U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: CONFIDENCE BUILDING FOR MODELS

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RENO, NEVADA
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Outline

Motivation

Models: types (uses) of models

Model validation: history and progress

INTRAVAL and other international projects

Modeling process

Three components for long-term predictions

Two types of “expert” inputs

Concluding remarks

References

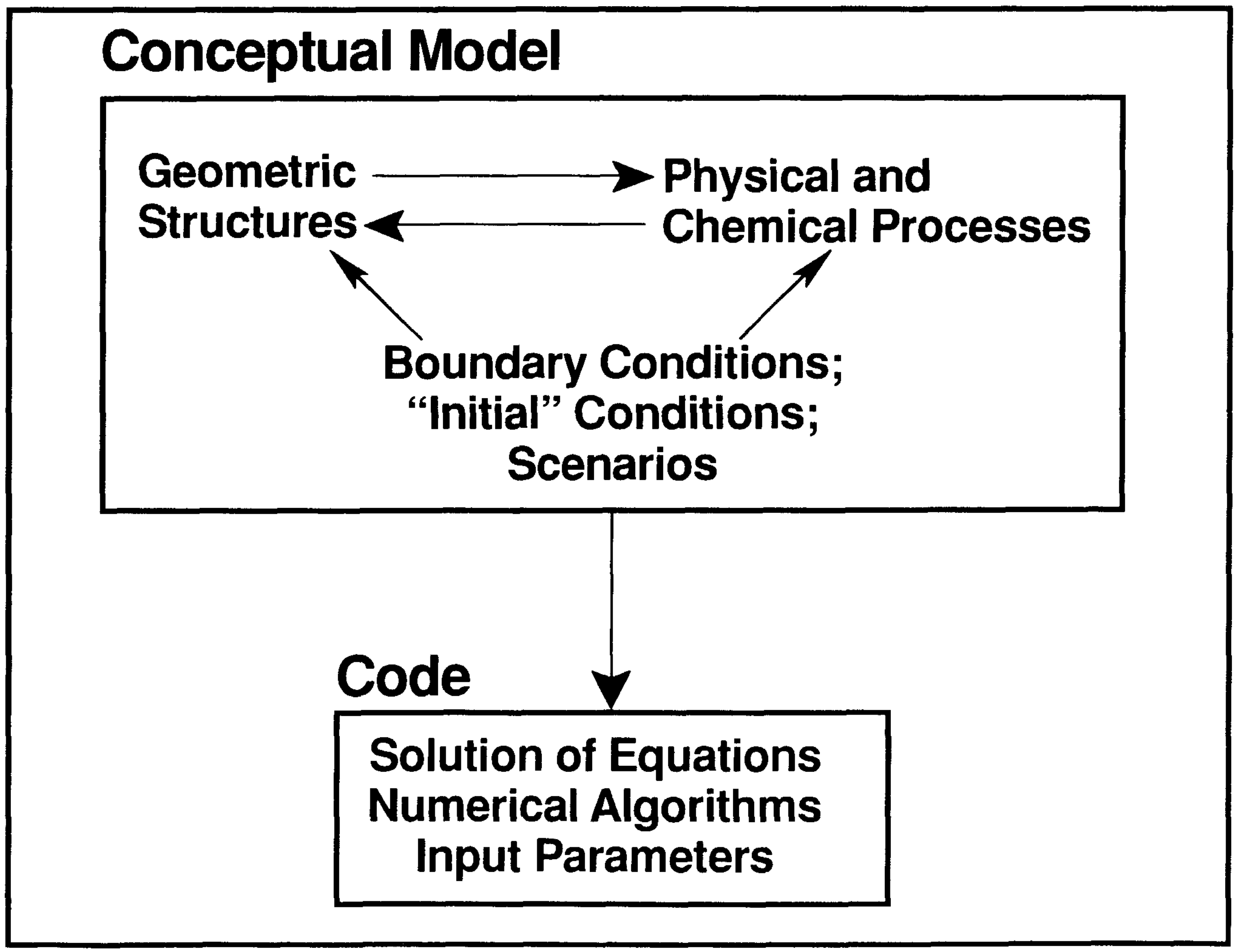
Tsang, C-F. Modeling Process and Model Validation. Journal of Ground Water, 19 (6) 825-831, December 1991.

Various Authors. Advances in Water Resources. Special Issues on Validation, Vol. 15, No. 1 and No. 3, 1992.

NTRAVAL Progress Reports. Swedish Nuclear Power Inspectorate (SKI), Stockholm, Sweden.

GEOVAL Symposia. Proceedings 1987 (Stockholm); 1990 (Stockholm); and, 1994 (planned for Paris). Swedish Nuclear Power Inspectorate, Stockholm, and Nuclear Energy Agency (OECD-NEA), Paris.

Schematic Diagram Relating Model, Conceptual Model, and Numerical Code for Site-Specific Modeling



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Four Types of Models (for Different Uses)

- Type A: to understand processes, effects, and sensitivity
  - Study selected processes
  - Analyze laboratory experiments
  - Controlled and prescribed conditions
  - Parameter determination

- Type B: to analyze field experiments
  - Real systems; relatively short duration and small scales
  - Distinguish between competing processes/features
  - Parameter determination (calibration)

Four Types of Models (for Different Uses)

(Continued)

- Type C: to make short-term predictions
  - Extrapolation, use of calibration
  - Can be revised with time
- Type D: to make long-term predictions
  - Requires correct physics and chemistry
  - Requires correct scenarios and boundary conditions
  - Requires completeness of slow processes
  - Requires proper choice of quantities to be predicted

(Concern is confidence building for Model Type D)

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Validation

- Verification and validation
- Hope for validation ⟶ International cooperation
- There is no absolute validation
  - Theory can only be invalidated (e.g., Newton's Law is not valid, ∴ Einstein)
- However, there can be practical or conditional validation-a model prediction may be valid
  - (a) For a particular site
  - (b) For a particular observation (performance measure)
  - (c) Over a range of parameters
  - (d) With an estimated range of uncertainties

cf. IAEA (1982); Schleisinger (1986)

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THE INTERNATIONAL INTRAVAL PROJECT

TO STUDY VALIDATION OF GEOSPHERE
TRANSPORT MODELS FOR PERFORMANCE ASSESSMENT
OF NUCLEAR WASTE DISPOSAL

PHASE 1, TEST CASES 10, 11 AND 12

Flow and Tracer Experiments in Unsaturated Tuff and Soil

APPENDICES

The Coordinating Group of the INTRAVAL Project
Swedish Nuclear Power Inspectorate (SKi)

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

NEA SKi

INTRAVAL

To study validation of geosphere transport model for performance assessment of nuclear waste disposal

France: ANDRA, CEA/IPSN
Canada: AECL
Australia: ANSTO
Germany: BGR/BFS, GRS, GBF
Spain: ENRESA
U.K.: NIREX, DOE, NRPB
Finland: TVO/VTT

Japan: JAERI, PNC
Switzerland: NAGRA, HSK
Netherlands: RIVM
Sweden: SKB, SKI
U.S.: NRC, DOE, EPA (obs)
NEA
IAEA (obs)
Nevada (obs)

INTRAVAL Approach

- Select best sets of lab (5) and field (8) experiments (including unpublished or ongoing)
- Each to be studied by a number of teams from different countries with own models
- Coordinating group meetings and workshops of 5 days duration every 8-9 months (most recent: Nov. 1992, San Antonio; Feb. 1992, Sydney)
- In-depth interaction among modeling teams, and
  - Commitment; broad "selection"; different backgrounds
  - Multiple groups study
  - Thorough discussion; understand differences
  - Suggestions for modeling
  - Suggestions for experiments

Validation Oversight and Integration Committee (VOIC)

- Jesus Carrera, Polytechnic University, Barcelona
- Neil Chapman, British Geologic Survey/Intera-Exploration
- Peter Glasbergen, National Institute of P.H.E.P., Netherlands
- David Hodgkinson, Harwell Lab./Intera-Exploration, UK
- Ivars Neretnieks, Royal Institute of Technology, Stockholm
- Tom Nicholson, U.S. Nuclear Regulatory Commission, Chairman
- Shlomo Neuman, University of Arizona
- Chin-Fu Tsang, Lawrence Berkeley Laboratory

Some Outcomes of INTRAVAL

Validation

- Semantics and definition: a big problem
- Cannot prove validity of long-term predictions
- Validation is a process
- Should be part of Performance Assessment and not independent
- Should be based on understanding of major experiments and general scientific reasonings
- Benefits of multiple groups
- Benefits of in-depth review and comments

Some Outcomes of INTRAVAL

(Continued)

Scientific (a few highlights)

- Matrix diffusion as a retardation mechanism
- Channeling: fast flow paths
- Stochastic modeling
- Expert inputs into field experiments:
  e.g., Las Cruces; WIPP-Culebra

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Steps of the Modeling Process and their Validation

The Modeling Process	Examples of Issues Requiring Validation
1. Data review and evaluation	Spatial correlation and parameter correlation
2. Conceptual model and scenarios; "reasonable" alternatives	Accuracy of conceptual model and probability of scenarios
3. Performance criteria	Appropriate choice of quantities of interest Are the criteria unnecessarily demanding?
4. Calculational models and lumped paramenters for all "reasonable" alternative conceptual models and scenarios	Simplification procedures and determination of lumped parameters from data
5. Modeling calculations, sensitivity studies, and uncertainty analysis	Uncertainties in data, in conceptual model, and in calculational model choices

6. Results evaluation by management

   (a) Uncertainty too large; define new data needs; design new site-characterization activities;

   - Feasible to perform further field studies, update data → GO TO STEP 1
   - Not feasible within reasonable time and cost → STOP

   (b) Results with estimated uncertainty good enough → INPUT TO DECISION MAKING

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Three Components for Long-Term Predictions

Modeling for long-term predictions

- Study key experiments
  History matching — **Site-specific studies**
- Correct physiochemical processes — **General scientific knowledge**
- Sensitivity analysis uncertainties
  Range of applications — **Qualifications or conditions on predictions**

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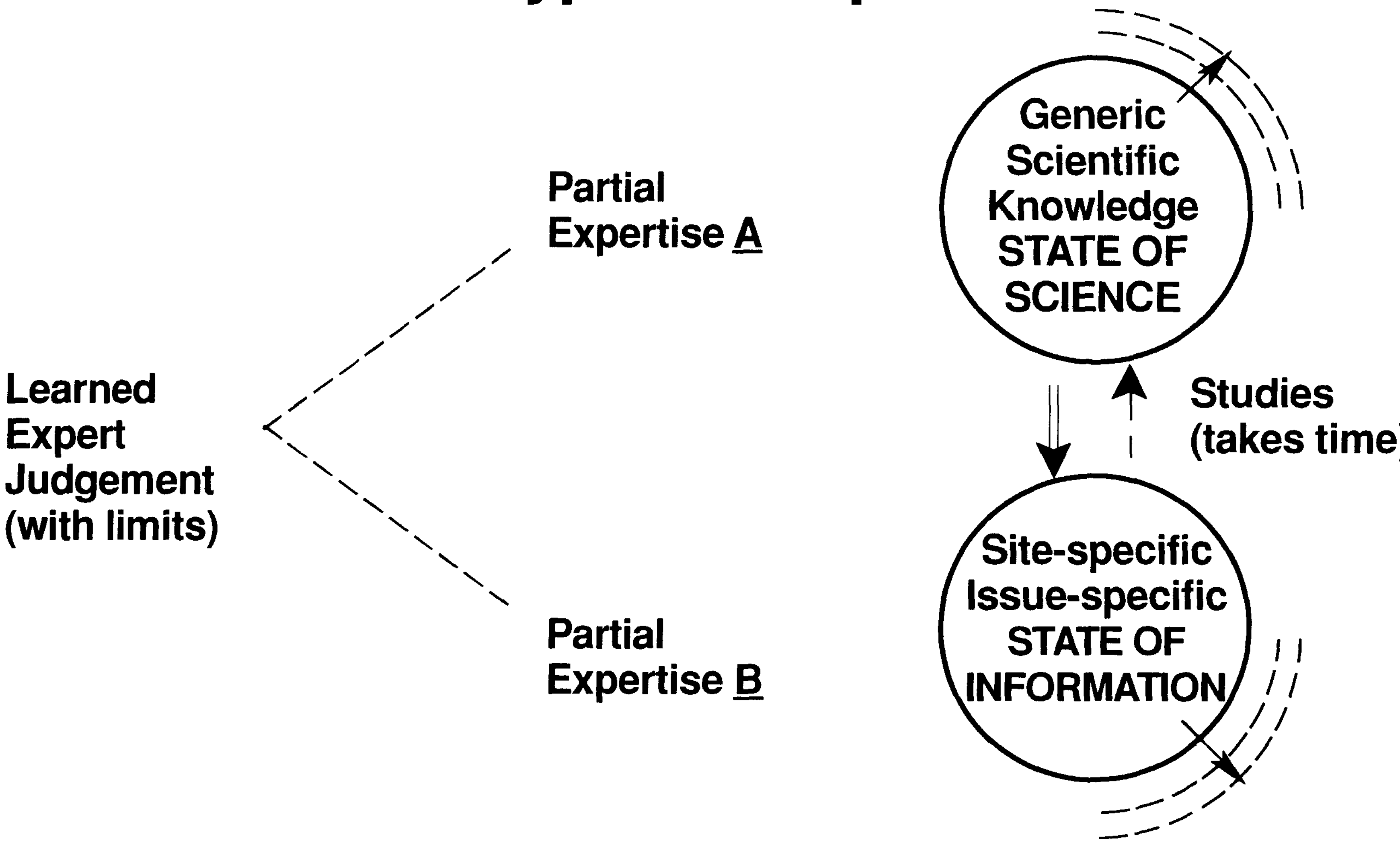
Two Types of Expertise



- Limits of A: Need to be educated on site- or issue-specific information
- Limits of B: need more science: study other sites and processes
- Both A and B limited by state of science and state of information
- Confidence building for models implies effective and sufficient inputs from A and B

How to Bring in Current State of Science

- Through broad selection of experts
- Through in-depth discussion of bases for judgments
- Through timely open literature for scrutiny by general scientific community

How to Bring in Proper Interpretation of Current State of Information

- Study site-specific data
  - Geometric structures
  - Relevant processes
- Multiple groups
  - Understand differences
  - Estimate uncertainties

Design Diversity

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- Confidence building for models requires careful site-specific studies:
  - Conceptual model: geometric structure process parameters and boundary conditions (scenarios)
  - Computer codes and numerics
- Requires broad and in-depth scientific inquiry
- Multiple assessment groups
  - Wide scientific public scrutiny
- Detailed discussions among groups, especially on differences and bases for alternative judgements