

**PROCEDURE FOR DECISION ANALYSIS
FOR EVALUATING THE SCC CLARIFICATION ALTERNATIVES**

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1. PURPOSE

The purpose of this procedure is to describe decision analysis methods for evaluating the "substantially complete containment" (SCC) clarification alternatives. The procedure involves analyzing the decision by attributes and ranking decision alternatives against weighted attributes and each other. It should be emphasized that the purpose of this decision analysis process is not to reach a consensus (although that would be a desirable result), but to systematically retrieve, organize, and present data representing various NRC perspectives to senior NRC management for consideration in choosing an appropriate alternative for clarification of "substantially complete containment."

2. BACKGROUND

Decision analysis techniques are used when decisions must be made for complex problems for which simple comparison of or ranking of alternatives cannot be readily done to reach a decision. Examples of problems for which decision analysis is appropriate are many, and they include those for which several objectives and many attributes exist, those for which conflicting objectives exist, and those requiring input from several people or groups whose objectives may conflict.

In decision analysis, a basic step is to assess various alternatives with respect to how well each meets an objective or set of objectives. Alternatives can be assessed with respect to one another in two basic ways: assessing each alternative according to a common scale and ranking by comparison of an alternative to each of the others. In cases where a common scale does not exist for all the alternatives, ranking should be done by comparison. When ranking by comparison, a mathematical consistency check can be made. Ranking by comparison has one disadvantage compared with assessment according to a common scale. When ranking by comparison, if all alternatives rate equally well (or equally poorly) as to meeting an objective, the degree to which an alternative meets the objective is not apparent from the relative ranking. Therefore, assessment according to a common scale will be done except in cases where a common scale does not exist for all the alternatives.

Two documents which have been used as guidelines for the development of this procedure are listed below.

- NRC NUREG/CR-3447: Research Prioritization Using the Analytical Hierarchy Process, August 1983, and
- CNWRA Technical Operating Procedure: TOP-015, Procedure for Decision Analysis, June 1990.

These guidelines have been amended and altered with subtle variations unique to the specific application. The resultant procedure presented here is intended as a specific guideline.

Many techniques are available to the decision-maker for special cases, and these may be found in the references cited below.

- Bonano, E. J., et al, NUREG/CR-5411, "Elicitation and Use of Expert Judgment in Performance Assessment for High-Level Radioactive Waste Repositories," Sandia National Laboratories, 1990.
- Trueman, R. E., An Introduction to Quantitative Methods for Decision Making, Holt Rinehart Winston, 1974.
- Keeney, R. L., Siting Energy Facilities, Academic Press, 1980.
- Keeney, R. L., and Raiffa, H., Decisions with Multiple Objectives, John Wiley, 1976.
- Saaty, T. L., The Analytic Hierarchy Process, McGraw-Hill, 1980.

3. RESPONSIBILITY

- 3.1 The decision analysis process will be conducted by a NRC-selected coordinator/elicitor and a NRC-selected panel. The Center for Nuclear Waste Regulatory Analyses (CNWRA or Center) will initially work with the coordinator/elicitor and the panel to ensure that all the necessary objectives and the associated attributes are covered. Also, the level and detailed description of each attribute will be examined for the purposes of clarity. The panel of participants will have input to review draft objectives and associated attributes, after which the Center, in conjunction with the coordinator/elicitor, will issue a report with the revised objectives and associated attributes.

The recorder for elicitation sessions will be provided by the Center, while the coordinator/elicitor will conduct the sessions. Once the panel has completed its deliberations, the Center will assist the NRC in the analysis of the data and participate in a presentation to NRC senior management at the end of the decision analysis activity.

- 3.2 Key personnel acting as organizational contacts are:

| | | |
|-------------------------------|---------------------|----------------|
| NRC Technical Lead | Dr. Lee Abramson | (301) 492-3949 |
| NRC Program Element Manager | Dr. Jerome Pearring | (301) 492-0508 |
| CNWRA Principal Investigator | Dr. Prasad Nair | (512) 522-5150 |
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4. DEFINITIONS

4.1 Basic Information

- 4.1.1 Decision Alternatives -- Decision alternatives are the choices available to the decision maker as possible outcomes for a candidate.
- 4.1.2 Decision Objectives -- Decision objectives are the goals of the decision. A decision may be based on one or more objectives. An objective has two characteristics: it identifies a concern about alternatives and it allows for the expression of preference, or choices among alternatives.
- 4.1.3 Attributes -- Attributes are salient characteristics of the alternatives which provide measures of the extent to which a decision objective would be met by choosing an alternative. Each alternative is ranked according to how well it facilitates the attribute. When ranking to a common scale, an attribute has an associated scale which may be natural or constructed.

4.2 Process-Related Information

- 4.2.1 Consistency Check -- A consistency check is a method for evaluating the results of the decision analysis in order to assure that the analysis is both repeatable and verifiable.
- 4.2.2 Decision Analysis -- Decision analysis is a systematic and logical procedure for rational analysis of complex decision problems.
- 4.2.3 Elicitation -- In the use of expert judgment, an elicitor assists the expert in expressing judgments and rationales during elicitation.
- 4.2.4 Expert Judgment -- Expert judgment is judgment expressed by an individual whose credentials qualify her or him as an expert or authority on the given subject.
- 4.2.5 Objectives Hierarchy -- An objectives hierarchy links objectives and attributes by their relative primacy and their relationship to each other.
- 4.2.6 Rank -- Rank is the extent to which an attribute applies to an alternative. The rank of an alternative against an attribute will be reflected in the scale associated with that attribute. Ranking is the act of assigning a rank to an alternative for a specific attribute. During the consistency check, attributes are ranked in order of importance or degree of application to each alternative.

- 4.2.7 Scale -- A scale is used when alternatives are ranked against attributes. There are two types of scales: "natural" scales (which exhibit common use and meaning) and constructed scales (which are developed to address a specific attribute or problem for which no natural scale exists). For example, the attribute of "cost" has a natural scale of dollars, while the attribute of "environmental damage" would use a constructed scale which would index relative damage by assigning numerical values ranging from "no damage" to "severe damage."
- 4.2.8 Sensitivity Analysis -- Sensitivity analysis is an investigation of the decision. This investigation is made by systematically changing relative weights assigned to the attributes and comparing variations in the results of the decision analysis. A sensitivity analysis is used to determine the relative influence which an attribute or specific objective has on the final result of the decision analysis. For a sensitivity analysis, the weights assigned to attributes must be relative, and the total sum of the weights must not vary.
- 4.2.9 Weight -- The weight assigned to an attribute indicates the relative importance of that attribute to the decision maker. Different attributes may be weighted differently or have different degrees of importance to the decision maker. For example, one attribute may be three times as important to the decision maker as another attribute, which may in turn be only half as important as another attribute. Weighting is the act of assigning weights to attributes. For the purpose of evaluating the SCC clarification alternatives, weighting will be done individually by participants by pairwise comparison of objectives and pairwise comparison of attributes.

4.3 Participants-Related Information

- 4.3.1 Decision Analyst -- A decision analyst is an individual performing the decision analysis, who provides documentation of both the method and the decision process. A decision maker may use the assistance of decision analysts or may function individually as a decision analyst.
- 4.3.2 Decision Maker -- The decision maker is the individual or organization responsible for the decision in question: the one making the actual decision.
- 4.3.3 Elicitor -- An elicitor is the individual who presents the process of the decision analysis to an expert or a panel convened for input to the decision and then elicits appropriate responses from the expert or panel

for use in the decision analysis. The elicitation of responses from the panel must be done without bias to the extent practical, and, as a result, it is preferable that the elicitor have training in such a process.

- 4.3.4 Normative Expert -- A normative expert is one who is familiar with the substance of the decision being made as well as with the techniques of decision analysis and with theories and concepts of probability.
- 4.3.5 Panel -- A panel is a group of individuals chosen to participate in the decision analysis and from whom responses are elicited for the purpose of ranking.
- 4.3.6 Recorder or Secretary -- The recorder or secretary is an individual who records elicited responses from a panel. By use of a recorder, the elicitor is not burdened with such recording, and the process of elicitation is often made more efficient as a result.

5. THE DECISION ANALYSIS PROCESS

5.1 Basic Features, Steps, and Options in the Process

The following outline gives the basic steps in the decision analysis for evaluating the SCC clarification alternatives.

OUTLINE OF STEPS TO BE USED IN THE DECISION ANALYSIS PROCESS

1. Define the general decision analysis process
2. Select the panel members
3. Introduce the panel to the problem
 - a. Distribution of background material (reports, etc.)
 - b. Distribution of draft objectives and attributes
4. Initial meeting of panel (November 19, 1990)
 - a. Technical briefing on background
 - b. Decision alternatives
 - c. Overview of the decision analysis procedure
 - i. Agreement on overall goals
 - ii. General steps in the procedure
 - A. Panelists rank alternatives as to how well they meet each attribute
 - B. Panelists weigh of objectives and attributes with respect to importance
 - C. Object is to get input, not necessarily consensus
 - d. Panel discussion and critique of objectives and attributes
 - i. Ground rules defined
 - ii. Develop revised objectives and attributes (if necessary)
5. Panel to receive and study procedure
6. Second meeting of panel (December 6, 1990)
 - a. Train panel on procedure for the particular decision analysis exercise
 - b. Description of elicitation details

- i. Compare objectives with respect to (w.r.t.) one another and describe rationale for the selected ranking
 - ii. Compare attributes w.r.t. meeting each objective and describe rationale for the selected ranking
 - iii. Assess each alternative w.r.t. how well it meets a specific attribute
 - A. Assess according to 0-10 scale
 - B. Describe rationale for the assessments
 - C. Review ranking of the alternatives to check consistency
 - D. Revise assessments according to scale and rationales, if desired
 - E. Do not bias assessments because objective or attribute is not considered important, as this information is captured separately when objectives and attributes are separately weighted
7. Elicitation of individual panel members (December 7-14, 1990)
 8. Analyses of elicitations
 9. Third meeting of panel (January 7, 1991)
 - a. Feedback of results to panel
 - b. Opportunity for change of opinion
 - c. Determine need for re-elicitation (secret ballot)
 10. Re-elicitations (if necessary)
 11. Analyses of elicitations, including feedback from third meeting (and re-elicitations, if necessary)
 12. Report of results

5.2 Discussion of Unique Features of the Procedure

This procedure uses features of decision analysis theory in a way intended to maximize benefit to the decision-maker. Ranking to a common scale is used wherever possible, since the mathematical manipulations required during analysis are more intuitive and simpler, and more information can be obtained than for ranking by comparison. On the other hand, pairwise comparison is used to advantage when a common scale is not possible to construct, as, for example, when comparing objectives and attributes to obtain weighting factors for each.

5.3 Group Elicitation and Analysis

When a panel of participants is convened for decision analysis, pressure to conform and other group dynamics must be contended with. For this procedure, the group is first convened to come to agreement on ground rules, objectives, and attributes and for orientation on the problem. After that, the first round of elicitation is done individually so that effects of group dynamics are avoided. When results from the first round of elicitation are presented, the panel again convenes as a group and individuals are allowed to alter their first round judgments. If, after results from the second round are tabulated and they indicate no consensus, a decision is made by secret ballot of participants whether or not to re-elicite judgments individually before preparing the final report of results.

6. ELICITATION TRAINING AND ELICITATION

The purpose of elicitation training is to help the participants learn how to encode their knowledge and beliefs into quantitative forms. Elicitation training can significantly improve the quality of the participants' assessments by avoiding psychological pitfalls which can lead to biased and/or overconfident assessments. It is useful to schedule the training session early in the decision analysis process, e.g., immediately following the selection of issues and participants. The training should be carried out by a substantive expert who is knowledgeable about the issues to be assessed and a normative expert who is knowledgeable about decision theory and the practice of probability elicitation.

The elicitation sessions should be held as soon as possible following the discussion of issue analyses and the selection of elicitation variables such as objectives and attributes. An elicitation team should meet separately with each expert, to avoid pressure to conform and other group dynamics interactions which might occur if the expert judgments were elicited in a group setting.

The elicitation team should consist of a substantive expert, a normative expert, and a recorder. It is also useful to add as a fourth member the person who will prepare the final documentation. Individuals may perform more than one function to reduce the number of participants. For example, the normative expert or the recorder may also be familiar with the substance of the decision to double as a substantive expert, and the recorder and normative expert may team to prepare the final documentation.

After elicitation and documentation, the results of the decision analysis should be presented to the panel of participants as a group, at which time each may change any decisions previously made. If the results produced from this second round do not indicate a choice or if they appear inconsistent, a second elicitation may be appropriate. In some cases, a consensus may not be reached even after the second elicitation, in which case the results should be presented to the decision-maker as a complete set of information upon which to base the decision. In such cases, the rationales presented by the participants may influence the decision as much as the results of the decision analysis.

7. DEFINING THE PROBLEM AND ALTERNATIVE SOLUTIONS/CHOICES

The problem for which a decision is required should be stated clearly and concisely, so that all who are involved in the decision analysis process are equally and fully aware of the problem. The alternatives which may be chosen should be equally clear and concise when presented to the persons who will rank them. In some cases a large number of alternatives are available, with slight variations for each of several principle alternatives. It is not necessary to list all possible alternatives, but the principle alternatives, those for which clear differences in results are apparent, should be included. This will assure that the spectrum of alternatives is covered without burdening the process with excess effort.

8. DEFINING OBJECTIVES

The goal of the decision is to meet one or more objectives by virtue of choosing an alternative. Each objective should be clearly stated and as independent as possible of the other objectives. Meeting one objective should not necessarily equate to meeting another objective.

9. DEFINING ATTRIBUTES ASSOCIATED WITH OBJECTIVES

For each objective, one or more attributes may be stated which connect the objective to the alternatives. Attributes should be written to clearly bring out particular facets of an objective with respect to the alternatives. As such, the set of attributes for a given objective should be as complete as possible without repetition. If two attributes express essentially the same aspect, then that aspect intrinsically receives an inadvertent additional weighting and the decision analysis process may be adversely affected.

10. CONSTRUCTING SCALES

When assessing to a common scale, it is best to use a "natural" scale whenever possible, since such a scale by definition has a common use and meaning (e.g., dollars, time, etc.). Scales should have the same relative direction for all attributes, so that a high assessment is understood as an assessment of how well an alternative meets the attribute and a low assessment is understood as an assessment of how poorly the alternative fares.

When a "natural" scale is unavailable, a scale must be constructed to index relative value ranging from an indication of "none" to "maximum." For the purpose of evaluating the SCC clarification alternatives, a scale of 0-10 will be used to assess alternatives.

When ranking the objectives and attributes by comparison, to index relative value ranging from an indication of "equal importance" between two choices to "absolute importance" of one choice over another, the scale of relative importance shown in Table I should be used.

TABLE I

Scale of Relative Importance

| <u>Intensity of Relative Importance</u> | <u>Definition</u> | <u>Explanation</u> |
|---|--|---|
| 1 | Equal importance | Two activities contribute equally to the objective |
| 3 | Weak importance of one over another | Experience and judgment slightly favor one activity over another |
| 5 | Essential or strong importance | Experience and judgment strongly favor one activity over another |
| 7 | Demonstrated importance | An activity is strongly favored, and its dominance is demonstrated in practice |
| 9 | Absolute importance | The evidence favoring one activity over another is of the highest possible order of affirmation |
| 2,4,6,8 | Intermediate values between the two adjacent judgments | Use when compromise is needed |

11. RANKING

Before ranking, it is very important that each individual participant asked to perform the ranking have a common understanding of the objectives, alternatives, attributes, and ranking scales. Before assessing alternatives, each participant will be asked to make pairwise comparisons of the objectives as well as the attributes associated with each objective in order of preference. The results will be used to weight objectives, and attributes by degree of importance. When assessing alternatives, each alternative should be judged only with respect to how well it correlates with the attribute of interest. How well it correlates with other attributes must be excluded, and participants' biases for or against the attribute and its associated objective should not enter into the assessment of alternatives. The participants will have had an opportunity to judge each attribute and objective separately before alternatives are assessed.

It should be noted that each participant's judgments will be questioned during the elicitation process, to ensure that the response recorded accurately portrays the participant's opinions.

11.1 Assessing to a Common Scale

Each alternative should be assessed individually to indicate the judgment of how well it meets each individual attribute. Ideally the common scale would be "natural," to avoid error in interpreting the scale. Since a scale is to be constructed, it will be based on a scale of 0 ("none") to 10 ("maximum"). When assessing to a common scale has been completed, a check for consistency will be done by arranging the alternatives in order of preference along with the ranking of each, to see if re-assessment is in order to most accurately reflect the participant's judgment. Rationales for decisions should be recorded by the recorder at the time the assessment is done.

For three of the objectives, attributes are categorized by time of importance; that is, attributes are classified as either pertinent prior to submittal of the license application or after submittal of the license application (see Attachment A). Participants will be asked to directly weight the importance of each of these two time periods with respect to each objective (e.g., pre-submittal = 0.6 and after submittal = 0.4). This will provide an additional measure of weighting which will be reported with the results of the analysis. Ranking by comparison is not used here for the case when only 2 items are to be compared since the mathematics in such a case does not allow sufficiently fine distinctions.

11.2 Ranking by Comparison

Each objective should be compared in a pairwise fashion to each other objective individually to indicate the judgment of how it compares to each of the other objectives in meeting the goals. The same process should next be used for comparing attributes to one another. The results will be used to weight objectives and attributes by degree of importance. Consider the following hypothetical ranking of objectives as an example. For the given four objectives, 'A', 'B', 'C' and 'D', 'A' and 'B' may be considered equally important to a participant, but 'A' may have strong importance when compared to 'C', 'A' may be considered absolutely more important than 'D'. Additionally, 'B' may have demonstrated importance when compared to 'C' and 'B' may be considered slightly favored (weak importance in Table I) over 'D'. Finally, 'D' may be considered slightly favored over 'C'.

Using the scale of relative importance in Table I, the relative importance assigned to each of 'A', 'B', 'C' and 'D' are given in the following example Table II, where the comparisons are done in terms of which element dominates, expressed as an integer. If element I dominates over element J, then the dominance integer is entered in row I and column J, and the reciprocal is entered in row J and column I.

TABLE II

Examp1 ~~Showing~~ Relative Importance in the Matrix

| <u>Attribute of Interest</u> | <u>'A'</u> | <u>'B'</u> | <u>'C'</u> | <u>'D'</u> | <u>Normalized Weights</u> |
|------------------------------|------------|------------|------------|------------|---------------------------|
| 'A' | 1 | 1 | 5 | 9 | .4801 |
| 'B' | 1 | 1 | 7 | 3 | .3604 |
| 'C' | 1/5 | 1/7 | 1 | 1/3 | .0556 |
| 'D' | 1/9 | 1/3 | 3 | 1 | .1039 |

Procedures for mathematical manipulation by matrix algebra to determine normalized weights are described in Saaty, T. L., The Analytic Hierarchy Process, McGraw-Hill, 1980.

Although the example given is for weighting objectives, the pairwise comparison process will be used also for weighting attributes, since there is also no common scale by which to rank them.

A normalized weight will be assigned to each of the objectives and attributes to reflect each participant's evaluation as a result of this exercise.

11.3 Recommended Practice

While there is merit to either assessing by a common scale or by relative importance in the decision analysis process, it is recommended that the former be used in evaluating alternatives and the latter for weighting the objectives and attributes.