POLICY ISSUE
(Information)

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FOR: The Commissioners

FROM: James M. Taylor
Executive Director for Operations

SUBJECT: STATUS REPORT ON ACCIDENT SEQUENCE PRECURSOR PROGRAM AND RELATED INITIATIVES

PURPOSE:

To inform the Commission of the staff's activities and progress with respect to the Accident Sequence Precursor (ASP) Program and related initiatives.

SUMMARY:

Since the last status report, dated April 16, 1993, the staff has made progress in the following areas:

(1) Developing the "Integrated Accident Sequence Precursor Program Plan"
(2) Developing a conceptual plan for trending industry risk
(3) Completed the 1992 "Accident Sequence Precursor Report"
(4) Adapting the ASP models to the IRRAS computer code
(5) Evaluating the statistical significance of trends in the annual index of ASP results for operating reactors

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(6) Extending the ASP methodology to other sources of operational experience information
(7) Applying the ASP methodology to NRR decision processes
(8) Formalizing the practice of obtaining licensee comments on ASP analyses before publication

The following activities have been started:

(1) Evaluating licensee event reports (LERs) submitted in 1982 and 1983
(2) Developing a methodology for estimating the underlying industry-average core damage frequency (CDF) using ASP analyses
(3) Developing an NRC-wide accessible data base of precursor events to be used for operating experience risk insights
(4) Developing ASP methodology training programs for NRC staff

Efforts to address the remaining issues discussed in the last status report are still in the planning stage. These include:

(1) Using individual plant examinations (IPEs) or information from IPEs for improving the accuracy of ASP analyses
(2) Evaluating an event which occurred at a specific plant for significance with respect to other plants which have features that make them more susceptible to the event
(3) Producing models for use in evaluation of events at shutdown, external events, and design deficiencies
(4) Estimating the uncertainty for each conditional core damage probability (CCDP) calculated in ASP analyses
(5) Comparing ASP results to probabilistic risk assessments (PRAs) to provide a context for precursors

Since the last status report, AEOD has reassigned responsibility for the ASP Program to its Trends and Patterns Analysis Branch, which has been reevaluating Program activities and priorities with NRR and RES. As a result, a comprehensive plan has been developed for the ASP Program and a conceptual plan has been prepared for estimating and trending the industry risk profile over time. The Integrated Accident Sequence Precursor Program Plan (Draft) is included as Enclosure 1. These plans, which will be finalized as part of the completion of the agency's PRA Implementation Plan, will address all of the issues discussed in this paper.

BACKGROUND:

The Accident Sequence Precursor Program was initiated by the Office of Research (RES) to provide a structured, probabilistic method of reviewing operational experience to determine and assess both known and unrecognized vulnerabilities that could lead to core damage accidents. The ASP Program is currently implemented by the Office for Analysis and Evaluation of Operational Data (AEOD) through a contract with the Oak Ridge National Laboratory (ORNL) and its subcontractor, Science Applications International Corporation (SAIC). Under this program, licensee event reports (LERs) submitted since 1969 have been screened, with the exception of those reports submitted in 1982 and 1983. Significance of the reported events that meet the screening criteria has been

quantified by computing their associated conditional core damage probabilities (CCDPs). Events with high CCDPs are highlighted for regulatory study and possible action.

These accumulated ASP results have been examined for trends. The Office of Nuclear Reactor Regulation (NRR) has constructed an index by dividing the sum of all CCDPs in each year by the number of reactor-years of operation in that year. This core damage index (CDI) shows a pronounced decrease from the 1970s to the 1980s.

In addition, the ASP methodology has been adopted by NRR, and its use has been extended to short-term review of licensee event notifications under 10 CFR 50.72, inspection findings, and other issues. The joint AEOD/NRR panel which designates "significant events" for the Plant Performance Indicator Program now uses ASP methodology as one means of determining significance of the events it considers. Designated "significant events" are forwarded to AEOD to be considered for inclusion in the ASP review and evaluation process. The discussion that follows summarizes the status of the ASP Program and related activities being pursued to improve the ASP methodology and expand its applications.

DISCUSSION:

AEOD, NRR, and RES have continued the efforts described in the last status report to the Commission, making important progress in some areas. Also during that time, AEOD has consolidated all of its PRA-related activities in its Trends and Patterns Analysis Branch (TPAB) and reassigned responsibility for the ASP Program to TPAB. In collaboration with NRR and RES, TPAB is conducting a reevaluation of the program and the many related activities. The progress reported and the issues discussed below are being incorporated into two agency plans, which will be coordinated with the recommendations of the PRA Working Group and incorporated in the PRA Implementation Plan. The Integrated Accident Sequence Precursor Program Plan addresses the issues related to review of operational occurrences for the purpose of identifying risk-significant events and issues. In addition, an "Integrated Plan for Trending Industry Risk" is being formulated to address the use of the ASP results and other reliability and PRA information and findings to estimate the level of risk and evaluate trends over time. Two plans are being developed because somewhat different approaches are required to address the two goals. The plans will be coordinated to the extent practicable to share common elements and resources. The plan for trending industry risk is still in the conceptual stages of formulation. It is described in Appendix A to Enclosure 1.

In addition to developing the attached plans, progress has been made in the following specific tasks:

ASP Evaluation of Operating Reactor Events for 1992: The 1992 Accident Sequence Precursor Report was completed in December 1993, and the final report has been issued. Licensees were allowed to review the draft report to check the accuracy of the representations of plant equipment and capabilities in the individual analyses addressing events at their plants. It was known that the

current ASP models were conservative, in that they do not consider some of the equipment or accident recovery procedures referenced in the plant abnormal or emergency operating procedures, or in the IPEs. The comments received from licensees on the 1992 draft ASP report identified several potential recovery actions which had not been considered in the ASP analyses, such as depressurization of the secondary side in a pressurized water reactor (PWR) to allow use of low-pressure pumps on the primary side. Other comments concerned the availability of additional equipment, such as potentially available steam generator feed pumps or additional standby electrical power systems, which could be used in emergencies but had received no credit. The ASP contractor reanalyzed a number of the preliminary precursor events to address the comments received from licensees. This resulted in reductions in CCDP for about two-thirds of the analyses, and a reduction in the sum of the CCDPs by about a factor of three between the draft and final versions of the 1992 report. The revised ASP models, when completed, will address most of the equipment or recovery procedures referenced by the licensee comments.

ASP Evaluation of Operating Reactor Events for 1993: Because of the limited number of contractor personnel with the necessary expertise, evaluations of 1993 events were suspended during review of licensees comments on the draft 1992 event evaluations. Evaluations of 1993 events are being accelerated so that the 1993 report can be issued earlier in the calendar year. To help expedite the process, the draft analyses will be peer reviewed by licensees and NRC staff as they are completed for each event. When comments are received, the analyses will be put in final form. The annual ASP report covering events in 1993 is scheduled for completion in September 1994.

Evaluation of 1982 - 1983 LERs: In 1992, evaluation was initiated for the years 1982 and 1983, to fill a gap which occurred due to funding limitations. ORNL has completed the computer screening of the 9383 LERS encoded in the Sequence Coding Search System (SCSS). A computer algorithm identified 2748 LERs for further consideration in the ASP process. The amount of time required for the ASP reviews and evaluations on these older LERs is greater than originally estimated. An effort is under way to improve efficiency of these evaluations. This effort is scheduled for completion in December 1994.

Adaptation of the ASP Models to the IRRAS Computer Code: As previously reported to the Commission, the Probabilistic Safety Assessment Branch (SPSB) in NRR has directed substantial efforts toward improving the ASP models, including making their accident sequences more consistent with current PRAs and implementing them for use with the IRRAS PRA code, developed by the PRA Branch in RES.

This portion of the effort has been moved to the Idaho National Engineering Laboratory (INEL), and is progressing well. INEL is producing simplified, plant-specific, train-level models for each unique plant design. Completed models for 33 plants have been received to date, including plants in all of the 9 ASP plant classes. All 74 plant-specific models are expected to be completed in the spring of 1994. The system models consist of train-level hardware failures and system-level operator actuation and recovery actions. Support systems are not modeled with the exception of train-level representation for emergency AC power.

RES supports an ongoing effort at INEL to improve the SAPHIRE code suite (IRRAS, SARA, etc.). Part of this effort has been directed toward improving capabilities required for event assessment. A new interface code, GEM, is being developed for this purpose. It was demonstrated to AEOD and NRR personnel in September 1993. A test version was delivered to NRC staff in December 1993.

Improvements of ASP Models: AEOD and RES are currently evaluating the best strategy for obtaining and incorporating the support system and other plant-specific features into the ASP models. The models will be revised periodically and updated when necessary to include recent risk-significant plant modifications and improvements in plant operations. AEOD, in concert with RES, is developing a new recovery model that considers dependencies among recovery actions and accounts for plant-specific performance shaping factors. A better technique for treating common cause failures also is being developed.

Evaluation of Uncertainty for CCDP Estimates: Use of the SAPHIRE computer codes with the new ASP models provides the software for evaluating the uncertainty associated with each CCDP, as it is produced. In order to implement this feature for ASP evaluations, it is only necessary to provide uncertainty estimates for the input data. In most cases, it will be possible to construct estimates of the uncertainty of the nominal values for ASP basic events by using the uncertainties for the component failures in the represented trains. It will be necessary to provide the analysts with guidance for the appropriate modification of the uncertainty parareters to be used when modifying basic event probabilities or model structure during the evaluation of operational events. Guidance also will be developed for estimation of uncertainty parameters when it is necessary to obtain data from other sources, such as expert judgement. AEOD will initiate these efforts in FY-94 with support from RES.

Evaluation of Statistical Significance of Trends in the Annual Index of ASP Results: For several years, NRR has been using the numerical results of the ASP Program to construct an annual index of the risk significance of events at operating reactors. Evaluation of the stochastic uncertainty associated with this index was conducted through a contract with Brookhaven National Laboratory (BNL). The results indicate that there is a statistically significant decrease in this index from the 1970s to the 1980s. The analysis also suggests, with less statistical confidence, that the less pronounced decrease of this index during the 1980s is due to more than random variations. The interpretation of trends in this index to reveal trends in the associated level of risk has to consider the influences of the factors discussed in the next section. However, it is clear that the level of risk has decreased since 1979. The staff is developing an Integrated Plan for Trending Industry Risk that will identify more effective means for evaluating risk trends using ASP results and other information.

Improvements of ASP Trending Capabilities: Improved methods for trending ASP results are being developed to address several issues raised with respect to the CDI. One issue concerns the representation of events that reveal a previously unidentified risk, which currently are quantified only for the year of identification. Thus, a graph of the annual ASP data shows a "spike" shape

for the year in which a long-standing problem was discovered and corrected, while the actual level of risk takes a downward step during the year that the problem is corrected. Another issue is the use of increasingly more accurate and detailed system models as the ASP Program has evolved over the years. Also, in order to have confidence in ASP trends, the uncertainties associated with sparsity of ASP results over time and the uncertainty associated with each CCDP estimate must be considered. The "Integrated Plan for Trending Industry Risk" will address all of these factors and place the ASP-related trending activities in the broader context of deducing risk trends from a variety of available data.

Developing Risk Insights from ASP Results: AEOD is initiating an effort to derive insights from the approximately 425 precursor events found to date. The insights will provide indications of the more significant events or plant conditions that should be considered in nuclear plant design and regulation in coming years. These insights would also be confirmation of the apparent trend of increased reactor safety that has been attained after the Three Mile Island Unit 2 accident.

In addition, AEOD is reviewing the concept of evaluating events that occur at a specific plant for significance with respect to other plants which have features that make them more susceptible to the event. This approach has been practiced by experienced analysts to good advantage when an analyst's experience is sufficient to provide the insight that an event could be more important at a different type of plant. As ASP models are improved and become more plant specific, this process becomes both more difficult and potentially more useful. AEOD is coordinating its review with RES to determine how IPE information could be used to advantage for this purpose.

Relationship of ASP Results to Industry Average Core Damage Frequency: RES has produced an analysis of the mathematical relationship between the conditional core damage probabilities (CCDPs) for events occurring at operating reactors and the core damage frequency (CDF) of the reactors experiencing the events. This analysis has shown that a simple sum of the CCDPs will overpredict the CDF associated with the accident sequences "sampled" by the operational events. Formulae have been developed that would allow (approximately) unbiased estimation of CDF associated with events that involve initiators (e.g., reactor trips and losses of coolant) but not for events that involve only degradation or loss of mitigation capability for initiating events that did not actually occur. These formulae require sequence-dependent correction factors to be developed and applied for each event evaluation. Corresponding formulae for estimating the confidence intervals associated with the CDF estimate have not been completed, due to the complex nature of the dependency of the parameters involved in the CDF estimation formulae. Therefore, it is not yet known if this process would improve our confidence in the CDF estimates provided by PRAs and experience to date.

RES is planning to conduct a simplified simulation study to explore the relationship between ASP CCDPs and CDF. The study is expected to yield insights on the usefulness of various modifications of the CCDP sum for estimating CDF.

Extending the ASP Program to Cover All Sources of Operational Event Data: NRR's Events Assessment Branch (OEAB) conducts a systematic events screening program in order to highlight important operating experience and to help ensure that valuable lessons from operating experience are fed back to the staff and the industry. The primary event sources reviewed are: the daily (morning) report from each regional office, 10 CFR 50.72 notifications (also called "ENs" or Prompt Notifications), preliminary notifications (PNs), project/region morning call items, and enforcement notifications. To a lesser extent, inspection reports and LERs are also reviewed. During the past 6 months, procedures were initiated to gather and screen additional information on unreported issues or conditions with potential risk significance from regional staff. These procedures are expected to foster improved awareness of risk significance among regional staff. One product of this screening process is the designation of "significant events" by the joint AEOD/NRR Events Assessment Panel. Of the events that occurred in 1993, 15 have been designated as significant events, and 6 are still being evaluated as potentials. Of the 39 items nominated by the regions during 1993 and the 8 items raised at the January 1993 Senior Management Meeting (most of which occurred before 1993), 3 were classified as "significant events" by the Panel. ASP methodology is used by NRR staff to provide CCDP estimates (for some events) as one measure of risk significance information for the panel's consideration. The list of designated "significant events" is sent to AEOD quarterly by memorandum from NRR. AEOD uses this list as an additional input to the ASP Program events screening process. In addition, NRR intends to forward to AEOD for more detailed evaluation any events for which NRR has performed scoping analyses which indicate CCDP values greater than the $1x10^{-6}$ value used as the reporting threshold for the annual Precursor Reports.

Providing Training in ASP Methodology for Additional NRC Staff: The number of NRC and contractor personnel trained and experienced in the use of the ASP models and methods is limited. Currently, ASP analyses are performed by contract personnel at ORNL and SAIC for AEOD to produce the annual Accident Sequence Precursor Report. Two staff members in NRR's Probabilistic Safety Assessment Branch (SPSB) use ASP-type methodology to perform scoping analyses (on a part-time basis) to support event assessment activities of OEAB and the Events Assessment Panel. The need to obtain additional personnel, both in the NRC and at contractors, trained in these methods is recognized as a high-priority item. AEOD has obtained training in ASP methods at ORNL and SAIC for one of its staff members. In NRR, SPSB staff has conducted a seminar for OEAB staff on the use of the current ASP models. In accordance with the "Program Plan in Response to the Shearon Harris Event," AEOD and NRR are developing a plan for training selected headquarters and regional staff in ASP methods. As part of its new responsibility for PRA training, AEOD is evaluating the needs for specific training in ASP methods. Details of ASP training will be treated, along with other PRA-related training, in the PRA Implementation Plan.

Use of ASP Methodology for Other NRR Decision Processes: NRR has several programs for utilization of PRA methods and insights to enhance and guide its regulatory efforts. The ASP concept of estimating a CCDP for an event is applied as appropriate to planned and ongoing events, as well as events that have already occurred, for purposes of considering regulatory discretion,

potential changes in technical specifications, assessing the importance of inspection findings and escalation of enforcement actions. In addition, the improved ASP models have been used as the basis for generic risk assessment efforts, where a CDF contribution is calculated (as in a traditional PRA) instead of a CCDP. Although this latter use is not considered an "application of ASP methodology," it illustrates the interrelationships among the PRA methods utilized by NRR and the benefits that derive from improvements to the ASP models and methods.

Other Issues: As part of the current reevaluation of the ASP Program, several additional issues are being considered. Among these are development of models for events with external initiators (e.g., fires, floods, seismic events) and events at shutdown or low-power operation. Methods for evaluating containment-related events and methods for assessing public risk are also being considered. As mentioned in connection with several topics discussed above, the use of IPEs is being considered from multiple perspectives. These issues and others will be addressed in the context of the "Integrated Accident Sequence Precursor Program Plan" and the "Integrated Plan for Trending Industry Risk." AEOD has proposed an interoffice coordinating group at the branch level to ensure the integrated development of models and methods for ASP and other applications which could use ASP models and related software.

CONCLUSIONS:

The ASP Program continues to provide a valuable quantitative means for identifying the risk significance of operational occurrences at nuclear power plants each year. Progress has been made in extending the breadth of the program to cover most sources of operational event information. Progress also is being made in the evaluation of the apparent trends in the ASP results, and in understanding the relationship between the ASP results, variations in the overall level of risk, and the underlying average core damage frequency. Substantial efforts are under way or planned to improve the ASP methodology. The staff is developing an Integrated Accident Sequence Precursor Program Plan and an Integrated Plan for Trending Industry Risk. These plans will be important elements of the agency's PRA Implementation Plan and will be finalized during the completion of that plan, due in June 1994. The process for completing these plans will include prioritizing the tasks described in the plans and estimating the level of effort required for each task. In the future, AEOD will be responsible for providing the semiannual updates on progress being made on ASP and related activities.

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Enclosure:
Integrated Accident Sequence
Precursor Program Plan

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Enclosure 1

Integrated Accident Sequence Precursor Program Plan

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Office of Nuclear Regulatory Research

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Integrated Accident Sequence Precursor Program Plan

1. INTRODUCTION

The application of PRA methods to the analysis of operational events is called accident sequence precursor (ASP) analysis. The figure of merit for ASP analyses is a conditional core damage probability (CCDP).

The ASP Program was initiated to identify and categorize precursors to severe core damage accident sequences. The program began under the auspices of the Office of Research (RES) with the first ASP precursor report being issued in 1982 which covered events from 1969-1979. This first report used one set of event trees for BWRs and one set for PWRs to model the same four initiating events: Loss of Feedwater (LOFW), Loss of Offsite Power (LOOP), Small Break Loss of Coolant Accident (SBLOCA), and Steam Line Break. Improvements to the program in 1985 incorporated eight plant classes that reflect design differences among the population. Three initiating events (Trip with LOFW, SBLOCA, LOOP) are now modeled using train-based system models. Responsibility of the ASP Program was transferred to the Office for the Analysis and Evaluation of Operational Data (AEOD) in 1985 and focused on the annual evaluation of LER data to determine precursor events. Since that time, the Office of Nuclear Regulatory Regulation (NRR) has begun to use ASP models and analysis techniques to provide early indication of the risk significance of events as part of the process of prompt screening of events, including those reported in 10 CFR 50.72 telephone notifications and inspection reports.

This plan presents the Staff's integrated efforts for using and improving ASP models, analysis techniques, and other activities. The major ASP-related activities of each office are summarized below:

AEOD Activities

AEOD is responsible for the overall management, direction, and coordination of the ASP Program. This includes development of analysis methods, models, and gleaning of insights from the ASP analyses. In addition, it has the responsibility of producing the annual ASP report which is the official listing of ASP events. The main objective of the program is to identify and quantitatively estimate the safety significance of operational events (that are classified as Accident Sequence Precursors). ASP event analyses are considered the most direct measure of core damage probability based upon actual operating experience. The principal source of accident sequence precursor information is Licensee Event Reports (LERs) identified from the Sequence Coding Search System (SCSS). Supplemental sources include the Significant Events (from the Performance Indicator Program) and results from NRR's screening analyses. The major steps in the analysis implemented by AEOD are outlined in a flow chart in Figure 1.

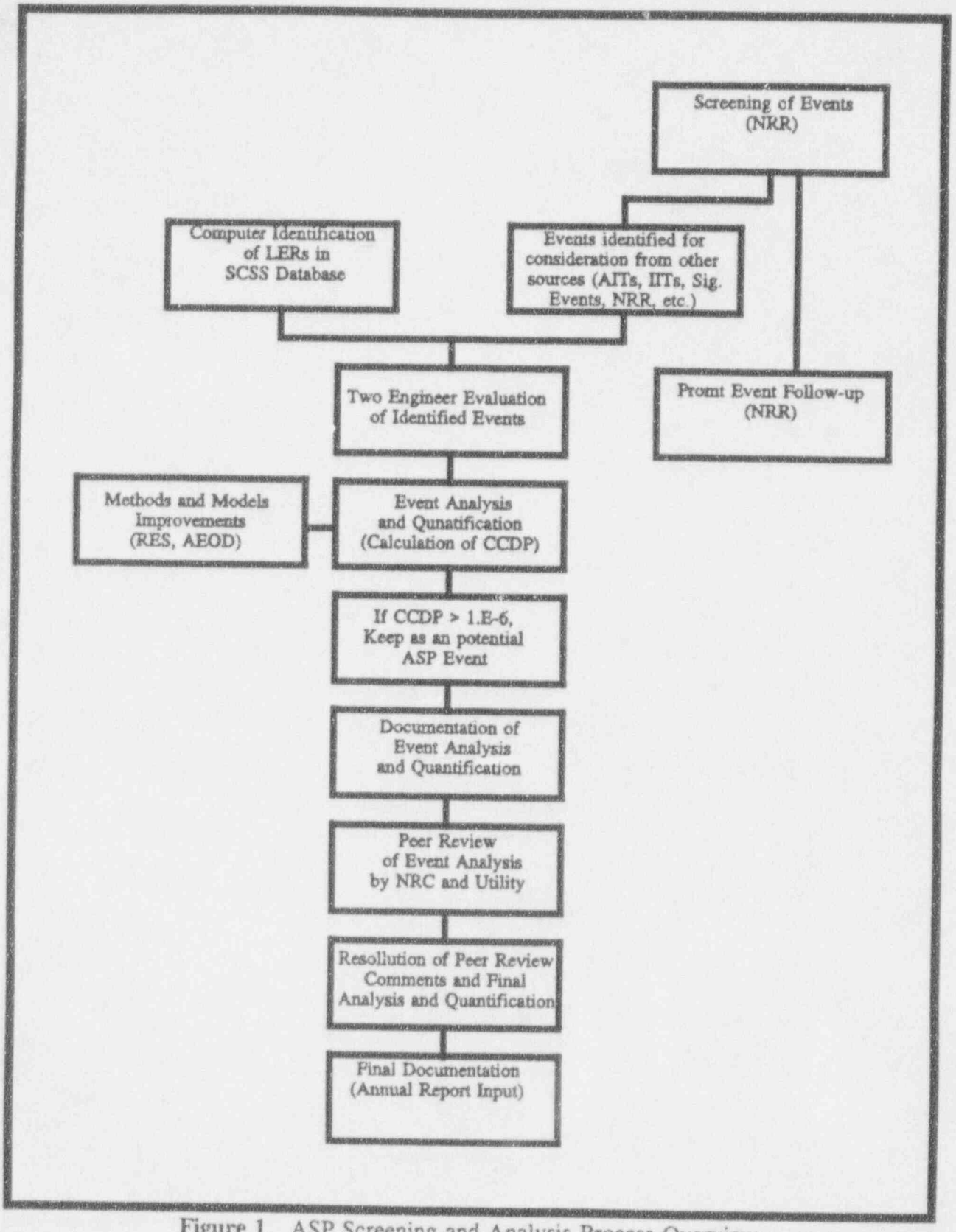

Figure 1. ASP Screening and Analysis Process Overview

These steps were used to identify the 1992 ASP events. The results are formally documented and are recognized as the agency's assessment of core damage probability from operational events classified as Accident Sequence Precursors.

NRR Activities

NRR uses ASP methods to support both routine and urgent management decisions that relate to operating reactor events considerations. Therefore, some of the analyses performed by NRR must be completed in a rapid manner. Examples of such situations are the following: (1) evaluation of daily telephone reports from plants to screen for follow-up and focus on follow-up actions, (2) evaluating a request for a waiver of a limiting condition of operation due to equipment being out of service, (3) approving restart of a reactor, and (4) deciding on issuance of generic communications. These analyses often require that a CCDP be calculated quickly to aid in the decision-making process. Some prompt analyses may suffer from the lack of information about the incident. Where appropriate, the results of screening analyses are forwarded to AEOD for a more thorough assessment in the Accident Sequence Precursor Program.

RES Activities

RES provides methods development support to AEOD and NRR for the ASP Program and related applications. The past several years have seen the development of the SAPHIRE set of PRA analysis codes, which are increasingly being used throughout headquarters and the regional offices. A special effort is currently under way to create additional modules for use with the SAPHIRE code package to support the newly integrated ASP effort.

Since its inception, the ASP Program has been recognized as a valuable tool in assessing the risk significance of operational events. Much has been learned about ASP event analysis in over ten years of experience with the methods. Over time, improvements were made to enhance the technique so that the results were consistent with and representative of the actual plant conditions and configurations.

Even with these efforts, conservatisms and limitations still exist within the current ASP models, data, and analyses. Some of the major ones are the following:

- Timeliness of the analyses,
- Consistency and completeness of the logic models used in the analyses,
- Treatment of uncertainties,
- Representation of plant-specific features,
- Recovery model,

- Plant-specific data, and
- Treatment of common cause failures.

Additional areas in the program requiring attention include:

- Usability of the annual report (i.e., report format),
- Comparison of ASP insights with PRAs,
- Feedback of ASP results and insights to NRR, Regions, and regional inspectors, and
- Limited quality assurance and peer review of the analyses.

To address these areas, improvements to the program and additional activities to fully understand and utilize ASP results have been identified for implementation. Since event assessments are so widely used in the agency, planned coordination of future activities is necessary to prevent duplication of effort and combine the strengths and resources of AEOD, NRR, and RES. This integrated plan is designed to provide the necessary framework for that coordination.

Future ASP activities can be divided into two areas - improvements to the current ASP events analysis (e.g., models, methods, data, and techniques) and utilization of ASP results and insights. Little has been done to reap the insights from past ASP evaluations and provide insights from these evaluations to the industry and NRC staff. The activities are described in this plan and will help the agency meet the defined ASP objectives.

The next section (Section 2) of this plan describes the objectives of the Integrated ASP Program. These objectives will be met by fulfilling the program improvements detailed in later sections of the plan. Section 3 shows the current activities of each office with regard to the ASP Program. Section 4 summarizes the ASP improvements with respect to the ASP Program objectives. The improvements are described in greater detail in Section 5. They are grouped according to implementation time (short term (1-2 years) and long term (3 to 5 years)) and category of improvement (e.g., model improvements and uncertainties) since some improvements address more than one objective. These improvements are then summarized, in chronological order, in a table that identifies a specific ASP Program improvement, the specific product to be produced, the responsible office(s), and when the product is needed for implementation in the ASP Program evaluations. Section 6 discusses the interfaces and coordination among AEOD, NRR, and RES needed to achieve the objectives of the plan. Section 7 discusses trending ASP results and the relationship of ASP results to core damage frequency (CDF). Appendix A presents a conceptual framework for trending industry risk using standard reliability and PRA methods.

2. OBJECTIVES OF THE ASP PROGRAM

As part of the staff's effort to develop the ASP Program plan, program objectives were defined. The objectives below were developed during two discussion meetings involving NRR, AEOD, and RES on September 8, 1993, and September 14, 1993. The intent of these meetings was to determine the extent of participation of each office in the overall agency ASP Program to clarify program goals. In turn, each office prepared lists of areas needing improvements for their ASP activities and their future plans. This process of enhanced communication concerning ASP is continuing through monthly interoffice meetings. The following five ASP objectives were defined:

- Identify and Rank Risk Significance of Operational Events

  Historically, this was the purpose of the ASP Program and it remains the primary objective. AEOD will continue to analyze potential ASP events for the annual precursor report and NRR will continue to screen daily events, nominating events, as appropriate, for consideration by AEOD for more thorough assessment.

- Determine Generic Implications of an Operational Event/Characterize Risk Insights

  ASP events can provide insight into potential problems at other plants and bring to light generic issues. This can be done by analyzing the trends and patterns of the ASP events as a whole, or it can be done on an event-by-event basis. Most importantly any risk insights need to be fed back to NRR, the Regions, and to the nuclear industry. (Sometimes these insights, either individual events or groups of events, result in issuance of generic communications.)

- Provide Supplemental Information on Plant Specific Performance

  ASP data is often used along with other performance data to report on plants at the Senior Management Meeting and in various agency studies. Distribution of event analyses to a wider audience and conducting ASP seminars with the staff will increase the understanding and usage of ASP.

- Provide a Check with PRAs

  ASP data and insights should be compared with expectations based on PRAs and IPEs. This will help gauge some of the uncertainties and will help identify some modeling errors or areas with important completeness problems.

- Provide an Empirical Indication of Industry Risk and Associated Trends

  ASP can be used as one input into trending of industry risk implications of operating reactor experience. The degree to which ASP can be used to support this objective is limited because of the limited models and data. A concept for characterizing industry risk trends is presented in Appendix A.

3. CURRENT ASP PROGRAM ACTIVITIES

The section describes the current ASP activities of AEOD, NRR, and RES.

3.1 AEOD Activities

AEOD has the responsibility for systematic identification, analysis, and evaluation of precursor events and documenting the results in the annual ASP precursor report. Oak Ridge National Laboratory, under contract to AEOD, produces the annual precursor report. Production of the annual report is broken down into a monthly cycle. AEOD is currently working on the production of the 1993 report and an analysis of 1982-1983 LERs. The current AEOD ASP-related activities are the following:

- Completion of 1992 ASP Annual Report
  - The analysis of the 1992 ASP events was completed and documented in NUREG/CR-4674, Volumes 17 and 18, dated December 1993.
- Review of 1993 Events
  - AEOD is reviewing the 1993 events and is implementing an expedited analysis schedule. As the events are analyzed, they will undergo peer review. The final report is scheduled to be issued in September 1994.
- Review of 1994 Events
  - The assessment of 1994 ASP events is targeted for accelerated processing.
- Review of 1982-1983 Events
  - AEOD has a two year contract with ORNL to review and analyze the two years of events that had not previously been evaluated in the ASP Program. This work was requested and funded by NRR. It is targeted for completion by the end of 1994.
- ASP Event Database
  - AEOD is developing an ASP event database to include all precursor event analysis information and reference information. A prototype version will be available for staff evaluation and use during the first quarter of 1994.

- ASP Program Plan and Coordination

  - AEOD is responsible for developing and updating the ASP Program plan on a periodic basis with input from NRR and RES. In addition, AEOD will coordinate the ASP-related improvements and analyses to avoid duplication and overlap.

3.2 NRR Activities

The principal activity of NRR is the prompt assessment of events reported by licensees under 10 CFR 50.72. The risk perspective helps NRR select events for allocation of follow-up efforts and focuses these efforts on the important aspects of the events selected. NRR/OEAB chairs the "Significant Events Panel," which designates appropriate events for consideration as plant performance indicators. "Significant events" are considered by AEOD for inclusion in their assessment of ASP events. The main NRR ASP- related activities are the following:

- Perform screening analyses of events reported under 10 CFR 50.72 and support the Significant Event determination process.

- Evaluate other events identified in inspection findings, enforcement actions, etc.

- Recommend events for further analysis and evaluation as part of the ASP Program.

- NRR is sponsoring the development of IRRAS-based models to facilitate prompt ASP types of evaluations. AEOD expects to adapt this safety tool for use in the ASP analysis activity.

3.3 RES Activities

The SAPHIRE set of PRA analysis tools currently consists of IRRAS, SARA, MAR-D, and FEP. IRRAS is being used extensively to create new PRAs of selected plants. SARA is being used to perform PRA-type sensitivity analyses on plant data loaded into the MAR-D database.

During FY 1993, prototype software was developed to provide a user-friendly interface to support the ASP effort. This software was called Graphical Evaluation Module (GEM). The primary capability was to permit performing train-level analyses, as required by the ASP Program, by using the full PRA data loads used in other analyses (i.e., without having to create special train-level loads). This was done in such a way that many of the analysis steps required by the user are now done automatically and are transparent to the analyst.

- Continue SAPHIRE maintenance and development

  - This will continue throughout FY 1994 and include special emphasis to support the needs of the integrated ASP effort.

- Complete the development and testing of GEM

  - The completed GEM code is to provide the capability to support the new ASP data models that NRR is developing, and the attributes of the code will be formulated in coordination with the ASP Technical Coordination Group. A letter report describing GEM and its application is scheduled for early July 1994. Depending on feedback from beta testing at the NRC, the code should be available during October 1994.

- Investigate the use of CCDP to estimate CDF

  - Work is underway to perform a simulation to investigate using variations of the sum of conditional core damage probability (CCDP) as an estimator of core damage frequency (CDF).

4. SUMMARY OF ASP PROGRAM IMPROVEMENTS

This section contains a summary of ASP Program improvements. They are grouped by the ASP Program objectives discussed in Section 2. They will be discussed in more detail in the next section where they may be subdivided. The activities are the following:

Identify and Rank Risk Significance of Operational Events

- Develop ASP analyses for a wider scope of events, including internal fire, earthquake, shutdown events, and containment events, for completeness of event analysis. This requires development or adaptation of models and related methods.

- Include other sources of operational experience data in the ASP event analysis process. This is currently in progress.

- Improve the plant-specific aspects of the ASP models using IPEs and other information sources; incorporate peer review.

- Develop methods for uncertainty analysis and include these calculations in the ASP quantification of CCDP.

- Utilize IPE/IPEEE information as appropriate in ASP activities (e.g., plant-specific features and recovery actions, identification of internal fire and earthquake accident sequences and cutsets).

Determine Implications of an Operational Event (Generic and Other Reactors)/Characterize Risk Insights

- Use IPEs to develop a list of plant-specific vulnerabilities that can be significant with respect to ASP events.

- Develop risk insights to identify plant-specific vulnerabilities and generic implications from ASP events.

- Evaluate events which occur at a specific plant for significance with respect to other plants which have features that make them more susceptible to the event.

- Routinely feed back ASP insights to industry and NRC staff; improve timeliness of routine ASP analyses.

Provide Supplemental Information on Plant Specific Performance

- Provide ASP results in support of the Senior Management Meeting.

- Conduct ASP seminars for NRC staff.

- Distribute ASP event analyses to a wider audience - including resident inspectors and project managers.

Provide a Check with PRAs

- Compare PRA/IPE/IPEEE results with ASP results and insights for consistency.

- Develop expected precursor frequencies and occurrence rates from PRAs and compare with actual ASP results.

- Use ASP risk insights as feedback mechanism to PRA, and vice versa, to improve both techniques.

Provide an Empirical Indication of Industry Risk and Associated Trends

- Trend CCDP bin counts over time to determine if precursor occurrence rates are increasing or decreasing over time.

- Develop a transformation from CCDP to CDF so that ASP results can be used more directly in industry risk implications.

- Rebaseline selected ASP events from previous years to account for the effect that plant improvements, procedure changes, and model changes have on CCDP. This will provide a more consistent historical perspective on ASP results, their trends, and implications.

5. DETAILS OF ASP IMPROVEMENTS

This section contains the detailed improvements identified by the staff to improve the ASP Program. These improvements have been divided into short term (1-2 years) and long term (3-5 years) and by category of improvement (e.g., model improvements and uncertainties). Each improvement builds upon the preceding ones related to it. The office(s) responsible for the improvement is(are) identified.

5.1 Short-Term Improvements (1-2 years)

The short-term improvements for the ASP Program are described in this section.

Timeliness and Quality of Event Analysis and Annual Precursor Report Production

- AEOD uses the SCSS database to identify candidates for ASP events. LERs are coded into the database within 2-3 months after the event. Therefore, preliminary precursor reports of individual events will be available 3-4 months after the event occurs. The annual report will be a compilation of those events analyzed throughout the year and will be issued in September of the next year (that is, the precursor report issued in September 1994 will include calendar year 1993 events). In subsequent years, AEOD will attempt to streamline and expedite the process to provide the preliminary screening and evaluation of events within 60 to 90 days.

- AEOD will reconfigure the ASP annual report to highlight the important information associated with the event analysis. That is, in addition to the conditional core damage probability, qualitative risk insights will also be highlighted.

- AEOD will distribute event evaluations as they are completed for peer review and comment to NRR, Regions, resident inspectors, and utilities. AEOD will also initiate an independent QA review of the analyses.

- NRR analysis time is controlled primarily by the availability of information about an event and the time available before a decision must be made. Some initial evaluations are performed by 8:50AM of the day the event is first transmitted to NRR. These evaluations are used only to select events for follow up, and they are often revised as the follow-up activities provide additional information. Revisions may be required in time for management briefings, restart decisions, etc. Due to resource limitations, analyses have not been available for some events on a timely basis. NRR is increasing the number of staff and contractors trained in and assigned to events evaluation so that more events can be analyzed in a timely manner.

Preliminary Screening Techniques in Selecting Events for Analysis

- AEOD will continue to improve the screening techniques for ASP events. Currently, the SCSS strategy selects approximately 40% of all LERs for further review. Those LERs selected then undergo review by two engineers which reduces the number of events to approximately 100-120. These remaining LERs are then reviewed in detail and quantified. About 25-30 events actually meet the precursor criteria. This process is costly and time consuming. AEOD seeks to streamline this process by improving the SCSS search algorithm and improving the selection criteria used during the two engineer review. Greater use will be made of NRR's 10 CFR 50.72 screening assessments.

Sources of Operational Data for ASP Event Analysis

- AEOD screens LERs for potential precursor events. All AIT and IIT events are also screened. AEOD will screen and track events proposed by other offices or the Regions.

- NRR reviews multiple sources for operational event information, including 10 CFR 50.72 reports, regional morning reports, AIT and IIT reports, escalated enforcement actions, and some inspection reports. In addition, NRR is beginning implementation of procedures for regional personnel to recognize and forward to NRR notifications of unreported conditions or events that may be risk significant. Events determined to be significant after OEAB evaluation are nominated to AEOD for evaluation as potential precursors.

Fault Tree/Event Tree Improvements

- NRR is funding conversion of current ASP models to a fault tree/event tree format for use with IRRAS. Models are being developed for each site or individual reactor. Some model improvements are being made by adding additional detail for ATWS and steam generator tube rupture to them.

- NRR and AEOD will verify and validate these ASP IRRAS models to determine that appropriate cutsets are being generated.

- AEOD will develop an improved recovery model which considers dependency between operator actions, performance shaping factors, and other information. This model will be implemented in IRRAS versions of the ASP models.

- An improved procedure for treatment of CCF in ASP models to handle changes in common cause component group size will be developed and implemented by AEOD for use with the IRRAS models.

- The new features (e.g., rule-based editor) of IRRAS 5.0, developed by RES, will make it easier to perform ASP analyses. RES will provide maintenance of IRRAS 5.0 and

user support for the NRC staff and their contractors. New report options in IRRAS 5.0 will be developed to aid in the ASP analyses and evaluation documentation preparation.

- The IRRAS ASP models will be improved by addition of support systems and other dependencies after the above improvements have been completed. AEOD and NRR will identify the desired model improvements, and RES will develop the improved models.

- The Graphics Evaluation Module (GEM) will be completed by RES to aid in the assessment of events. GEM will provide an interface between the IRRAS models and the user by providing additional manipulation capabilities and a user-friendly interface for the analysis of events.

- Additional plant-specific features will be added to the event trees and fault trees by RES and AEOD to make the models more representative of respective plants.

Unavailability Data Improvements

- Equipment and train demand failure probabilities and unavailabilities from system and component studies will be utilized in ASP analyses. These estimates will be published by AEOD for use by others.

Qualitative ASP Improvements

- RES and AEOD will initiate a pilot study to determine the feasibility of and develop a method for identifying important events from internal fire and seismic perspectives.

- RES and AEOD will initiate a pilot study to determine the feasibility of and develop a method for identifying important events related to containment performance based upon insights gained from the IPEs and other PRAs.

- RES and AEOD will initiate a pilot study to determine the feasibility of and develop a method for identifying important shutdown/ low power events based upon insights gained from low power/shutdown PRAs and other information sources.

Uncertainty Consideration and Calculations

- AEOD will develop a procedure and data for performing parameter uncertainty calculations commensurate with the level of detail in the IRRAS ASP models.

- With the help of RES, AEOD will develop a procedure for using expert opinion for required issues in ASP analyses.

Feedback of ASP Results

- AEOD will analyze the ASP events and develop insights with respect to initiators, conditions, system failures, human actions, and other factors. These insights will be documented in a report.

- The ASP insights will be compared with insights obtained from PRAs and IPEs. Reasons for differences will be discussed and examined. AEOD will perform this task.

- AEOD and NRR will develop a procedure for distributing event analyses to resident inspectors, project managers, and regional inspectors on a timely basis so that they may be informed about the events being analyzed at their plants.

- AEOD will conduct ASP seminars in the Regions, NRR, and RES on the ASP Program and what has been learned from ASP insights.

ASP Trending

- AEOD will begin trending CCDP bins on an annual basis. Every year the events in each probability bin are summed and charted. Trending over time indicates whether the trend in the number of events in each bin (e.g., events with a CCDP in the range of 1E-5 to 1E-4) is increasing, decreasing, or remaining constant.

- AEOD will begin rebaselining selected ASP events to account for conditions and features that now exist in the affected units. The results of this activity will provide a measure of how the CCDP may have changed with plant improvements over time.

5.2 Long-Term Improvements (3-5 years)

The improvements identified in the previous section will provide a good foundation and direction for the improvements which follow. This section provides an overview of the proposed long-term improvements. They are summarized below.

Fault Tree/Event Tree Improvements

- To the extent necessary, based on ASP model improvements made in previous years, the set of event trees for the ASP models will be expanded to include an event tree for each initiating event included in a PRA. Fault trees will be developed or modified as necessary for use with each event tree. This work will be done by RES with guidance from AEOD and NRR.

- The improved event trees and fault trees will be validated and verified to ensure that the cutsets generated are logical. This will be done by RES in coordination with AEOD and NRR.

- RES will develop models for analysis of low power/shutdown events based on the low power/shutdown PRAs performed by RES and industry.

Unavailability Data Improvements

- Updated equipment and train demand failure probabilities and unavailabilities from updated system and component studies will be utilized in ASP analyses. These estimates will be published periodically by AEOD for use by other offices.

- AEOD is working with INPO and NUMARC to develop a new reliability data base that will contain failures, demands, and unavailability of trains and equipment. The target date for having this database operational is June 1996, the date when the maintenance rule comes into effect.

Qualitative ASP Improvements

- RES will develop containment performance insights from the IPEs that can be used to identify important containment events. These insights will be used by AEOD to develop search strategies for identifying these events.

- Consideration of internal fire and earthquake initiators in ASP will be on a plant specific basis. RES will develop lists of important random failures that, when combined with the external initiator, lead to core damage. These lists will be implemented by AEOD to search for operational events that involve these random failure combinations.

- RES will develop risk insights from the low power/shutdown PRAs performed by RES and industry to aid in the identification of the important low power/shutdown operational events.

Uncertainty Considerations and Calculations

- As the details in the models increase and new measures are calculated, additional methods and data for uncertainty analysis will be needed. NRR, AEOD, and RES will work together in defining the needs, and RES will develop the required methods and data for use in the treatment of these uncertainties.

Containment and Consequence Considerations

- AEOD will incorporate consequences as part of the ASP quantification process in the 1996 annual report. ASP will use the Level 1 to Level 3 risk transformation for plant classes developed by RES. The transformation should take into account such issues as early and late failure and containment overpressurization.

Feedback of ASP Results

- AEOD will continue to compare PRA insights with insights from ASP.
- AEOD will compile and disseminate risk insights from the ASP events.
- AEOD will continue to rebaseline selected ASP events.

ASP Trending

- AEOD will continue trending of probability bins on an annual basis.
- AEOD and RES will develop the relationship between CCDP and CDF.

5.3 Summary of ASP Improvement Products

Table 1 summarizes the ASP Program improvements chronologically. Since the ASP events are analyzed and evaluated annually, Table 1 is organized according to how the improvements will be phased in over time in the evaluation and analysis of the annual ASP events and report. The left column shows the improvement, and the right column shows the product needed to achieve the improvement, the responsible office(s), and an estimated completion date for the product. Activities not directly related to the annual report are listed under the heading "Other Activities."

Table 1. Accident Sequence Precursor Program Improvements	
Features of ASP Analyses	**Products for Needed Improvements**
1982-83 Accident Sequence Precursors	
Use existing models.	
Have the results peer-reviewed in a qualitative way by utilities and NRC.	Qualitative peer review guidelines for reviewing 1982-83 events (AEOD, April 1994).
1993 Accident Sequence Precursors	
Use existing models.	Improved procedure for screening and performing analyses. (AEOD, June 1994).
Have analyses peer-reviewed by utilities and NRC.	Peer review guidelines (AEOD, Feb. 1994).
Redesign structure of annual report.	New report format (AEOD, April 1994).
Consider additional events in the analysis process.	Process for identifying and tracking special events to be considered in ASP evaluations (AEOD, April 1993).
1994 Accident Sequence Precursors	
Use NRR models for the plant classes with IRRAS 5.0.	New ASP models for each plant (NRR, April 1994) Verification and validation of plant class models (NRR/AEOD, May 1994).
Use new recovery model.	New recovery model using rules in IRRAS 5.0 (AEOD, May 1994).
Use improved CCF modeling approach.	CCF approach and new CCF probability parameters implemented in IRRAS 5.0 (RES & AEOD, May 1994).
Have analyses peer-reviewed by utilities and NRC.	Standard transmittal cover page (AEOD, April 1994)
Include uncertainty analysis after peer review.	Uncertainty analysis approach and associated data (AEOD, Sep. 1994).
Use new IRRAS-generated ASP analysis reports.	New ASP reports in IRRAS 5.0 (RES, June 1994).
Trend ASP probability bins.	Procedure for trending ASP probability bins (AEOD, August 1994).

Table 1. Accident Sequence Precursor Program Improvements	
Features of ASP Analyses	**Products for Needed Improvements**
Other Activities Pilot studies for feasibility of identifying important events related to shutdown/low power risk, containment performance, internal fire, internal flood, and earthquake.	Initiate pilot studies for feasibility of identifying important events related to shutdown/low power risk, containment performance, internal fire, internal flood, and earthquake (RES, June 1994).
Development of user-friendly event analysis module for use with IRRAS.	Completion of the GEM module (RES, September 1994)
Inclusion of other sources of information in ASP analyses using a systematic approach.	Development of a systematic procedure for collection and analysis of expert opinion for use in ASP analyses (AEOD, RES, September 1994)
Develop ASP insights and compare to PRA insights.	Report containing ASP-related insights and comparison to PRA insights (AEOD, December 1994)
Inform Office and Region personnel about ASP Program and ASP-related insights.	Provide Seminars to the Regions and Offices (AEOD, begin Fall 1994).
Rebaseline selected ASP events from previous years.	Initiate rebaselining activity (AEOD, June 1994)
1995 Accident Sequence Precursors	
Use new plant-specific models that include support systems and other plant-specific recovery features.	Plant-specific models that include support-system dependencies, special plant specific equipment that can be used for recovery, etc. (RES, April 1995).
Use available plant-specific train and equipment failure data from AEOD system and equipment studies and other sources.	Plant-specific data from system and component studies and IPE data comparisons (AEOD, Mar. 1995).
Other Activities Pilot studies for feasibility of identifying important events related to shutdown/low power risk, containment performance, internal fire, internal flood, and earthquake.	Finish pilot studies for feasibility of identifying important events related to shutdown/low power risk, containment performance, internal fire, internal flood, and earthquake (RES, March 1995).
1996 Accident Sequence Precursors	
Include low power/shutdown events identified using screening algorithm developed from LP/SD risk insights.	Low Power/Shutdown Risk Insights (RES, Dec. 1995). LP/SD screening ASP algorithm (AEOD, April 96).
Include consequences as part of the ASP quantification process.	Level 1 to Level 3 risk transformation for classes of plants (RES, Dec. 1995).

Table 1. Accident Sequence Precursor Program Improvements	
Features of ASP Analyses	**Products for Needed Improvements**
Include containment events as part of the ASP process.	Screening criteria for identifying important containment-related events (RES, Dec. 1995; AEOD, Mar. 1996).
Include additional plant-specific failure data.	Updated plant-specific data from system and component studies and IPE data comparisons (AEOD, Mar. 1996).
1997 Accident Sequence Precursors	
Include more plant-specific failure data in the ASP quantification process.	Phase III plant-specific data (AEOD, Mar. 97).
Address internal fire and seismic events in the ASP process.	Internal fire and earthquake risk insights for risk-important accident sequences from IPEEE (RES, Dec. 1996). Computer algorithm for external events (AEOD, Mar. 1997).
1998 Accident Sequence Precursors	
Use plant-specific models and failure data in the ASP quantification process.	Updated plant specific models (RES, Dec. 1997). Updated plant-specific data (AEOD, ongoing).
Address internal fire and seismic events in the ASP process.	Additional internal fire and earthquake risk insights for risk-important accident sequences from IPEEE (RES, ongoing).

6. OFFICE INTERFACES AND COORDINATION

With the increased use of ASP models and analysis methods, it is imperative that NRR, RES, and AEOD work closely with each other. To aid in this effort, an ASP Technical Coordination Group has been organized. This group plans to meet on a monthly basis, more often if necessary, to keep each other informed of progress on projects and potential problems that may be developing. This will provide the opportunity for better communication and sharing of experiences and products developed by each office.

In addition to the ASP Technical Coordination Group, a management coordination group will be formed. The members of this group are the branch chiefs of the cognizant branches in the respective offices. This group will meet less frequently (e.g., quarterly) to evaluate progress towards the goals and milestones contained in this plan.

Several interfaces among AEOD, NRR, and RES exist that require routine exchange of information. To expedite the exchange of information, formalized procedures or tracking systems will be developed for the following:

- AEOD and NRR will develop a procedure to distribute event analyses to resident inspectors, project managers, regional inspectors, on a timely basis so that they may be informed about the events being analyzed at their plants.

- AEOD and NRR will formalize a procedure for routinely transmitting event analyses performed by NRR to AEOD for consideration in the ASP analysis process.

- AEOD will develop a system to track the status of events which have been identified from other sources for inclusion into the ASP analysis process.

- AEOD and NRR will formalize a procedure for sending preliminary ASP analyses to the licensees and the Regions for review. Timeliness of sending them to the licensees and receiving pertinent information for revising the analyses, if required, is of utmost importance.

- AEOD and NRR will coordinate ASP methods and model improvements.

- RES will conduct regular briefings on ASP development work to assure compatibility with user (AEOD and NRR) needs and schedules.

7. TRENDING ASP RESULTS AND RISK

Activities associated with the trending ASP results are the following:

- Compilation CCDP bin occurrence rates over time,
- Rebaselining selected ASP events to improve the year to year consistency of the estimated CCDP which may be due to model changes and plant-specific design and procedural improvements,
- Evaluation of statistical significance of trends in the annual index of ASP results,
- Development of a transformation from ASP results (CCDPs) to industry average core damage frequency, and
- Trending core damage frequency implied by ASP analyses and evaluation of related uncertainty.

These activities can be divided into two groups: (1) trending of ASP results, and (2) trending activities associated with core damage frequency. The first two bullets above are trending activities associated directly with the ASP Program. These trending activities are a meaningful part of the ASP Program and provide useful information that has high information content (i.e., we can have high confidence in the results produced by these activities) and thus will be very useful.

The activities related to the last three bullets are related to trending core damage frequency. The information produced from these activities will contain large uncertainties and, thus, will not be very useful for trending CDF. Therefore, our confidence their results will be much less than in the results of the other two trending activities.

These trending activities are summarized below.

Evaluation of Statistical Significance of Trends in the Annual Index of ASP Results

For several years, NRR has been using the numerical results of the ASP Program to construct an annual index of the risk significance of events at operating reactors. Evaluation of the stochastic uncertainty associated with this index was conducted through a contract with Brookhaven National Laboratory (BNL). The results indicate that there is a statistically significant decrease in this index from the 1970s to the 1980s. The analysis also suggests, with less statistical confidence, that the less pronounced decrease of this index during the 1980s is due to more than random variations. The interpretation of trends in this index to reveal trends in the associated level of risk has to consider the influences of the factors discussed in the next section. However, it is clear that the level of risk has decreased significantly since 1979. The staff is developing an Integrated Plan for Trending Industry Risk that will identify more effective

means for evaluating risk trends using ASP results and other PRA and reliability results and information.

Rebaselining ASP Events

The ASP Program was not designed with the intent of trending its results over time. There are several aspects of the current practices which make trend identification difficult. The most important of these practices is that events which indicate a previously unidentified risk are quantified only for the year of identification. Thus, a graph of the annual ASP data shows a "spike" shape for the year in which a long-standing problem was discovered and corrected, while the actual level of risk takes a downward step at that year. Compounding this effect is the potential for interaction between the discovered problem and earlier event quantifications, which assumed that the problem did not exist. In addition, the models used for ASP quantifications have changed over the years. The removal of excessive conservatism from these models could produce a false impression of decreasing risk. Conversely, the inclusion of a wider spectrum of events (e.g., shutdown events) in later years could mask the effects of real decreases in risk on the annual sum of the CCDPs from the ASP Program.

In order to properly depict the time-dependence of the level of risk indicated by ASP results, it will be necessary to adjust for recent findings (e.g., previously unknown plant conditions) and model changes. AEOD will initiate an effort in FY 1994 to rebaseline selected ASP events to evaluate these effects. About ten events with large CCDPs and representing a variety of scenarios will be selected for re-analysis from the period 1984 to 1991. The effect of current plant configurations and procedures, as well as other considerations, will be included in the analysis.

There also are other factors which make trend identification difficult. One factor is the sparsity of ASP events over time. In addition, there is uncertainty associated with each estimated CCDP. The Integrated Plan for Trending Industry Risk will address all of these factors and place the ASP-related trending activities in the broader context of deducing risk trends from a variety of available data.

Relationship of ASP Results to Industry Average Core Damage Frequency

RES has produced an analysis of the mathematical relationship between the conditional core damage probabilities (CCDPs) for events occurring at operating reactors and the core damage frequency (CDF) of the reactors experiencing the events. This analysis has shown that a simple sum of the CCDPs will overpredict the CDF associated with the accident sequences "sampled" by the operational events. Formulae have been developed that would allow (approximately) unbiased estimation of CDF associated with events that involve initiators (e.g., reactor trips and losses of coolant) but not for events that involve only degradation or loss of mitigation capability for initiating events that did not actually occur. These formulae require sequence-dependent correction factors to be developed and applied for each event evaluation. Corresponding formulae for estimating the confidence intervals associated with the CDF estimate have not been

completed, due to the complex nature of the dependency of the parameters involved in the CDF estimation formulae. Therefore, it is not yet known if this process would improve our confidence in the CDF estimates provided by PRAs and experience to date.

RES is planning to conduct a simplified simulation study to explore the relationship between ASP CCDPs and CDF. The study is expected to yield insights on the usefulness of various modifications of the CCDP sum for estimating CDF.

Industry Risk Trends

In light of the inherent uncertainties associated with trending risk implied by ASP events, AEOD has undertaken an initiative to characterize risk trends using a broader spectrum of reactor operating experience data. A conceptual discussion is provided in Appendix A.

APPENDIX A

A CONCEPT FOR TRENDING INDUSTRY RISK

A CONCEPT FOR TRENDING INDUSTRY RISK

The NRC has long recognized the need to have some type of an integrated measure of industry risk. Some efforts by the staff have been simple - estimating the frequency of core damage by the number of core damage accidents divided by the number of years of reactor operation. Other efforts have tried to use other sources of information such as accident sequence precursor (ASP) results or core damage frequencies from PRAs or individual plant examinations (IPEs). None of these attempts has been satisfactory, and each has brought criticisms about the use or misuse of the respective information.

The need for such an industry risk measure still exists and, thus, the need for an integrated plan for solving this problem. The initial step is to define the objectives of such an effort. The principal objective of this effort is to provide:

> ***a measure of industry risk that is as complete as possible to determine whether the risk is increasing, decreasing, or remaining constant over time.***

Figure 1 is a conceptual picture of how industry risk might be trended. It requires that plant operating experience be analyzed through a PRA framework or, at least, in a risk-based context. Plant performance can be monitored at several levels - component, train, system, safety function, accident sequence, combined plant. It can be measured using unreliability, unavailability, accident sequence frequency, containment failure probability, size of release, person rems, etc. Trends can be generated for any of these measures for a plant, for a class of plants, or for the whole industry. Thus, component availability (e.g., for emergency diesel generators, turbine-driven pumps) can be trended over time for a plant or class of plants and also across the industry. Similarly, train and system reliability can be trended for a plant or class of plants and also across the industry. A PRA framework can then be used to derive the risk implications from this information.

The top portion of Figure 1 shows different measures for trending industry risk and also different sources of risk - internal initiating events, external initiating events, and different operational conditions. Each provides additional information about risk. All of these are required to obtain a more complete risk perspective. The placement of these items also implies a phased approach for implementing them in a risk trending activity. Because the risk elements are not as well known or defined for all contributors, the integrated risk picture will be somewhat fuzzy in certain areas (e.g., external events). It may even be unknown or not addressed in some other areas (e.g., sabotage).

The short-term risk trends focus on trending characteristics of dominant accident sequences. For example, station blackout accident sequences are characterized by loss of offsite power, performance of emergency diesel generators, and performance of turbine-driven pumps. Trending these items provides an initial trend of the risk from these accident sequences. However, while component- and train-level trends might provide early indication of risk trends, care must be taken to recognize normal fluctuations in performance which do not indicate

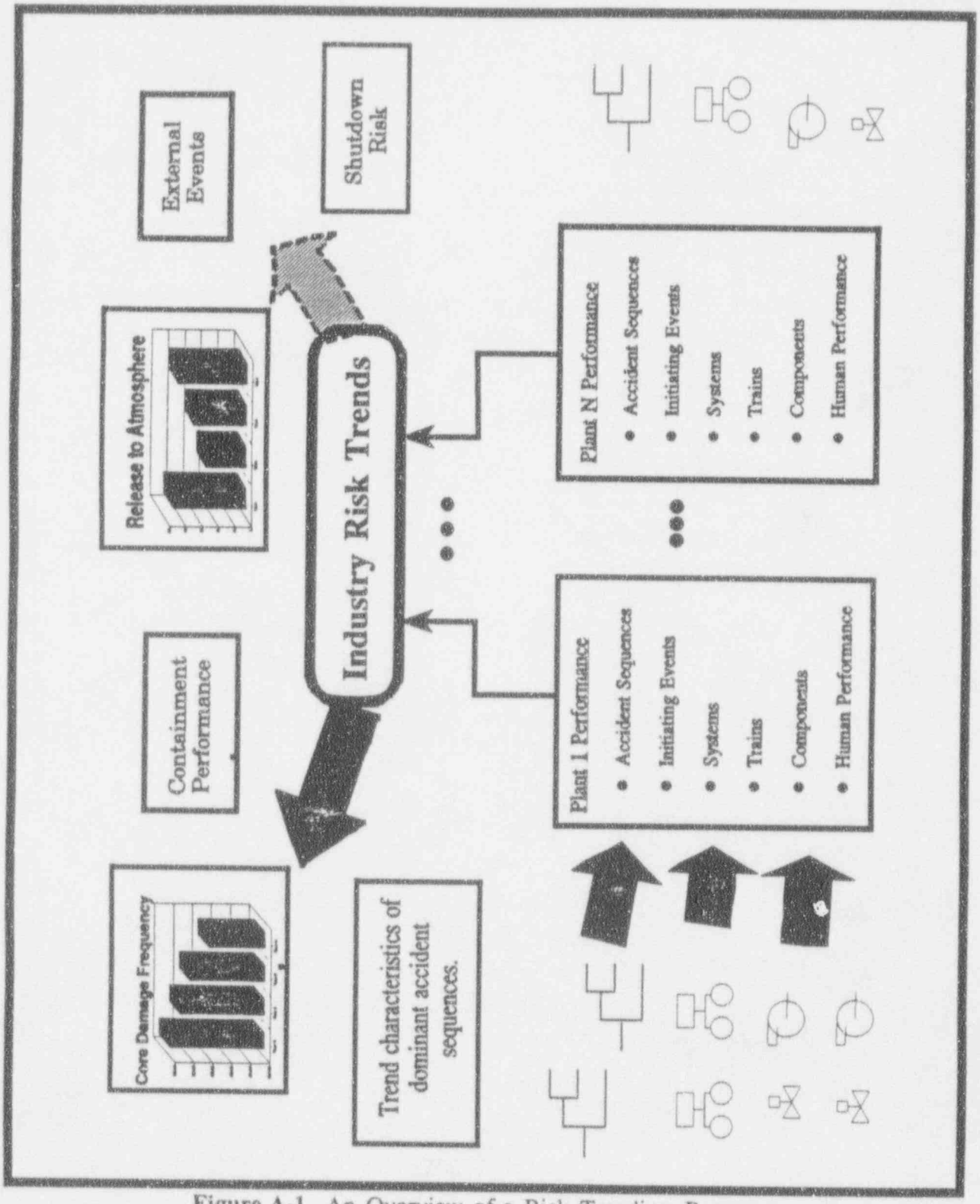

Figure A-1. An Overview of a Risk Trending Process.

substantial changes in risk by themselves.

The risk picture will be put together like building blocks or pieces of a puzzle. This will involve putting together the best current understanding of the various elements of risk, how they are changing over time, why they are changing, and the level of uncertainty associated with each element. Risk-related information and insights currently being compiled from IPEs (and later IPEEEs) will be used to construct the risk-based framework for analyzing operating experience data and evaluating significant trends.

Based upon the preceding discussion, the following subordinate objectives, related to core damage frequency, are identified:

- Trend dominant PRA accident sequences,
- Trend risk-important system performance,
- Trend risk-important component performance,
- Trend human performance, and
- Trend initiating event frequencies.

These subordinate objectives provide a realistic approach to trending industry risk.