. Varied to determine the effects of forgetting.
Stress Threshold	1.0-5.0	2.3	Point at which stress degrades performance. Varied to determine the effects of maintainers' susceptibility to stress. Prior experience (Ref. 2) has shown a stress function to be valid and have its maximum effect when stress thresholds are between 1.9 and 2.8.
Prior Radiation	0-3000(mrem)	0.0	Level of absorbed radiation at start of task. Varied to determine the effects of radiation absorption levels on performance.
Prior Work	0-72(Hours)	0.0	Hours on the job prior to the start of the task. Used to simulate varing fatigue levels.
Aspiration	0.0-1.00	0.90	Individual motivation or desire to do well. Varied to determine the effects of different levels of motivation among maintainers. The default value represents the average maintainer's level of aspiration.
Perceptual-Motor	1.0-7.0***	5.0	Index of perceptual-motor ability. Changing this parameter reveals the effects of the perceptual-motor proficiency of the maintainers.
Intellective	1.0-7.0***	5.0	Index of intellective ability. Varied to determine the effects of maintainers' intellective proficiency. (See scale definition above.)
			Task Parameters
Temperature	60-110(°F)	70	Temperature at place of task. This parameter can be set to simulate the effects of existing environmental conditions.
Radiation Level	0-999(mrem/min)	0.0	Radiation level at place of work. Varied for radiation studies.
Time Limit	0-48(Hours)	0.0	Allotted time in hours and minutes to accomplish the task. Varied when the presence of time pressure is of interest

Table 2.1. Cont.

Menu Name	Range (Units)	Default	Description/Use
Time Limit Importance	Yes/No	No	Importance of completing the task within the allotted time. Used to investigate time pressure.
Supervisor Expectation	0.0-1.00	0.9	Supervisor's expectation of the quality of work performed by the work group. Varied to determine the effects of supervisor's motivation.
Supervisor Acceptance	0.0-1.00	0.98	Supervisor's level of acceptable performance. Varied to study the effects of the supervisor's criterion of acceptable performance quality.
Risk Weight	0-4	0.0	Index of the impact of failure on this task on public safety. Used in risk analyses. Risk Weight — Impact on Public Safety 0 — None 1 — Minor 2 — Moderate 3 — Major 4 — Critical
Essentiality	0.0-1.00	0.0	Indicator of criticality, above which a subtask may never be ignored. Varied to eliminate unessential subtasks. 0.0 = unessential, 1.0 = absolutely essential.
Noise Level	0-120(dB)	60	Acoustic noise level at place of maintenance. Varied to investigate environmental conditions.
Procedures Use Probability	0.0-1.00	1.0	Probability that maintenance procedures are used during performance of the task. Manipulated to study the effects of maintenance policy and procedures quality.
Organizational Climate	F/I/U	NA	Management-labor relations. (F=Favorable, I=Indifferent, U=Unfavorable) This parameter is varied to determine the effects of morale.
Emergency Duration	0-240(minutes)	0.0	Duration of emergency at some location other than site of task. Used to study the effects of the occurrence of an emergency.
Over-manning	Yes/No	No	Indicator for the assignment of additional (extra) personnel to the task. Varied to study changes in manning.
Iterations	1-100	10	Number of independent simulations of the task to be completed.

*Not applicable.

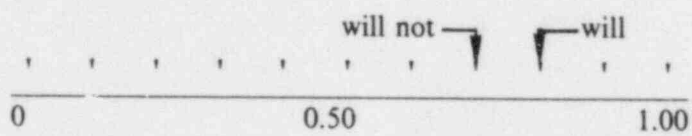
**Refers generically to any control room personnel.

***Actual limits are 1.01-6.99. The current use of "1.0" and "7.0" may disrupt existing parameter files.

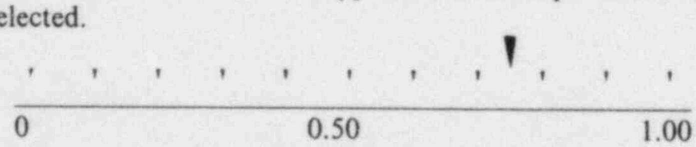
Table 2.2. Required Task Data

Data item	Range	Default
Maintainer types (E, M, O, etc.) to which shift change is applicable	Yes/No	No
Subtask after which the shift change is to take place	1-100	100
Time (in hours) after which the shift change is to take place	1-48	48
Task name	Up to 40 characters	NA
Nuclear power plant type at which the task analysis was performed	PWR/BWR/HTGR	NA

Then, based on any relevant information, users can (mentally) place a mark on the point of the continuum that seems to represent their confidence in the affirmative, i.e., that the procedure *will* be used. In the illustration below, this mark is placed at 0.80.



Next, a second mark is placed to represent the negative, i.e., that procedures will *not* be used, which has been judged to be 0.30. Above, this is shown at 0.70, i.e., 1.00 – 0.30. It now remains to refine the respective estimates so that they will sum to unity. In other words, the point of compromise between the affirmative (will) and the negative (will not) judgment now must be identified. In the hypothetical example shown below the midpoint (0.75) has been selected.



This compromise is the value to be entered into MAPPS, i.e., 0.75 for the example shown here.

Where appropriate (e.g., for Aspiration), judgments should consider and be guided by the default or average or "normal" values shown in Tables 2.1 and 2.3. In other words, consider whether the given situation suggests a value above or below the default value and by how much.

Table 2.3. Required Subtask Data

Menu Name	Range (Units)	Default	Description/Use
Subtask Description	40 Characters	NA	Description of subtask.
Essentiality	0.0-1.00	1.0	Degree of subtask importance or criticality. 0 = unessential, 1 = must be performed.
Procedures Quality	0.0-1.00	0.7	Quality of maintenance procedures. May be held constant to represent existing quality or altered to determine the effects of improved procedures on task performance. 0.0 = Low, 1.0 = High.
Average Success Probability	0.0-1.00	NA*	Average probability of successful subtask completion.
Accessibility	0.0-1.00	1.0	Indicator of manual and visual accessibility. May be held constant to represent existing accessibility or altered to determine the effects of this factor on task performance.
If Success	0-100	Current Subtask + 1	Next subtask to be performed following successful completion of current subtask. Zero indicates end of task.
If Failure	0-100	Current Subtask	Next subtask following failure on current subtask.
Work Group Error Detection Probability	0-1.00	0.98	Probability of members of work group detecting an error.
Supervisor Error Detection Probability	0.0-1.00	0.95	Probability of supervisor detecting an error in subtask performance. (Used in combination with QC check, below).
QC Check	Yes/No	No	Indicator of the presence of a QC check following the current subtask. May be held constant or altered by user.
Fixed Duration	Yes/No	No	Indicator of fixed or variable subtask duration.
Average Duration	0-1000 (minutes)	NA*	Average subtask duration.
Sigma Duration	0-500(minutes)	NA*	Standard deviation of subtask duration.
Duration Group	L/I/S	NA	Indicator of subtask membership in duration group. (L=Long, I=Intermediate, S=Short).
Rank In Group	1-96	NA	Subtask's rank within one of the three duration groups.
Precedent Subtask	0-100	0.0	That subtask which must be completed before the current subtask can begin.
Precedent Time	0-2880 (minutes)	0.0	Time before which work group cannot begin current subtask.

Table 2.3. Cont.

Menu Name	Range (Units)	Default	Description/Use
Communications Importance	Yes/No	No	Indicator of the importance of aural communication to the successful completion of the current subtask.
Anyone, Everyone	A/E	E	Starting personnel indicator. (A=Anyone, each maintainer starts subtask when available; E=Everyone, all work group members must be available before subtask can begin).
Subtask Kind	1-28	NA	Indicator of the nature of the activity represented by the subtask. (See Appendix A).
Validity (V), Specificity (S), Accuracy (A)	1/0 for each (V, S, and A)	111	Indicator of the quality of information regarding equipment malfunction. Used for simulating troubleshooting. V=1: all pertinent informational elements present, and no others. S=1: no ambiguous/equivocal informational elements. A=1: no spurious/untrue informational elements.
Total Maintainers Required	0-8	0.0	Number of maintainers required by type.
Clothing Type 2	0-8	0.0	Number of maintainers wearing (or donning) partial protective clothing, by type.
Clothing Type 3	0-8	0.0	Number of maintainers wearing (or donning) full protective clothing, by type.
Decision Subtask Data — Alternatives			
Number	2-5	NA	Number of decision alternatives. Varied to represent changes in problem complexity.
Next Subtask for Each	1-100	NA	Used for program control. Each alternative must be represented in the sequence of subtasks as an individual subtask.
Probability of Each	0.0-1.0	NA*	Probability of decision maker's choosing each alternative. Optional input.
Correct	0-5	NA*	Identification of the nominally correct decision alternative. Optional input.
Decision Subtask Data — Goals			
Number	1-5	NA	Number of goals the decision maker is considering or attempting to satisfy.
Descriptor	20 characters	NA	Verbal description of each of the goals.
Importance	0.0-1.0	NA	Goal importance. The values distributed over all goals must sum to one.
Course of Action Effects	0.0-1.0	NA	The extent to which each alternative satisfies the stated goals. Values must sum to one for each alternative.

*When no input value is provided the data item is calculated by the model.

2.2.5 Back on Course: Setting Input Parameters

After it has been established that the task of interest ("Source Range Channel N31 Calibration" in our above example) is resident in the Task Library, the user will access the menus which enable him to modify the task parameters. Together with a comprehension of the scales used for certain Input Parameters (as well as Task and Subtask Data, discussed later) the explanations below equip the user/analyst to make these modifications (though details are given in Section 3.0 (p. 34)).

Basically, after calling up the Initial Menu, the user must respond to it by entering "P." This will result in the appearance of the first portion of the Input Parameter display. Modifications of displayed values can then begin.

The parameters include maintainer characteristics such as ability levels and fatigue levels, and task characteristics such as environmental conditions. The primary use of the MAPPS model will be to investigate how variations in parametric conditions affect task performance, that is, error likelihood and task duration. A complete list of MAPPS parameters is given in Table 2.1. This table also gives the range of possible values for each parameter, the default value (used in the absence of user input), and a brief description of each parameter along with an indication of its use. A step-by-step description of entering and modifying parameters is given in Section 3.4 (p. 38).

Proceeding in accordance with plans developed earlier to the first simulation run (conditions for option "a") includes selection for "P" in response to MAPPS' initial menu as pointed out. The first step (separately for each page of Parameters) might be to set all values to default. Then, selective editing (E) of those values for option "a" that were prepared previously can be implemented.

2.2.6 Specifying Run Output

Upon completion of the editing of the Parameters, the Initial Menu is called up and the "R" operation is specified. When the output selection for the simulation run is presented by MAPPS, the "R" response is again made. This response produces the first Run Summary (i.e., for option "a") such as that shown in Figure 2.4. (For further details see Section 3.7 (p. 60)).

2.2.7 Analysis of Run Output

It should be evident that Parameters must be reedited for the two subsequent runs to enter the conditions corresponding to options "b" and "c" respectively. Also, for each run the desired output level (i.e., "R") needs to be respecified. In this way, output analogous to Figure 2.4 is obtained for options "b" and "c."

To facilitate comparisons, it is useful to extract and list the major respective output values side by side. This is shown in Table 2.4. It may be noted that all indices in Table 2.4 correspond to those in the top portion of the run summaries (see Figure 2.4) with the

TITLE: CASE I RUN I ONE I-C HIGH ABIL/PWORK — RUN DATE 06-01-84
RUN SUMMARY. ITERATIONS 50, TASK 10, — SUCCESS PROPORTION 0.56
SOURCE RANGE CHANNEL CALIBRATION — NUCLEAR POWER PLANT TYPE PWR

	TASK DURATION	REPEAT TIME	OVER/ UNDER	PERFORM- ANCE	EFFEC- TIVENESS	PRODUC- TIVITY	ERROR DETC	ERROR CONS INDEX
AVERAGE	128.7	15.0	-21.3	0.86	0.98	1.00	0.93	0.0
SIGMA	15.2	8.8	15.2	0.05	0.12	0.0	0.14	0.0

	EMERGENCY DURATION	STRESS END	STRESS MAX	END ABILITY INTEL	END ABILITY PM	TASK OUTCOME SUCCESS	FAILURE TIME	FAILURE UND	FAILURE REPEAT
AVERAGE	0.0	1.1	1.6	4.0	4.6	28	4	14	9
SIGMA	0.0	0.2	0.3	0.3	0.2				

RESULTS BY TYPE OF MAINTAINER

TYPE	NUMBER	TIME WORK	TIME WAIT	TIME REST	OUTCOME SUC	DET	UND	FA	IGN	TOTAL
MECH	0	0.0	0.0	0.0	0	0	0	0	0	0
IC	1	128.7	0.0	0.0	1628	237	15	21	0	1901
ELEC	0	0.0	0.0	0.0	0	0	0	0	0	0
QC/S	0	0.0	0.0	0.0	0	0	0	0	0	0
OPER	0	0.0	0.0	0.0	0	0	0	0	0	0
TOTAL	1	128.7	0.0	0.0	1628	237	15	21	0	1901

PRESS RETURN TO CONTINUE

RESULTS BY SUBTASK

SUB-TASK	DURATION AVG	DURATION SIGMA	END TIME	STRESS MAXST	STRESS TOT	STRESS TIM	ABILITY INT	ABILITY PM	TRY	OUTCOME SUC	DET	UND	FA	IGN
1	1.2	0.3	1.3	1	1.1	1.0	4.3	4.7	55	50	5	0	0	0
2	1.7	0.5	3.1	1	1.1	1.0	4.3	4.7	54	50	3	0	1	0
3	4.5	1.6	8.3	2	1.1	1.0	4.3	4.7	58	50	7	0	1	0
4 BRANCH														
5	10.2	31.0	20.8	0	1.0	1.0	4.3	4.6	6	5	1	0	0	0
6	1.5	0.5	11.1	1	1.1	1.0	4.3	4.6	52	49	1	1	1	0
7	6.4	2.4	18.5	2	1.1	1.0	4.3	4.6	57	48	6	2	1	0
8	5.4	2.1	25.2	2	1.1	1.0	4.2	4.7	64	48	14	1	0	0
9 BRANCH														
10	4.0	10.1	31.5	2	1.2	1.0	4.2	4.8	8	7	1	0	0	0
11	3.1	1.2	29.0	3	1.1	1.0	4.2	4.7	51	49	1	1	0	0
12	8.7	3.3	39.8	0	1.1	1.0	4.3	4.7	61	50	10	0	1	0
13	1.1	0.2	41.0	6	1.2	1.0	4.2	4.6	53	50	3	0	0	0
14	7.3	2.5	49.4	1	1.1	1.0	4.2	4.7	56	50	5	0	1	0

Fig. 2.4. Sample Source Range Channel Calibration Simulation Run Output.

RESULTS BY SUBTASK

SUB-	DURATION		END	-----STRESS-----			ABILITY		------------OUTCOME------------					
TASK	AVG	SIGMA	TIME	MAXST	TOT	TIM	INT	PM	TRY	SUC	DET	UND	FA	IGN
15 BRANCH														
16	2.4	3.0	55.8	0	1.2	1.0	4.2	4.7	22	20	2	0	0	0
17	5.5	2.2	58.7	1	1.1	1.0	4.2	4.7	75	54	11	0	1	0
PRESS RETURN TO CONTINUE														
18	1.4	0.5	60.8	2	1.1	1.0	4.2	4.7	79	55	14	1	2	0
19	1.1	0.3	62.1	0	1.1	1.0	4.2	4.6	73	57	10	1	0	0
20	2.9	1.1	65.6	1	1.1	1.0	4.2	4.7	81	55	18	0	0	0
21 BRANCH														
22	2.6	0.9	68.6	1	1.1	1.0	4.1	4.7	54	50	3	0	1	0
23	5.7	1.7	75.4	1	1.1	1.0	4.1	4.7	58	50	6	0	2	0
24	2.2	0.8	77.9	1	1.1	1.0	4.1	4.7	56	48	6	2	0	0
25 BRANCH														
26	9.6	23.8	90.2	0	1.0	1.0	4.0	4.7	7	7	0	0	0	0
27	13.2	4.9	93.7	4	1.1	1.0	4.1	4.7	54	49	4	1	0	0
28 BRANCH														
29	1.8	2.6	92.8	0	1.1	1.0	4.1	4.6	19	16	3	0	0	0
30	3.8	1.6	99.3	1	1.1	1.0	4.1	4.7	63	50	11	0	2	0
31 BRANCH														
32	2.2	4.6	97.7	0	1.1	1.0	4.1	4.7	16	8	6	1	0	0
33	1.7	0.5	101.8	1	1.1	1.0	4.1	4.7	52	50	2	0	0	0
34	2.8	1.1	105.1	2	1.1	1.0	4.1	4.7	58	50	8	0	0	0
PRESS RETURN TO CONTINUE														
35	2.1	0.8	107.6	1	1.1	1.0	4.1	4.7	61	50	10	0	1	0
36	2.2	0.7	110.1	1	1.1	1.0	4.1	4.7	61	49	9	1	2	0
37 BRANCH														
38	12.2	48.3	119.3	0	1.0	1.0	4.0	4.8	4	3	1	0	0	0
39	1.6	0.5	112.8	1	1.1	1.0	4.1	4.6	54	50	4	0	0	0
40	1.2	0.5	114.3	2	1.1	1.0	4.1	4.6	58	49	8	1	0	0
41	2.0	0.7	116.6	1	1.0	1.0	4.1	4.6	58	49	7	1	1	0
42 BRANCH														
43	8.7	26.3	134.1	1	1.0	1.0	4.0	4.8	8	5	3	0	0	0
44	1.6	0.4	120.3	1	1.1	1.0	4.1	4.6	64	49	13	0	1	0
45	2.8	0.8	123.2	2	1.1	1.0	4.1	4.7	53	50	3	0	0	0
46	2.4	0.9	125.7	2	1.1	1.0	4.1	4.6	52	50	1	0	1	0
47	1.4	0.3	127.2	0	1.1	1.0	4.1	4.7	56	50	6	0	0	0
48	1.2	0.3	128.7	2	1.1	1.0	4.0	4.6	62	49	11	1	1	0

ENTER SELECTION: M=INITIAL MENU, F=FIRST PAGE OF RUN SMMMARY

Fig. 2.4. (Cont.)

Table 2.4. Results of MAPPS Runs

Output Measure	Option a	Option b	Option c
Success Proportion (%)	0.56	0.28	0.18
Task Duration (min)	129	144	150
Repeat Time (min)	15	50	55
Over/Under (min)	−23	−6	0
Performance	0.86	0.80	0.78
Effectiveness	0.98	0.84	0.79
Productivity	1.00	0.99	0.99
Error Detection	0.93	0.93	0.94
Total Errors	252	410	453
	Task Outcome		
Success Percentage (%)	28	14	9
Failure:			
Time Overrun (%)	4	15	23
Undetected Error (%)	14	17	22
Repeated Failures (%)	9	22	22

exception of "Total Errors." Note that this result is immediately calculable by adding total detected (DET) and undetected (UND) errors under "Results by Type of Maintainer-Outcome." Dividing by 50 (the number of specified iterations) will yield the average number of "Total Errors" per iteration, though comparisons of absolute values will serve as well for present purposes.

Interpretation of information from run output can be facilitated further by making plots or graphs of the critical indices. MAPPS does not generate graphics. The user must prepare plots from MAPPS output. Figure 2.5 shows examples of such graphs for the example at hand. The data provided by the three MAPPS runs should supply the decision maker with sufficient information that he can weigh trade-offs and make the appropriate decision.

2.3 Developing a Simulation Run Based on a "New" Task

The previous example was based on a task that had been analyzed and made resident in the MAPPS Task Library. The present example is based on a task that has not yet been analyzed and for which data have not yet been stored. Of course, the overall procedures are still those outlined in Figure 2.2. However, now we branch to the "NO" choice in response to the question (decision diamond) "IS TASK IN LIBRARY?". Also, we must accomplish the steps outlined under "NEW TASK" in Figure 2.3.

2.3.1 Developing the Problem

The first step is still to define the problem to be solved or the questions(s) the simulation will help to answer.

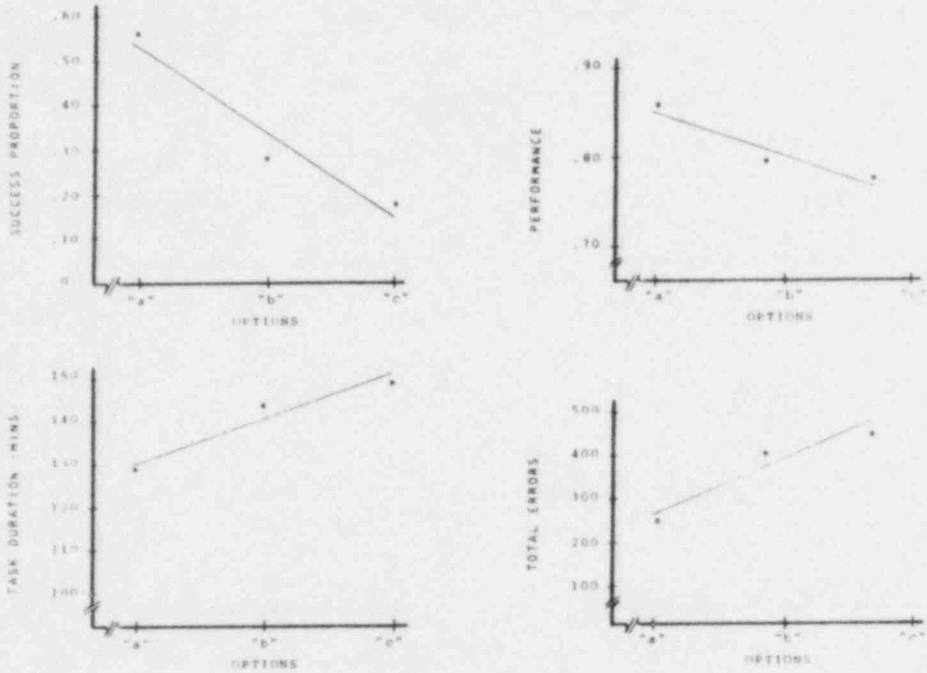


Fig. 2.5. Graphs of Selected Output Indices.

Example II: Inspection and Preventative Maintenance of Limitorque Valve Actuator

Background

Refueling outages are scheduled every 18 months at the XYZ nuclear power plant. The average length of an outage is seven weeks. In order to perform the scheduled preventative maintenance for the next outage, the plans include adding ten contractor technicians to the normal operating group of five technicians. The 15 technicians are scheduled for 10-hour daily shifts, seven days per week.

Problem

Requests have been received from some of the technicians that the work time be reduced, particularly because the outage will occur during summer months when the technicians would like more time with their families. In an attempt to satisfy the crew, several different approaches to reducing the 70-hour weekly work requirement are considered. The inspection and preventative maintenance of the limitorque valve actuators is selected as one of the tasks to use in trying to reach a decision. Although, on average, it takes a team of two technicians some 60 to 75 minutes to complete the task, the total time spent on this task is considerable because of the many limitorque valve actuators in the plant.

The options under consideration for the moment are:

a. reduce team size to one technician,

b. increase team size to three technicians, or

c. improve the quality (efficiency) of maintenance procedures and impose a stricter task completion time limit.

The three main areas of concern are:

a. probability of successful task completion,

b. errors, and

c. time to complete the task.

2.3.2 Task Information

While the content and nature of this second example differs from the first one, the MAPPS user procedures for its simulation analysis are parallel. Were it not for the fact that it will be assumed here to involve a "new" task, i.e., one not yet in the task library, the previously outlined procedures (for Example I), with slight adaptations, could be followed for this second example. With the assumption of a new and not previously simulated task, the task must first be made resident in the MAPPS Task Library (see Figure 2.2).

2.3.3 Task/Subtask Analysis

Before engaging in on-line interaction with MAPPS so as to enter the task and subtask data, these data must be established. Appendix B presents procedures for deriving these data.

2.3.4 Entering Task Data

After organizing and preparing the information obtained in the task/subtask analysis (e.g., determining subtask type, order, etc.), these data are entered to establish the task in the MAPPS task library.

Task data, for the given example, are straightforward. Only a single shift is involved. The task's name or title as given in the example, or some briefer version might be used (e.g., PM of Limitorque MOV). While this type of task occurs in all types of nuclear power plants, the plant where the current task analysis was performed was a PWR type plant. The number of subtasks is 11.

The user must first access the Initial Menu (see page 35) and proceed to the Task Data Menu (see page 45). In response to this menu the user enters the data listed in Table 2.2. The step-by-step procedures for accomplishing this are given in Section 3.5 (p. 45).

2.3.5 Entering Subtask Data

Next, subtask data are entered for each of the 11 subtasks (see Section 3.0 (p. 34), Subtask Data/Description). The procedure is similar to that for task data. It will be advisable to prepare subtask data in written form (as shown in Figure 2.6), for convenience during actual data entry on-line. A complete list of the subtask data items together with their explanations is given in Table 2.3.

The MAPPS model was designed to require a minimum amount of input data. For the majority of data items, if the user cannot supply a value, MAPPS uses default values. One area in which the user may not be able to provide input values is subtask durations. MAPPS contains a method for predicting subtask durations when these values are not input (see Ref. 2). Prior to initiating a simulation run of MAPPS, the user may wish to review the results of the duration estimation method. The procedures for accomplishing this are described in Section 3.8 (p. 63).

2.3.6 Setting Input Parameters

The procedure for setting parameters parallels that described for the preceding case. Note that the normal manning of this task consists of two electricians, and this was established during task/subtask analysis. While default values might be used for all other input parameters, the manning information (team size and composition) must be specified. It should be noted that editing of parameter data requires the user to perform a "store" operation (described later) in order for newly entered data to become effective.

2.3.7 Subsequent Procedures

After input parameters have been specified, the remaining procedures for obtaining simulation run information pertinent to Example II are parallel to those outlined for Example I: specify the desired run output, reset parameters for the additional runs, extract key indices from run outputs, and plot key indices across conditions (runs) for a convenient overview.

2.3.8 Run Output

For each run, output such as that in Figure 2.7 for the two-man team, high maintenance procedures quality, and with a 1 hr. 20 min. time limit will be obtained. Note that, while a time limit (a very moderate restriction) was imposed, no importance (or criticality) was attached to it.

2.3.9 Analysis of Run Output

As in the previously presented example, it will be convenient to extract the run indices from the various run outputs and to list them for comparison. The extracted listing is shown in Table 2.5.

Once again it will be convenient to plot the key indices of interest. Sample graphs are shown in Figure 2.8.

SUBTASK NUMBER	SUBTASK DESCRIPTION	ESSENTIALITY	MAINT. PROCEDURES QUALITY	AVERAGE SUCCESS PROBABILITY	ACCESSIBILITY	IF SUCCESS	IF FAILURE	FOR WORK GROUP	FOR SUPERVISOR	QC CHECK	FIXED DURATION	AVERAGE	SIGMA	SUBTASK NUMBER	TIME IN MINS	COMMUNICATIONS IMPORTANCE	ANYONE/EVERYONE	KIND	TOTAL	CLOTHING TYPE 2	CLOTHING TYPE 3
1.	Inspect Valve Stern	0.5	0.5	0.0	0.65	2	1	0.98	0	N	N	1	2	0	0.0	N	A	10	00200	00000	00000
2.	Inspect Stern Nut Locknut	0.6	0.85	0.0	0.75	3	2	0.98	0	N	N	2	2	0	0.0	N	A	10	00200	00000	00000
3.	Inspect, Lubricate Bearings, Threads, Gears	0.75	0.85	0.0	0.75	4	3	0.95	0	N	N	3	3	0	0.0	N	A	10	00200	00000	00000
4.	Open Compartment; Inspect Gears	0.75	0.85	0.0	0.75	5		0.95	0	N	N	14	6	0	0.0	N	A	10	00200	00000	00000
5.	Inspect Wiring and Conditions in L.S. Compartment	1.0	0.85	0.0	0.85	6	5	0.98	0	N	N	6	4	4	0.0	Y	E	10	00200	00000	00000
6.	Manually Operate Valve and Test L.S. Settings	1.0	0.75	0.0	0.80	7	6	0.95	0	N	N	26	6	4	0.0	Y	E	24	00200	00000	00000
7.	Measure and Record Insulation Resistance	0.5	0.60	0.0	1.0	8	7	0.98	0	N	N	3	2	0	0.0	Y	E	14	00200	00000	00000
8.	Measure and Record Winding Resistance	0.5	1.0	0.0	1.0	9	8	0.98	0	N	N	2	2	0	0.0	Y	E	14	00200	00000	00000
9.	Manually Crank Valve	0.5	1.0	0.0	1.0	10	9	0.98	0	N	N	2	2	6	0.0	N	A	13	00200	00000	00000
10.	Operate Valve; Measure and Record Valves	1.0	0.75	0.0	1.0	11	10	0.98	0	N	N	3	3	9	0.0	Y	E	14	00200	00000	00000
11.	Inspect Cover Seal and Close Compartment	1.0	1.0	0.0	1.0	0	11	0.95	0	N	N	3	3	4	0.0	N	A	10	00200	00000	00000

Fig. 2.6. Illustration of Subtask Data Listing Prior to On-Line Data Entry.

TITLE: CASE II TWO MAINT PMQ/ESS COU 1HR 20 MIN RUN DATE 06-18-84
RUN SUMMARY: ITERATIONS 50, TASK 11, SUCCESS PROPORTION 0.76
VALVE ACTUATOR INSPECTION/PM NUCLEAR POWER PLANT TYPE PWR

	TASK DURATION	REPEAT TIME	OVER/ UNDER	PERFORM- ANCE	EFFEC- TIVENESS	PRODUC- TIVITY	ERROR DETC	ERROR CONS INDEX
AVERAGE	65.3	2.2	-11.6	0.95	1.09	1.00	1.00	0.0
SIGMA	26.4	10.2	22.9	0.09	0.33	0.00	0.0	0.0

	EMERGENCY	STRESS		END ABILITY		--------TASK OUTCOME--------			
							-----FAILURE-------		
	DURATION	END	MAX	INTEL	PM	SUCCESS	TIME	UND	REPEAT
AVERAGE	0.0	1.0	1.4	4.7	4.3	38	12	0	0
SIGMA	0.0	0.1	0.4	0.1	0.1				

RESULTS BY TYPE OF MAINTAINER

TYPE	NUMBER	-----------TIME-----------			-----------------OUTCOME-----------------					
		WORK	WAIT	REST	SUC	DET	UND	FA	IGN	TOTAL
MECH	0	0.0	0.0	0.0	0	0	0	0	0	0
IC		0.0	0.0	0.0	0	0	0	0	0	0
ELEC		136.8	0.0	0.0	529	10	0	1	21	561
C/S	U	0.0	0.0	0.0	0	0	0	0	0	0
PER	0	0.0	0.0	0.0	0	0	0	0	0	0
TOTAL	2	136.8	0.0	0.0	529	10	0	1	21	561

PRESS RETURN TO CONTINUE

RESULTS BY SUBTASK

SUB-	DURATION		END	-----STRESS-----			ABILITY		-----------OUTCOME-----------					
TASK	AVG	SIGMA	TIME	MAXST	TOT	TIM	INT	PM	TRY	SUC	DET	UND	FA	IGN
1	1.1	0.4	1.1	1	1.0	1.0	5.3	4.6	50	50	0	0	0	0
2	2.1	0.9	3.3	0	1.0	1.0	5.2	4.6	51	50	0	0	1	0
3	3.2	1.6	6.5	0	1.0	1.0	5.1	4.6	50	50	0	0	0	0
4	13.1	6.6	20.2	0	1.0	1.0	5.1	4.5	52	50	2	0	0	0
5	6.0	4.5	26.6	6	1.1	1.0	4.9	4.5	52	50	2	0	0	0
6	23.8	17.2	52.5	9	1.1	1.0	4.9	4.4	52	50	2	0	0	0
7	2.9	1.7	51.2	8	1.1	1.2	4.8	4.4	50	40	0	0	0	10
8	1.9	1.2	53.7	9	1.1	1.2	4.7	4.3	51	41	1	0	0	9
9	2.2	0.8	58.9	2	1.0	1.0	4.7	4.3	52	50	2	0	0	0
10	6.8	6.4	65.6	15	1.2	1.0	4.7	4.3	50	50	0	0	0	0
11	2.9	1.1	68.0	0	1.0	1.1	4.7	4.3	51	48	1	0	0	2

ENTER SELECTION: M=INITIAL MENU, F=FIRST PAGE OF RUN SUMMARY

Fig. 2.7. Sample Valve Actuator Inspection Simulation Run Output.

Table 2.5. Results of MAPPS Runs

	Conditions			
Team Size	1	3	2	2
Maint. Proc. Qual.	"LO"	"LO"	"LO"	"HI"
Time Limit	1:30	1:30	1:30	1:20
	Results			
Success Proportion (%)	0.46	0.58	0.64	0.76
Task Duration (min)	84	84	78	65
Repeat Time (min)	11	28	13	2
Over/Under (min)	+1	−1	−8	−12
Effectiveness	0.84	0.85	0.98	1.09
Productivity	1.00	1.00	1.00	1.00
Error Detection	0.89	0.93	0.94	1.00
Total Errors	77	93	53	10
	Task Outcome			
Success (%)	23	29	32	38
Failure:				
Time Overrun (%)	21	16	12	12
Undetected Error (%)	9	7	6	0
Repeated Failures (%)	0	3	2	0

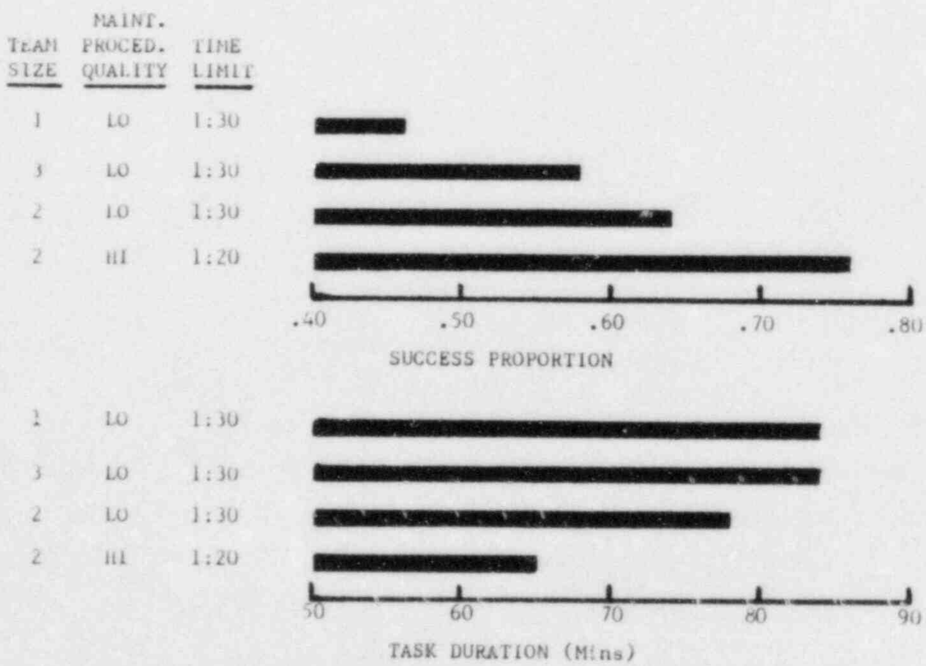


Fig. 2.8. Graphs of Selected Output Indices for Case II.

2.4 More About MAPPS Output

After all data (task data, subtask data, parameters) are prepared for a run, the user is ready to execute the task simulation portion of MAPPS. This is accomplished through the initial menu (Section 3.2 (p. 35)). The user specifies the number of the task to be simulated and the degree of detail of the results of the simulation to be obtained. The procedures for indicating the degree of detail in the output are given in Section 3.7 (p. 60). The MAPPS model provides information at varying degrees of granularity. The user may request information in one, several, or all of the output categories depending on his needs. The output categories are:

- Subtask — detailed information about each subtask the first time it is simulated.
- Shift — summary information about the simulation of a task from the beginning of the task to the point at which personnel are changed (over 5 iterations only).
- Iteration — summary information about each iteration (simulation) of the task (over the first ten iterations only).
- Run summary — information summarizing all iterations (independent simulations) of the task.

A complete list of the information provided by the model at each output level is given in Table 2.6. An example of subtask output as well as instructions on its interpretation are given in Section 3.9 (p. 65). A description of shift output is presented in Section 3.10 (p. 68). Iteration output is described in Section 3.11 (p. 70). The most general and comprehensive type of model output is the run summary. Modeling experience reveals that users will generally request only run summaries as they represent the results of many simulations of the task and are thus the most stable form of output. A detailed description of the run summary is located in Section 3.12 (p. 74).

2.5 Additional MAPPS Functions

The discussion to this point has dealt largely with the main interactions between the user and the MAPPS model: data input and/or modification and task simulation. During program execution the user will desire to accomplish additional functions such as terminating the session and responding appropriately to error messages. A discussion of these issues is presented in Section 3.13 (p. 78).

Table 2.6. Detail of Content of Each Output Type

Output	Subtask	Shift	Iteration	Run Summary
	Output Type			
General Information				
Subtask Number	X		X	X
Subtask Type Number	X			
Subtask Description	X		X	X
Task Number		X	X	X
Task Description		X	X	X
Iteration Number			X	X
Number of Iterations				X
Shift Number		X		
Reason for Shift Change		X		
Run Identifier			X	X
Run Date			X	X
Source of Task Analysis				X
Subtask Performance				
Attempts	X		X	X
Outcome—Success	X		X	X
Outcome—Detected Error	X		X	X
Outcome—Undetected Error	X		X	X
Outcome—False Alarm	X		X	X
Outcome—Ignore	X		X	X
Probability of Success	X		X	X
Start Time	X			
End Time	X	X	X	X
Work Duration	X		X	X
Wait Duration	X			
Accessibility Effect	X			
Procedures Effect	X			
Last Subtask Performed		X	X	X
Task Performance				
Outcome			X	X
Performance			X	X
Effectiveness			X	X
Error Detection Ratio			X	X
Productivity			X	X
Error Consequence Index			X	X
Duration			X	X
Time Overrun/Underrun			X	X
Time Spent in Repeats			X	X
Emergency Duration			X	X
Subtask Preceding Emergency			X	X

Table 2.6. Cont.

Output	Output Type: Subtask	Shift	Iteration	Run Summary
Personnel Characteristics				
Ability Level—Intellective	X		X	X
Ability Level—Perceptual-motor	X		X	X
Ability Difference—Intellective	X			
Ability Difference—Perceptual-motor	X			
Ability Difference—Effect	X			
Fatigue Effect—Intellective	X			
Fatigue Effect—Perceptual-motor	X			
Heat Effect—Intellective	X			
Heat Effect—Perceptual-motor	X			
Pace Adjustment Factor	X			
Time Stress	X		X	X
Communication Stress	X			
Total Stress	X		X	X
Maximum Total Stress			X	X
Subtask with Maximum Stress			X	X
End Total Stress		X	X	X
Number of Maintainers	X			
Personnel Ratio	X			
Characteristics by Maintainer Type				
Type			X	X
Number			X	X
Work Time			X	X
Wait Time			X	X
Rest Time			X	X
Outcome—Successes			X	X
Outcome—Detected Errors			X	X
Outcome—Undetected Errors			X	X
Outcome—False Alarms			X	X
Outcome—Ignores			X	X
Personnel Shift Change Information				
Maintainer Type		X		
Personnel Replaced		X		
End Ability Level—Intellective		X		
End Ability Level—Perceptual-motor		X		
Radiation Absorption		X		
Time on Task		X		

3.0 PROCEDURES

3.1 Introduction

This section presents the step-by-step procedures for interacting with the MAPPS program. Each section presents either a separate model function, such as input of data or selection of output type, or a description of the various types of output. A final section describes additional model functions and error messages.

3.1.1 Logging On and Off

MAPPS is a simulation of nuclear power plant maintenance which has been programmed into a computer. This user's manual assumes that the user is familiar with using a computer, at least to the extent of being able to sign on (log-on) and sign off (log-off). Also, as it is expected that the MAPPS program will be run on many different computer systems, and each system has an idiosyncratic log-on procedure, it serves little purpose to give explicit log-on procedures here. Likewise, each computer system has an idiosyncratic method of initiating program execution. The IBM 3033 system, on which MAPPS was developed, uses the following command to execute (begin) the MAPPS program (after a "READY" indication):

EX MAPPS

This manual presents only MAPPS procedures; it does not present any computer system procedures.

3.1.2 Entering Information

Each entry to the computer (alphabetic or numeric character, or character string) must be followed by pressing the "Carriage Return" key on the computer keyboard. (On some keyboards, this key is labeled "Enter.") Throughout the succeeding procedures, the abbreviated symbol "C/R" reminds the user to depress this key.

3.1.3 Interrupting and Terminating a Simulation

At times users may need, for some reason, to terminate program execution abruptly. Although doing so is not advised, it can be achieved by initiating a "break" from the user's terminal (see prescribed procedure for type of terminal used). After interrupting MAPPS the user can proceed directly to log-off. However, on resuming interaction with MAPPS later it may be necessary to apprise the host computer system of the desire to resume operations (determine proper procedure from host computer center). The use of this emergency procedure should be avoided except when special circumstances warrant it. Normally, the standard procedure for terminating MAPPS should be used (see Sections 3.2 and 3.13 (p. 35 and 78)). At times, use of this emergency procedure may cause some unwelcome consequences. In particular, parameter files may be disrupted (upset) whenever the break has occurred after a parameter menu has been accessed, but before a subsequent run has been made (or at least initialized). In effect, parameters for the subject task, and possibly for all tasks in the task library may be in disarray and would disallow any meaningful runs to be initiated.

The procedure for recovery, when parameter files have been thrown into disarray, is as follows:

1. If necessary, re-establish connection with (log on) the host computer.
2. Type the following:

   COPY MAPPS.PARAMETR.DATA SAVE.PARAMETR.DATA (C/R)

   Note: parametr *not* parameter.
3. Wait for the system response and then type the following:

   COPY MAPPS.PARMBKUP.DATA MAPPS.PARAMETR.DATA (C/R)
4. Wait for the system response and then restart MAPPS (i.e., EX MAPPS) and proceed normally. [**Note:** If the PARAMETR and PARMBKUP files have also been disrupted, they must be restored from the local daily system backup.]

3.2 Initial Menu

How to Respond to the INITIAL MENU

I. WHAT YOU WILL SEE ON THE CRT

```
M A P P S   I N I T I A L   M E N U

P —    PARAMETERS     (ENTER, DISPLAY, PRINT)
S —    SUBTASK DATA   (ENTER, DISPLAY, PRINT)
D —    LIST SUBTASK DURATIONS
T —    TASK DATA      (ENTER, DISPLAY, PRINT)
L —    TASK LIBRARY
R —    RUN SIMULATION
E —    END SESSION

MAPPS, A NUCLEAR POWER PLANT MAINTENANCE SIMULATION MODEL
VERSION 2, COMPILED 1/7/85
COPYRIGHT 1985 APPLIED TECHNICAL ASSOCIATES, INC.

ENTER SELECTION ==
```

This first and key display (menu) lets you select the major kinds of control you want to exercise over the simulation. You may specify certain values (P, S, and T), ask for certain kinds of information (D, L), or initiate certain actions (R, E). The meaning or effects of these choices are explained below.

II. WHAT THE CHOICES MEAN

If you enter	The effect will be
P	A display (menu) will appear on which you must enter values for parameters to be used in the simulation such as "Maintainer Type," etc. Note that parameter data requires the user to *store* new values entered. (See Section 3.4 (p. 38.))
S	A display (menu) will appear on which you must enter values for certain subtask characteristics such as the essentiality of the subtask, the next subtask to be performed on successful accomplishment of the current one, etc. (See Section 3.6 (p. 50).)
D	You are asking for average subtask durations to be listed for you. (See Section 3.6 (p. 50).)
T	A display (menu) will appear by means of which you can define a new task or introduce changes such as new personnel, or new shift conditions. (See Section 3.5 (p. 45).)
L	A display (menu) will appear that lists tasks currently in the MAPPS library plus information such as the number of subtasks for each task. (See Section 3.3 (p. 37).)
R	You are indicating that you want the simulation to go ahead, but further displays will appear first requesting some information and some choices, and offering you certain options about levels of detail in the information you may wish to be displayed. (See Section 3.8 (p. 63).)
E	You want to end the simulation and are ready to log-off. (See Section 3.13 (p. 78).)

III. HOW TO MAKE YOUR CHOICE

1. Select the letter corresponding to your choice.
2. Type this letter on your terminal's keyboard.
3. Press C/R.

How to Examine the TASK LIBRARY

I. WHAT YOU WILL SEE ON THE CRT (IN RESPONSE TO "L" ON INITIAL MENU)

TASK LIBRARY

DATA ARE STORED FOR THE FOLLOWING TASKS. PAGE: 1

LN NO.	TASK NO.	TASK NAME	NO. OF SUBTASKS	DATA OF LAST RUN	NPP TYPE
1)	1	TEST SAFETY INJECTION ACCUM	51	11-11-83	PWR
2)	2	TEST STEAM LINE ISOLATION	35	02-10-84	BWR
3)	3	TEST REACTOR RECIRC SYSTEM	38	02-07-84	PWR
4)	4	ROD CONTROL DRIVE MOTOR	32	11-11-83	HTGR
5)	5	R/I REACTOR COOL PUMP SEALS	59	11-16-83	PWR

SELECTION OPTIONS: N — NEXT PAGE; F — FIRST PAGE; M — INITIAL MENU
ENTER SELECTION = = =

II. WHAT ENTRIES AND CHOICES MEAN

Explanations below are given by line of the above display, and, within lines, proceeding from left to right.

Item	Explanation
Task Library – Page No.:	The list of tasks available for simulation and the page number, when this listing extends over more than one page.
Ln No.:	Line number. Sequential number of tasks in the library.
Task No.:	The ordinal number assigned to the given task within the listing.
Task Name:	The short descriptive title or label (up to 30 characters) assigned to the given task.
No. of Subtasks:	The number of subtasks comprising this task.
Date of Last Run:	Month-Day-Year of last simulation of this task.
NPP Type:	The type of plant providing the environment for task performance (BWR, PWR, HTGR).

III. HOW TO MAKE YOUR CHOICE

Since the task library is a list of tasks immediately available for simulation, choices in relation to the task library are:

- To see the first page of the listing: type "F" plus C/R
- To see the next page of the listing: type "N" plus C/R
- To return to the initial menu: type "M" plus C/R

3.4 Parameters

How to Respond to the PARAMETERS MENU

I. WHAT YOU WILL SEE ON THE CRT (IN RESPONSE TO "P" ON INITIAL INITIAL MENU)

TASK 3 WAS RUN LAST.
ENTER TASK NUMBER (1-200) = = =

e.g.: 10

PARAMETERS — PAGE 1
TASK NO. 10

LN NO.	TEAM VALUE	PARAMETER	RANGE & UNITS	1	2	3	4	5	6	7	8
1)		MAINTAINER TYPE E-ELECTRICIAN M-MECHANIC O-OPERATOR I-I AND C O-OC		I	I	X	X	X	X	X	X*
2)	0	TIME BEFORE	0–36 MOS	0	0						
3)	2.3	STRESS THRESHOLD	1–5	2.3	2.3						
4)	0	PRIOR RADIATION	0–3000 MREMS	0	0						
5)	0	PRIOR WORK	0–72 HRS	0	0						
6)	0.90	ASPIRATION	0–1	0.90	0.90						
		ABILITY	1–7 **								
7)	5.20	PERCEPTUAL/MOTOR		5.2	5.2						
8)	5.70	INTELLECTIVE		5.7	5.7						

TO EDIT — ET = TEAM VALUE EM = MAINTAINER VALUES M = INITIAL MENU
N = NEXT PAGE R = RESET D = DISPLAY S = STORE
SELECT OPERATION =

Note: Selecting operation "N" will produce Page 2 (below).

*MAPPS fills unused maintainer numbers with "X."

**Although the parameters menu indicates that the range of ability levels is from 1–7, the current limits are actually 1.01–6.99. Use of the "1" and "7" end point values may lead to disruption of parameter files.

P A R A M E T E R S — P A G E 2

LINE	VALUE	PARAMETER DESCRIPTION	RANGE	UNITS
1)	70	TEMPERATURE	60-110	DEGREES F
2)	0.0	RADIATION LEVEL	0-999	MREM PER MINUTE
3)	2, 0	TIME LIMIT	0-48, 0-59	HOURS, MINUTES
4)	Y	TIME LIMIT IMPORTANCE	Y OR N	Y = IMPORTANT
5)	0.90	SUPERVISOR EXPECTATION	0-1	1 = HIGH
6)	0.80	SUPERVISOR ACCEPTANCE	0-1	1 = HIGH
7)	0.0	RISK WEIGHT	0-4	4 = HIGH
8)	0.0	ESSENTIALITY LIMIT	0-1	1 = HIGH
9)	70	NOISE LEVEL	0-120	DECIBELS
10)	1.00	PROCEDURES USE PROBABILITY	0-1	1 = HIGH
11)	I	ORGANIZATIONAL CLIMATE	F, I, U	F = FAVORABLE
12)	0	EMERGENCY DURATION	0-240	MINUTES
13)	N	OVER-MANNING	Y OR N	Y = EXTRA MAINT.
14)	5	ITERATIONS	1-100	NUMBER

E = EDIT M = INITIAL MENU R = RESET F = FIRST PAGE D = DISPLAY S = STORE
SELECT OPERATION = =

Note: Selecting operation "F" will return Page 1 (above).

II. WHAT THE PARAMETERS MEAN

A. PARAMETERS — PAGE 1

Line No.	Menu Name	Explanation
1	Maintainer Type	Defined in Line #1 (see leftmost column for Line #) as: E(Electrician), M(Mechanic), O(Operator), I (I and C), and Q(Quality Control or Supervisor). Default N/A.
2	Time Before	Months (up to 36) since this task was performed last by this technician? Default = 0.
3	Stress Threshold	The value of the Stress Threshold, from low = 1.0 to high = 5.0. Default = 2.3.
4	Prior Radiation	The amount of radiation absorbed up to the start of this task, from none = 0 to high = 3000 millirems. Default = 0.
5	Prior Work	The number of continuous duty hours of the maintainers up to the start of this task, ranging from 0 to 72 hours. Default = 0.

6	Aspiration	The level of aspiration of each maintainer, ranging from low = 0.0 to high = 1.0. Default = 0.90.
7	Ability: Perceptual-Motor	The level of perceptual-motor ability possessed by each maintainer, ranging from low = 1 to high = 7* (varied, normally, over successive iterations). Default = 5.
8	Ability: Intellective	The level of intellective ability possessed by each maintainer, ranging from low = 1 to high = 7* (varied, normally, over successive iterations). Default = 5.

Column** No.	Menu Name	Explanation
1	Line #	The "Line #" in the page 1 table which can be cited to edit parameters (see below).
2	Team Value	The average value of the given parameter for the given team in this simulation run.
3	Parameter	The given parameter is explained above.
4	Range & Units	The range of acceptable values, and the units of measurement (where applicable) for the given parameter.
5	Maintainer Number	A team of up to 8 maintainers may be specified. (Values in the body of the table are arbitrary, for illustration only, and can be changed by editing).

B. PARAMETERS — PAGE 2

1	Temperature	The ambient temperature of the worksite in degrees Farenheit, ranging from 60 to 110. Default = 70.
2	Radiation Level	The ambient radiation level of the worksite in millirems/min, ranging from 0 to 999. Default = 0.

*Although the parameters menu indicates that the range of ability levels is from 1–7, the current limits are actually 1.01–6.99. Use of the "1" and "7" end point values may lead to disruption of parameter files.

**From left to right.

3	Time Limit	The permissible length of time for completing the given task ranging from 0 minutes up to 48 h and 59 mins. Default = 0 h 0 mins (*but a higher value must be set!* Note: If a time limit is not important, an arbitrary value must still be entered. This value is usually chosen to be very large, e.g., 48 h 59 mins.
4	Time Limit Importance	Whether or not the stated time limit is important or critical: Y(Yes) or N(No). Default = N. N(No). Default = N.
5	Supervisor Expectation	The supervisor's ambition as to the level of performance his team should reach, ranging from low = 0.0 to high = 1.0. Default = 0.90.
6	Supervisor Acceptance	The supervisor's acceptance of a level of performance by his team, ranging from low = 0.0 to high = 1.0. Default = 0.98.
7	Risk Weight	The degree of risk entailed by the consequences of inadequate task performance, ranging from low = 0 to high = 4. Default = 0.
8	Essentiality Limit	The criterion for determining subtask essentiality, e.g., whether or not the subtask may be omitted under time pressure, ranging from low = 0 to high = 1. Default = 0.
9	Noise Level	The level of ambient noise at the worksite, ranging from low = 0 to high = 120 decibels. Default = 60.
10	Procedures Use Probability	The probability that the written procedures will be used in performing the given task, ranging from low - 0 to high = 1. Default = 1.
11	Organizational Climate	Management-labor relations. (Favorable = F, Unfavorable = U, Indifferent = I). Default = I
12	Emergency Duration	An emergency of specified duration will occur during this task performance (Range = 0 to 240 mins) and preempt some maintainers currently on the team. No emergency = 0. Default = 0.

13	Over-Manning	Establishes that additional maintainers can be assigned to a subtask if they are available: Y(Yes) or N(No). Default = N.
14	Iterations	How many times task performance will be simulated within the current simulation run (maximum = 100). Default = 10.

III. HOW TO MAKE YOUR CHOICES

A. Interacting with PARAMETERS - PAGE 1

1. Have you made your simulation plans and prepared the appropriate data values?

   NO: Determine requirements.
   YES: Go to the next step.

2. Do you want to accept the values currently displayed in the table, set default values, or do you want to change some or all of them?

   ACCEPT: Go to Step 7.
   CHANGE: Go to next step.
   SET DEFAULT VALUES: Go to Step 6.

3. Do you (first) want to change (edit) some or all team values? Note: You may enter a single (average) value for the team and MAPPS will randomly select values around the mean to represent the individual maintainers. Or you may enter a value for each individual maintainer. Note that editing need not be done sequentially as given in the menu; any order (sequence) is permissible. Note also that in order to make effective any data entered, the "store" operation must be performed (see steps A.5.e and B.4.e).

   NO: Go to Step 5.
   YES: Go to next step.

4. a. Type "ET" plus C/R on your keyboard.

   (Next, you will be asked to specify the line number corresponding to the parameter you want to edit, or "99.")

   b. Type the line number plus C/R, if you want to specify a new team value, and wait for a system response. When you have completed editing team values, type "99" plus C/R.

   (Next, you will be asked to specify the new team value.)

   c. Type the new team value plus C/R.

   Note: In response to the team value, MAPPS randomly assigns values to each maintainer so that the mean equals the team value. Because of this randomization, when values at the upper and lower limits are desired, you should use the "EM" command.

d. To verify (see) the newly made change on the CRT, type "D" plus C/R.

e. To make satisfactory parameter values *effective* you *must store* them

(1) Type "S" plus C/R.

MAPPS will respond with:

STORING IN TASK [Task #] IS THIS CORRECT Y/N:

(2) If correct, type "Y" plus C/R; else type "N."

Note: The storing operation may be deferred until editing of Page 2 has been completed. All changes in both pages may be stored in a single operation.

f. If you have executed the storing operation, MAPPS will automatically return you to the "INITIAL MENU." However, you may wish to review Step 2 (above).

5. a. Type "EM" plus C/R on your keyboard.

(Next, you will be asked to specify the line number corresponding to the parameter—maintainer *type* or maintainer *value*—you want to edit, or "99.")

b. Type "1," if you want to edit maintainer type; type other number (2-8) corresponding to line number in which you wish to change value(s) plus C/R, and wait for a system response. (When you have completed editing maintainer values, type "99" plus C/R.)
(Next, you will be asked to enter the new values.)

c. Type the new maintainer type, or the new maintainer value plus C/R; to enter more than one value, separate successive values (up to 8) by a space or a comma, and press C/R only after all values for the given line have been specified.

d. To verify (see) the newly made changes on the CRT, type "D" plus C/R.

e. To make satisfactory parameter values *effective* you *must store* them

(1) Type "S" plus C/R.

MAPPS will respond with:

STORING IN TASK [Task #] IS THIS CORRECT Y/N:

(2) If correct, type "Y" plus C/R; else type "N."

Note: The storing operation may be deferred until editing of Page 2 has been completed. All changes in both pages may be stored in a single operation.

f. If you have executed the storing operation, MAPPS will automatically return you to the "INITIAL MENU." However, you may wish to review Step 2 (above).

6. To reset all of the PAGE 1 parameters to the default (normal) values specified for them, type "R" plus C/R. (CAUTION! Does not provide manning data). Then go to Step 2.

7. Proceed with this step only if you are entirely satisfied with the values in "PARAMETERS - PAGE 1" and will do no more editing (otherwise return to Step 2).

   - To proceed to "PARAMETERS - PAGE 2": Type "N" plus C/R.
   - To see the "INITIAL MENU": Type "M" plus C/R.

B. Interacting with PARAMETERS - PAGE 2

1. Have you planned and prepared the appropriate data values?

   NO: Determine requirements.
   YES: Go to the next step.

2. Do you want to accept the values currently displayed in the table, or set default values, or do you want to change some or all of them?

   ACCEPT: Go to Step 5.
   CHANGE: Go to Step 4.
   SET DEFAULT VALUES: Go to Step 3.

3. To reset all of the PAGE 2 parameters to the default values specified for them, type "R" plus C/R, then go to Step 5.

   Note: After resetting, a Time Limit greater than zero (0) *must* be set in on Line #3! To eliminate the effect of Time Limit, set in a value of 4859 (48 hrs 59 mins, i.e., the upper limit).

4. a. Type "E" plus C/R on your keyboard.

   (Next, you will be asked to specify the line number corresponding to the parameter you want to edit, or "99.")

   b. Type the line number plus C/R, if you wish to specify the new value for the parameter in question, and wait for a system response. (When you have finished making changes, type "99" plus C/R.)

   (Next, you will be asked to specify the new value.)

   c. Type the new value plus C/R. (Note: For Line #3 enter hours and minutes using the format "HHMM.")

   d. To verify (see) the newly made change on the CRT, type "D" plus C/R.

   e. To make satisfactory parameter values *effective* you *must store* them.

(1) Type "S" plus C/R.

MAPPS will respond with:

STORING IN TASK [Task #] IS THIS CORRECT Y/N:

(2) If correct, type "Y" plus C/R; else type "N".

Note: The storing operation may be deferred until editing of Page 2 has been completed. All changes in both pages may be stored in a single operation.

f. If you have executed the storing operation, MAPPS will automatically return you to the "INITIAL MENU." However, you may wish to review Step 2 (above).

5. Proceed with this step only if you are entirely satisfied with the values in "PARAMETERS – PAGE 2."

   - To return to PAGE 1: Type "F" plus C/R.
   - To see the "INITIAL MENU": Type "M" plus C/R.

3.5 Task Data Menu

TASK DATA: PRELIMINARY

I. WHAT YOU WILL SEE ON THE CRT (IN RESPONSE TO "T" ON THE INITIAL MENU)

TASK 14 WAS LAST PROCESSED. DO YOU WISH TO PROCESS THE SAME TASK (S), PROCESS A DIFFERENT TASK (D), OR RETURN TO THE INITIAL MENU (M)? ENTER CODE ==

Note: The task number specified is arbitrary and only an illustration.

II. HOW TO MAKE YOUR ENTRIES

1. Do you want to:

   - Process the same task again: Go to Step 2.
   - Process a different task next: Go to Step 3.
   - Return to the initial menu: Go to Step 4.

2. Type "S" plus C/R on your keyboard. (Task data for the "same" task will be displayed next.)

3. a. Type "D" plus C/R on your keyboard. Next, MAPPS will respond with the message:

ENTER THE TASK NUMBER == 8

b. Type the number of the task as established in the task library plus C/R. (In the example, Task No. 8 was specified.)

Next, MAPPS will respond with:

YOU ENTERED TASK 8. IF CORRECT ENTER YES(Y); IF NOT, ENTER NO(N) == Y

c. Type "Y" (as in this example) or "N" plus C/R, as appropriate. If you specified a task number that was not previously used (new task), MAPPS will respond with:

TASK 8 IS A NEW TASK.

It will now be established in the task library automatically. In any case, the task shift data display (menu) will appear next.

4. Type "M" plus C/R.

How to Respond to TASK (SHIFT) DATA

I. WHAT YOU WILL SEE ON THE CRT (IN RESPONSE TO SPECIFYING THE TASK NUMBER)

T A S K - 1 2 S H I F T D A T A

LN NO.	SHIFT NO.	MECH	MAINTAINER REPLACED I&C N=NO	ELEC	QC Y=YES	OPER	SHIFT CHANGE SUBTASK NO. (XXX)	CONDITION TIME (HRS) (XXX)
1)	1	N	N	N	N	N	100	48
2)	2						0	0
3)	3						0	0
4)	4						0	0
5)	5						0	0
6)	6						0	0
7)	7						0	0
8)	8						0	0
9)	9						0	0
10)	10						0	0

11) TASK NAME :PRESSURIZER LEVEL CHANNEL TEST
12) NPP TYPE :PWR (PWR, BWR, HTGR)
13) NO. OF SUBTASKS :36

TO EDIT — E	TO DELETE SHIFT — Z	
D = DISPLAY TASK	T = SELECT ANOTHER TASK	X = DELETE THIS TASK
M = INITIAL MENU	S = DISPLAY SUBTASK DATA	R = RESET SHIFT DATA
SELECT OPERATION ==		

Note: The entries in the body of the table are arbitrary and illustrative only.

II. WHAT THE CHOICES MEAN

Column* No.	Item	Explanation
1	Ln No.	The successive lines (1-10) on which data can be entered are designated (see, also, Line Nos. 11 and 12 below).
2	Shift No.	The successive *changes* in the originally specified work group or team (see PARAMETERS – PAGE 1) who will be performing the maintenance work (up to 10 changes/shifts); each shift can change the work group composition.
3	Mech	Whether or not maintainers of the mechanic type are being replaced.
4	I&C	Whether or not I&C technicians are being replaced.
5	Elec	Whether or not electricians are being replaced.
6	QC	Whether or not supervisors (or quality control personnel) are being replaced.
7	Oper	Whether or not operators are being replaced.
8	Subtask No.	After completion of the specified subtask, a shift change will be made.
9	Time (Hrs)	After the specified number of (simulated) hours have elapsed, a shift change will be made.

* From left to right.

Line No.	Item	Explanation
11	Task Name	This is the task designation (task number) in the task library to which this data table applies.
12	NPP Type	The type of NPP environment that is being simulated (BWR, PWR, HTGR).
13	No. of Subtasks	The total number of subtasks in this task.

III. HOW TO MAKE YOUR CHOICES

1. Do you want to:

   - Add or edit a shift: Go to Step 2.
   - Delete a shift: Go to Step 3.
   - Verify your revisions: Go to Step 4.
   - Select another task: Go to Step 5.
   - Delete this task: Go to Step 6.
   - Use default shift data: Go to Step 7.
   - Display subtask data: Go to Step 8.
   - Return to the initial menu: Go to Step 9.

2. a. Type "E" plus C/R on your keyboard.

   (Next, you will be asked to specify the line number corresponding to the parameters you want to edit, or "99." Note that editing need not progress in the sequence presented in the menu; any order (sequence) is permissible.)

   b. Type the line number plus C/R, if you wish to specify new values for the parameter(s) in question, and wait for a system response. (When you have completed making changes, type "99" plus C/R.)

   (Next, you will be asked to enter new values.)

INPUT SHIFT DATA. **ENTER MAINTAINER TYPE REPLACEMENT CODES (Y/N).**

   c. Type the appropriate new maintainer replacement codes (all 5), separated by a space or comma, plus C/R.

   Next, MAPPS will ask you to:

ENTER SHIFT CHANGE SUBTASK NUMBER AND TIME (HRS).

   d. Type *both* appropriate values, separated by a space or comma, plus C/R.

   Next, MAPPS will acknowledge:

DATA ENTERED.

   Notes: (1) In lines 1 through 10 *all five values* must be entered before C/R. This is true even when normal task manning does *not* include certain maintainer types. In the latter case, simply enter "N" for nonexistent maintainer types.

   (2) To make shift change entirely contingent on a given subtask, enter that subtask number, and enter "48" as the time value. Vice versa, if shift change is to be solely contingent on time, enter "100" as the subtask number, and then specify the critical time value.

   e. Go to Step 1.

3. a. Type "Z" plus C/R on your keyboard.

   (Next, you will be asked to specify the line number of the shift you wish to delete, or "99.")

   b. Type the line number of the shift to be deleted plus C/R. (When you have completed this step, type "99" plus C/R.)

   (Next, MAPPS will acknowledge the deletion.)

   c. Go to Step 1.

4. If you wish to verify (see) that your revisions have been entered, type "D" plus C/R on your keyboard. Then go to Step 1.

5. a. Type "T" plus C/R on your keyboard.

   (Next, you will be asked to specify the task numbers, or "99.")

   b. Type the task number from the task library plus C/R. (When you have completed this step, type "99" plus C/R.)

   c. Go to Step 1.

6. a. Type "X" plus C/R on your keyboard.

   MAPPS will ask for confirmation:

YOU ASKED TO DELETE THE TASK. IF THIS IS CORRECT ENTER YES(Y); IF NOT, ENTER NO(N) ==

   b. Type "Y" or "N" plus C/R, as appropriate. (If response is "Y," the task will be eliminated from the Task Library.)

   c. Go to Step 1.

7. To reset all task data to default values type "R" plus C/R. In the context of shift changes, however, default amounts to a clean slate; it means you must furnish all shift change information. Therefore, MAPPS responds as for a new task:

TASK 12 IS A NEW TASK.

8. To see a display of subtask data for the given task (see, also, SUBTASK DATA/DESCRIPTIONS) type "S" plus C/R. When finished, go to Step 1.

9. Type "M" plus C/R.

3.6 Subtask Data Menu

I. WHAT YOU WILL SEE ON THE CRT (IN RESPONSE TO "S" ON THE INITIAL MENU):

TASK 14 WAS LAST PROCESSED. DO YOU WISH TO PROCESS THE SAME TASK (S), PROCESS A DIFFERENT TASK (D), OR RETURN TO THE INITIAL MENU (M)? ENTER CODE ==

Note: The task number specified (14) is arbitrary and only an illustration.

II. HOW TO MAKE YOUR ENTRIES

1. Do you want to:
   - Process (review or edit) the same task again: Go to Step 2.
   - Process a different task next: Go to Step 3.
   - Return to the initial menu: Go to Step 4.
2. Type "S" plus C/R on your keyboard (Subtask Data/Descriptions for the "same" task will be displayed next).
3. a. Type "D" plus C/R on your keyboard.

   Next, MAPPS will respond with the message:

ENTER THE TASK NUMBER == 8

   b. Type the number of the task as established in the task library plus C/R. (In the example, Task No. 8 was specified.)

   Next, MAPPS will respond with:

YOU ENTERED TASK 8 IF CORRECT ENTER YES(Y); IF NOT, ENTER NO(N) ==

   c. Type "Y" or "N" plus C/R, as appropriate.

   If you specified a task number that was not previously used (new task), MAPPS will respond with:

TASK 8 IS A NEW TASK.

   It will now be established in the task library automatically. In any case, the Subtask Data/Description display (screen) will appear next.
4. Type "M" Plus C/R.

How to Respond to SUBTASK DATA MENU

III. WHAT YOU WILL SEE ON THE CRT (IN RESPONSE TO SPECIFYING THE TASK NUMBER)

DATA FOR TASK — 6, SUBTASK — 1 OF 1

1) SUBTASK DESCRIPTION --- DEFAULT VALUES

N#	VALUE	DATA ITEM 1	: VALUE	DATA ITEM 2	: NOTES
2)	1.00	ESSENTIALITY	: 0.70	PROCEDURES QUALITY	: 0.00 TO 1.00
3)	0.0	AVG SUCCESS PROB	: 1.00	ACCESSIBILITY	: 0.00 TO 1.00
4)	2	IF SUCCESS	: 1	IF FAILURE	: NEXT SUBTASK NO
5)	0.98	FOR WORK GROUP 0,1.00	: 0.98	FOR SUPERVISOR 0,1.00	: ERR DETECTION PROB
6)	N	QC CHECK	: N	FIXED DURATION	: Y OR N
7)	****	AVERAGE 0,1000	: ****	SIGMA 0,500	: DURATION, IN MINS
8)	*	DURATION GROUP L,I,S	: 0	RANK IN GROUP 1,96	: DURATION INFO
9)	0	SUBTASK NUMBER 0,100	: 0	TIME IN MINS 0,2880	: PRECEDENCE
10)	N	COMM IMPORTANCE Y,N	: E	ANYONE, EVERYONE A,E	: START SUBTASK
11)	****	SUBTASK KIND, 1 TO 28	: 111	VALID, SPEC, ACCURATE	: TROUBLE SHOOTING

	MECH	IC	ELEC	QC:S	OPER	MAINTAINERS REQUIRED
12)	0	0	0	0	0	TOTAL
13)	0	0	0	0	0	CLOTHING TYPE 2
14)	0	0	0	0	0	CLOTHING TYPE 3

E = EDIT SUBTASK R = RESET SUBTASK X = DELETE SUBTASK C = SUBTASK DECISION DATA
M = INITIAL MENU D = DISPLAY SUBTASK S = DECISION SUBTASKS N = DISPLAY NEXT SUBTASK
SELECT OPTION ===

This menu is the chief means for describing tasks and subtasks, i.e., for entering the data that characterize each subtask and, collectively, a task.

II. WHAT SUBTASK DATA MEAN

Line No.	Data Item	Menu Name	Explanation
		Above Line 1	The task number of the task to which this subtask belongs is given together with the number of this subtask within the total sequence of subtasks for this task.
1		Subtask Description	Up to 40 characters (including spaces) may be used to label (title, describe, define) the subtask.
2	(1)	Essentiality	An indicator of the importance of criticality of the subtask. Less essential subtasks may be skipped under conditions of high time stress. Range: 0.0-1.0, Default = 1.0.

	(2)	Procedures Quality	A measure of the quality of the maintenance procedures available for the subtask. Subtask intellective requirements are modified by the quality of procedures thus affecting subtask outcome. Range: 0.0-1.0, Default = 0.7.
3	(1)	Avg Success Probability	A user may enter the average probability of success, if that value is known from prior experience or data banks. If no value is entered, the model calculates a value. If a value is entered, it is treated as an average value. Note: For type 28 (Branch) subtasks, average success probability *must* be provided. Note also that if no value is entered, i.e., the entry is left as a zero, MAPPS will calculate an average success probability. Range: 0.0-1.0, Default value calculated by MAPPS.
	(2)	Accessibility	An indicator of the manual and visual accessibility level at the site of the subtask Alters the perceptual-motor requirements of the subtask. Range: 0.0-1.0, Default = 1.0.
4	(1)	If Success	The subtask to be performed next, if this one is performed successfully. Range: 1-100, Default = Current Subtask + 1.
	(2)	If Failure	The subtask to be performed next, if this one is performed unsuccessfully. Current Subtask Range: 1-100, Default = Repeat.
5	(1)	For Work Group	The probability that the work group will detect its own error and repeat the given subtask performance. Range: 0.0-1.0, Default = 0.98.
	(2)	For Supervisor	The probability that the supervisor will detect the work group's error. Range: 0.0-1.0, Default = 0.98.
6	(1)	QC Check	Whether or not the supervisor or QC/QA personnel will inspect (make quality control check) following performance of the subtask. Range: Y(Yes) or N(No), Default = N.
	(2)	Fixed Duration	Whether or not this subtask has a fixed duration. Note: If Y(Yes) is entered, the average (mean) duration of the subtask (in minutes) must be entered on Line 7, Item 1, *and* a value of zero *must* be entered on Line 7, Item 2. Range: Y(Yes) or N(No), Default = N.

7*	(1)	Average	The average duration of the performance of this subtask. If known, the value may be be entered; if unknown, MAPPS will calculate a value. Note: If no average duration is entered, MAPPS assumes that an average duration is to be calculated and requires that both entries on Line 8 be completed. If an average duration *is* entered, Line 7, Item 2 must also be supplied, *and* Line 8 (both entries) should *not* be completed. The only exception is for the entry of data for the shortest and longest subtasks in each duration group. For this case, an average duration and sigma must be supplied *and* line 8 must be completed. Range: 1-1000 mins, Default value calculated by MAPPS.
	(2)	Sigma	The standard deviation (variability) of average subtask duration. Note: Sigma can only be entered if Line 7, Item 1 is entered. If duration is fixed (Line 6, Item 2 = Y), a value of zero must be entered here. Range: 0-500, Default = Average Duration/3.
8*	(1)	Duration Group	In the event that the user does not wish to enter the average duration of the subtask (line 7, item 1) MAPPS will calculate it. Users must assign each subtask of unknown duration to one of three duration categories: L(Long), I(Intermediate), and S(Short) and enter the appropriate letter (L,I,S) here. Also, users must supply the durations of the shortest and the longest subtask in each category on Line 7. Range: L(Long) or I(Intermediate) or S(Short), Default = Not Applicable.

***Note:** Inadvertent editing of entries on Lines 7 and 8 requires special handling to correct the error. This is because, once they have been edited, there is no direct means of resetting default values. The special handling is as follows:

1. Given that the user has edited Line 7 or Line 8 (accidentally), some arbitrary data must be entered for both items. Then type C/R.
2. Type "99."
3. Exercise select option "R."
4. Begin data entry for this subtask from the beginning. (All previous data for this subtask will have been reset to their default values.)

	(2)	Rank in Group	Complete this entry only if line no. 8, data item 1 has been completed. The entry made is the rank of the subtask within its appropriate duration group. The user, after partitioning subtasks into long, intermediate, and short duration groups, must rank the subtasks in ascending order and number each subtask within the group. This number is entered here. Range: 1-96, Default = Not Applicable.
9	(1)	Subtask Number	The number of a preceding subtask, if any, that must be completed before this subtask can begin. Range: 0-99, Default = 0.
	(2)	Time in Mins	The minimum number of minutes that must have elapsed from the start of this task before this subtask can be performed. Range: 0-2880, Default = 0.
10	(1)	Comm Importance	An index of the importance of oral/aural communication to the performance of this subtask, i.e., whether or not its effective accomplishment is contingent on such communication. Range: Y(Yes) or N(No), Default = N.
	(2)	Anyone, Everyone	Whether any one member of the work group (team) may begin performing this subtask, or whether the entire team must be present (all members). Range: A(Anyone) or E(Everyone) Default = E.
11	(1)	Subtask Kind	A specification of the type of subtask (of 28 types listed in Appendix A) this subtask represents.* Note: This entry is always required. Because of the way subtask data is entered, i.e., two items per line, data for Line 11, Item 2 must also be supplied, even though it is only relevant when Type 25 subtasks (trouble-shooting) are indicated. Thus, it is suggested that "111" be entered for Line 11, Item 2, when subtasks are not Type 25. Range: 1-28, Default = Not Applicable.
	(2)	Valid, Spec, Accurate	Only relevant for Type 25 (trouble-shooting) subtasks, and refers to the "quality" of the information given in the report of a malfunction. For other types of subtasks enter "111."

*For "Branch" subtasks (Type 28), see special rules below. For "Decision Making" subtasks (Type 6), see special rules at the end of this section (how to enter subtask decision data).

Valid (V) = Validity. If V=1, the report contains all pertinent informational elements (symptoms), and no others.

Spec(S) = Specificity. If S=1, the report contains no ambiguous or equivocal information elements.

Accurate(A) = Accuracy. If A=1, the report contains no spurious or untrue informational elements. Range: V = 0,1; S = 0,1; A = 0,1. Default = 111.

12 This line specifies the number of maintainers, by type, who are required for the performance of this subtask. Note: The maintainers specified here should be a subset of the maintainers specified on Line 1, page 1 of the parameters menu (see Section 3.4 (p. 38)). Range: 0-8, Default = Not Applicable.

13 The number of maintainers, by type, required to wear or to don Type 2, partial protective clothing. Range: 0-8, Default = Not Applicable.

14 The number of maintainers, by type, required to wear or to don Type 3, full protective clothing. Range: 0-8, Default = Not Applicable.

Special Rules for Type 28, "Branch" Subtasks

The special character of the "Branch" type of subtask introduces the necessity for the following rules to be observed in planning and entering subtask description data. Note: Only two branches are allowed.

Line 3, Item (1) *Avg Success Probability* — the larger of the two probabilities (frequencies of choosing each alternative) must be specified; when probabilities for both equal 0.5, specify the alternative having the longer duration.

Line 4, Items (1) and (2) *If Success & If Failure* — In order to complete the "If Success" and "If Failure" entries (line no. 4, data item 1, and line no. 4, data item 2, respectively) for a "Branch" subtask, the first subtask in each branch must be examined. Complete the "If Success" entry with the subtask number of the first subtask in the branch that has the greater probability. The "If Failure" entry will be completed by entering the subtask number of the first subtask in the other branch.

If the probabilities are the same, "If Success" is completed by entering the subtask number of the first subtask (in either branch) that has the longest duration. "If Failure" is completed by the subtask number of the first subtask in the other branch.

Line 9, Item (1) — *Subtask Number* — for the first subtask in both alternatives specify the "Branch" subtask as the precedent subtask.

Line 10, Item (2) — *Anyone, Everyone* — when either branching sequence of subtasks requires more than one maintainer, enter "E" on the first subtask following the branch.

Lines 12–14 — *Maintainers Required* — enter the same number and pattern as in the subtask immediately preceding the branch.

III. HOW TO MAKE YOUR ENTRIES

1. Do you want to:

   - Return to INITIAL MENU: Go to Step 6.
   - See the next SUBTASK DATA MENU: Go to Step 4.
   - See some other SUBTASK DATA MENU: Go to Step 5.
   - Delete a subtask: Go to Step 6.
   - See the list of DECISION SUBTASKS: Go to Step 7.
   - Enter subtask decision data: See "How to Enter Subtask Decision Data" (following this Section).
   - Enter standard (default) values for this subtask: Go to Step 2.
   - Enter some or all values for this subtask: Go to Step 3.

2. To reset all of the values for this subtask to the default values, type "R" plus C/R; then go to Step 1. Note, however, that choice of this option requires that you furnish subtask specific data: title, type, duration, manning, etc.

3. a. Type "E" plus C/R on your keyboard.

   (Next, you will be asked to specify the line number corresponding to the parameter you want to edit, or "99." Note, editing need not progress in the sequence presented in the menu; any order (sequence) is permissible.)

   b. Type the line number plus C/R, if you wish to specify a new value for the parameter in question, and wait for a system response. (When you have completed making changes, type "99" plus C/R.)

   (Next, you will be asked to enter new values.)

   c. Type the appropriate new values separated by a space or a comma, and press C/R only after all values for the given line have been specified. All values must be reentered even when only one is being changed.

Notes: (1) For the *last* subtask in any task, the entries on Line 4 must be made as prescribed here. For "If Success" enter "0" (zero). For "If Failure" enter the number of the last preceding subtask.

(2) A user may elect to specify for any subtask its average duration and the associated standard deviation (Line 7), or he must specify the duration group and the rank of the subtask within that group (Line 8). In the latter case, the user must specify the durations of the shortest and the longest subtask in each category, i.e., L(Long), I(Intermediate), S(Short). Both approaches may be combined within a single task, if desired.

d. Go to Step 1.

4. To proceed to the next subtask: type "N" plus C/R; then go to Step 3 (if you wish to edit), or Step 6 (if you wish to delete).

5. To proceed to any particular subtask of this task:

   a. Type "D" plus C/R on your keyboard.

      (Next, you will be asked to specify the subtask in question.)

   b. Type the ordinal number of the subtask within this task plus C/R.

   c. Go to Step 1.

6. To delete the currently displayed subtask from this task: type "X" plus C/R on your keyboard.

   Next, MAPPS will doublecheck your intentions by responding:

YOU REQUESTED TO DELETE THE SUBTASK. HIT RETURN TO SELECT DIFFERENT OPTION OR ENTER X TO CONTINUE THE DELETE. X

   If you confirm your intention (as in the illustration above) by entering "X" plus C/R, the deletion will be carried out and acknowledged.

SUBTASK DELETED.

   Note that changes in the subtask sequence (i.e., If Success, If Failure) may now be necessary

7. To see which of the subtasks of this task are of the decision type (subtask kind = 6): type "S" plus C/R. You might see, for example:

   ```
   THE FOLLOWING SUBTASKS ARE DECISION SUBTASKS.
        4
        10
        15
   HIT RETURN KEY TO CONTINUE
   ```

   and, after C/R:

3 DECISION SUBTASKS WERE FOUND.

8. To return to the INITIAL MENU: type "M" plus C/R.

HOW TO ENTER SUBTASK DECISION DATA

Special procedures are required to establish a subtask of the decision type. The steps in this procedure are described below. You will encounter these requirements as soon as you attempt to enter subtask data for a subtask previously designated as being of Type 6 (by typing "C" plus C/R on your keyboard). For example, here Subtask No. 4 (the user's response in this example) was previously so designated:

```
ENTER SUBTASK NUMBER. 99 = RETURN TO SUBTASK OPTIONS.
?
4
```

1. Next, the following message will appear:

```
ENTER ONE OF THE FOLLOWING:
    A = ALTERNATIVE DECISION DATA
    B = GOAL DECISION DATA
ENTER CODE ==
```

Assuming that you are introducing a new decision subtask (rather than modifying an already established one), both alternative decision data and goal decision data must be provided. Typing an "A" plus C/R produces the following display (entering "B" allows the user to enter goal data first).

```
                    DECISION SUBTASK DATA
                          SUBTASK 4
LINE         DATA ITEM               NOTES            VALUES
        ALTERNATIVES
        *********************
 1      NUMBER                  (5 MAX)          3
 2      NEXT SUBTASK FOR EACH   (1-100)          12   18   27   0    0
 3      PROBABILITY OF EACH     (OPTIONAL)       .4   .3   .3   .0   .0
 4      CORRECT                 (OPTIONAL)       1
OPTIONS: E = EDIT      D = DISPLAY DECISIONS SUBTASKS
OPTIONS: N = NEXT DECISION SUBTASK      M = INITIAL MENU
OPTIONS: R = RETURN TO SUBTASK OPTIONS      G = GOALS
SELECT OPTION ==
```

The options associated with this display are analogous to those for the SUBTASK DATA/MENU or are self explanatory. How to make entries (responses) is also described there. Do not proceed until the next step is clearly understood.

2. The above display (DECISION SUBTASK DATA: ALTERNATIVES) requires you to specify the next subtask to be performed for each decision (course of action). Up to five "next" subtasks may be specified.

a. Specify the number of "next" subtasks (choices) on Line #1 using the "E" option procedure.

b. Specify the ordinal number of each of these "next" subtasks within this task on Line #2.

c. Specify the probability that each of the "next" subtasks will be, in fact, performed next (Line #3). Base this on empirical data or experience. Note that the probabilities must sum to 1.0. Since entry of these data is optional, you may elect to have MAPPS use its own default values.

d. Last, specify (Line #4) which of the previously listed choices is the "correct" one, i.e., the first (1), second (2), or etc. Entry of this information, too, is optional; MAPPS will furnish default values. Now proceed, via Option "G," to the next step.

3. On exercising Option "G," the following display will appear:

```
                         DECISION SUBTASK DATA
                               SUBTASK 4
LINE          DATA ITEM              NOTES              VALUES
------------------------------------------------------------------------
              GOALS
              *********************
 1            NUMBER                 (5 MAX)            2
 2            DESCRIPTOR             (20 CHAR)   1-  TASK DURATION
                                                 2-  SAFETY
                                                 3-
                                                 4-
                                                 5-
 3            IMPORTANCE             0-1             .2    .8    .0    .0    .0
 4            COURSE OF ACTION EFFECTS           1-  .8    .3    .6    .0    .0
                                                 2-  .2    .7    .4    .0    .0
                                                 3-  .0    .0    .0    .0    .0
                                                 4-  .0    .0    .0    .0    .0
                                                 5-  .0    .0    .0    .0    .0
------------------------------------------------------------------------
OPTIONS: E = EDIT       D = DISPLAY DECISIONS SUBTASKS
OPTIONS: N = NEXT DECISION SUBTASK      M = INITIAL MENU
OPTIONS: R = RETURN TO SUBTASK MENU      A = ALTERNATIVES
SELECT OPTION ==
```

Again, the options (at the bottom) are self-explanatory, or have been explained previously. It is evident that the required data entries will require prior preparation.

a. You may specify up to five goals or objectives on Line #1. For example, you might want to:

   (1) minimize task duration, and
   (2) maximize radiation safety.

   On Line #1 enter only the number of your goals.

b. On Line #2, using no more than 20 character spaces, label your goals successively. According to the above example, you might enter: (1) Task Duration, and (2) Safety.

c. On Line #3, state the proportional importance of each of your goals. Note that the proportions must sum to 1.0.

d. On Line #4 the course of action effects (i.e., correspondence of choices) must be entered. This refers to the impact of each of the specified decision choices on the specified goals. In effect, the user specifies the extent (proportion) to which each choice of action satisfies the requirements for each goal/objective. For example, in Step 1 three choices of course of action are shown (DECISION SUBTASK DATA: ALTERNATIVES); and in Step 3 a. (above) two goals/objectives were suggested (illustratively). In accordance with these examples, the user must construct (or imagine) a table such as:

		Course of Action, i.e., If Next Subtask Is		
		12	18	27
Contribution to	For Goal 1	0.8	0.3	0.6
Satisfaction is	For Goal 2	0.2	0.7	0.4

The column sums must be 1.0. In this example, the first alternative (represented by subtask 12) is more successful at satisfying Goal 1 than Goal 2. (An example of the proportional allocation may be seen in DECISION SUBTASK DATA: GOALS above.)

4. You may readjust values by returning to ALTERNATIVES from GOALS, or vice versa.

5. Follow the procedures outlined here for all decision making subtasks.

3.7 Making Model Runs

SIMULATION RUN: PRELIMINARY INTERACTION

I. WHAT WILL HAPPEN ON THE CRT AND HOW TO RESPOND TO IT

When you indicate your desire to proceed with a simulation run by exercising option "R" on the INITIAL MENU, you will be asked first to provide certain information:

1. The first display you will see will be:

```
TASK 10 WAS LAST PROCESSED. DO YOU WISH TO PROCESS
THE SAME TASK (S), PROCESS A DIFFERENT TASK (D), OR
RETURN TO THE INITIAL MENU (M)? ENTER CODE ==
```

- To simulate the same task over again: type "S" plus C/R on your keyboard.
- To simulate a new or different task: type "D" plus C/R.
- To return to the initial menu: Type "M" plus C/R.

2. If you indicated "S," this Step will be skipped; if you indicated "D," this message will appear on the CRT (The task number is arbitrary and for illustration only):

ENTER THE TASK NUMBER == 11

Enter the task number (as shown in the task library) plus C/R. MAPPS will respond with:

YOU ENTERED TASK 11 IF CORRECT ENTER YES(Y); **IF NOT, ENTER NO(N) ==**

Enter "Y," if correct, and "N," if incorrect (plus C/R).

3. Whether you entered "S" or "D" in the first step, you will be asked, next, to provide a label for this simulation run. This designation is at your choosing. It is especially important for the user to provide a meaningful designation during runs made in the "Batch" mode. Arbitrary designations may lead to the inability to identify specific batch runs. The designation may contain up to 40 alpha-numeric characters (and spaces) in any combination (the label below is arbitrary and for illustration only):

ENTER RUNID (40 CHARACTERS) == DEMONSTRATION RUN

After you have typed your run identification (RUNID) and pressed C/R you will be able to specify the result levels you wish for your simulation run.

How to Specify Result Level for A SIMULATION RUN

I. WHAT YOU WILL SEE ON THE CRT

SIMULATION RUN — OUTPUT SELECTIONS

SELECTION	OUTPUT RESULT LEVEL
R	RUN SUMMARY
I	ITERATION AND RUN
W	WORK SHIFT, ITERATION AND RUN
S	SUBTASK AND ALL OF THE ABOVE
M	DISPLAY INITIAL MENU

This menu enables you to specify the level of detail you wish to see in the results of a simulation run.

II. WHAT THE CHOICES MEAN

If you select	The effect will be
R	You will have printed out a summary table showing the values (state) of all dependent variables at the end of the simulation run.
I	Values for all dependent variables will be printed out for the first ten iterations as well as for the entire simulation run.
W	Values for all dependent variables will be printed out for every work shift within the first five iterations, for iterations (up to ten), and for the entire simulation run.
S	Values for all dependent variables will be printed out for each subtask in the first task iteration in addition to iteration and run summaries.
M	The INITIAL MENU will be displayed and no simulation run will be initiated.

III. HOW TO MAKE YOUR CHOICE

Before you make a decision

Consider that, except for an exit to the INITIAL MENU, the only difference in the output data you will receive is in the level of detail and the quantity of data. The recommended strategy is to specify "R" unless interest centers on certain specific and detailed effects of selected input parameters.

Specifying your choice

1. Select the letter corresponding to your choice.
2. Type that letter.
3. Press C/R.

A final choice

After making the above entry, you will be asked whether this run is to be of the "interactive" type (output shown at your terminal and printer) or of the "batch" type (results printed out on a main printer at the site of the computer). If you wish to make:

an interactive run: type "I" plus C/R on your keyboard
a batch type run: type "B" plus C/R.

If your choice was "I," the system will indicate shortly that it is "INITIALIZING" and will then proceed to providing the previously specified output.

If your choice was "B," the system will respond with:

BATCH RUN SUBMITTED

3.8 Subtask Durations

How to Obtain AVERAGE SUBTASK DURATION RESULTS

I. WHAT YOU WILL SEE ON THE CRT:

DO YOU WISH TO SHOW SUBTASK DURATIONS? ENTER YES(Y) OR NO(N) ==

Note: This is the preliminary MAPPS response to Option "D" in the INITIAL MENU.

II. HOW TO MAKE YOUR ENTRY

Do you wish to have average subtask durations displayed or printed out for you on this run?

If "yes": type "Y" plus C/R on your keyboard.
If "no": type "N" plus C/R.

Notes: (1) There will be a delay in obtaining these data. They will be provided later, as the first output after a simulation run has been initiated.

(2) Whenever "Y" has been entered, subtask durations will be printed out in all subsequent simulation runs of the given task. Therefore, when subtask durations are no longer desired, select Option "D" in the INITIAL MENU and, then, respond with "N" to the above question.

How to Interpret AVERAGE SUBTASK DURATION RESULTS

I. WHAT YOU WILL SEE ON THE CRT (AFTER THE TASK SIMULATION HAS BEGUN)

```
AVERAGE DURATION RESULTS
REPORT DATE — 07-09-84      PAGE — 1

SUB   AVG DUR-   SIGMA-
NUM   MINUTES    MINUTES   S              DESCRIPTION

 1     16.00      5.00     I   NOTIFY SUPERVISOR; OBTAIN KEY; SETUP
 2      1.22      0.41     C   OPEN CABINET; ACTIVATE SWITCHES: VERIFY
 •       •         •       •                 •
 •       •         •       •                 •
 •       •         •       •                 •
17      1.00      1.00     I   BRANCH

SELECT ONE OF THE FOLLOWING CODES AND ENTER IN
ORDER TO CONTINUE ON—
     TO SEE THE NEXT PAGE OF AVERAGE DURATION RESULTS — N
     TO CONTINUE ON WITH THE PROCESSING OF THIS RUN — R
     TO GO BACK TO THE INITIAL MENU — M
```

II. WHAT THE AVERAGE SUBTASK DURATION RESULTS MEAN

Column* No.	Item	Explanation
1	Sub Num.	The ordinal number assigned this subtask within this task.
2	Avg Dur-Minutes	The average (mean) duration required for the performance of this subtask in minutes.
3	Sigma-Minutes	The standard deviation around the average duration, in minutes.
4	S(Source)	Whether the average duration was specified by a user (I), or whether it was calculated by computer (C).
5	Description	A short (40 or fewer characters) characterization of the subtask.

* From left to right.

III. HOW TO GO ON

1. If all subtasks in this task are not listed within the current CRT display, do you want to see the continuation of the subtask list?

   NO: Go to Step 3.
   YES: Go to Step 2.

2. To see the continuation of the subtask list type "N" plus C/R, and repeat this procedure for any further continuations; to go back to the first page type "F" plus C/R. Then, go to Step 1.

3. Are you ready to initiate the simulation run?

   NO: Go to Step 4.
   YES: Type "R" plus C/R.

4. To continue your preparations for a simulation run type "M" plus C/R.

3.9 Subtask Output

How to Interpret SUBTASK OUTPUT

I. WHAT YOU WILL SEE ON THE CRT

SUBTASK	1	REQUEST FORMS AND KEY				TRY	1
OUTCOME	D	PROB SUC	0.90	START	0.0	END	5.0
WORK DUR	5.0	TIME STRESS	1.0	COM STRESS	1.1	TOTAL STRESS	1.0
ACCESS EF	−0.27	PROCED EF	0.24	ABIL DIF EF	0.98	PACE ADJ FAC	1.00
NO OF MAINT	2	PERS RATIO	1.00	SUBTASK TYPE	4		
ABILITY TYPE		FATIGUE EFFECT		HEAT EFFECT	REQ ABIL	ABILITY DIFF	
INTELLECTIVE		0.0		0.24	6.7	−2.29	
PERCEPTUAL MOTOR		0.0		0.30	1.9	1.82	

II. WHAT SUBTASK OUTPUT DATA MEAN

Note: (1) Subtask results can be obtained only for the first, but not succeeding, iterations. Therefore, the contents of the subtask output table(s) represent results for the first iteration only.

(2) Explanations below are given by line of the above display, and, within lines, proceeding left to right.

Item	Explanation
Subtask	The number of the subtask (within the task sequence) is given followed by its title, i.e., the subtask description.
Try	Whether this represents the first, second, or third attempt to complete this subtask.
Outcome	Whether subtask performance was: S successful and recognized as such (success), D unsuccessful, but recognized as such (detected error), U unsuccessful, but *not* recognized as such (undetected error), F successful, but thought to have been unsuccessful (false alarm), or I skipped due to pressure of time (ignore).
Prob Suc	The probability of successful completion of this subtask.
Start	The number of minutes and 0.1 minutes that have elapsed from the task start when this subtask was started.
End	The number of minutes and 0.1 minutes that have elapsed from the task start to the moment when this subtask was completed.
Work Dur	End — Start = Work Dur.
Time Stress	The ratio of the time required to complete the remaining work to actually available remaining time; ranges from 1.0 to 5.0.
Com Stress	A measure generated as a function of noise level, message length, and the size of the work group; ranges from 1.0 to 5.0.
Total Stress	A measure of the totality of generated stress which is a weighted average of stress from four contributing sources: time, communications, radiation, and ability difference (deficit); ranges from 1.0 to 5.0.
Access Ef	A measure of the effects on performance created by variations in accessibility; positive values represent the deleterious effects of restricted access while negative values represent the beneficial effects of good accessibility.

Proced Ef	A measure of the effect on performance of the use of technical procedures of a given quality; positive values represent the effect of poor procedures while negative values represent the effect of good procedures.
Abil Dif Ef	A measure of the effect on subtask duration of a discrepancy between required and possessed ability levels (intellective and perceptual-motor); values greater than 1.0 increase duration while values less than 1.0 decrease duration.
Pace Adj Fac	An index of the pace of performance which varies from subtask to subtask as a function of the individuals' and supervisor's aspiration and stress level; normally, Pace Adjustment Factor (PAF) = 1.00, PAF greater than 1.00 implies a slower pace, and PAF less than 1.00 implies a faster pace.
No of Maint	The total number of work group or team members.
Pers Ratio	The ratio of actual work group size to the (normally) required work group size, i.e., a measure of over- and under-manning.
Subtask Type	A code indicating which of the 28 types of subtask this subtask represents.
Ability Type	As indicated below this column heading, the types are intellective and perceptual-motor (values in further columns given for each).
Fatigue Effect	The proportion of the decremental effect of accumulating fatigue (continuous performance) on each ability type; the effect ranges from 0.0 to 1.0.
Heat Effect	The proportion of the decremental effect from performance in high temperature environments on each ability type; ranges from 0.0 to 1.0.
Req Abil	Required ability; work load on maintainers; ranges from 1.0 to 7.0.
Ability Diff	The difference between the current ability level of the maintainers and the level of required ability for the performance of this subtask. A positive (+) value signifies a surfeit, and a negative (−) value a deficit of maintainers' ability level.

III. HOW TO RESPOND

No response is required.

3.10 Shift Output

How to Interpret SHIFT CHANGE SUMMARIES

I. WHAT YOU WILL SEE ON THE CRT:

CONDITIONS: END OF SHIFT 1, BASED ON SUBTASK PRESSURIZER LEVEL CHANNEL TEST
TASK 12 LAST SUBTASK 29 END TIME 73.6 END STRESS 1.0

MAINT NO	MAINT TYPE	REPLACED	END ABILITY INT	PM	RADIATION MREM	SHIFT TIME
1	I	Y	4.1	5.4	0.0	73.6
2	I	Y	5.3	4.0	0.0	65.1
MEAN			4.7	4.7		

PRESS RETURN TO CONTINUE OR ENTER M TO TERMINATE RUN AND RETURN TO INITIAL MENU

II. WHAT SHIFT CHANGE DATA MEAN

Notes: (1) Shift change output is provided only for the first five iterations.

(2) Explanations below are given line-by-line of the above display, and, within lines, proceeding from left to right.

Item	Explanation
Conditions	The status at the moment when the shift change occurs is specified as explained hereafter.
End of Shift	The ordinal number of the now terminating shift is given.
Based On	One of three possible reasons for initiating a shift change are specified: (a) "subtask" — the occurrence of a stipulated subtask within the task, (b) "time" — the normal, alloted shift working time was used up, or (c) "no time" — completion of the next subtask would run over the allowed time for (length of) the shift.

Task	The number of the currently simulated task in the Task Library (preceded by the task's title).
Last Subtask	The ordinal number, for the given task, of the last completed subtask.
End Time	The cumulative elapsed time, in minutes and 0.1 minutes, from the start of the task to the moment of shift change.
End Stress	The overall average level of total stress experienced by maintainers at the end of the given shift.

Column Headings	Explanation
Maint No	The ordinal number designating a maintainer as specified (see Parameters — Page 1).
Maint Type	The job specialty of each maintainer assigned on this shift (see Parameters — Page 1).
Replaced	An indication of whether (Y) or not (N) this maintainer was replaced.
End Ability	The level of ability or competence (intellective and perceptual-motor) of each assigned, departing maintainer at the moment of shift change. (Means across maintainers are also shown).
Radiation	The total, cumulative radiation, in millirems, to which each maintainer was exposed during the just completed shift.
Shift Time	The total of each maintainer's work time, in minutes, as a member of the designated team during the just completed shift.

III. HOW TO RESPOND

If you wish to:

- Continue and receive further output: press C/R.
- Terminate and return to the INITIAL MENU: type "M" plus C/R on your keyboard.

3.11 Iteration Output

How to Interpret ITERATION SUMMARIES

I. WHAT YOU WILL SEE ON THE CRT

```
           BASELINE SENSITIVITY TEST                                           RUN DATE 08-05-83
ITERATION       1           TASK               4          TEST CONTROL ROD DRIVE MOTOR
OUTCOME FAIL                PERFORMANCE     0.70          EFFECTIVENESS     0.67  PRODUCTIVITY  0.80
ERR DETC     1.00           ERR CONSEQ       0.0
END STRESS    1.0           MAX STRESS       3.0          ON SUBTASK          31
TASK DUR    498.7           REPEAT TIME    259.5          TIME OVR/UND      18.7
EMER DUR      0.0           AFTER SUBTASK      0

RESULTS BY TYPE OF PERSONNEL                          -----------------OUTCOMES-----------------
    TYPE     NUMBER     WORK      WAIT     REST       SUC      DET    UND     FA      IGN    TOTAL
    MECH       1       304.1     194.6     0.0        12        7      0       0       0      19
    IC         0         0.0       0.0     0.0         0        0      0       0       0       0
    ELEC       1       498.7       0.0     0.0        30       13      0       0       0      43
    QC/S       0         0.0       0.0     0.0         0        0      0       0       0       0
    OPER       0         0.0       0.0     0.0         0        0      0       0       0       0
    TOTAL      2       802.8     194.6     0.0        42       20      0       0       0      62
  RESULTS FOR EACH SUBTASK
   SUBTASK          TRY     DUR       END           STRESS           ABILITY       PROB   OUTCOME
  NO   KIND                           TIME       TOT    TIME       INT    PM       SUC
  1   COMM           1      6.2        6.2       1.0    1.0        4.7   4.6       0.92     D
  1   COMM           2      4.8       11.0       1.0    1.0        4.6   4.4       0.90     S
  2   DON            1      8.8       19.9       1.0    1.0        4.6   4.4       0.92     S
  .    .             .       .          .         .      .          .     .         .       .
  .    .             .       .          .         .      .          .     .         .       .
  .    .             .       .          .         .      .          .     .         .       .
 30   COMM           1     15.5      457.5       1.0    1.0        3.7   3.6       0.90     D
 30   COMM           2     20.6      478.1       1.2    1.4        3.7   3.7       0.91     S
 31   OBTAIN         1     13.2      491.3       3.0    4.7        3.6   3.9       0.91     S
 32   SERVICE        1      7.4      498.7       1.0    1.0        3.5   3.9       0.96     S
 TOTAL                               498.7                                         0.87
 OUTCOME TOTALS        SUC = 30    DET = 13    UND = 0    FA = 0    IGN = 0
```

II. WHAT ITERATION OUTPUT DATA MEAN

Notes: (1) Iteration summaries are provided only for the first ten iterations.

(2) Explanations below are given line-by-line of the two parts of the data display, and, within lines, proceeding left to right.

Item	Explanation
(Top left)	The RUNID, or the user assigned label for the given run is printed out here.
Run Date	The date of this iteration (and run).
Iteration	The ordinal number (1-10) of the iteration that is being summarized.
Task	The number of the task (in the task library) being simulated followed by its title or description.
Outcome	Whether task performance (in this iteration) was, in fact, successful or a failure. There are three criteria for task failure: (1) time overrun, (2) presence of an undetected error, and (3) three consecutive detected errors on any subtask.
Performance	The ratio of the total number of successfully performed subtasks to the total number of attempts (i.e., repetitive attempts at completing the same subtask).
Effectiveness	Performance (see above) × (1 — proportional amount of time over or under the time limit); meaningful only when a genuine — not an arbitrary* — time limit has been stipulated.
Productivity	The ratio of time spent in active effort (not waiting or resting) to the total time for completing this task.
Err Detc	Error Detection Ratio, or the number of detected errors in subtasks to the total number of errors (subtasks containing errors).
Err Conseq	Error Consequence Index, a measure combining Risk Weight (see Input Parameters) and undetected errors (see Error Detection Ratio above): Risk Weight × (2 — Error Detection Ratio).
End Stress	The level of stress (a weighted average of contributions from time pressure, communications, radiation, and ability deficit) at the conclusion of this task; min = 1.0 and max = 5.0.
Max Stress	The maximal level of stress (see above) reached in this task iteration.
On Subtask	The ordinal number of the subtask within this task iteration during which the level of stress reached the maximum.

*Arbitrary time limits are usually set when a time limit for task performance is not important (see parameter data, Section 3.4, II, p. 39)

Task Dur	The length of time, in minutes and 0.1 minutes, for task completion in this iteration; this is not the sum of subtask durations, since subtask performance may be overlapping.
Repeat Time	The amount of time, in minutes and 0.1 minutes, devoted to repeating subtasks thought to have been unsuccessful in this task iteration.
Time Ovr/Und	The time, in minutes and 0.1 minutes, in excess (+) or below (−) scheduled time for task performance.
Emer Dur	The amount of time, in minutes and 0.1 minutes, during this task for which a stipulated emergency (see Input Parameters) existed.
After Subtask	The ordinal number of the subtask within this task after whose completion the emergency (see above) began.

Results by Type of Personnel

Type	The type of maintenance personnel in question, e.g., Mechanic, Instrument and Control Technician, etc.
Number	The number of each type of maintenance personnel (see above) in the work group or team.
Work	The amount of time, in minutes and 0.1 minutes, spent in active work effort by the given type of maintainer(s).
Wait	The amount of time, in minutes and 0.1 minutes, spent in inactive waiting.
Rest	The amount of time, in minutes and 0.1 minutes, spent in scheduled coffee breaks, lunch, etc.
Suc	The number of subtasks that were successfully completed.
Det	The number of subtasks in which errors were detected.
Und	The number of subtasks incorporating undetected errors.
Fa	"False Alarms," i.e., the number of subtasks repeated unnecessarily, because the actually successful performance was believed to be unsuccessful.

Ign	"Ignored," i.e., the number of subtasks that were skipped, because their performance was below the essentiality threshold when stress was high.
Total	The total number of subtasks within this task iteration in which each given personnel type was involved.

Results for Each Subtask

Subtask	
(1) No	The ordinal number of the subtask within this task iteration.
(2) Kind	The kind or type of subtask.
Try	The ordinal number of the attempt to achieve subtask completion.
Dur	The length of time, in minutes and 0.1 minutes, to perform this subtask.
End Time	The cumulative elapsed number of minutes and 0.1 minutes from start of task to the completion of this subtask.
Stress	
(1) Total	The level of stress due to all contributing factors.
(2) Time	The value of time stress.
Ability	
(1) Int	The work team's current level of intellective ability during the performance of this subtask.
(2) PM	The work team's current level of perceptual-motor ability during the performance of this subtask.
Prob Suc	The *a priori* probability of successful performance of this subtask.
Outcomes	See explanations for first part of display.

III. HOW TO RESPOND

No user intervention is required or possible.

3.12 Run Summary Output

How to Interpret RUN SUMMARIES

I. WHAT YOU WILL SEE ON THE CRT

```
   TITLE:  DEMONSTRATION RUN                                              RUN DATE 08-27-84
   RUN SUMMARY:  ITERATIONS 25, TASK 16,                            SUCCESS PROPORTION 0.80
   VALUE ACTUATOR INSPECTION/PM                                     NUCLEAR POWER PLANT TYPE PWR
          TASK        REPEAT        OVER/        PERFORM-   EFFEC-        PRODUC-        ERROR     ERROR CONS
          DURATION    TIME          UNDER        ANCE       TIVENESS      TIVITY         DETC           INDEX
AVERAGE   66.3        5.5          -10.7             0.96    1.10          1.00          1.00            0.0
SIGMA     13.4        14.9          15.4             0.07    0.21          0.00          0.0             0.0
          EMERGENCY       STRESS         END ABILITY    ------------------TASK OUTCOME-----------------
          DURATION     END     MAX      INTEL   PM      SUCCESS       ---------------FAILURE-----------
                                                                       TIME            UND      REPEAT
AVERAGE    0.0         1.0     1.5        4.8   3.4        20           5               0          0
SIGMA      0.0         0.0     0.6        0.1   0.0

RESULTS BY TYPE OF MAINTAINER
  TYPE NUMBER           ----------TIME----------     -----------------------OUTCOME------------------
                        WORK        WAIT       REST        SUC     DET     UND     FA     IGN     TOTAL
MECH      0              0.0        0.0        0.0           0       0       0      0       0        0
IC        0              0.0        0.0        0.0           0       0       0      0       0        0
ELEC      2            132.7        0.0        0.0         275      11       0      2       0      288
QC/S      0              0.0        0.0        0.0           0       0       0      0       0        0
OPER      0              0.0        0.0        0.0           0       0       0      0       0        0
TOTAL     2            132.7        0.0        0.0         275      11       0      2       0      288
PRESS RETURN TO CONTINUE

RESULTS BY SUBTASK
SUB-     DURATION      END     -------STRESS-------      ABILITY   ------------------OUTCOME-----------------
TASK   AVG    SIGMA    TIME    MAXST    TOT     TIM     INT    PM   TRY     SUC     DET     UND     FA     IGN
1       1.7    1.2      1.9     0       1.0     1.0     5.1   3.6   20      25       2       0      1       0
2       2.9    1.7      4.8     0       1.0     1.0     5.0   3.6   26      25       1       0      0       0
3       3.5    2.7      8.5     0       1.0     1.0     5.0   3.6   26      25       1       0      0       0
4      11.8    6.9     20.6     0       1.0     1.0     5.0   3.6   26      25       1       0      0       0
5       5.4    3.4     26.1     5       1.1     1.0     4.9   3.5   26      25       1       0      0       0
6      21.8    5.8     49.8     2       1.1     1.0     4.9   3.5   27      25       2       0      0       0
7       2.4    1.1     52.8     5       1.1     1.0     4.8   3.4   26      25       1       0      0       0
8       2.1    1.2     54.9     7       1.1     1.0     4.8   3.4   25      25       0       0      0       0
9       1.9    1.1     56.8     0       1.0     1.0     4.8   3.4   25      25       0       0      0       0
10      5.8    2.2     63.4     6       1.1     1.0     4.8   3.4   28      25       2       0      0       0
11      2.9    1.4     66.3     0       1.0     1.0     4.8   3.4   25      25       0       0      0       0
ENTER SELECTION:  M=INITIAL MENU, F=FIRST PAGE OF RUN SUMMARY
```

II. WHAT RUN SUMMARY DATA MEAN

Notes: (1) A run summary reflects the results of the multiple independent simulations of the performance of a single task. If more than one task is to be simulated, separate runs must be scheduled for each task in question.

(2) Explanations below are given by line of the data display, and, within lines, proceeding left to right.

Item	Explanation
	First Display
Title	The user-generated designation (up to 40 alphanumeric characters) for this run.
Run Date	The month, day, and year of this simulation run.
Iterations	The number of iterations summarized within this run summary.
Task	The numerical designation of this task as it appears in the task library.
Success Proportion	The proportion of successful iterations out of all iterations specified for this task simulation run.
(Task Title)	The title or description of this task.
Nuclear Power Plant Type	Whether the task environment is a BWR, PWR, or HTGR type of plant.

{Note: For the next 13 data items the results are given in terms of an average (mean) and sigma (standard deviation).}

Item	Explanation
Task Duration	The average length of time, over all included iterations, in minutes and 0.1 minutes, to complete this task.
Repeat Time	The average amount of time, over all included iterations, spent in repeating subtasks in the course of accomplishing this task.
Over/Under	The average amount of time, over all included iterations, in minutes and 0.1 minutes, in excess (+) or below (−) scheduled time for task performance.
Performance	The average ratio, over all included iterations, of the total number of successfully performed subtasks to the total number of attempts.

Effectiveness	The average effectiveness, i.e., Performance × (1-Ovr/Und), value over all iterations. Meaningful only when a genuine rather than a mock Time Limit has been stipulated.
Productivity	The average ratio, over all included iterations, of time spent in active effort to the total time for completing this task.
Error Ratio	The average Error Detection Ratio, over all included iterations, or the ratio of the number of detected errors to the total number of errors in each included iteration.
Error Cons Index	The average Error Consequence Index, over all included iterations, a measure combining Risk Weight (see Input Parameters) and undetected errors (in Error Detection Ratio above): (Risk Weight) × [(1 + (1 − Error Detection Ratio))].
Emergency Duration	The average duration, in minutes and 0.1 minutes, of Duration of the emergency state during the iterations of this task.
Stress	
(1) End	The average level of stress, over all included iterations, (a weighted average of contributions from time pressure, communications, radiation, and ability deficit) at the conclusion of this task simulation run (i.e., at end of each iteration).
(2) Max	The average maximal level of stress (see above) reached in the various iterations within this task simulation run.
End Ability	
(1) Intel	The average Intellective Ability over all included iterations at time of task completion.
(2) PM	The average Perceptual-Motor Ability over all included iterations, at time of task completion.
Task Outcome	
(1) Success	The number of iterations (within this run) for which none of the three criteria for failure (see below) were met.
(2) Failure	The number of iterations meeting one or more of the following criteria for failure.
a. Time	Exceeding the permissible time limit.
b. Und	Undetected errors in subtasks.
c. Repeat	Number of attempts to accomplish one or more subtask(s) exceeds three.

Results By Type of Maintainer	Self-explanatory heading.
Type	The type of maintenance personnel in question, e.g., mechanic, I&C technician, etc.
Number	The number of each type of maintenance personnel (see above) in the work group.
Time	The average amount of time, over all included iterations, in minutes and 0.1 minutes.
(1) Work	Time spent in active work effort.
(2) Wait	Time spent in inactive waiting.
(3) Rest	Time spent in coffee breaks, lunch, etc.
Outcome	The (total) number of subtasks over all included iterations to which the following are applicable.
(1) Suc	Successful accomplishment.
(2) Det	Detected errors.
(3) Und	Undetected errors.
(4) Fa	False alarms, i.e, unnecessary repetitions of successfully completed subtasks.
(5) Ign	Ignored, i.e., subtasks skipped, because performance is less than absolutely essential.
(6) Total	Self-explanatory.

Second Display

Results By Subtask	Self-explanatory heading.
Subtask	The ordinal number of the subtask within this task.
Duration	
(1) Avg	The mean duration in minutes and 0.1 minutes.
(2) Sigma	The standard deviation of this average.
End Time	The cumulative elapsed number of minutes and 0.1 minutes from task start to the completion of this subtask (averaged over all included iterations).
Stress	
(1) Maxst	The number of iterations in which the highest level of stress was reached during performance of this subtask.
(2) Tot	The average level of stress taken over all occurrences of this subtask over all iterations.
(3) Tim	The average time stress value over all attempts of this subtask.

Ability	The average current ability over all involved maintainers in all occurrences of this subtask over all iterations.
(1) Int	Intellective Ability.
(2) PM	Perceptual-Motor Ability.
Outcome	Subsumes all of the following aspects:
(1) Try	The total number of attempts.
(2) Suc	The number of successful completions of this subtask.
(3) Det	The number of detected errors.
(4) Und	The number of undetected errors.
(5) Fa	The number of "false alarms."
(6) Ign	The number of times this subtask performance was ignored.

III. HOW TO RESPOND

Do you wish to:

- Return to Initial Menu: Type "M" plus C/R.
- Return to the 1st display: Type "F" plus C/R.

3.13 Additional Functions

This section discusses the ending of a MAPPS session, responding to error messages, and retrieval of inactive task information from the computer archives.

To end a MAPPS session, following the typing of the run summary, respond with "M," which will return control to the initial menu. In response to the initial menu simply enter an "E." The response from MAPPS will be:

BACKING UP TASK INDICATOR FILE
ENDING MAPPS
READY

"READY" is a message generated by the host computer operating system. You may now log off.

Each task in the MAPPS library is stored in the computer as a file. In many computer installations, it is customary to purge inactive files on a periodic basis by placing them in an "archive file." Hence, the user who wishes to call up a file that has not been exercised for some time may find it unavailable. This can occur even if the task is still listed in the library. The procedure for retrieving from the archive is specific to the hosting computer installation. Users must ascertain the procedure(s) by contacting the host installation.

In interacting with MAPPS and responding to the various displays (menus), often the model will generate some message. For example, it may acknowledge a data entry as shown here and request further information.

```
NUMBER OF MAINTAINERS ENTERED = 2
ENTFR LINE NUMBER.  99 = RETURN TO SELECT OPTION.
?
9
```

Especially in the context of given specific directions, such messages will be self-explanatory. In the above example, the MAPPS user specified "9" as the line number. This constitutes data entry error and MAPPS responded with the error message shown below.

```
INVALID LINE NUMBER.  MUST BE 1-8 OR 99.
ENTER LINE NUMBER.  99 = RETURN TO SELECT OPTION.
?
2
```

This message makes the nature of the data entry error quite clear. Evidently the user understood and now has specified "2" as the line number (i.e., a legitimate line number).

Here is another example of messages in an interactive exchange with MAPPS:

```
TASK 11 WAS LAST PROCESSED.  DO YOU WISH TO PROCESS
THE SAME TASK(S), PROCESS A DIFFERENT TASK (D), OR
RETURN TO THE INITIAL MENU (M)?  ENTER CODE ==   D

ENTER THE TASK NUMBER ==   10
```

Here, the user entered code "D" to indicate that he wished to process a different task. Thereafter, MAPPS asked for a specification of the task's number (in the task library), and the user specified that number.

In some cases, the error message may require some understanding of the internal workings of MAPPS. For example, consider the following case.

```
ERROR--NO VALUE INPUT FOR AVGDUR, SUBTASK ILDUR = 7
ABORT AFTER RETURN FROM SUBROUTINE PREPRO ERROR RETURN
CODE IS  1
```

A problem for the MAPPS preprocessing module (PREPRO) was created, because no value for the given subtask's average duration (AVGDUR) was available to it. The preprocessor needs a minimum input of six durations to calculate AVGDUR. Subtask 7 (in the illustration above) was one of the six subtasks which define the longest and shortest subtasks in each of the three duration groups. Specifically subtask 7 is the longest subtask in the intermediate duration group, and the error message indicates that a value of its average duration (LLDUR) was not supplied by the user.

Group Duration	Rank in Group	Data Name
Short	Shortest	SSDUR
	Longest	SLDUR
Intermediate	Shortest	ISDUR
	Longest	ILDUR
Long	Shortest	LSDUR
	Longest	LLDUR

While the missing data value must be furnished to the MAPPS preprocessor, the system automatically initiates the necessary actions to make this possible.

In still another type of case, messages generated by the host computer system may appear. One such example is:

```
TRACEBACK ROUTINE CALLED FROM ISN   REG. 14    REG. 15    REG.  0    REG.  1
     LDFIO                          001161A8   001131B8   00000002   00000000
     SUBTASK      0336              42110728   00114460   00000065   00000000
     MAIN                           00021708   0010E570   00000000   000F8EC0
ENTRY POINT = 0010E570
STANDARD FIXUP TAKEN, EXECUTION CONTINUING
```

This particular error message was generated in response to a data input error. MAPPS required the input of a number, but a letter was entered.

It is only necessary to recognize such messages for what they are. No user action is required. As is evident, the system initiated the necessary action and then continued to process MAPPS.

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4. T. S. Wahler, "Structured Assessment Approach (SAA): Vol. 1. Data Gathering Handbook (Physical Security), Vol. 2. Data Gathering Forms (Physical Security)," NUREG/CR-1744.

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APPENDIX A

DEFINITIONS OF SUBTASK KINDS

MAPPS bases its estimates of subtask outcome and duration in part on the intellective and perceptual-motor load placed on the simulated maintainers by the activities represented by each subtask. For this reason it is important that the task analysis identify the appropriate subtask kind for each subtask. Table A.1 lists the 28 MAPPS subtask kinds with the number and definition for each kind. Note that many subtask kinds combine complementary aspects of the same activities, such as assembly and disassembly. Five subtask kinds are identified as requiring special processing. This refers to additional input data requirements or the use of a special logic within MAPPS to simulate these subtasks.

Table A.1. Definitions of Subtask Kinds

Number	Kind	Definition
1	Activate switches, levers, pushbuttons, toggles	Changing the condition or state of a system by energizing or engaging a control or set of controls.
2	Assemble, disassemble	Putting together the parts of a unit to produce a complete unit; separating a unit into component parts.
3	Calibrate, adjust	Manipulating controls in a continuous manner so that inputs/outputs are within specified tolerances.
4	Communicate	Transmitting or requesting information verbally.
5	Connect, disconnect	Attaching one equipment with one or more other equipments, and the reverse.
6*	Decision making	Formulating a course of action from several different potential courses of action.
7*	Doff protective clothing	Removing protective clothing.
8*	Don protective clothing	Putting on protective clothing (full or partial).
9	Fabricate	Building or constructing a part or item.
10	Inspect	Examine objects critically for deviations or unacceptable conditions.
11	Install, mount	Placing and securing an item in position.

Table A.1. (cont.)

Number	Kind	Definition
12	Instrument reading	Obtaining information visually from a display, meter, or indicator.
13	Manipulate (thread, rotate, tighten, loosen)	Changing the position of an object by using fingers and hands.
14	Measure	Determining a value (through some type of measurement) which is descriptive of rates, dimensions, quantity, or characteristics.
15	Move (push, pull, raise, lower)	Transferring an object from one position in space to another.
16	Obtain, return	Acquiring or replacing an object.
17	Open, close	Uncovering or unlocking so as to gain access, and the reverse.
18	Read procedures, texts	Extracting information from written or printed materials.
20	Record, write, copy	Placing letters, numbers, or symbols on paper.
21	Remove, replace	Taking a unit or component from a system, and/or the reverse.
22*	Rest break	Periods during a work shift in which no work is performed.
23	Service, clean, lubricate	Performing maintenance activities on equipment (or at the task site) to keep the equipment in proper operating condition.
24	Test	Determining whether a system is functioning within prescribed limits.
25*	Trouble-shoot	Isolating the cause of a fault through a systematic, analytic process.
26	Weld, solder, burn	Joining metal through a process of heating and separating metal through a process of melting.

Table A.1. (cont.)

Number	Kind	Definition
27	Wire, rewire	Producing a system of wires (in accordance with a schematic representation) for the transmission of electric current.
28*	Branch	Dummy subtask used to stimulate probabilistic sequences of subtasks.

*Special processing required.

APPENDIX B

TASK ANALYSIS PROCEDURES

Appendix B describes procedures for analyzing tasks, partitioning them into subtasks for application in the MAPPS model, and for acquiring required MAPPS input information.

B.1.0 Task Analysis

Task analysis seeks to describe a task in terms of its subtasks, their performance sequence, and their characteristics.

Because the subtask order may depend on decisions contingent on future events (conditions applicable to a given step or operation), or because there may be an indifference about the order in which some steps may be carried out, partial rather than strict orders of subtasks are usually involved.

B.1.1 Tasks and Subtasks

Each of the diverse, differentiable activities performed by an incumbent job title holder (e.g., Maintenance Mechanic, Electrician) is a task. Subtasks are segments of tasks. While the separation of a task into subtasks can be to any degree of minuteness, in practice each successive subtask is defined by observable initial conditions and observable results. Normally, the output from a preceding subtask serves as the input to succeeding subtasks, though additional information may be required. For example, in the course of the "Test, Repair/Replace Safety Injection Accumulator Water Level Channels" task, I&C Technicians: (1) place weights on or apply fixed amounts of pressure to a pressure source mechanism for each unit, (2) record "as found" data on a calibration chart, (3) adjust channel sensor, and (4) record "as left" data on a calibration chart. These four subtasks can be readily observed, although finer subdivisions could be made. Similarly, the dependence of each successive subtask performance on the accomplishment of the preceding one can be seen.

B.1.2 Task Analysis Procedures

B.1.2.1 Selecting Tasks for Analysis

The choice of task(s) for MAPPS analysis will be largely determined by the purposes of the analyst. For example, the task selection during the development of the MAPPS model was guided by these criteria:

- Frequently performed in most nuclear power plants.
- Representation of each maintenance job specialty.
- Intermediate length or complexity (neither a trivial number, nor an inordinate number of likely subtasks).
- Common to BWR and PWR plants.

In each specific case, the choice of criteria will depend on the purposes at hand.

B.1.2.2 Subtask Determination

The maintenance tasks performed in nuclear power plants are usually supported by written plant-generated procedures. These procedures represent a useful starting point for determining subtasks and the subtask performance required. The degree of detail in these procedures varies greatly from task to task and plant to plant and may be more molecular than desired by the analyst. For example, the procedures for calibrating a minor component of a circuit may include five or six steps (to the level of "apply voltage," "turn potentiometer clockwise," etc.). The analyst's goals may be better served by grouping steps together into larger subtasks (such as "calibrate preamplifier"). The upper limit on the number of subtasks per task in the MAPPS model is 100. Initial experience with MAPPS indicates that, for tasks longer than two hours, 30 to 50 subtasks produce an optimal tradeoff between molecularity and molarity. The user will find that, although detail is lost with few subtasks, the convenience of model use is greatly increased.

The plant-produced procedures represent a good starting point for the identification of subtasks and the sequence in which they are performed.

Once the subtasks and the subtask sequence are identified, persons knowledgeable about the performance of the task are shown the listing and asked to review it for accuracy. Two separate reviews are probably adequate provided that differences between the reviewers are resolved between them.

B.1.2.3 Subtask Attributes (Characteristics)

In the context of a formal structure such as a simulation model, a subtask is defined and differentiated from other subtasks by the attributes or characteristics it possesses. For instance, the average duration of its performance in minutes and tenths of minutes is one attribute that characterizes a subtask.

Table 2.3 (p. 19) lists the attributes characterizing subtasks in the MAPPS model, provides a brief explanation, and indicates the type and range of the measurement scale for each attribute or the applicable symbols. When collecting task analysis data, the analyst may wish to use a data sheet such as that shown in Figure B.1, which identifies the required subtask input data.

B.1.2.4 Determining Attribute Values

For many of the attributes listed in Table 2.3 the determination of the appropriate value for the given subtask is either transparent or self-explanatory. For example, "subtask type" (a nominal designation) is obtained from the listing and definition of subtask types (see Appendix A), a "quality control (or supervisory) check" is either made or not made, or "number required" asks only for the number of maintainers, by type, required to perform the given subtask. These kinds of attributes require no estimates, and determination of these values can be made from technical documents alone, or a knowledgeable individual can furnish them.

TASK NAME: ______________________________ PAGE____ OF____

MENU LINE 1		2		3		4		5		6		7		8		9		10		11		12	13	14
SUBTASK NUMBER	SUBTASK DESCRIPTION	ESSENTIALITY	PROCEDURES QUALITY	AVG SUCCESS PROB	ACCESSIBILITY	NEXT SUBTASK IF SUCCESS	NEXT SUBTASK IF FAILURE	FOR WORK GROUP	FOR SUPERVISOR	QC CHECK	FIXED DURATION	AVERAGE DURATION	SIGMA OF DURATION	DURATION GROUP	RANK IN GROUP	SUBTASK NUMBER	TIME IN MINS	COMM IMPORTANCE	ANYONE, EVERYONE	SUBTASK KIND	VALID, SPEC., ACCURATE	TOTAL	CLOTHING TYPE 2	CLOTHING TYPE 3

Fig. B.1. Sample Subtask Data Sheet.

A number of attributes require that estimates of the appropriate values be made, e.g., "essentially," "procedures quality," "accessibility," etc. In virtually all of these cases, the value is a probability or a proportion expressed along a continuum from zero (0.0) to one (1.0). At least three approaches exist for making the estimates of probability:

1. data banks
2. human factors expert judgment
3. MAPPS default/calculated values.

Whenever data banks exist that store such data, these data can be used. Data banks of various types are reviewed in NUREG/CR-1744 (Ref. 4).

When a store of objective observations is not available, estimates can be obtained from knowledgeable and experienced maintenance and/or human factors experts. Either a panel can be assembled to deliberate and arrive at joint probability estimate, or such estimates can be obtained successively from two or more experts. Reliance on only a single human factor expert is best avoided, since it precludes the determination of the stability or reliability of obtained ratings.

The third approach is to use MAPPS default or calculated values. MAPPS will provide a default value for most subtask data items if the user does not supply a value. The default values are based on the modeling and human factors judgment of the model designers. There is no default value for average success probability; this value is generated by the internal logic of the model and reflects the influences of all of the personnel, environmental, and task factors simulated by the model.

The task analyst also has a choice for obtaining subtask duration values. The analyst can employ a data bank or request the information from a task-knowledgeable person (supervisor or foreman). The estimator should be advised to provide realistic, average values, not idealized values. An estimate of the standard deviation (sigma) can be obtained by using as a rule of thumb one-third of the duration value or asking the supervisor foreman for an estimate of the range (fastest time and slowest time) and using one-half of the range.

A third approach to duration estimation is to use a grouping and ranking procedure. In this procedure, the task expert does not make a specific duration estimate for each subtask but rather assigns each subtask to one of three duration groups: Long, Intermediate, or Short. The boundaries of these groups will change from task to task and are dependent only on the expert's judgment. After group membership has been identified, the task expert should identify the longest and shortest subtask durations within each group and make measures of the actual durations of these six subtasks. Following this, the task expert should assign a rank to each subtask within each group on the basis of its duration (increasing rank indicates increasing duration). When supplied "duration group" and "rank in group" information for each subtask, MAPPS will calculate an estimate of each subtask's duration and standard deviation. When the grouping and ranking procedure is used, the user need enter only six average (mean) and standard deviation values. The task analyst may find this procedure easier and more accurate than the direct estimation for each subtask procedure.

B.1.2.5 Additional Data

In addition to the subtask data, the task analyst will need to obtain information which the MAPPS model labels task data and parameters. Task data refers primarily to personnel rotations during the performance of the task (shift changes). This information can be obtained by direct questioning of a task expert.

The parameter values required for MAPPS runs are listed in Table 2.1 (p. 16). Most of the values can be supplied by estimates of the supervisor/foreman. Information on environmental conditions, such as temperature, noise, and radiation level, can be obtained by actual physical measurement, or, again, through the estimates of plant experts.

The maintainer characteristics values can also be directly measured or MAPPS default values can be used. The direct measurement of these characteristics requires some experience in testing and assessment. During the evaluation/validation phase of model development, measurements were made of maintainer characteristics. Maintainer intellective ability was measured using the Wonderlic Personnel Test and perceptual-motor ability was measured by the Crawford Small Parts Dexterity Test. For descriptions of these tests see Buros' *Test in Print II* (Ref. 5).

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