Structured Decision Analysis for Performance Assessments

Recent Development and Trends in Integrated Risk Assessment Methods, Tools and Decision Analysis Support
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NEPTUNE AND COMPANY

Improving the quality of environmental decision making.

Decision Analysis for PA
(and other complex environmental decisions)

- Decision Analysis can provide a different approach to the way in which Radioactive Waste Disposal is considered/evaluated
  - A “Paradigm Shift”
  - A “Revolution”?
- Some other environmental programs are ahead of PA in this regard (e.g., EPA sustainability and land use programs)
  - Although both NRC and DOE have previously performed cost-benefit analysis (using population risk)

Why Does PA Need a Makeover?

If we want nuclear industries, then we need to:

- Make the best use of our existing disposal facilities
- Move beyond compliance determinations
- Optimize use of ever more scarce funding
- Remove conservatism
  - over-engineering, creating problems that do not exist
  - use “reasonable realism” – will improve communication

So, stop wasting money

- nuclear industries (which really means the current generation) foots the unnecessary bill

and maximize benefits to all stakeholders

Why Does PA Need a Makeover?

- Optimized decision making is needed for
  - future disposal (including consideration of storage and retrieval, transport/shipping)
    at a disposal site, or choosing between sites
  - closure
  - long term monitoring (with stopping rules)
  - maintenance and management
- Conservatism is limiting waste disposal, which leads to the need for more waste disposal sites and unnecessary expense

Thoughts?

- "All models are wrong, but some are (hopefully) useful" (George Box, 1979)
- "Models should be as simple as possible and no simpler" (Morgan &Henrion, 1990)
  - Smarter tools, not bigger ones
- Remove "*conservatism on top of conservatism on top of conservatism*…." – otherwise GIGO
- Radioactive waste management tail is wagging the nuclear industry dog
  - and we still have legacy waste to deal with

ALARA opens the door

10 CFR 20.1101(b) requires that:

> "The licensee shall use, to the extent practicable, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (**ALARA**)."

ALARA implies value, implies objectives, and implies *decision analysis*

What PAs Should Be

- Decision-focused, addressing
  - stakeholder values, costs and benefits
  - uncertainty (with probabilistic modeling)
- Sustainable – 3 pillars of sustainability
  - economics, environment (ecology), society
- Transparent
- Defensible
- Adaptive depending on attainment of objectives
  - consideration given to compliance

So, What is Decision Analysis?

- "Formalized common sense"
- A set of tools for structuring and analyzing complex decision problems
- An approach for making logical, reproducible, and defensible decisions in the face of:
  - Technical complexity
  - Uncertainty
  - Costs and value judgments
  - Multiple, competing objectives

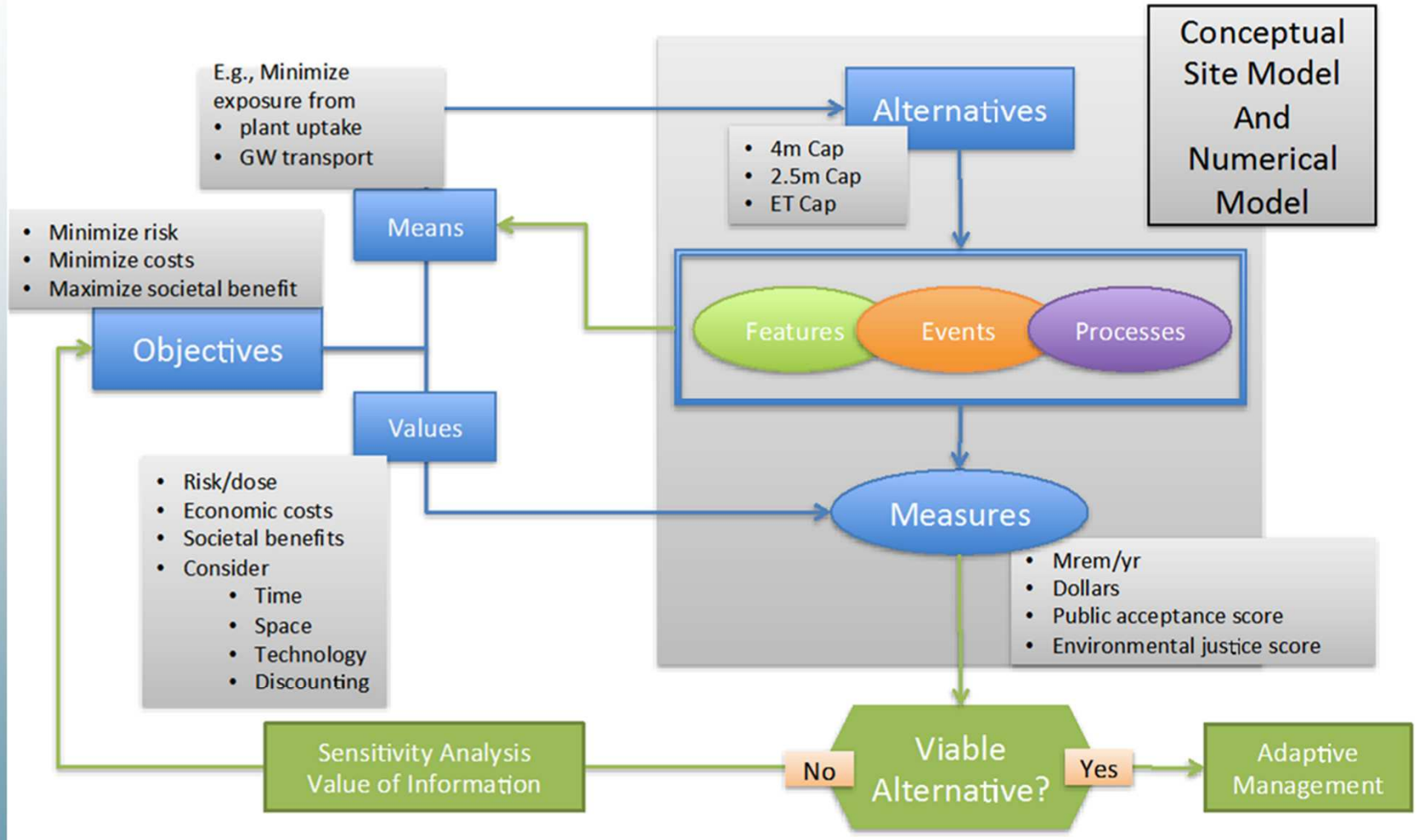
Applying Decision Analysis

- Identify objectives, decision options, and events that define the decision analysis
- Clearly communicate judgments about costs and values, uncertainty (probabilities), and risks
- Actively involve stakeholders, customers or users at all stages of the decision analysis process (instead of only at later stages, which is more typical)

Decision Analysis Components

- Decision options
- Probabilistic model (uncertainty)
- Costs and value judgments
- Uncertainty analysis
- Sensitivity analysis
  - Value of information
- Make decision or collect new information and iterate

PA as a Structured Decision Analysis Process



Decision Analysis Overview

- In the long run, it is best to choose the alternative (decision option) that provides the best expected outcome, given what you know or believe about future events.
- This is the basis of *cost-benefit analysis.*
- Evaluates sustainability: economics, environmental and social aspects
- For example: ***Maximize expected societal welfare***

Also – Risk management, Economic analysis….

Roots of Decision Analysis

- Bayesian probability theory (Bayes, 1765)
- Utility theory (von Neumann & Morgenstern, 1947)
- Bayesian Statistical Decision Theory (de Finetti, 1930s, Savage, 1954, DeGroot, 1970)
- Behavioral Science (von Winterfeldt and Edwards, 1986)
- Policy Analysis (Morgan and Henrion, 1990)
- Structured Decision Making (Gregory et al., 2012)

Common Application Areas

- Oil and gas industry
- Risk analysis (business decision risk)
- Pharmaceutical and biotechnology industries
- Public sector applications
  - Department of Defense
- Environment – moving in this direction

Environmental Evolution

- Compliance using deterministic models
  - Difficult to overcome inertia and intransigence in the industry (old dogs – new tricks)
  - Changes at the top-level take a long time to trickle down through Regions and States
- Strong evidence of an evolutionary change
  - OMB (Circular A-4, 2003)
  - EPA SAB, EPA CREM, NAS, NRC, SRA
  - CERCLA, NEPA, NRDA, ALARA
    - all open the door

EPA ORD Examples

- SMARTe – Brownfields revitalization – www.smarte.org
- Re-imagining Cleveland
  - Regional land use planning
- DASEES – Decision Analysis for a Sustainable Environment, Economy, and Society – www.dasees.org
  - Land reuse and watershed management

ALARA/DA precedents?

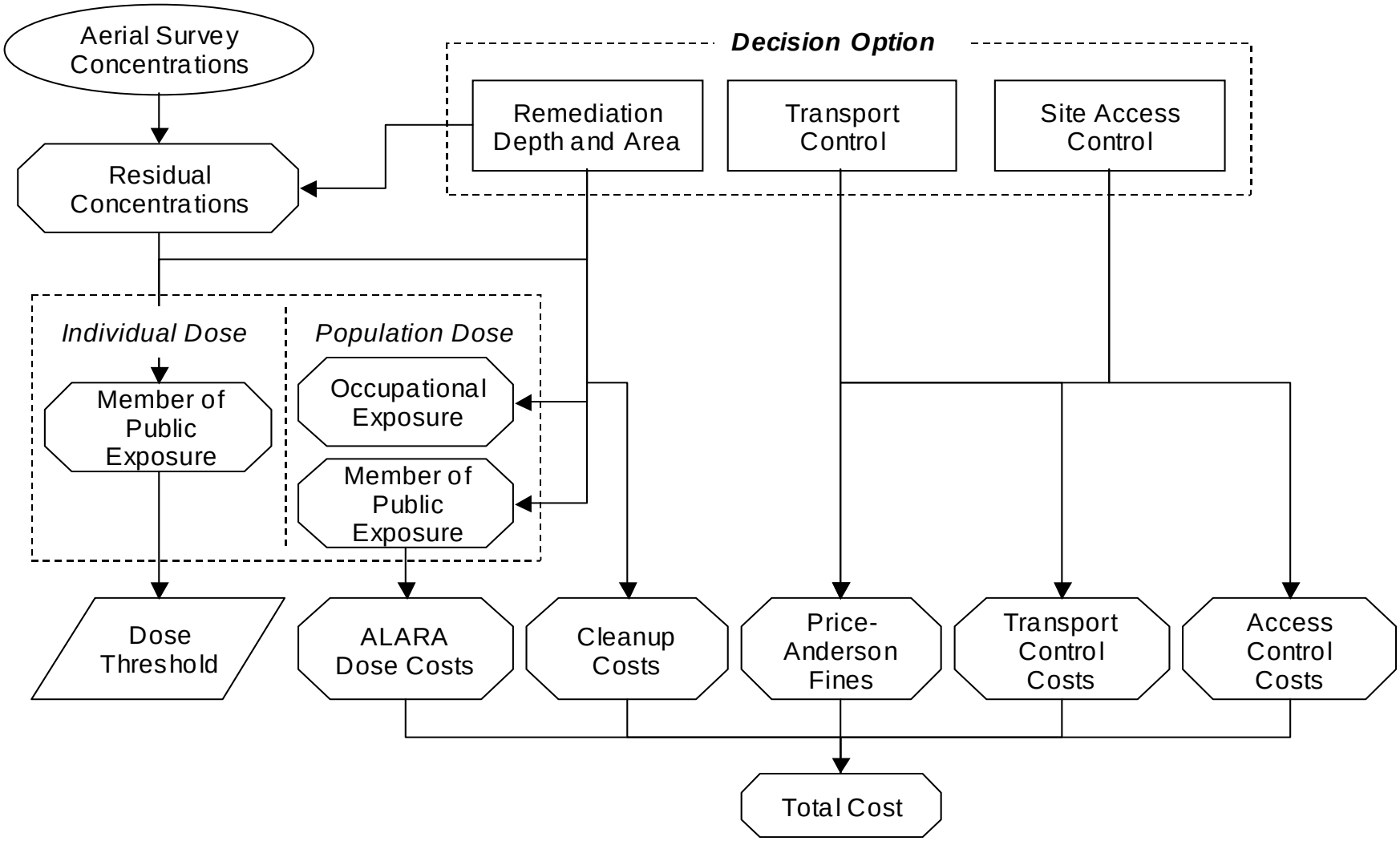
- Application of population risk using cost measures
- Initially $2,000 per person rem per year with no discounting (NUREG/BR 0058, Rev 2, 1995)
- "Upgraded" to a distribution from $1,000 - $6,000 per person rem per year with a 7% discount rate (NUREG 1757, 2003)

From NRC's Decommissioning Guidance

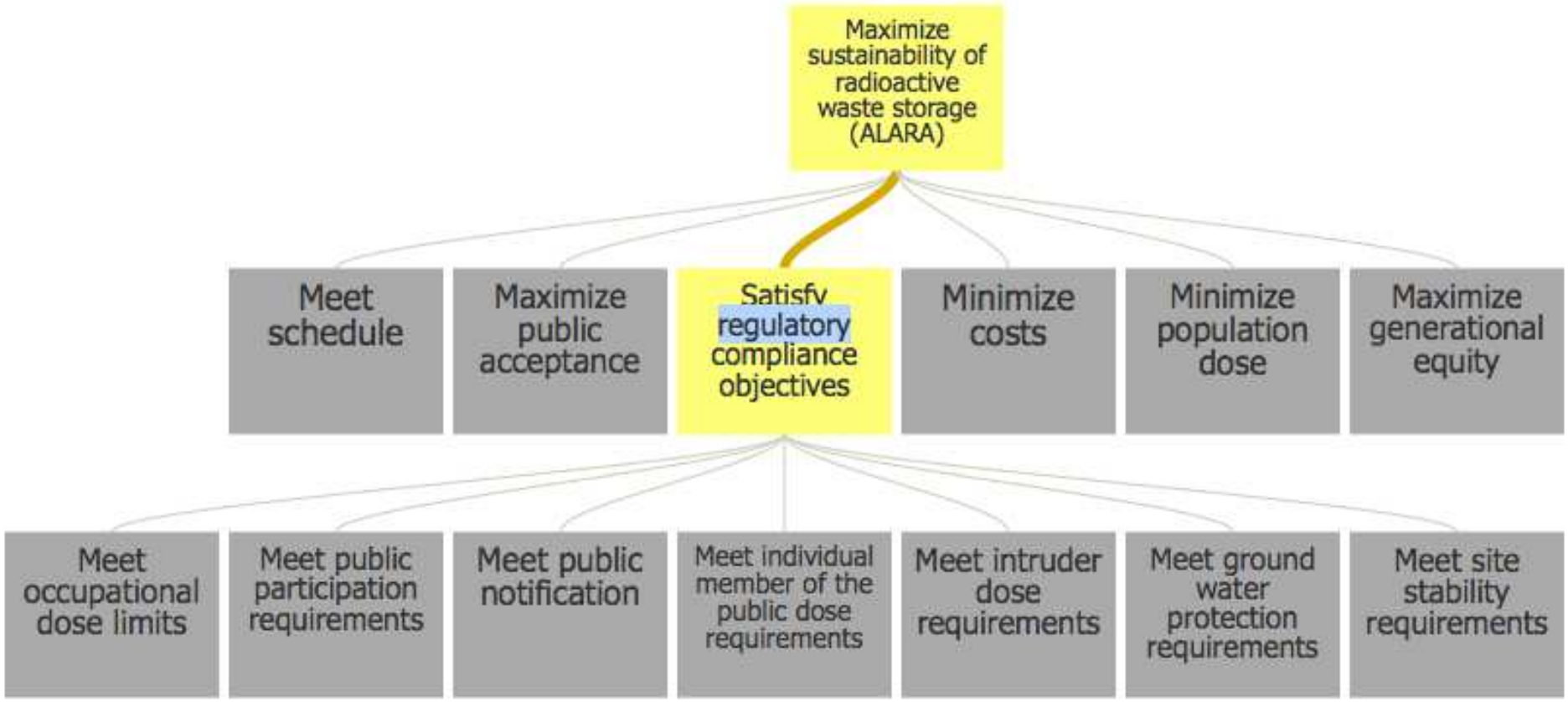
- DOE application from "DOE ALARA Standard, Vol. 2, pg. E-20" 1997

Implies need for Population Risk Assessment

DOE – Smoky Site Example



PA "Objectives Hierarchy" based on DASEES tool (EPA)



The Problem of Conservatism

There is conservatism in

- Modeling (and modeling tools)
- regulations and guidance
- performance objectives

Conservatism on top of conservatism on top of conservatism…

The resulting dose and risk calculations

- might not actually be conservative because of confounding influences, and
- cannot be meaningfully interpreted probabilistically or for decision making

It is fine to make conservative decisions, but not to make decisions based on conservative models

Site-Specific Scenarios

- *Why do we not simply evaluate reasonable site-specific exposure scenarios?*
- No need to explain MOP vs. IHI

"MOP is offsite, but up against the fence, so exposed to onsite conditions, but without effects of IHI"

"IHI is onsite, but only after AIC, and only exposed to water use and drill cuttings, so the well is onsite, but the MOPs are not, except people exposed to the drill cuttings". *Huh? Aren't they the same people?*

Note – EPA does not require consideration of residential scenarios if there are no residents

Site-specific Decision Making

Site-Specific Exposure Scenarios

can make a difference in

distinguishing site performance.

Economic or Cost-Benefit Issues

- Market and non-market costs and benefits
  - Market – Engineering costs
  - Non-market – Risk reduction
- Decision management options
  - Engineering options
  - Storage and retrievability
  - Trust funds – e.g., for generational re-evaluation (changes in society/technology), facility maintenance
  - Insurance – disasters, problems
- Modeling components
  - Discounting
  - Generational equity issues
  - Population risk/dose

DA for PA – Summary

Decision Analysis provides the appropriate paradigm for evaluating cost-benefit of alternative options

This approach is achievable with current technology for PA-related decisions, and has been implemented for other complex environmental decision problems

It can (should) be stakeholder driven

Decision models should be based on "reasonable realism"

It is fine to make conservative decisions, but not to make decisions based on conservative models

We need this approach to help optimize decision making for the nuclear industry