

Engineering Technologies & Developments

PEER REVIEW of UKRAINIAN NPPs PROBABILISTIC RISK ASSESSMENT PROJECTS

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1. INTRODUCTION

1.1 THE UKRAINIAN NPPs ISA PROJECTS: OBJECTIVS, SPONSORSHIP, CONTENT, STRUCTURE, AND STATUS.

- ISA projects are being conducted at a number of Ukrainian NPPs under the National Nuclear Security Administration (NNSA, USA) sponsorship.
- The primary objective of the NNSA – sponsored projects is to help foster and further develop the safety analyses capabilities at NPPs in Ukraine and their technical support organizations, to the extent that it supports safe operation.
- Ukrainian NPPs ISA projects are part of the US DOE INSP program. An ISA project encompasses with one or more of the following safety analysis areas: Internal Events Level-1 PRA, DBA, Internal/External Hazards Analysis, and Level-2 PRA.

1. INTRODUCTION (cont.)

- In-country Peer Review is an integrated part of the ISA projects. The independent Ukrainian organization, Engineering Technologies and Developments (ET&D), is the Ukrainian Quality Assurance and Peer Review (QA/PR) Team selected by the US DOE to provide the review part for the above ISA projects.
- Type and Status of the ISA projects' in-country peer review:
 - SUIISA/ Internal Events Level-1 PRA:
off-line review, Final Review Report is completed. The review comments resolution is completed.
 - SUIISA/ DBA:
off-line review, the review is nearly completed.

1. INTRODUCTION (cont.)

- ZISA/ Internal Events Level-1 PRA:
off-line review, Top Level Review Report is completed.
- RIVISA/ Internal Events Level-1 PRA:
off-line review, Top Level Review is in progress.
- RIVISA/ DBA:
off-line review, Top Level Review is in progress.
- KhISA/ Data Bases:
off-line, In-depth Review. Contractual negotiations are in progress.

1. INTRODUCTION (cont.)

■ The Peer Review Major Objectives:

- ensure that the current PRA/DBA would provide an adequate basis for the SAR of the plant under consideration, and
- recommend improvements that could enhance the PRA if it is used for risk management applications in the future.

2. PEER REVIEW PROJECTS: FUNDING & ORGANIZATIONS

- Funding is being provided by the U.S. Department of Energy (US DOE).
- Technical work is being provided by ET&D under a contract with Pacific Northwest National Laboratory (PNNL).
- Technical Cognizance by Brookhaven National Laboratory (BNL).
- Close cooperation with German Reactor Safety organization GRS (focused review of selected IE/AS/some specific aspects of the SUSA PRA, under a separate domestic contract).
- Close cooperation with NPPs.

3. MAIN STEPS OF A PEER REVIEW PROCESS (taking a PRA product as an example)

- Review the PRA Procedure Guidelines and develop review methods to be applied. Prepare Review Plan (RP).
- Conduct Top Level Review of the PRA product. Determine to what extent the PRA can usefully be further examined and update the RP.
- Conduct In-Depth Review:
 - detailed review of selected PRA elements
 - “Vertical Slice” approach

3. MAIN STEPS OF A PEER REVIEW PROCESS (cont.)

3.1 TOP LEVEL REVIEW

- Top Level Review is concerned with formal aspects of the PRA element of interest. The Top Level Review surveys the apparent completeness of the deliverable, its scrutability, and determines to what extent the deliverable can usefully be further examined.

3.2 IN-DEPTH REVIEW

- In-Depth Review is an extensive qualitative examination of the PRA, followed by some quantification tasks, selected and applied in a natural logical sequence. Scope and extent of in-depth review for each of the PRA element vary depending upon conclusions of Top Level Review.

4. BASIC SET OF EVALUATION CRITERIA

- The basic set of Evaluation Criteria for In-Depth Review is:
 - modeling adequacy (the validity of the assumptions, limitations, models and analyses used in the PRA),
 - input data adequacy,
 - adequacy of quantification technique, and
 - reasonableness of results (the validity of the qualitative and quantitative conclusions obtained in the PRA).

5. THE «VERTICAL SLICE» APPROACH

- The «vertical slice» is a part of overall In-Depth Review process and it is applied at the final stage of the PRA review.
- The «vertical slice» provides a consistent and integrated framework for qualitative and quantitative examination of some selected issues arisen from detailed consideration of:
 - dominant contributors to CDF of the plant of interest
 - the most important insights gained from a similar plant PRA, and
 - the most important findings derived from the previous steps of the PRA's in-depth review.

5. THE «VERTICAL SLICE» APPROACH (cont.)

- The objective, scope and extent of a «vertical slice» depend upon the nature of the issue under examination. The following two types of «vertical slice» might be applied for a PRA peer-review:
 - full-scope «vertical slice», and
 - limited-scope «vertical slice».

5. THE «VERTICAL SLICE» APPROACH (cont.)

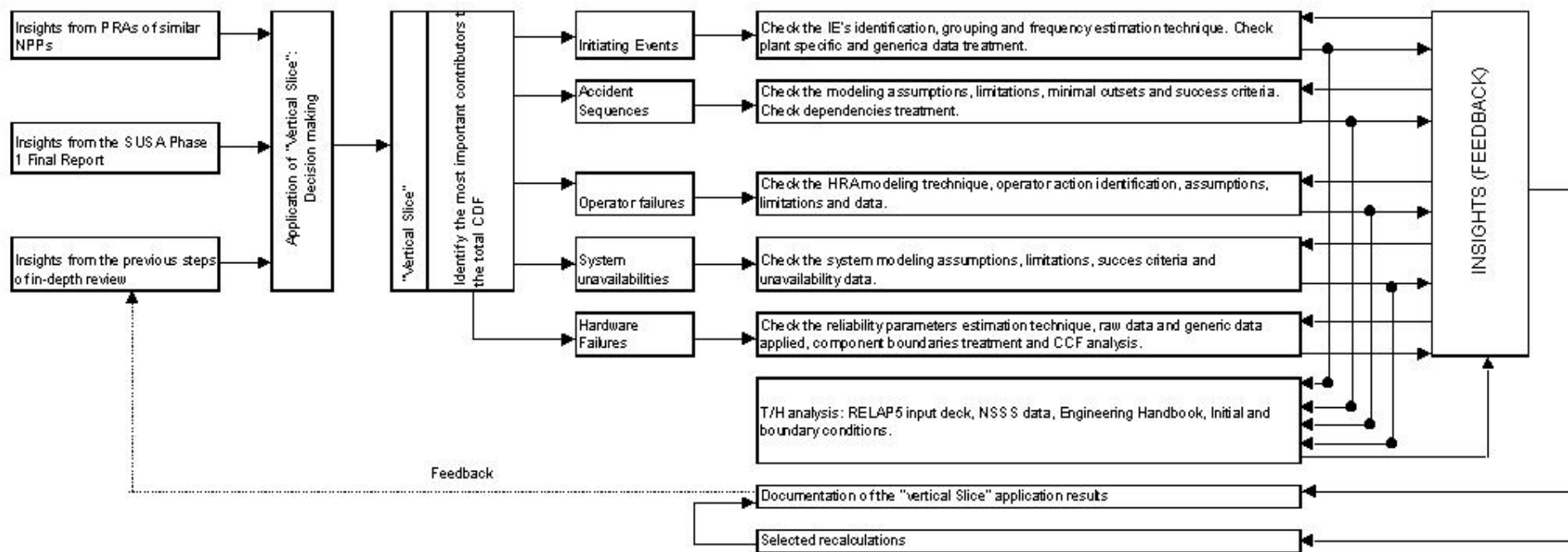


Fig. 1 “Vertical slice” Process Flow Chart

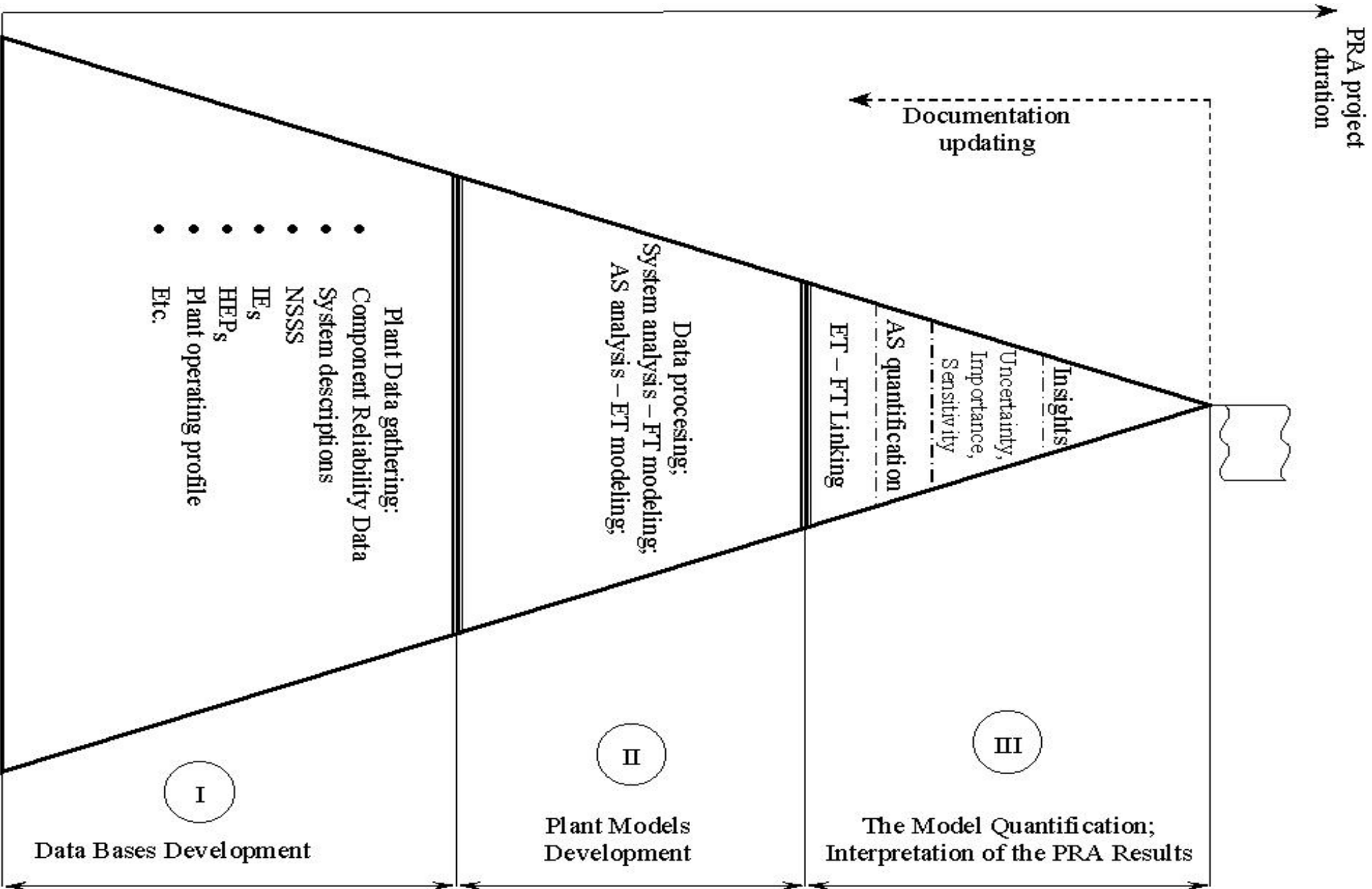


Fig. 2. Simplified “anatomy” of a PRA

6. PRA REVIEW COMMENT RESOLUTION

6.1 List of unresolved comments: prospective origins of the comments and their categorization

- List of unresolved comments is a natural output of any peer review process. Below are listed some prospective reasons for arising of an unresolved comment:
 - Misunderstanding
 - Discrepancies in terms and notions
 - Differences in expertise
 - Peculiarities of NPP licensing practice (SAR requirements)
 - The PRA project's programmatic constrains (i.e. timing-funding limitations, ultimately leading to limitation in scope of the PRA and/or simplification of methodology applied).

6. PRA REVIEW COMMENT RESOLUTION (cont.)

- List of unresolved comments could be sub-divided in to two main groups:
 - The comments, that potentially impact the quantitative PRA results, and
 - The comments, that potentially impact the qualitative PRA results.
- Resolution of qualitative issues, though important, is often a matter of professional judgement. Thus, a qualitative issue may not be readily resolved comparing with a quantitative issue.

6. PRA REVIEW COMMENT RESOLUTION (cont.)

6.2 An approach for resolution of a comment that potentially impacts the quantitative PRA results (organizational part)

- The approach presented below had been developed by Mr. Chet Everline of “Sciencetech” Inc. (USA) specifically for the SUIA PRA Review Comment Resolution Meeting (CRM) convened at the request of the SU NPP plant management (March 11 - 16, 2002, SUNPP).
- The purpose of the CRM was to transfer technology which would enable SUNPP to judge the impact of in-country peer review comments and expedite their ultimate resolution.

6. PRA REVIEW COMMENT RESOLUTION (cont.)

- The approach has successfully been applied during the CRM by several Working Groups composed of representatives of the SU NPP, Energorisk (the SUIA PRA developer), and ET&D. The USA Technical Advisors attended the workshop in order to facilitate and coordinate technical efforts needed.
- The approach has been applied through a set of quantitative technical studies conducted by the Working Groups in order to evaluate the importance of several comments. Resolution of a comment includes (among the others) some recommendations on how to improve the PRA product, especially if the PRA is to be used for risk management purposes.

6. PRA REVIEW COMMENT RESOLUTION (cont.)

6.3 An approach for resolution of a comment that potentially impacts the quantitative PRA results (technical part)

- A top down comment resolution approach is proposed, predicated upon a hierarchy of five unresolved comment classifications:

- 1 scope;
- 2 methodology;
- 3 modeling;
- 4 other issues; and
- 5 low impact issues.

The proposed hierarchy is intended to address the potential magnitude of impact an issue can have on the PRA results.

6. PRA REVIEW COMMENT RESOLUTION (cont.)

■ Scope Issues:

- Issues pertaining to scope could imply that some potentially important contributors to risk were excluded from consideration.
- In order to ensure that the overall risk profile is adequately represented, significant additional analyses (outside of the present scope) may be required.

6. PRA REVIEW COMMENT RESOLUTION (cont.)

■ Methodology Issues:

- Methodology issues can impact the fundamental techniques used to quantify risk.
- If a method is incorrect, appreciable revisions to the PRA may be needed to produce a satisfactory risk profile.

■ Modeling Issues:

- Modeling issues tend to be more limited than scope and methodology issues, generally focusing on relatively detailed aspects of the PRA.

6. PRA REVIEW COMMENT RESOLUTION (cont.)

■ Other Issues:

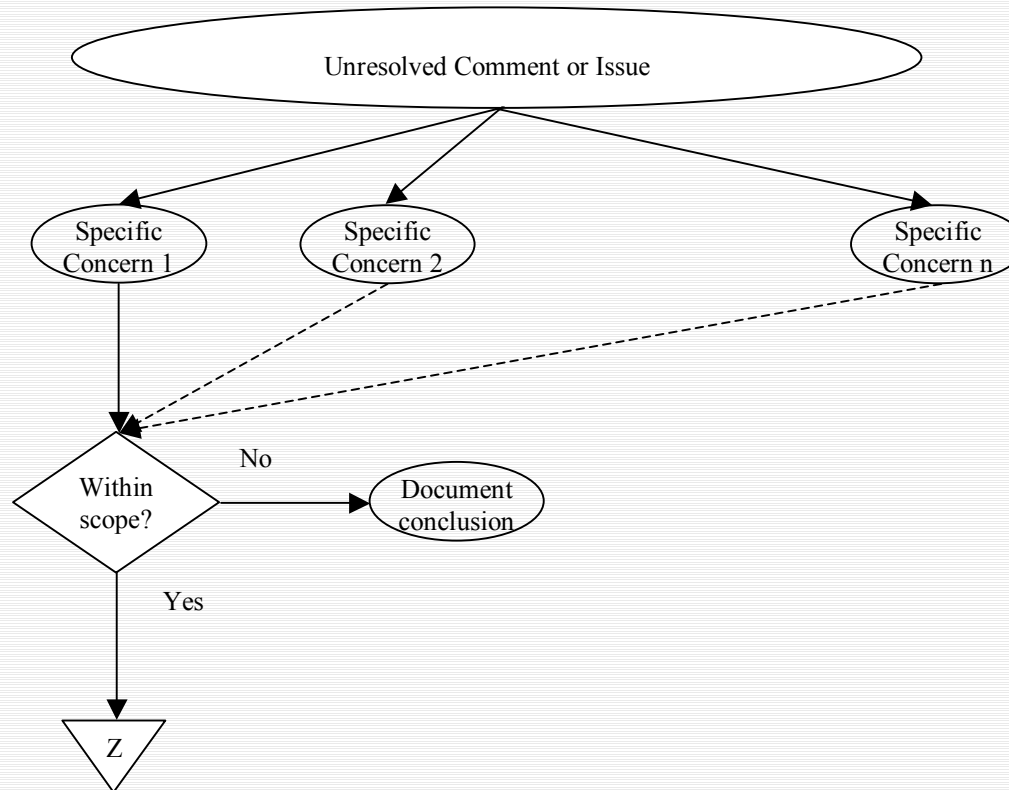
- Some issues that could appreciably impact the PRA may be excluded from this initial listing (e.g., QA or qualitative issues).
- Assigning such issues to the "other issues" category during the CRM will permit them to be considered at a later time.

■ Low Impact Issues:

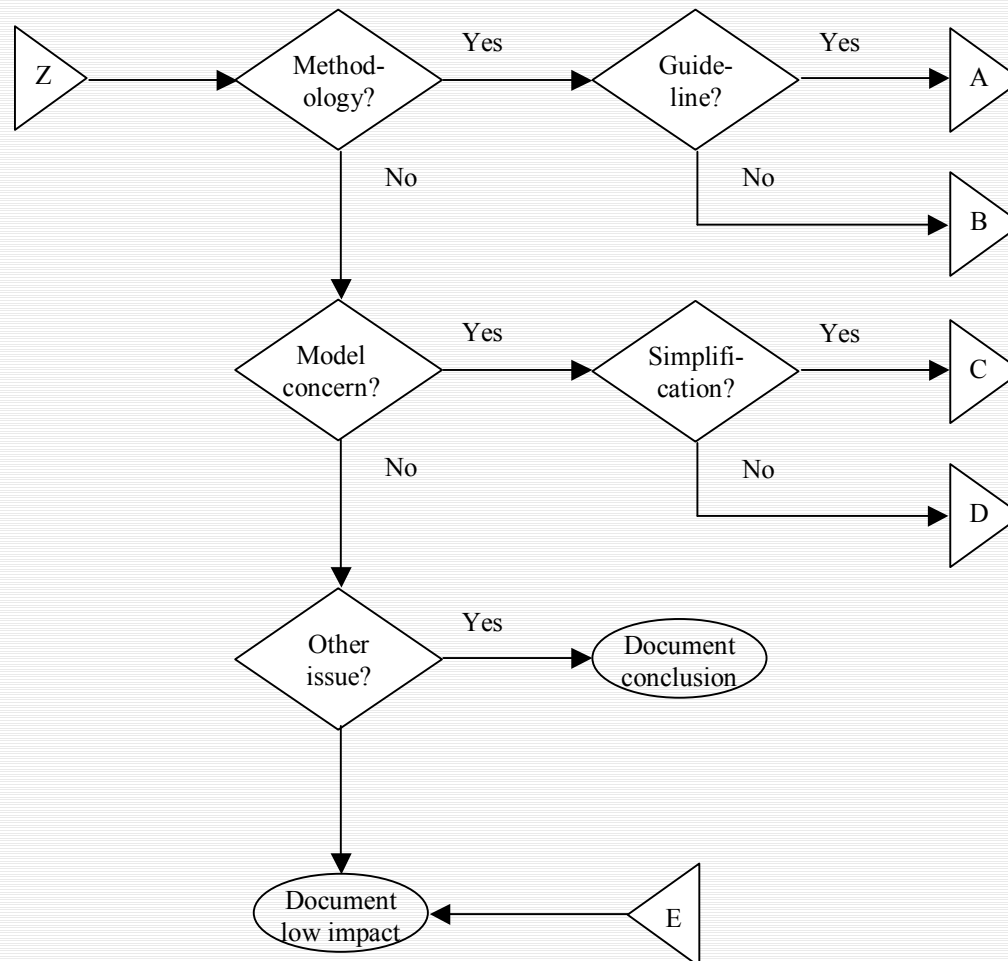
- Any issues that do not belong to one of the other four categories will have a negligible impact on the PRA.
- Such issues are assigned to the lowest hierarchical category.

6. PRA REVIEW COMMENT RESOLUTION (cont.)

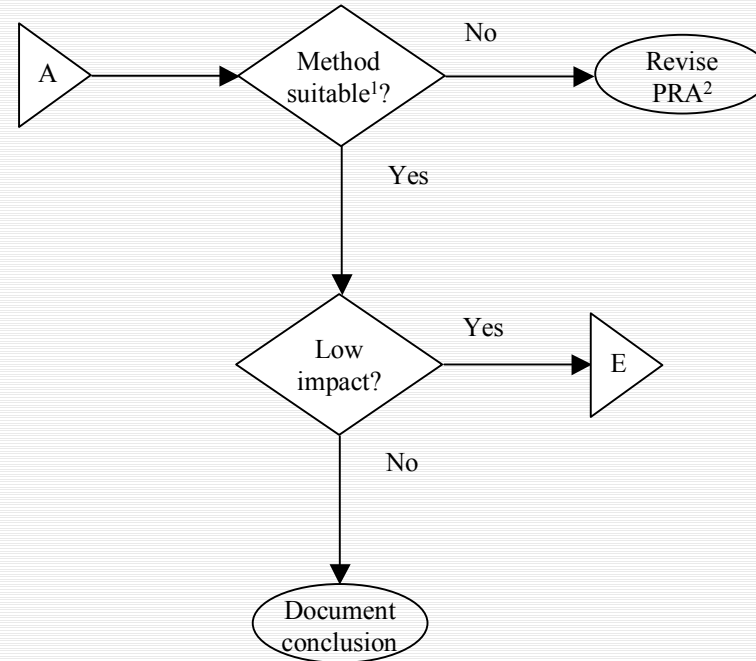
6.4 Comment Resolution Flowchart



6. PRA REVIEW COMMENT RESOLUTION (cont.)



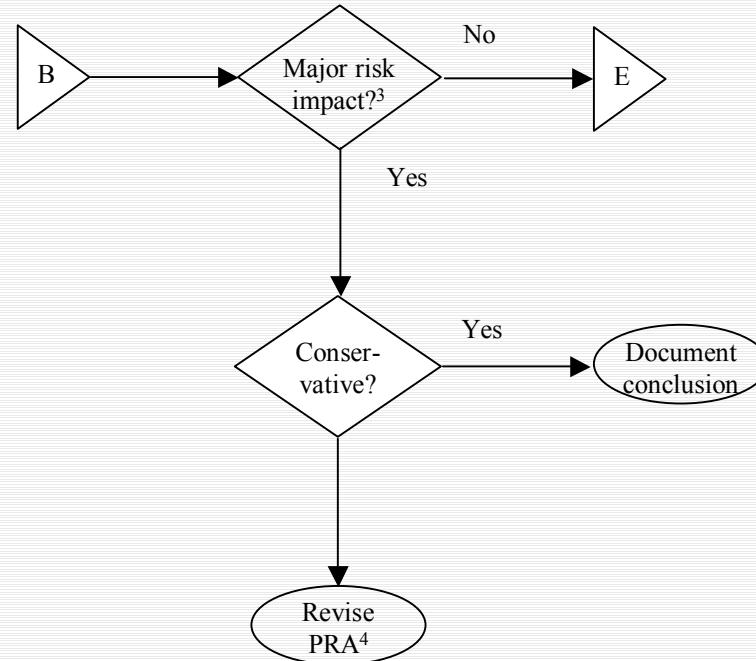
6. PRA REVIEW COMMENT RESOLUTION (cont.)



Legend

1. Guideline methods are considered suitable if they have been satisfactorily applied to similar situations in other PRAs, or if they are conservative.
2. Revising the PRA if a guideline is in error requires:
 - correcting the methodology;
 - applying the corrected methodology to the PRA model; and
 - quantifying the risk.

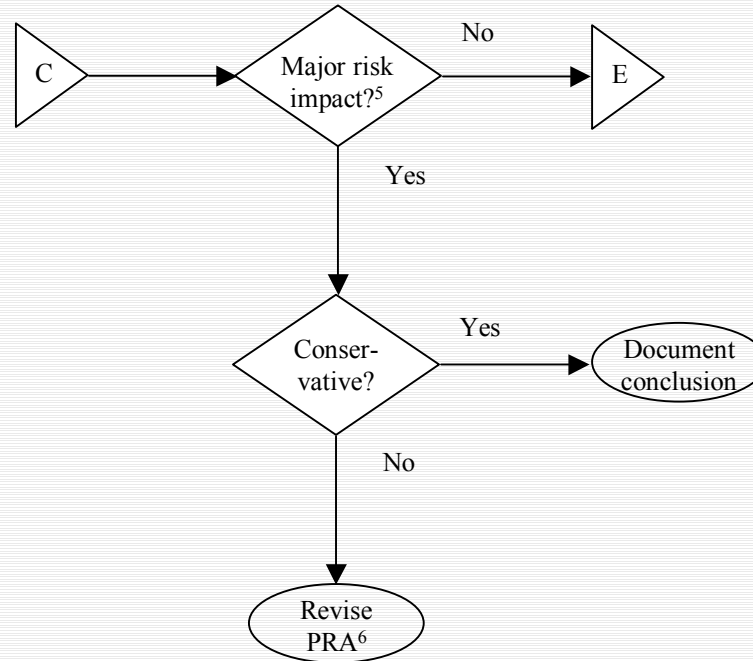
6. PRA REVIEW COMMENT RESOLUTION (cont.)



Legend

3. The impact is not considered major if the risk metrics reported in the PRA change by less than the reported uncertainty factors.
4. Revising the PRA if a guideline is incorrectly applied requires:
- applying the methodology established by the project guideline; and
 - quantifying the risk.

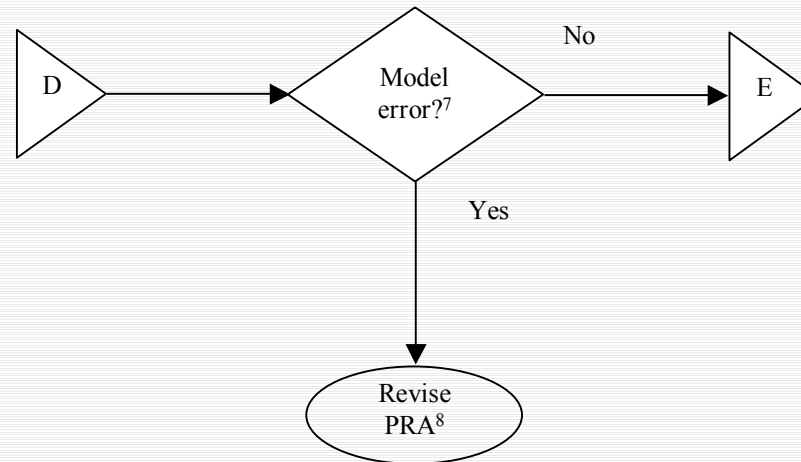
6. PRA REVIEW COMMENT RESOLUTION (cont.)



Legend

5. The impact is not considered major if the risk metrics reported in the PRA change by less than the reported uncertainty factors.
6. Revising the PRA if an inappropriate simplification occurs requires:
- correcting the simplification; and
 - quantifying the risk.

6. PRA REVIEW COMMENT RESOLUTION (cont.)



Legend

7. A modeling error exists when the PRA model differs from the current configuration or operation of the plant.

8. Revising the PRA if a modeling error exists requires:

- correcting the error; and
- quantifying the risk.

7. AN OVERVIEW OF PRA REVIEW CONSIDERATIONS

■ Plant Data gathering:

- No major problem has been revealed so far by the PR team for this particular PRA task.
- This PRA task is one of the most time - and resource - consuming one and it is being done mostly at the site, with extensive involvement of the plant personnel.
- This PRA task provides a good basis for establishing at the plant of a “state-of-the-art” MULTIPURPOSE SYSTEM for Component Reliability Data & Abnormal Events/ Incidents Data gathering and processing.

7. AN OVERVIEW OF PRA REVIEW CONSIDERATIONS (cont.)

■ Data processing:

- Some data processing problems were revealed in those cases where IE frequency is estimated based upon FT technique (e.g. ignoring the plant-specific data while assigning a basic event probability, ignoring CCFs and prospective pre-accident HEs, etc.). Ultimately this led to the fact, that some IEs are erroneously screened out by the “IE Frequency Screening Value” applied.
- Another type of data processing problems is originated from inadequate treatment of a component boundaries established. This resulted in underestimation of failure probabilities for some safety-related pumps and motor operated valves (MOVs).

7. AN OVERVIEW OF PRA REVIEW CONSIDERATIONS (cont.)

■ Plant model development:

- In some cases an excessive simplification (which is sometimes quite conservative by nature, sometimes non-conservative one) of the plant model resulted in compromising of existing inter-system dependencies and/or man-machine interactions (so called “AS #1 problem”).
- Ignoring of some important plant specific design features/plant specific response features.
- Ignoring of some important secondary effects (secondary phenomena) imposed by specific IE.
- CCF modeling adequacy.
- Some of the modeling issues (primarily those related to HRA) are resulted from ambiguity of the plant normal and (or) emergency operating procedures.

7. AN OVERVIEW OF PRA REVIEW CONSIDERATIONS (cont.)

■ The model Quantification. Uncertainty, Importance, and Sensitivity analyses:

- Some cumulative quantification errors are, in fact, originated from those specific errors which were committed at the earlier stages of the PRA (e.g., wrong failure probability, wrong plant response model, etc.). Some other quantification errors are being arisen directly within the framework of the “AS Quantification” task.
- Errors, related to incomplete and (or) incorrect application of methodology for some Preliminary Quantification Sub-tasks. This led to the fact, that some potentially important insights were lost at the very beginning of the overall quantification process.

7. AN OVERVIEW OF PRA REVIEW CONSIDERATIONS (cont.)

- Inadequacy in selecting and treating of “truncation value” applied for both the preliminary and final quantification.
- Sensitivity analysis: the main objective of a sensitivity study is to assess how the PRA qualitative and quantitative results sensitive to the assumptions and limitations undertaken. Though there are considerable amount of assumptions and limitations either declared or actually undertaken in the PRA study, only a few of them are specifically addressed in framework of the “Sensitivity Analysis” task.