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EARLY IDENTIFICATION OF TECHNICAL ISSUES-
A SENSITIVITY STUDY TO CHECK
LISTRAIA INTERNAL CONSISTENCY AND STRUCTURE

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ABSTRACT

This report describes a sensitivity study using LISTRAIA, a model for use in the development of a long-range, time-dependent plan for licensing nuclear waste repositories. The objectives of the model are 1) to provide information concerning the impact of various licensing strategies on the ability to dispose of nuclear waste effectively, and 2) to provide long-range budget forecasts for differing strategies of the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE). The model is designed to analyze the interaction between NRC regulatory policy and DOE technical programs. A sensitivity study is reported for a single parameter in a hypothetical review process.

INTRODUCTION

There are two interfaces that NRC must consider in developing a nuclear waste repository licensing strategy. These are the technical-regulatory interface and the legal-regulatory interface. How NRC structures and handles these two interfaces will have a definite impact on the public's perception of the safety of the nation's waste disposal system and the effectiveness of NRC's licensing policy.

The development of the physical waste disposal system is the responsibility of DOE. DOE also has primary responsibility for developing the data base with which to ascertain the safety of the system. NRC plans to make an independent assessment of the system safety using its own evaluation model and a data base mostly compiled by DOE. DOE's information in the data base must be consistent with NRC's schedule and technical support activities which include standards development, scenario choices, and evaluation models. To ensure that the regulatory and technical programs are consistent with one another requires licensing guidance to DOE with sufficient lead time for them to collect the NRC mandated information. Most data collected in the past appear to be insufficient for resolving the unique problems associated with establishing the safety of long-term disposal of high-level nuclear waste.

To provide a more complete set of information to help develop NRC's long-range licensing plan, a set of possible NRC strategies should be scrutinized for consistency with the technical program and with legal precedents. This is best accomplished by looking at the possible interactions of technical, legal

and licensing actions as a function of time. For example, under a certain strategy, NRC-required information obtained by DOE during site selection could lead to unacceptable hydrological performance of the repository over the long term. The acquisition of dynamic information on the interaction of the various agencies, if postponed, might destine the repository licensing process to failure. Such consideration and its impact on the waste management system development can best be obtained by structuring a long-range, time-dependent, licensing strategy model. This discussion focuses on such a model. It is named LISTRA1A, a time dependent model which includes the high-level NRC licensing policy, NRC organization and DOE physical system development strategy. LISTRA1A is designed to analyze the interaction of NRC regulatory policy and the DOE technical interface. Version B (LISTRA1B) will be expanded to include the legal-regulatory interface.

The Dynamics Model

The LISTRA1A code has two primary objectives: to provide information on the impact of various licensing strategies on the ability to effectively dispose of nuclear waste and to provide long-range NRC budget forecasts for differing NRC and DOE strategies. The technical-regulatory interface is described mainly as a DOE/NRC interaction. DOE's primary job of developing a functional disposal system is a relatively straight-forward engineering assignment. On the other hand, assuring its safety is an unprecedented scientific forecasting problem.

For the DOE side of the interface, LISTRAIA models the technical issues (discovered and undiscovered). Each technical issue has a current level of knowledge associated with it, a current level of effort dedicated to improving the knowledge about it, and a current marginal increase in knowledge to cost curve. The cost-knowledge relationship changes as a function of the physical system development stage. The knowledge increases as the system is developed. If the knowledge on a technical issue is found to be insufficient by NRC, manpower constraints keep information from being acquired more rapidly than a specified rate. This can lead to costly delays in obtaining the information necessary to proceed safely with the development of the repository.

On the NRC side of the interface, LISTRAIA models the review schedule, the issues reviewed as a function of time, and the stringency of the standards at each review action. There are hearings. At each hearing NRC weighs the technical information versus the information required. If the site is a good one but the information is inadequate, the decision is made not to proceed; DOE must adapt the system by gaining more information or by changing the design (see Figure 1). DOE then determines how the resources will be spent during the adaptive period to strengthen the case that their plan and system are safe ones. They return to NRC with new information to try to get approval on the amended information and plans. This adaptive looping proceeds until approval is given or fifty years pass. When fifty years have passed without NRC approval, the repository is abandoned.

Figure 1: The Structure of the Fundamental Decision Loop in LISTRA1A

Such a set of possible decision paths rapidly becomes prohibitively complex with a deterministic decision-tree approach (see Figure 2). Fortunately, complex multiple-decision strategies have been successfully analyzed by using a numerical Monte-Carlo approach. The complexity of the decision policy is the basis for our choice of the Monte-Carlo approach in LISTRAIA. The state of the system changes the decision probabilities at each review as a function of the history of the system. Thus, as the system evolves, the probability of getting approval at an NRC control point depends on how often approval has been denied in the past and why. The code allows for political disruptions. As approval is denied and time passes, the data base grows for identified technical issues. At the same time, the disruptive political factors become stronger, since it is recognized that the technical program is in trouble. This provides for a climate (and numerical situation) much more conducive to abandonment of the repository for nontechnical reasons.

The Sensitivity Study

In this paper we have looked at the sensitivity of a single parameter in a hypothetical review process. A study has been made on the "major technical issues initially identified by NRC." In the model, if NRC does not identify the issues, then the unidentified issues have a habit of showing up in the hearing process.

FIGURE 2: THE TRADITIONAL STRUCTURE OF A DECISION TREE. IF EACH BRANCH ON A PATH HAS A PROBABILITY AND TIME SPECIFIED, THE TIME OF COMPLETION AND THE PROBABILITY OF THAT PATH BEING TAKEN CAN BE DETERMINED.

There are 13 decision nodes for the case studied. Not all of them need to have hearings, but all should be NRC control points. It is assumed that the planned activities take one year and NRC's review and decision takes one year. Thus, if there are no license denials, closure would take place in 26 years. Surprises at reviews because of unidentified technical issues or because of standards that are too stringent can lead to long delays and little chance for successful development of the repository.

For this study, we have chosen as the important figures-of-merit:

- time to closure; and
- probability of success.

A mean time of closure that is short with a high probability of reaching closure is indicative of a good licensing strategy.

All parameters have been fixed except the number of technical issues identified by NRC and DOE. For this generic case there are 30 issues. The issues are made up of both identified and unidentified issues. The model predicts the outcome for 0, 5, 15, 20, 25, 27 and 29 initially identified technical issues. The histograms for time to closure are shown in Figures 3-9, respectively. Figure 10 shows the mean time to closure as a function of the fraction of issues identified. Figure 11 shows the probability of reaching closure.

Figure 3: Computer generated histogram showing years to closure when no technical issues have been clearly identified before site selection begins. The Monte Carlo analysis consisted of 100 trials. The plot shows three successful repository completions within 100 years.

Figure 4: Same as Figure 3 but with five identified technical issues. There are four successes.

Figure 5: Same as Figure 3 but with 15 identified technical issues. There are four successful trails.

Figure 6: Same as Figure 3 but with 20 identified issues.
There are 20 successes.

Figure 7: Same as Figure 3 but with 25 identified technical issues. There are 41 successes.

Figure 8: Same as Figure 3 but with 27 identified technical issues. There are 41 successes.

Figure 9: Same as Figure 3 but with 29 issues identified. There are 63 successes.

Figure 10

- * CLOSURE LICENSE BEFORE 100 YEARS
- ** TECHNICAL ISSUES IDENTIFIED BEFORE SITE SELECTION BEGINS

MEAN CLOSURE TIME*
-VS-
FRACTION OF IDENTIFIED**
ISSUES

* YEARS AFTER SITE SELECTION BEGINS
WHEN CLOSURE LICENSE IS AWARDED

** TECHNICAL ISSUES IDENTIFIED
BEFORE SITE SELECTION BEGINS

Figure 11

Budget Considerations

There is other information available in the code that can provide budget estimates for the manager. For example, the technical cost of the program can be displayed as a function of time (see Figure 12). The total cost of the program can also be displayed as a function of the fraction of technical issues initially identified.

Figure 12: Technical Cost as a Function of Time
for a Given Strategy

The technical cost of the program, however, does not appear to be as important as time to closure. It is program feasibility, not cost, that could substantially affect the country's ability to become more energy independent via the use of nuclear power. Under the present political climate it seems much more important to have a national waste management program with a high probability of success that will allow the nuclear energy option to go forward than to have the lowest-cost technical program. However, whether or not the nation has the "right" strategy, the long-term planner might find LISTRAIA budget information useful.

CONCLUSION

It is a well-known fact among systems analysts that a system's organization and policy can lead to system behavior that is unacceptable. There are economic, legal, political and technical constraints on a system that must be considered in organizing its structure and developing its policies. Behavioral characteristics of a system that are not heuristically obvious, many times are discovered from dynamic analysis including constraints. If NRC is to carry out its responsibility as defined by national law and also keep the public trust, then NRC must do a credible, responsible, and scrutable job of regulating DOE. Certainly, one of the most important interfaces in the nuclear waste program is the technical-regulatory interface. To comply with NRC's information requirements, this work shows that DOE will need early guidance on NRC's information needs. How early and how complete this guidance must be is a function of NRC's schedule, stringency of standards and how NRC perceives its interaction with the technical and legal communities.

LISTRAIA is an assessment model of the technical-regulatory interface. Its parameters are currently hypothetical and its algorithms need to be presented, analyzed and revised based upon a broader experience than is now the case.

With care, LISTRAIA might become a useful tool for high-level NRC strategy development. It can also be used as a long-range budgeting tool. As the code is revised and refined, it should provide a useful structure for addressing many licensing questions that are as yet not well-posed.

The current output is from a simple hypothetical case to test code structure. The next phase of code development could provide a realistic set of output with input based on the emerging national and NRC nuclear waste management program policies.