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TITLE: EARLY SCREENING OF NUCLEAR WASTE RETRIEVAL AND PROCESSING ALTERNATIVES

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Slides

Title

Early Screening of Nuclear Waste Retrieval and Processing Alternatives

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INTRODUCTION

The Department of Energy (DOE) is studying the feasibility of removing the transuranic-contaminated waste stored at the Idaho National Engineering Laboratory (INEL). Transuranics are the elements with an atomic number greater than uranium. Plutonium and americium are the most common. Between 1954 and 1970 approximately 65,000 m^3 of TRU waste was buried. This includes about 149,000 steel drums and 17,000 cartons and boxes. An additional 14,000 m^3 of beta-gamma waste are also buried. Since the beta-gamma waste cannot be identified and segregated from the TRU waste, it will have to be handled along with it. This raises the total volume of waste to be retrieved from the burial grounds to 80,000 m^3. Two pilot programs and selected retrieval system shake-down operations will decrease the volume under full scale operations to 71,000 m^3. Since the waste is buried, a significant amount of soil will be contaminated. Estimates for the additional amount of soil waste generated range between factors of 1 and 2. After 1970 TRU waste was stored above ground in 55-gal drums, metal bins, or in fibre-glass coated boxes. About 200,000 m^3 of TRU waste will be stored by the year 2000.

OBJE' "IVE

Objectiv

There are two distinct requirements for the task at INEL: (1) retrieve the buried wastes; (2) process the buried waste and attendant soil plus the stored wastes so that they will be safe for shipment and storage at a national repository.

Concept

Two task forces were organized to evaluate systems for buried waste retrieval and for processing buried and stored wastes. Fifteen people of diverse backgrounds representing ten DOE contractors were to apply their specialties to the problems. Each task force worked on only one consideration (retrieval or processing) and shared no common member. However, each task force needed to consider both retrieval and processing. Each kept abreast of the others' work. In addition to the task force members, many other people contributed by providing formal briefings on special topics. These included potential vendors for the competing systems and other specialists at DOE contractor facilities.

Because of a general lack of radwaste processing experience on the volume and type of wastes to be handled, a substantial effort of the waste processing task force was to identify technological deficiencies and to recommend related research and development areas. Similar problems were faced by the retrieval task force, but they were mostly related to engineering design.

Several methods of evaluation were investigated. Operational considerations required that the evaluation procedure be: easy to understand, easy to implement, economical to use, stable against small errors in estimates, able to consider intangibles, and easy to modify if neccessary. Both task forces decided that a preferred method would result in a single number that represented the worth of an alternative for the entire group. These requirements seemed to be met by a scoring model. Further examination showed that a linear additive scoring model would serve the needs of the task forces and would be highly acceptable to all their members. Because of ease of use and low cost, scoring

Concept

models are highly suitable reliminary screening. In certain controlled situations linea ditive scoring models have been shown to do about as well or ter than more complex models.

The foundation of the evaluation procedure is a linear additive model where FOM stands for Figure-of-Merit, u is some measure of worth of a system attribute, x, and w is a weighting factor used to express the relative importance of the system attributes to the overall measure of system worth or FOM.

The next step in the evaluations was to determine the important system attributes (x). To achieve this, task force members developed a comprehensive list of everything they could think of which would bear on the evaluation. Then numerous items were combined, deleted, and modified to produce a set of main concerns called evaluation criteria. Because the purposes of the task forces were different, each produced a different criteria structure. In most cases each criterion was broken down to include several subcriteria. From the detailed and agreed upon definitions of the criteria, system attributes or performance measures (x) were specified that would satisfy the criteria. The final concern involved selecting a way for constructing the scoring functions. This shows the final criteria for the retrieval task force.

WEIGHTS

Next the highest level or main criteria weights were calculated. Several methods of determining weights were presented to the task forces. All their members preferred the constant-sum method where each individual allocates 100 points between every pair of criteria. This scheme gives relative values between all criteria pairs. For example, if criterion A is awarded 60 points by someone and criterion B 40 points, criterion A is 1.5 times as important as criterion B is to him. Likewise criterion A is 3 times as important as C.

Again, m is the number of criteria. Only m-1 comparisons were needed to calculate the weights, but the constant-sum method gave m(m-1)/2. All comparisons were used to calculate the weights. The use of all comparisons tends to smooth out within individual errors in judgement, and they can be used to check for within individual transitivity of judgements.

Criteria rankings changed slightly throughout the first half of the evaluation. This was because the task force members were becoming more informed about the systems' objectives. A Kendall Coefficient of Concordance was computed for each ranking to check for group agreement for both task forces. Then, transitivity of group orderings was verified. Finally, the weights were averaged to produce a set of weights for the group. The processing task force operated similarly. Each task force reviewed its weights as a group and made slight modifications.

The retrieval task force assigned individuals to investigate subcriteria related to their field of expertise. These individuals also supplied the subcriteria weights. However, each individual defended his weights to the task force and made minor adjustments if appropriate. The processing task force used the constant-sum method to produce group weights for all criteria and subcriteria. In both task forces the groups agreed to all final sets of weights.

VALUE FUNCTIONS

The final step of the model development was to construct the value functions (u). The retrieval task force member who was assigned a specific subcriteria determined the value function for the related performance measure. As you recall, the value function transforms the level of performance to value of performance or worth on a scale of 0 to 1. Again, the evaluator presented his value function(s) and described his rationale to the task force. Slight modifications were made when necessary to

meet with group approval. Nearly all performance levels were subjective estimates of how well each system would probably serve the criteria such as fair, average, difficult, etc. More detailed information about actual systems' parameters was not possible at this stage of design. Care was taken to reduce dependences of the performance measures and preferential independence of the value functions was minimized by the manner in which they were constructed.

Sample Value Function

SYSTEM EVALUATION

Each task force produced its systems' evaluations in a different manner. Each retrieval task force member evaluated all alternatives against the value function he produced. However, a detailed written description was provided justifying the estimated performance level for each alternative. The alternatives were not necessarily the ones initially addressed in the early stages of the study. Rather, they were modifications of these or additional alternatives derived from the knowledge of the participants and their interaction during the course of the study and augmented by discussing these potential modifications with vendors.

The processing task force estimated performance levels differently. Two task force members prepared a preliminary evaluation estimate of the performance levels for a major criterion for each of the 10 alternatives. Each member worked on three major criteria but with a different partner in each case. When this was done, the task force reviewed the results and modified them according to consensus judgement to produce the final worths for each alternative against each performance measure.

The final FOM's for the retrieval systems suggested a clear winner. Here the overall FOM's were not composites in the sense that each task force member evaluated all alternatives against all value functions, but rather, they were composites where each

individual was involved in a few parts of the evaluations. All reviewed the results and recommended changes where appropriate. In addition, all individual results were multiplied by group weights for the main criteria.

Several other systems were close. Because of the inability to check for individual variation for the retrieval systems and because total cost was not included extreme care must be taken before a final system is selected. The next step of the process is to estimate costs for the leading system after a few vendors submit more detailed design studies.

Two processing systems had very close FOM's with another system close behind. Because there were multiple estimates, a Monte Carlo simulation was performed to determine the sensitivity of the leading FOM. It was assumed that the values of performance could be wrong by one level above or below the nominal level. The results of the sensitivity analysis showed that the first three alternatives were not significantly different. The largest variations were identified to be in three performance measures for the top three systems. These should be of major concern in the final selection of a system.

SIGNIFICANT RESULTS

What are the real results of these task forces? First they have addressed problems of major concern to the nuclear defense industry which have never been addressed before in the detail and scope addressed here. The studies identified preferred alternatives and recommended the next phases of work needed to begin design on the retrieval system and to gain more information on the top three rated processing systems. Vital research and development areas were identified that when completed will have a large impact on the nuclear industry as a whole--defense and civilian. However, the real results are that people from different backgrounds and contractors could get together and address

major technical problems so that the end product was acceptable to all. Most task force members had never conducted a similar evaluation before. However, they were all enthused about the evaluation scheme and made definite suggestions and contributions. At first there was a lot of confusion and uncertainty about the objectives and systems. These uncertainties rapidly diminished as the people worked together.

An interesting sidelight is that engineers working independently and using different types of analyses arrived at essentially the same conclusions.

SUMMARY AND CONCLUSIONS

Summary

The simple linear model was able to rank the alternatives so that the task force members were satisfied with the final rankings. The most useful aspect of the evaluation procedure, even if not completely satisfactory, forced the task force members to clarify and partially quantify factors important to the overall evaluation. The detailed written analysis of the rationale used to make the evaluations will help with the design of the alternatives selected.

EARLY SCREENING

OF

NUCLEAR WASTE RETRIEVAL

AND

PROCESSING ALTERNATIVES

EARLY SCREENING OF NUCLEAR WASTE RETRIEVAL AND PROCESSING ALTERNATIVES

N. D. COX

W. J. WHITTY

OBJECTIVE

RETRIEVE: BURIED TRANSURANIC CONTAMINATED WASTES

PROCESS: BURIED AND STORED WASTES TO MAKE THEM SUITABLE FOR TRANSPORTATION TO AND STORAGE AT A NATIONAL REPOSITORY

CONCEPT

GROUP WITH DIVERSE BACKGROUNDS IN NUCLEAR

WASTE MANAGEMENT EVALUATE PROPOSED SYSTEMS

CONCEPT

GROUP WITH DIVERSE BACKGROUNDS IN NUCLEAR

WASTE MANAGEMENT EVALUATE PROPOSED SYSTEMS

SINGLE NUMBER USED TO REPRESENT

THE WORTH OF A SYSTEM

MODEL

$$FOM = \sum_{j=1}^{m} w_j u_j(x_j)$$

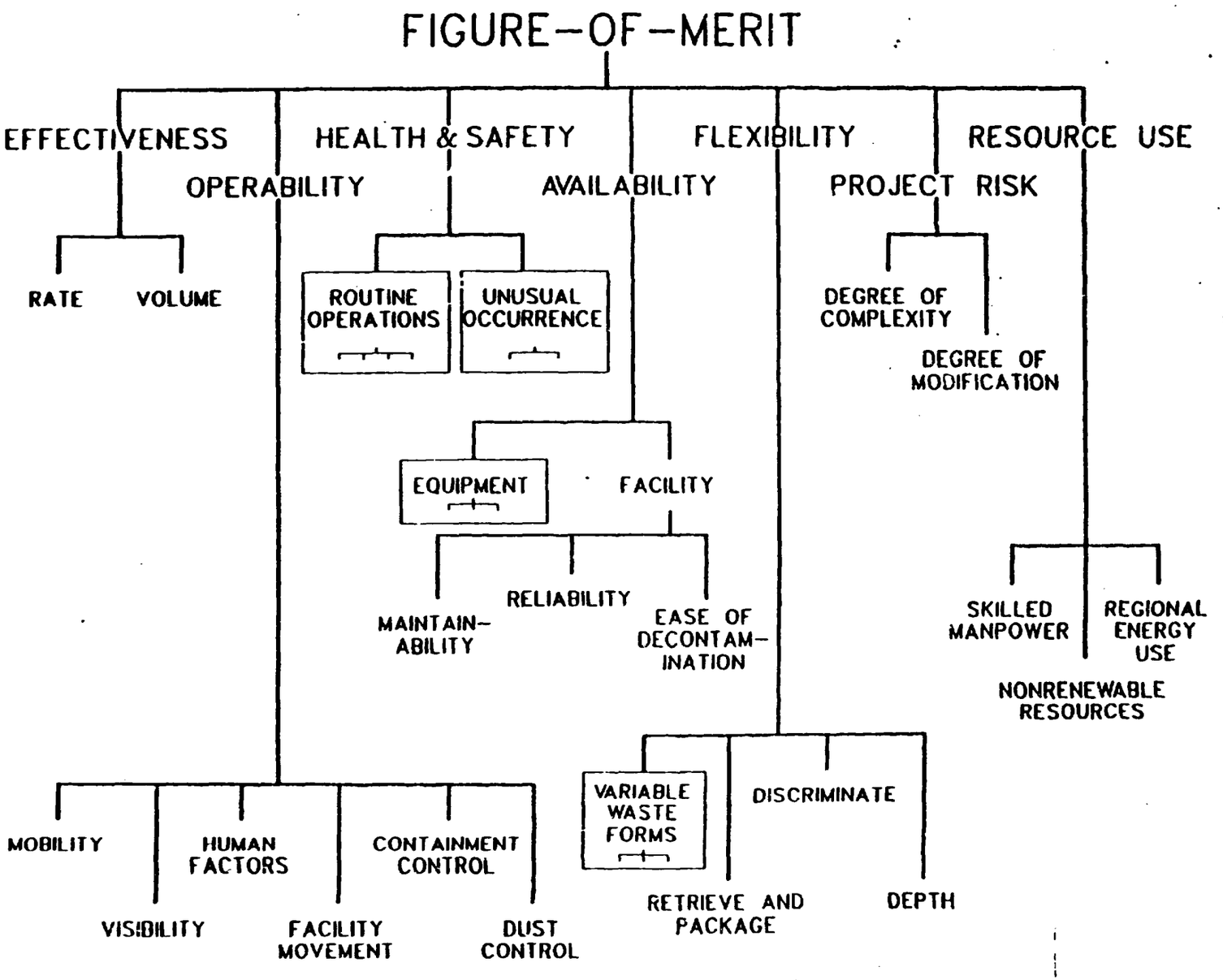
$$0 \leq w's \ \& \ u's \leq 1$$

$$\sum_{j=1}^{m} w_j = 1$$

PROCEDURE

DEFINE: EVALUATION CRITERIA
AND PERFORMANCE MEASURES

SELECT: PROCEDURES FOR CONSTRUCTION
OF WEIGHTS AND VALUE
FUNCTIONS


FIGURE–OF–MERIT
EFFECTIVENESS
HEALTH & SAFETY
FLEXIBILITY
RESOURCE USE
OPERABILITY
AVAILABILITY
PROJECT RISK
RATE
VOLUME
ROUTINE OPERATIONS
UNUSUAL OCCURRENCE
DEGREE OF COMPLEXITY
DEGREE OF MODIFICATION
EQUIPMENT
FACILITY
MAINTAIN–ABILITY
RELIABILITY
EASE OF DECONTAM–INATION
SKILLED MANPOWER
REGIONAL ENERGY USE
NONRENEWABLE RESOURCES
MOBILITY
HUMAN FACTORS
CONTAINMENT CONTROL
VARIABLE WASTE FORMS
DISCRIMINATE
VISIBILITY
FACILITY MOVEMENT
DUST CONTROL
RETRIEVE AND PACKAGE
DEPTH

WEIGHTING BY CONSTANT-SUM

A	60	B	40
A	75	C	25
B	65	C	35

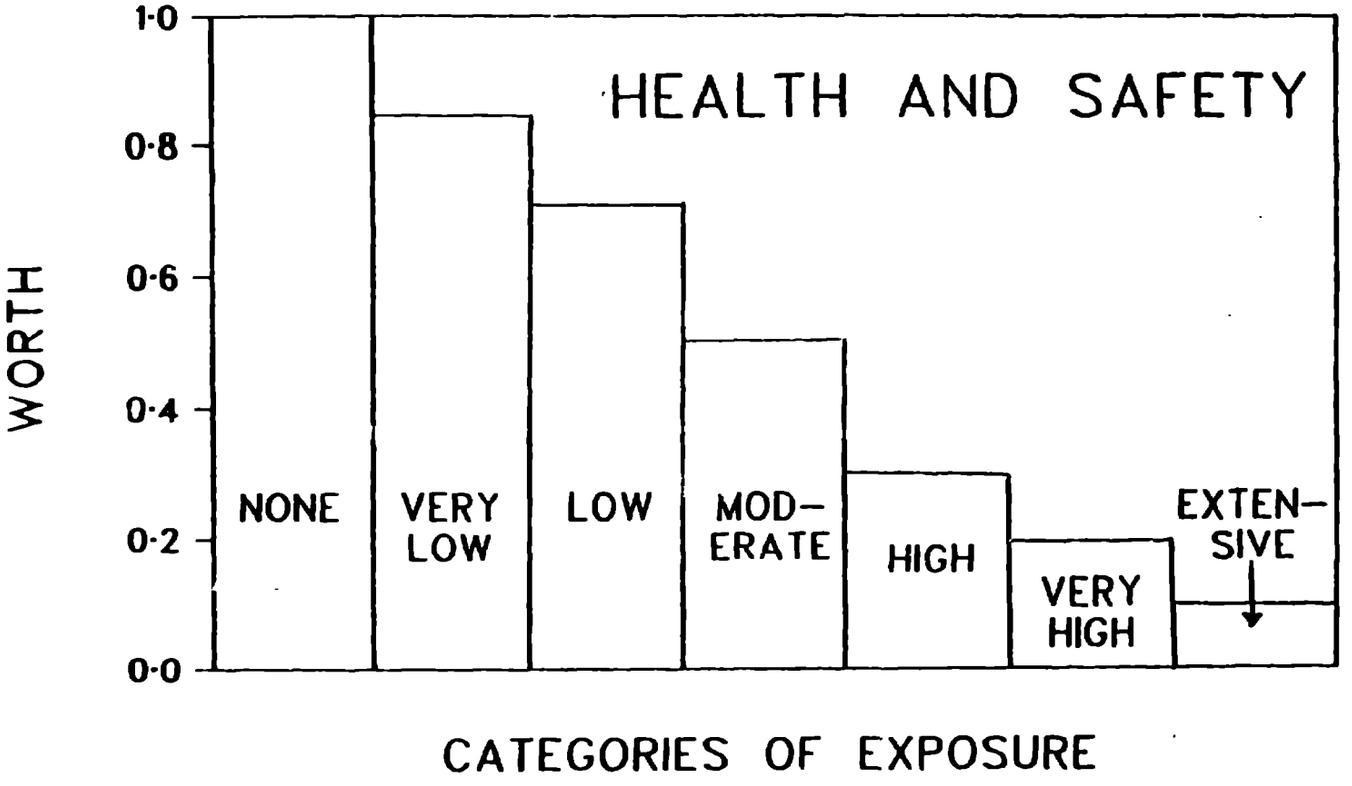
m(m−1)/2 COMPARISONS

GROUP CONSENSUS

WEIGHTS CONVERTED TO RANKS

KENDALL COEFFICIENT OF CONCORDANCE

WEIGHTS AVERAGED


HEALTH AND SAFETY
WORTH
1·0
0·8
0·6
0·4
0·2
0·0
NONE
VERY LOW
LOW
MOD–ERATE
HIGH
VERY HIGH
EXTEN–SIVE
CATEGORIES OF EXPOSURE

SENSITIVITY ANALYSIS

PROCESSING: MONTE CARLO SELECTION OF WEIGHTS AND WORTH VALUES FOR HIGHEST RANKED SYSTEM. SIGNIFICANT DISCRIMINATION BETWEEN THE FIRST 3 SYSTEMS AND THE REMAINING 7

RETRIEVAL: ONE SYSTEM STOOD OUT. NO FORMAL SENSITIVITY ANALYSIS CONDUCTED

SIGNIFICANT RESULTS

PREFERRED ALTERNATIVES IDENTIFIED

R&D AREAS DETERMINED

DIVERSE GROUP AGREED TO EVALUATION PROCEDURE AND RESULTS WERE ACCEPTED BY ALL

SUMMARY AND CONCLUSIONS

LINEAR MODEL

FORCED EVALUATORS TO CLARIFY AND QUANTIFY SUBJECTIVE EVALUATIONS

PROVIDED SYSTEMATIC APPROACH FOR EVALUATION, WHERE DISCUSSION CAN FOCUS ON RESOLUTION OF UNCLEAR IDEAS AND CONFLICTS