CONF-860145--1

By acceptance of this article, the publisher or recipient acknowledges the U.S. Government's right to retain a nonexclusive, royalty-free license in and to any copyright covering the article.

CONF-860145--1

TI86 006218

PRISIM - A COMPUTER PROGRAM THAT MAKES PRA USEFUL*

J. B. Fussell
D. J. Campbell

JBF Associates, Inc.
Knoxville, Tennessee

J. C. Glynn
G. R. Burdick

U.S. Nuclear Regulatory Commission
Washington, DC

Presentation Made To:

IAEA Technical Committee Meeting on Status, Experience, and Future Prospects for the Development of Probabilistic Criteria

Vienna, Austria

January 27-31, 1986

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MASTER

*Research sponsored by the U.S. Nuclear Regulatory Commission under Interagency Agreement 40-550-75 with Martin Marietta Energy Systems, Inc., under Contract No. DE-AC05-84OR21400 with the U.S. Department of Energy.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

PRISIM - A Computer Program That Makes PRA Useful

J. B. Fussell
D. J. Campbell

JBF Associates, Inc.
Technology Drive
1000 Technology Park Center
Knoxville, Tennessee 37932

J. C. Glynn
G. R. Burdick

U.S. Nuclear Regulatory Commission
5650 Nicholson Lane
Rockville, MD 20852

PRISIM is an IBM personal computer program that translates probabilistic risk assessment (PRA) information and calculates additional PRA type information for use by those who are not PRA experts. Specifically, PRISIM was developed for the U.S. Nuclear Regulatory Commission for use by their resident inspectors at nuclear power plants. Inspector activities are either scheduled or are in response to a particular status of a plant. PRISIM is useful for either activity.

To use PRISIM in response to a given plant status, the inspector calls on an interactive routine and designates which plant components are out of service. Results include:

1. a measure of instantaneous risk increase above the plant's average risk
2. an updated listing of plant components in order of decreasing importance
3. a listing of groups of events and component outages that will result in core melt arranged in order of decreasing importance
4. the decrease in instantaneous risk as the individual components that are designated as out of service are returned to service

In addition, when individual safety system components are removed from service, PRISIM will display a listing of plant components that are not covered by the plant's technical specifications and whose individual outage will disable the safety system. Considerable additional component information is also available from PRISIM.

PRISIM also contains vast amounts of pre-processed information relevant to inspection planning and inspector training. In addition to instantly available licensee event report data, dominant accident sequence explanations and other data base information, PRISIM has routines that are directly related to the NRC inspection modules, i.e., the guidelines for scheduled inspection activities. For each module, PRISIM provides all the PRA type information that can be useful in making decisions required in executing the module activities. New component "importance" measures had to be derived for this portion of the program.

PRISIM is the most advanced software of its type available. All information is virtually instantaneously available even though a 20 mega bite hard disk is required for storing the information for one plant.

The first version of PRISIM was developed for the Arkansas Nuclear One - Unit 1 (ANO-1) Plant and is currently being updated to reflect the plant's changes that have been made to the design since the PRA for ANO-1 was completed. This paper describes PRISIM and its application to ANO-1 in detail.

PRISIM - A Computer Program That Makes PRA Useful

J. B. Fussell
D. J. Campbell

JBF Associates, Inc.
Technology Drive
1000 Technology Park Center
Knoxville, TN 37932

J. C. Glynn
G. R. Burdick

U.S. Nuclear Regulatory Commission
Washington, DC 20555

A Probabilistic Risk Assessment (PRA) of a nuclear power plant is supported by a large body of information and wisdom that has not been fully utilized. This paper describes a computer program, called PRISIM, that allows a higher degree of utilization of such a PRA. PRISIM, in effect, translates many aspects of a PRA for use by those who are not PRA experts.

The results of PRISIM are formulated so that the effect of the uncertainty in the PRA failure data is minimized. This is accomplished by formulating results from the qualitative aspects of the PRA, such as the failure logic models, and by binning probabilistic results in broad categories.

PRISIM was designed for the U.S. Nuclear Regulatory Commission (NRC) for use by their resident inspectors at nuclear power plants. The first application of PRISIM was to the Arkansas Nuclear One -Unit 1 (ANO-1) Plant. This version is currently being updated to reflect the changes that have been made to the plant's design since the PRA for ANO-1 was completed.

The program was written for an IBM XT personal computer with special high resolution graphics and a 20 mega-byte hard disk. To ensure success, PRISIM had to:

1. present dependable information useful in making inspection decisions
2. use the inspector's nomenclature, not PRA jargon
3. be convenient and fast

Present PRA documentation does not accomplish any of the above objectives; PRISIM accomplishes them all.

PRISIM aids U.S. NRC resident inspectors in activities that include:

1. determining an appropriate response to a given plant status
2. scheduling required activities
3. preparing inspection reports
4. training

To use PRISIM to decide how to respond to a given plant status, the inspector calls on an interactive routine and designates which plant components are out of service. He identifies the components on system schematics that are displayed on the computer screen. An example of such a schematic is shown in Figure 1.

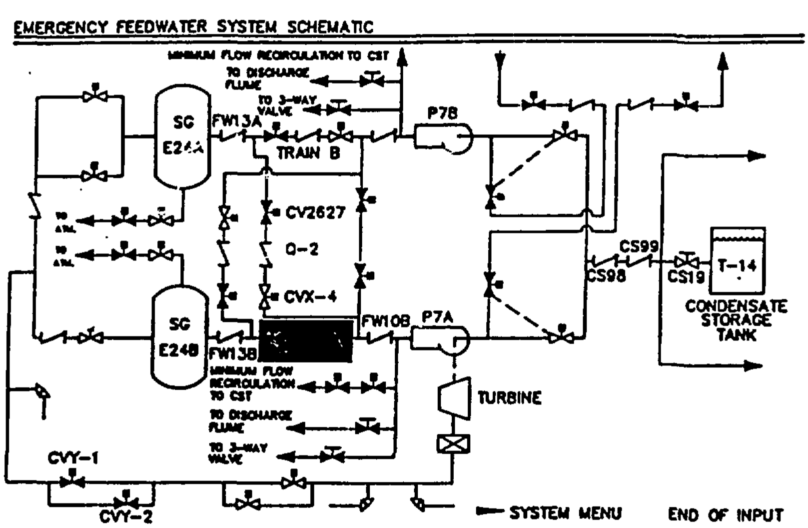
Within 8 seconds the following information is available.

1. The factor by which the instantaneous core melt frequency increases above the average plant value because the specified components are out of service. This factor is a relative measure of the significance of the simultaneous outages of the specified components, and it gains additional meaning when compared to the factor for other groups of components that could be specified out of service.

2. A ranking of the components that are specified to be out of service according to the factor of decrease in the instantaneous core melt frequency when the components are individually returned to service. This ranking then gives the relative benefit of restoring each component to service.

3. A ranking of the components that are not specified to be out of service according to their contribution to the updated instantaneous core melt frequency. Since this list potentially contains an extremely large number of components, the list is truncated when the contribution to risk is very small. This list then ranks the components with respect to their impact on core melt frequency if added to the list of components specified to be out of service.

4. A ranking of core melt scenarios (each with a specified initiating event and possible additional component outages) according to their contributions to the updated instantaneous core melt frequency. This lets the inspector know, for the specified plant status, what the "weak links" are for core melt.



REPRODUCED FROM BEST AVAILABLE COPY

Figure 1

The interactive routine has limitations. The routine uses only those failure scenarios that comprise 85% of the plant's total core melt frequency. Therefore, it is possible that PRISIM will give incorrect, optimistic results. We estimate that such a misleading result will be encountered once every 3 or 4 years if the routine is used once a day. Misleading results would most probably be obtained when multiple front-line system components are failed, a situation where the inspector would not usually bother to query a personal computer for guidance.

In addition to the interactive routine, PRISIM has an efficient data base manager. The data base contains pre-processed screen images that are independent of the plant's status. The screen images contain both text and graph material. The data base manager selects a screen image from hundreds in the PRISIM data base and displays the image on a monitor in less than 1 second.

When the user enters the program, he is presented a series of screens with only menu options that allow him to quickly "zoom in" on the information of interest. Subsequent screens present information and provide options that allow the user to see more detailed information relevant to his needs. The following are examples of pre-processed information stored in the program.

Safety-Related System Importances

The PRISIM data base provides four types of risk importance measures for safety-related systems: safety assurance importance, risk reduction importance, risk sensitivity importance, and risk significance importance. Since inspection personnel are most concerned with preventing core melt, the measures of importance in PRISIM are based on core melt frequency. Table 1 defines these four importance measures.

Table 1 Definitions of Measures of Importance

Measure of Importance	Definition
Safety Assurance	The factor by which risk increases when the equipment is out of service
Risk Reduction	The decrease in risk when the equipment is assumed to be perfectly reliable. (When normalized to the average risk, these results represent the likelihood that the equipment would contribute to a core melt if a core melt were to occur.)
Risk Sensitivity	The rate at which risk changes with changes in equipment failure probabilities (or frequencies)
Risk Significance	The combined risk reduction importance and risk sensitivity importance. (Equipment is grouped according to risk reduction importance. Equipment with a high risk sensitivity importance is then moved to the next higher group.)

Safety-Related Subsystem Importances

PRISIM provides the same four types of risk importance measures for safety-related subsystems that it provides for systems. It also lists the surveillance tests for each subsystem and indicates whether each test is an integral test. If a test is not integral, the components that are not tested are identified.

Safety-Related Component Importances

In addition to the same four importance measures, PRISIM provides information that is based on a particular component being out of service. This information includes lists of single component failures for the system when the specified component is out of service. These failure modes are of two categories: those that are covered by the licensee in response to the plant's technical specifications and those that are not.

Support System Interfaces

To identify dependencies among front-line safety systems and support systems (e.g., electrical power and service water) and among different support systems, PRISIM provides, for each system, a table that shows the support services required by components in that system.

Component Failure Data

Two types of information on component failure data are incorporated in the PRISIM data base. First, PRISIM includes summaries of licensee event reports (LERs), by component type, for the plant. Second, there are comparisons of plant-specific failure data with industry-averaged failure data for plant equipment. These comparisons highlight plant equipment that is more or less reliable than the industry average for equipment of the same type.

Fire Zones

PRISIM provides a ranking of fire zones at the plant with respect to their importance to risk. An assumption that is inherent in these rankings is that a fire will fail all equipment in the zone where it occurs.

Accident Sequences

The accident sequences that make the largest contributions to a plant's risk are listed in PRISIM. An inspector can command PRISIM to display information on a particular accident sequence. He will then see a description of the accident sequence and a listing of the most important causes of the sequence.

As an example of the use of the interactive routine in PRISIM, an inspector has specified a valve in the Emergency Feedwater System (EFS), shown in Figure 1, is out of service. The valve highlighted in Figure 1 being out of service will disable Train A of the EFS. Also, the inspector has similarly specified a component in the Battery and Switchgear Cooling System is out of service. The effect is to disable Train A of this system. Using PRISIM to specify the plant status requires about 1 minute.

The program, in about 8 seconds, displays Figure 2. The instantaneous core melt frequency is 70 times higher for this plant status than it is under average conditions. The program user can now obtain additional information on the "Ranking of Safety-Related Equipment" is pursued in this example. The results shown in Figure 3 are available in less than 1 second. This list can be scrolled to obtain additional components of decreasing importance.

Demonstrating the dozens of features and information types available from PRISIM is far beyond the space limitations of this paper. The menu-driven program is user friendly and fast. The response to the program by the U.S. NRC and U.S. utilities has been extremely favorable. Plans include application to additional plants and implementation of an efficient system to keep the PRISIM versions for different plants updated.

RISK IMPLICATIONS OF THE CURRENT PLANT STATUS

70 IS THE RISK FACTOR WITH THE FOLLOWING EQUIPMENT OUT OF SERVICE

Emergency Feedwater System--Train A fails
Battery and Switchgear Room Cooling System--CW Train A fails

MENU FOR ADDITIONAL INFORMATION

→ 1. Ranking of safety-related equipment
2. Ranking of core melt scenarios
3. Improvement from repair
4. Return to Master Menu

Figure 2

RANKING OF EQUIPMENT NOT KNOWN TO BE OUT OF SERVICE

1. Battery and Switchgear Room Cooling System--CW Train B fails
2. Blockage of EFW Train A-to-Train B Crossover Line
3. Both safety/relief valves fail to reclose
4. Auxiliary Cooling Water System Isolation Valve CV3643 fails
5. Intermediate Cooling Water System Isolation Valve CV3820 fails
6. EFW Initiation and Control--Vector Signal Path 1D-32D fails
7. EFW Initiation and Control--Vector Signal Paths 2D-22D and 3D-22D fail
8. Both safety/relief valves open and fail to reclose
9. High Pressure Injection System Pump P36C fails
10. EFW Initiation Signal Paths AC01-AC04 and BD01-BD04 fail

ESC to return to the Selection Menu.

REPRODUCED FROM
BEST AVAILABLE COPY

Figure 3