MODEL VALIDATION AND COMPUTER CODE VERIFICATION:

NRC REGULATORY PERSPECTIVE

U.S. DEPARTMENT OF ENERGY/
U.S. NUCLEAR REGULATORY COMMISSION
TECHNICAL EXCHANGE ON
TOTAL SYSTEM PERFORMANCE ASSESSMENT
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MODEL VALIDATION: BACKGROUND

- COMPUTER MODELS WILL BE USED TO EVALUATE LONG-TERM PERFORMANCE OF PROPOSED GEOLOGIC REPOSITORY

- CONFIDENCE[1] IN MODELS IS LIKELY TO BE KEY ISSUE AT TIME OF LICENSING
  - DECISION-MAKING BASED ON MODELING OF PHYSICAL/ ENGINEERING PROCESSES AND SYSTEMS
  - NEED TO ESTABLISH CONFIDENCE IN MODELS THAT REPRESENT (ABSTRACTED) PHYSICAL/ ENGINEERING PROCESSES AND SYSTEMS ARE APPROPRIATE

- USUAL AVENUE FOR DEVELOPING CONFIDENCE IN COMPUTER MODELS IS PRECLUDED
  - SPACE AND TIME SCALES
  - UNCERTAINTIES AND COMPLEXITIES IN MODELING REPOSITORY SYSTEM

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[1] i.e., "VALIDATION"

REGULATORY PERSPECTIVE: CONFIDENCE BUILDING

- *QUESTION:*
  - HOW MUCH CONFIDENCE IS NEEDED IN MODELS USED TO DEMONSTRATE COMPLIANCE WITH REGULATIONS ?

- *ANSWER [2]:*
  - CONFIRM THAT THE RELEVANT NUMERICAL PERFORMANCE STANDARDS HAVE BEEN MET
  - CONFIRM THAT THE REPOSITORY DEVELOPER'S ANALYSES OF SITE AND DESIGN ARE:
    - REALISTIC WITH REASONABLE CONSERVATISM FOR UNCERTAINTIES
    - LIMITATIONS IN THE ANALYSES ARE WELL UNDERSTOOD
    - APPROPRIATE ALLOWANCES HAVE BEEN MADE FOR TIME PERIOD, HAZARDS, AND UNCERTAINTIES
  - LEVEL OF CONFIDENCE SHOULD BE PROPORTIONAL TO IMPORTANCE TO PERFORMANCE

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[2] CONSISTENT WITH PROPOSED PART 63

THE DILEMMA IS.....

- LACK OF CONSENSUS ON WHAT "VALIDATION" IS AND HOW IT CAN BE ACHIEVED

- VAST LITERATURE EXISTS ON SCIENTIFIC MODEL VALIDATION REPRESENTING DIVERSE VIEWS

- RECOGNITION OF DIFFERENCES BETWEEN THE GOAL OF SCIENTIFIC VALIDATION AND THE NEED TO DEVELOP CONFIDENCE THAT A MODEL SUFFICIENTLY VALID FOR REGULATORY PURPOSES

- INTERNATIONAL EFFORTS TO ACHIEVE CREDIBILITY AND CONFIDENCE PERFORMANCE ASSESSMENT MODELS [3]

  - **INTERNATIONAL STRIPA PROJECT**
  - INTERNATIONAL TRANSPORT MODEL VALIDATION (**INTRAVAL**) PROGRAM
  - BIOSPHERIC MODEL VALIDATION STUDY (**BIOMOVS**)
  - **CHEMVAL**
  - DEVELOPMENT OF COUPLED MODELS AND THEIR VALIDATION AGAINST EXPERIMENTS (**DECOVALEX**)

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[3] OTHERS INCLUDE **INTRACOIN** AND **HYDROCOIN**

NRC/SKI WHITE PAPER
NUREG-1636 – SKI REPORT 99:2

- JOINT EFFORT BETWEEN STAFF MEMBERS OF THE NRC, THE SWEDISH NUCLEAR POWER INSPECTORATE (SKI), AND THE CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

- OUTLINES AUTHOR'S[4] VIEWS ON AN APPROACH TO MODEL VALIDATION FROM A REGULATORY PERSPECTIVE FOR LICENSING A GEOLOGIC REPOSITORY

- IDENTIFIES TYPES OF INFORMATION REGULATORS WOULD EXPECT TO FIND IN AN ACCEPTABLE MODEL VALIDATION APPROACH

- IS NOT INTENDED AS FORMAL STAFF GUIDANCE OR AS A *DE FACTO* STAFF POSITION

- REFLECTS CURRENT THINKING OF THE AUTHORS IN BOTH AGENCIES

- NRC STAFF INTENT IS TO INTEGRATE CONCEPTS INTO YUCCA MOUNTAIN REVIEW PLAN (CURRENTLY UNDER DEVELOPMENT)

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[4] NRC: N. Eisenberg, M. Lee, M. Federline
SKI: S. Wingefors, J. Andersson, S. Norrby
CNWRA: B. Sagar, G. Wittmeyer

NUREG-1636 – SKI REPORT 99:2 RECOMMENDATIONS

- PRIMARY RESPONSIBILITY FOR MODEL VALIDATION RESTS WITH REPOSITORY DEVELOPER

- DEGREE OF VALIDATION NECESSARY SHOULD BE COMMENSURATE WITH THE EXTENT TO WHICH THE SAFETY CASE DEPENDS ON MODEL(S) IN QUESTION

- REPOSITORY DEVELOPER WILL NEED TO:
  - ESTABLISH ADEQUACY OF THE SCIENTIFIC BASIS FOR MODEL(S)
  - DEMONSTRATE THAT THE MODEL(S) IS SUFFICIENTLY ACCURATE

- DEGREE OF MODEL VALIDATION IN REGULATOR'S MODELS MAY BE LESS RIGOROUS
  - REVIEW INTENDED TO BE INDEPENDENT CONFIRMATION
  - FUNDAMENTAL DEMONSTRATION OF REPOSITORY SAFETY RESTS WITH THE DEVELOPER, NOT WITH THE REGULATOR

NUREG-1636 – SKI REPORT 99:2 RECOMMENDATIONS (continued)

- EXAMPLE APPROACH OF A MODEL VALIDATION STRATEGY (FIGURE 3 OF NUREG-1636 – SKI REPORT 99:2)

  1. DEFINE A COMPLIANCE DEMONSTRATION STRATEGY
  2. DETERMINE GOALS FOR MODEL VALIDATION
  3. DETERMINE THE EXISTING DEGREE OF VALIDATION FOR THE MODEL(S) SELECTED
  4. COMPARE VALIDATION GOALS TO EXISTING DEGREE OF VALIDATION
  5. DECIDE WHETHER TO REVISE COMPLIANCE DEMONSTRATION STRATEGY
  6. OBTAIN FURTHER SUPPORT/INFORMATION
  7. DOCUMENT STATEMENTS OF MODEL VALIDITY

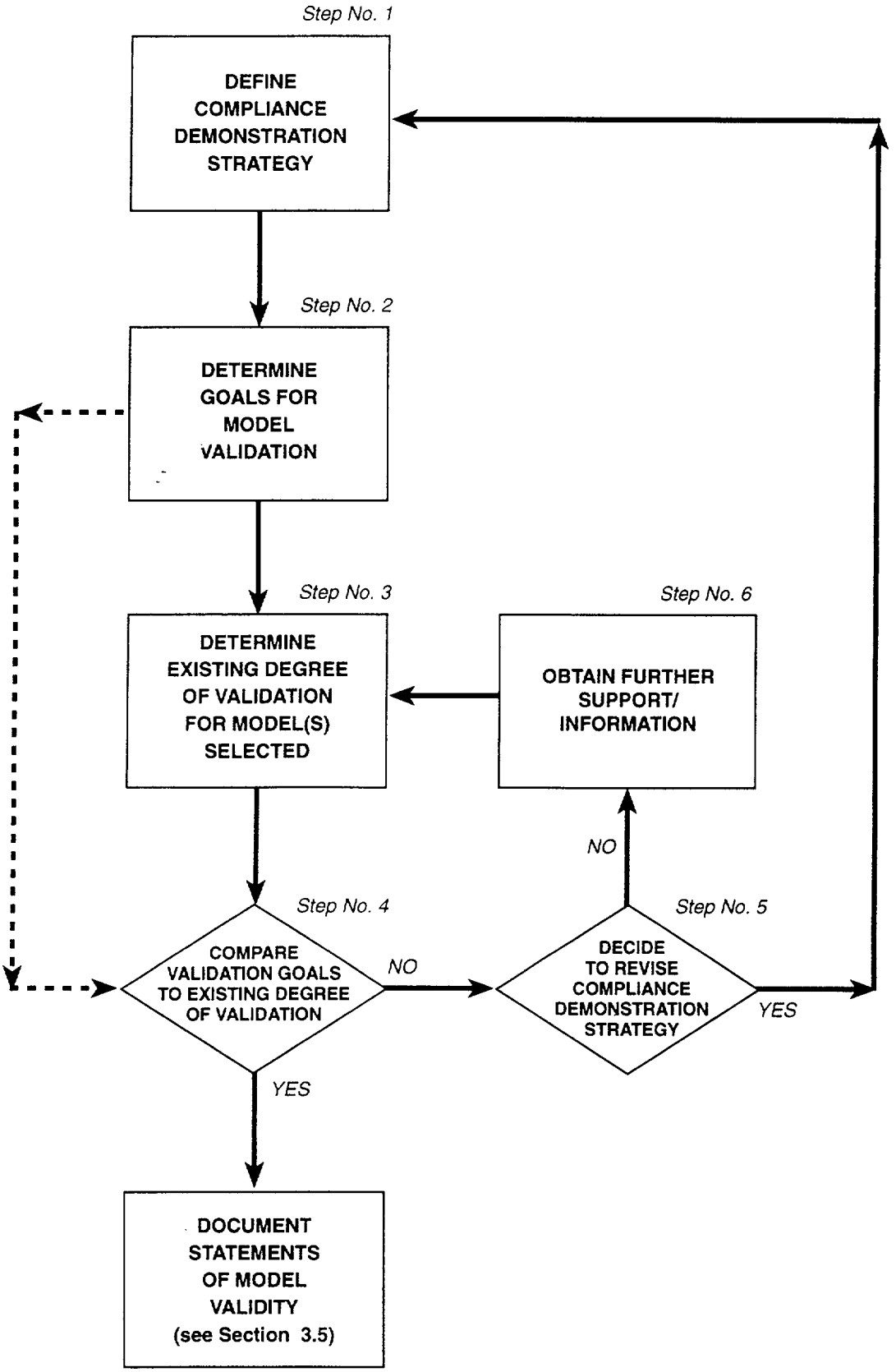

Figure 3. Regulatory strategy for developing confidence in models.

COMPUTER CODE VERIFICATION

- INTEGRAL TO MODEL VALIDATION
- IMPORTANT ELEMENT OF REPOSITORY DEVELOPER'S QUALITY ASSURANCE (QA) PROGRAM
- OVERALL QA REQUIREMENTS FOUND IN SUBPART G OF PROPOSED PART 63
- SPECIFIC NRC GUIDANCE CAN BE FOUND IN THE FOLLOWING:

NUREG-0856	FINAL TECHNICAL POSITION ON DOCUMENTATION OF COMPUTER CODES FOR HIGH-LEVEL WASTE MANAGEMENT
NUREG/BR-0167	SOFTWARE QUALITY ASSURANCE PROGRAM AND GUIDELINES
NUREG/CR-4640	HANDBOOK OF SOFTWARE QUALITY ASSURANCE TECHNIQUES APPLICABLE TO THE NUCLEAR INDUSTRY
NUREG/CR-4369	QUALITY ASSURANCE (QA) PLAN FOR COMPUTER SOFTWARE SUPPORTING THE U.S. NUCLEAR REGULATORY COMMISSION'S HIGH-LEVEL WASTE MANAGEMENT PROGRAM