Future, Model, and Parameter Uncertainty

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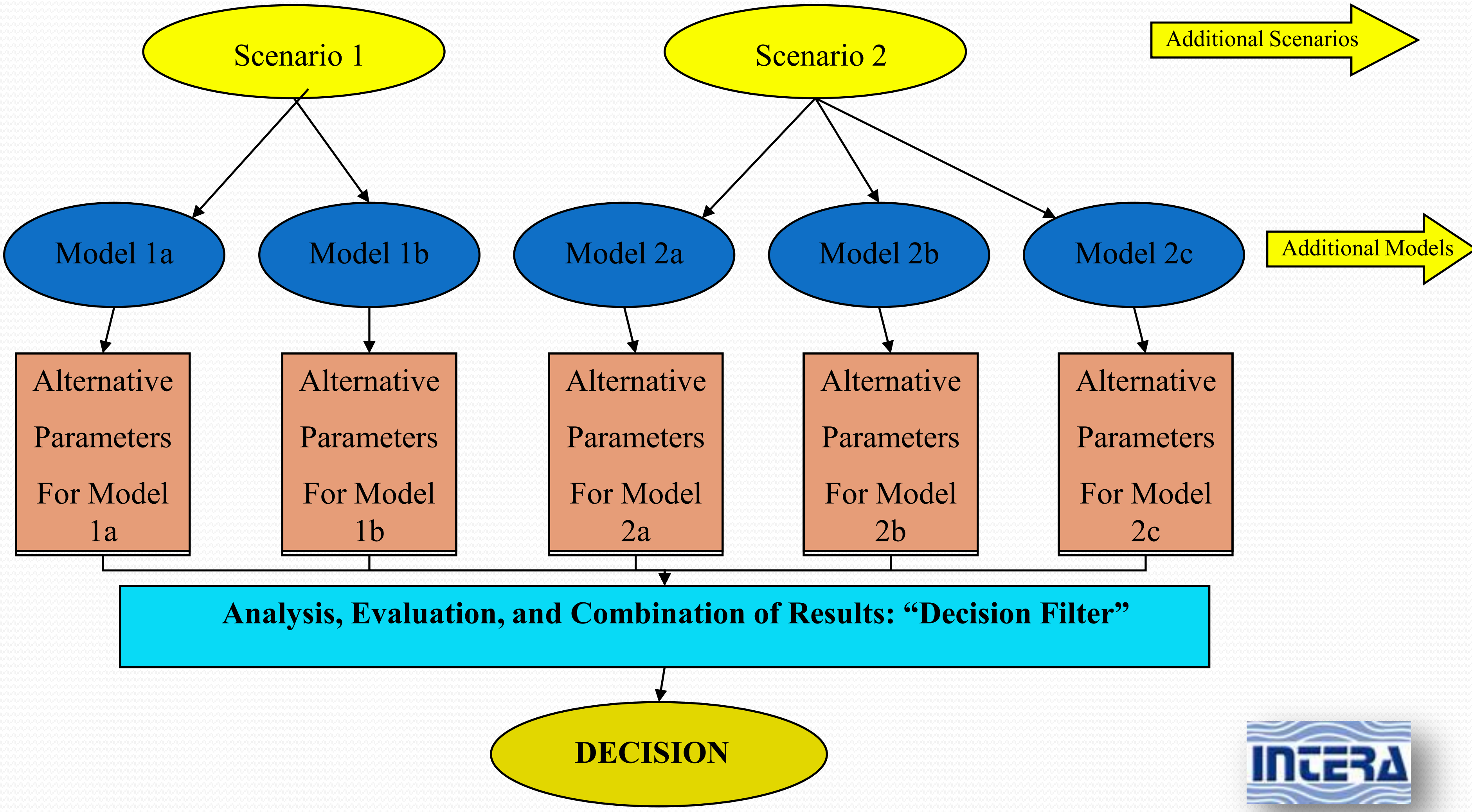
Scope of the Presentation

- Structure of uncertainty analysis
- Characterization of uncertainties
- Propagation of uncertainties
- Implications for results of performance assessments

Introduction

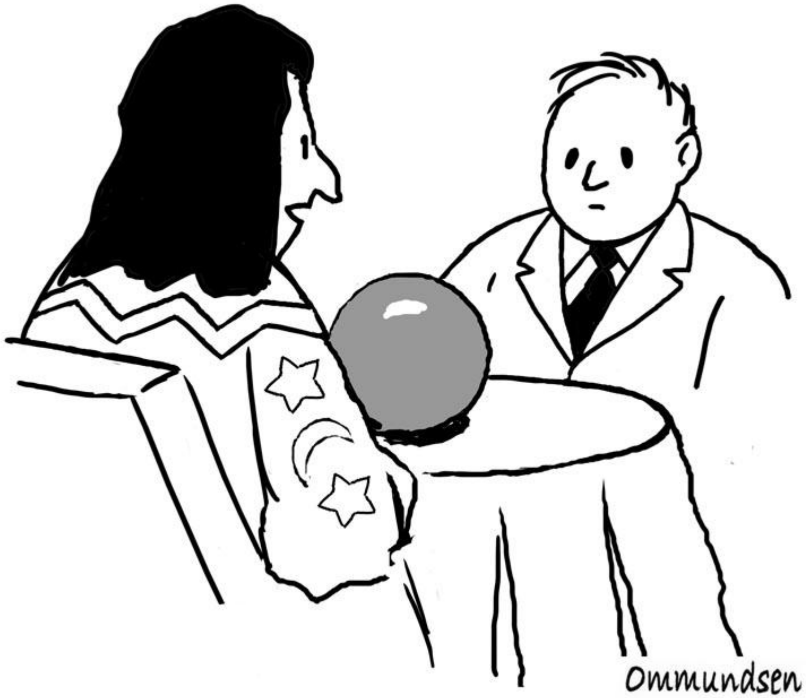
- Sensitivity and uncertainty analyses are well-studied in the literature
- Caution must be used in adopting available methods for use in performance assessment
  - Performance assessment is an unusual activity
  - Frequent misunderstandings have arisen
- NCRP Report 152 introduced a new term to describe the approach for safety assessment
  - Importance Analysis: the integration and interpretation of performance assessment results to identify those that influence the decision regarding compliance

Structure of Uncertainty or Importance Analysis



A General Approach for Treating Uncertainty

- Evaluate Multiple Line of Reasoning for Each Type of Uncertainty
  - Consideration of alternative scenarios for future uncertainty
  - Consideration of alternative models for conceptual uncertainty
  - Consideration of alternative parameter sets for parameter uncertainty
- The result is a potentially large number of calculations that represents the uncertainty



"Is this needed for a Bayesian analysis?"

Decision Filter

- Each set of scenario, model, and parameter set is assigned a weighting factor
  - May be implicit (disregarding a model = weighting factor of zero)
  - May be qualitative (Model 1a is better than Model 1b)
  - May be quantitative (probabilistic)
- The filter defines how the information is used in making a decision
- The choice of filter depends on
  - Assessment context
  - Philosophy of analyst
- A few comments about probabilistic approaches
  - Subjective probabilities and ranges are easy to assign: we are not representing variability
  - Technically superior way to span the range of the input space
  - That superiority comes at a cost

Characterization of uncertainties 1
Aleatory vs. epistemic

- Performance assessment uncertainties are dominated by epistemic uncertainties (Type B)
- Even when large amounts of data exist, uncertainty about application to future field conditions is more important
  - Transition to different constitutive behavior under different boundary conditions (e.g. hydraulic conductivity)
  - Transition to different constitutive behavior in time
- Aleatory uncertainties (Type A) are generally unimportant
  - This situation differs from power plant risk assessments
  - Also differs from other types of risk assessment activities

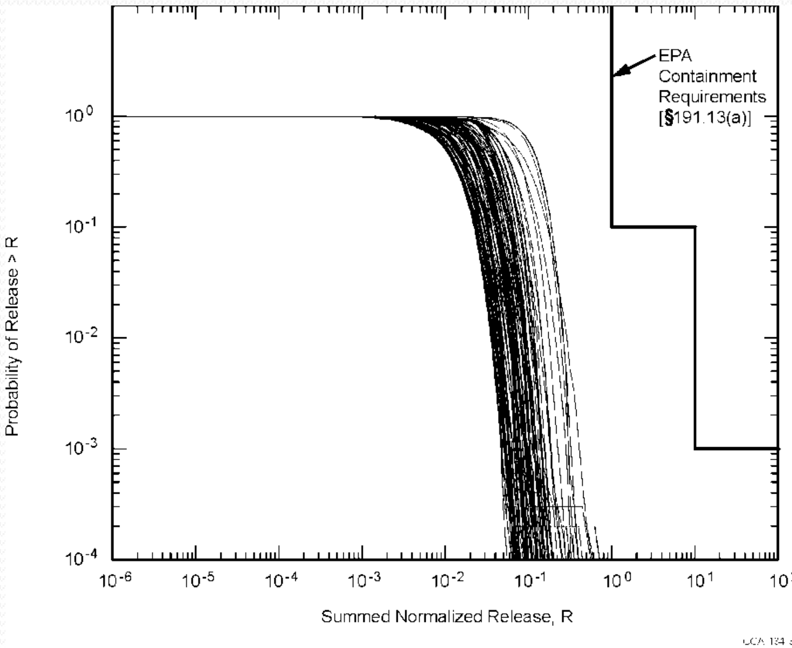


Figure 6-35. Distribution of CCDFs for Normalized Radionuclide Releases to the Accessible Environment from the WIPP, Replicate 1

Attempted differentiation between Type A and Type B uncertainties in WIPP performance assessments

Characterization of uncertainties 2
Future, Model, and Parameter

- When is an uncertainty a “scenario” a “model” or a “parameter”
  - Largely semantics; these divisions are not fundamental
  - One approach: does the initiating FEP act on the system or is it part of the system?
- More important: is the issue clearly addressed in the assessment?

Characterization of Uncertainties 3:
Features, Events, and Processes (FEPs)

- Features
  - Aspects of the disposal system associated with performance
  - Generally thought of as physical components
- Events
  - Discrete occurrences
  - Relatively short duration
- Processes
  - Longer term evolutionary aspects of the system
  - Generally represent relationships between features

In practice, little differentiation between these three, and one simply discusses "FEPs"

FEPs Background

- Scenario approaches developed in the 1980s
  - Sandia methodology
  - Developed for U.S. HLW waste program
  - Legal requirement to represent all events and processes
  - Requirement to combine them probabilistically
  - Intended to identify scenarios
- Scenario approaches developed in the 1990s
  - SKB methodology
  - A move way from probabilistic approaches
  - Inclusion of FEPs representing the model
- Scenario approaches developed in the 2000s
  - Multiple methodologies with common features
  - Extension to FEPs for near surface disposal

Scenario Development Methodologies

four basic steps

- Comprehensive FEP list
- Screening
- Describing relationships between FEPs
- Arranging them into calculational cases, or scenarios

Differences between published approaches represent differences in ordering of these basic steps

Why do we use FEPs?

- The historical (1980s) use was to identify all initiating events and processes for scenarios
- Modern usage is broader, and includes both identification of scenarios and construction of models
- The path from FEPs to models is not clear
  - Typically a leap occurs between FEPs and models
  - Current assessments often receive criticism for this leap
  - The reality is that models are developed using professional judgment, informed by FEPs
- FEPs are best viewed as a communication tool, not a fundamental feature of scenarios and models
- Strong use as an auditing tool to ensure conceptual completeness

Conceptual model uncertainty:

Origins of alternative conceptual models

- Differing assessment context
  - Degrees of conservatism
  - Regulator vs. developer
  - Differing analysts
- Differing scenario definitions
- Exploratory conceptual models
  - Evaluation of alternative assumptions
  - Performance margin analysis

Conceptual mode uncertainty

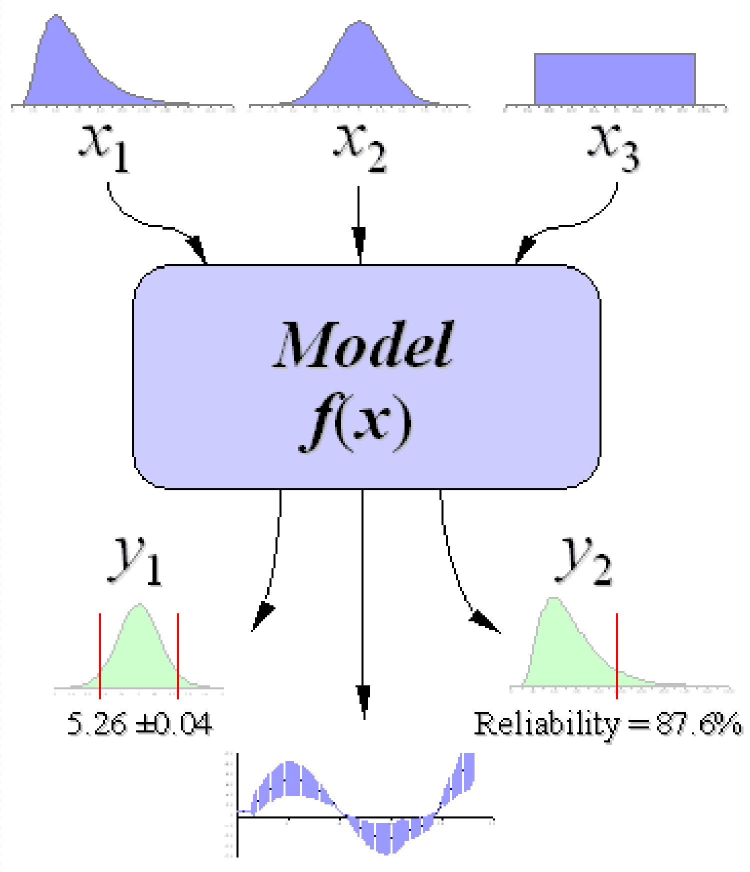
Performance margin analysis

- Evaluate assumptions that are credible, but difficult to defend
- A quantification of "conservatism"
- Can provide strength to licensing arguments

Resolution of alternative models

- Data are often not available
- Elimination of a competing model should be based on evidence
- Model intercomparison seen as a primary tool for producing credibility
- Necessarily involves consideration of alternative points of view
- Alternative models are best resolved by focusing on details of each to come to consensus

Probabilistic Treatment of Parameters



- Sample from input distributions
  - Random sampling
  - Latin Hypercube Sampling (LHS)
- Run the model for "enough" times to produce a stable output distribution
  - There are no useful rules for establishing stability
  - Large numbers of realizations usually needed
- Need to manage the massive inputs and outputs

Non-probabilistic Treatment of Parameter Uncertainty

- Easier to communicate and understand
- May be harder to defend
- Needs to address the same uncertainties

Maximum entropy approach to parameter distributions

If you know…	The distribution should be…
Range (a,b)	Uniform distribution on (a,b)
Mean and standard deviation (μ,σ)	Normal distribution
Positive and given mean (μ)	Exponential
Mean, standard deviation, range (μ,σ, a,b)	Beta
Mean occurrence rate between discrete events	Poisson

When data span many orders of magnitude, often a log-uniform or log-normal distribution is used.

Summary

- Performance assessment is a practical analysis
  - Do not become bound up with sematics
  - Need to identify uncertainties that truly represent a concern
  - Different people see “concern” in different ways
- Any information is useful if viewed in the right context
- Clarity in communication is needed
  - A mixture of probabilistic and nonprobabilistic
  - Clear reasoning on the reason specific scenarios and models are used, and what they are intended to represent