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# Integrating Risk and Decisions

Society of Toxicology Workshop: July 25-27

Scott Farrow

Chief Economist, Government Accountability Office

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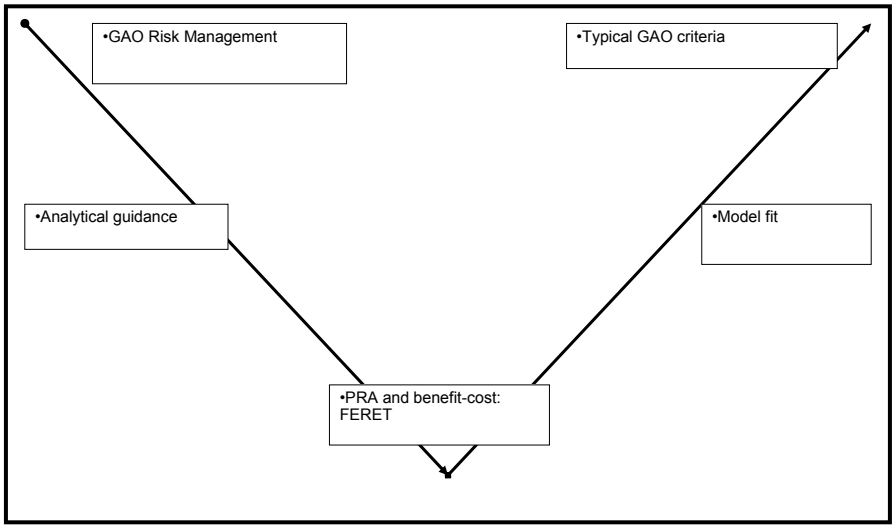
## Outline

- Risk and uncertainty: forecasting, decisions, evaluation
- Risk management: GAO
- Analysis guidance
- Examples of integration
- Some GAO criteria

## Context

- Statistical forecasting:
  - Mental model of a multiple (conditional) regression analysis—formal structure for statistical distribution associated with coefficients (typical "Probabilistic Risk Assessment") and overall goodness of fit.
- Performance informed management decisions in multiple domains
  - Statutorially constrained models
  - Targeted mission performance: PEL's? Cases?
  - Economic performance
    - Deterrmanistic: standard B-C; cost-effectiveness (most of OMB A-4; A-94, A-11)
    - Integrated uncertainty: expected value, mean and variance trade-off/risk aversion; multi-criteria or multi-objective based on personal utility, irreversibility and flexibility (options)
- Evaluation/retrospective analysis: what outcomes actually occurred to inform sequential decisions and improve models?





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**Risk management: GAO**

1. Historically, mission specific agency concerns: safety, defense, health, investments, natural events.
2. Evolving tools for evaluating risk (likelihood and outcome—generally bad) and integrating with decisions.
3. 9/11 brought new visibility to the issue
4. Emerging area on GAO High Risk list: risk management
5. GAO default framework for risk management



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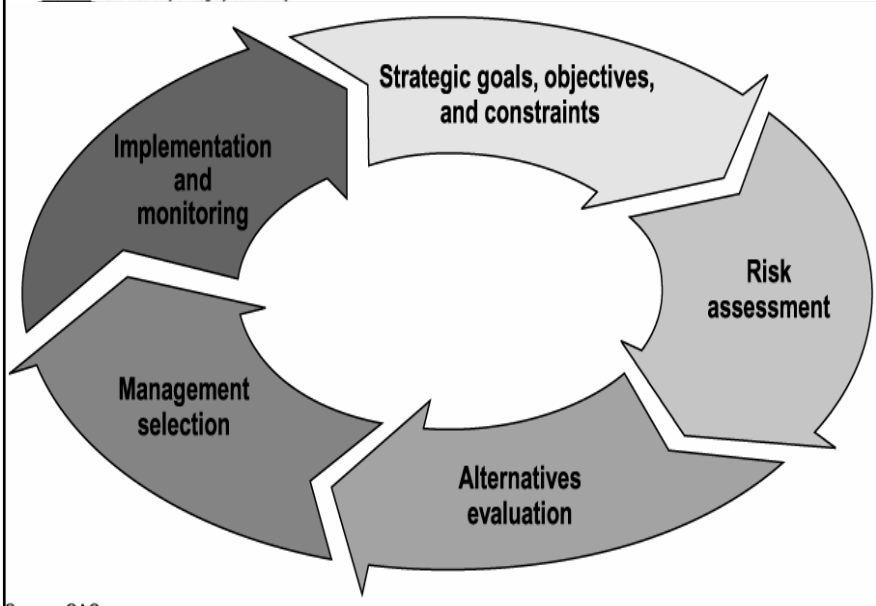
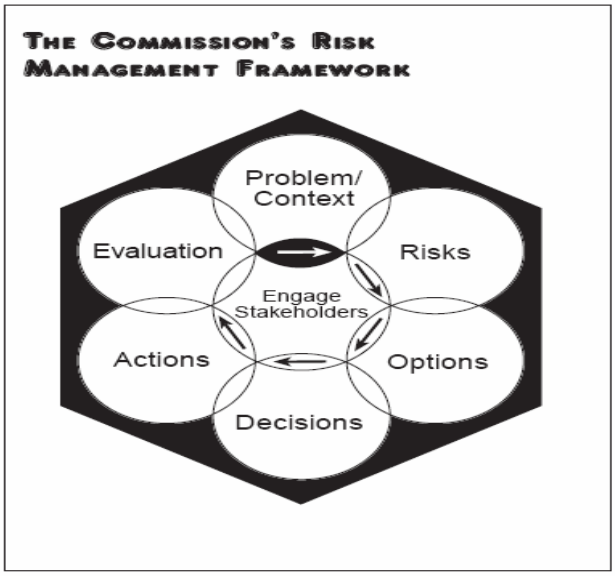
GAO Default Risk Management Approach:
Recognition of other approaches

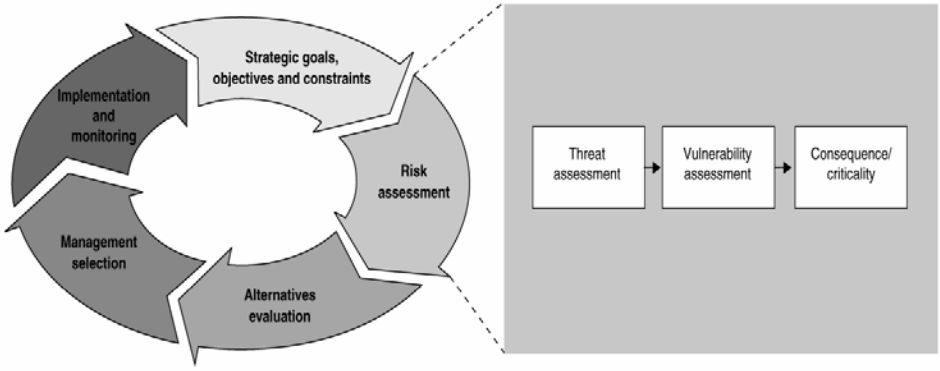



Source: GAO.

Presidential/Congressional Commission on
Risk Assessment & Risk Management




Specific risk assessment steps are application specific
Toxicology: Exposure, Dose, Response a specific logic model
Typical Homeland Security Example Below

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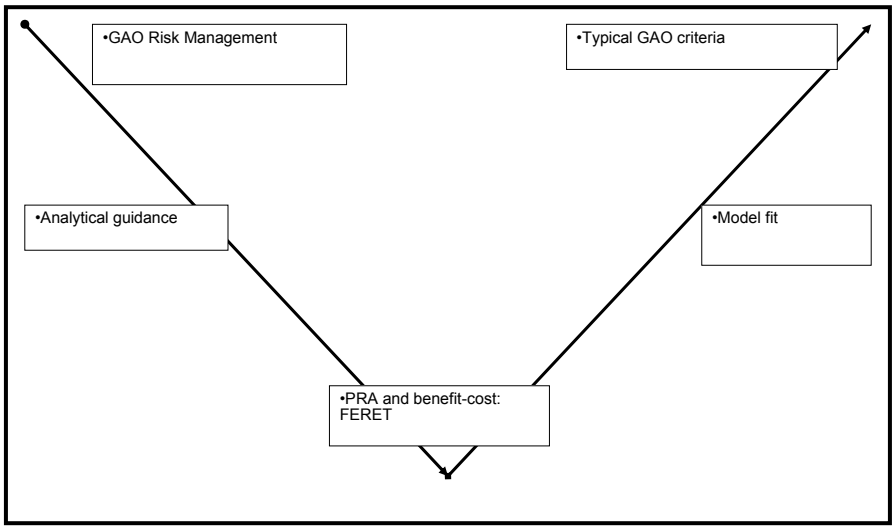




Analytical Guidance

## Context

- Professional analytical guidance:

Example: accounting guidance from standard setting bodies (next slide)

- Risk and regulations: Central guidance
  - OMB circulars: A-4 (latest of best practices); A-94 (benefit-cost, cost effective)

    A-4: 81 mentions of risk; expected values and importance of compatibility with "formal risk assessments"; if economic impacts of $1 billion or more—should provide formal quantitative analysis of distributions of benefits and costs

- Agency specific guidance: detailed testing (?) through to benefit-cost analysis (EPA: Guidelines for Preparing Economic Analysis (Sept. 2000))—section on analyzing and presenting uncertainty.)

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## Accounting Guidance Hierarchy

| | Hierarchy of Principles of accounting for | |
|---|---|---|
| **Category** | **Nongovernment** | **Federal government** |
| a | Financial Accounting Standards Board (FASB), Statements and Interpretations;<br>Accounting Principles Board (APB), Opinions; and<br>American Institute of Certified Public Accountants (AICPA), Accounting Research Bulletins. | FASAB Statements and Interpretations and<br>AICPA and FASB pronouncements if made applicable to federal government entities by FASAB Statements and Interpretations. |
| b | FASB Technical Bulletins and<br>AICPA Industry Guides and Statements of Position if they have been cleared. | FASAB Technical Bulletins and<br>Cleared AICPA Industry Guides and Statements of Position if specifically applicable to federal government entities. |
| c | Consensus positions of the FASB Emerging Issues Task Force and<br>Cleared AICPA Practice Bulletins. | AICPA Practice Bulletins if specifically applicable to federal government and cleared by FASAB and<br>FASAB Accounting and Auditing Policy Committee technical releases. |
| d | AICPA accounting interpretations;<br>FASB "Q and As";<br>Industry practices if widely recognized and prevalent; and<br>FASB, AICPA audit guides, SOPs, and practice bulletins that have not been cleared. | Implementation guides FASAB staff publishes and<br>Practices widely recognized and prevalent in the federal government. |
| e | Other accounting literature, including FASB concept statements, AICPA Issues Papers, International Accounting Standards Committee statements, Governmental Accounting Standards Board (GASB) statements, interpretations, and Technical Bulletins;<br>Pronouncements of other professional associations or AICPA technical practice aids and regulatory agencies; and<br>Accounting textbooks, handbooks, and articles. | Pronouncements in hierarchy categories "a" through "d" for nongovernment entities when not specifically applicable to federal government entities;<br>Other accounting literature, including FASB concept statements, AICPA Issues Papers, International Accounting Standards Committee statements, GASB statements, interpretations, Technical Bulletins, and concept statements;<br>Pronouncements of other professional associations or AICPA technical practice aids and regulatory agencies; and<br>Accounting textbooks, handbooks, and articles. |

Source: D. M. Pallais, M. L. Reed, and C. A. Hartfield, *PPC's Guide to GAAS: Standards for Audits, Compilations, Reviews, Attestations, Consulting, Quality Control and Ethics: Audit Reports* (Fort Worth, Texas: Practi



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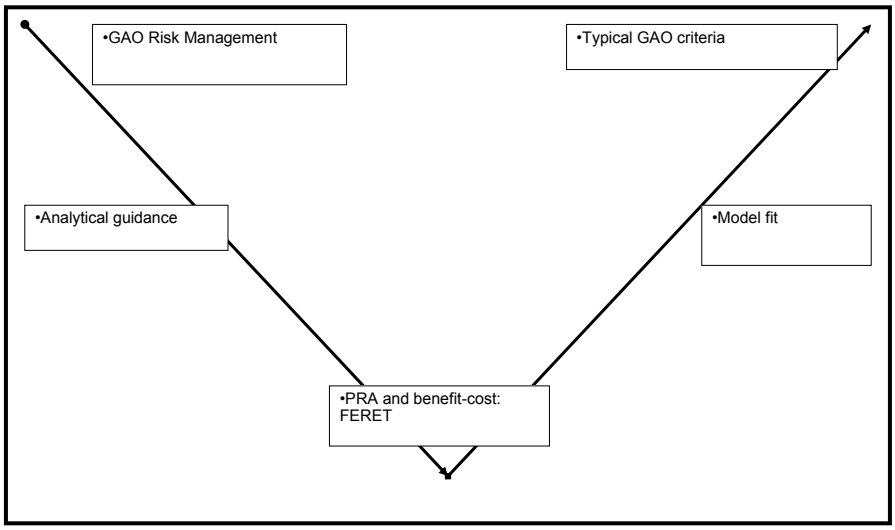

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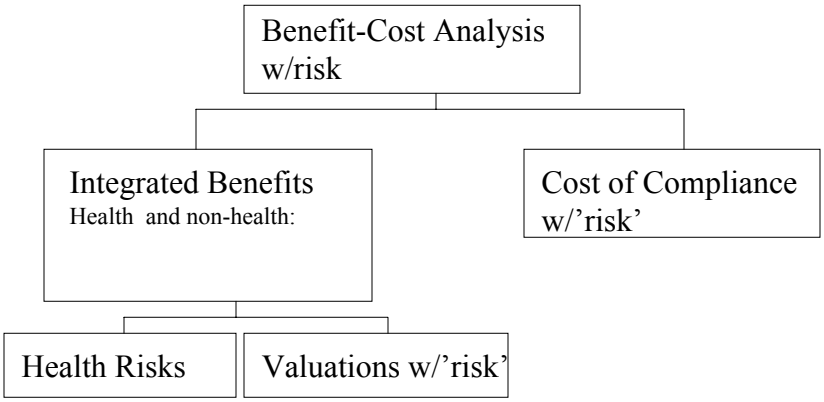
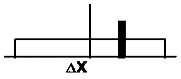
## Example: Integrating Risk and Benefit-Cost Analysis



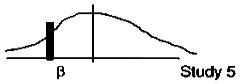



1. Sample from impact of regulatory design, $\Delta X$ (e.g., change in concentration, can be any distribution)



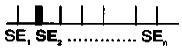

2. Randomly selects health study (among those selected to be true)

3. Samples from concentration-response function, $\beta$, of selected study, study 5 in this example.

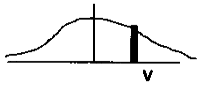



Result after substitution in study response equation: one "observation" = $\Delta$ cases$_j$

4. Randomly selects economic study, SE (among those selected to be true)



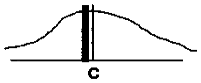

5. Samples from valuation function of selected study, $SE_2$




**Result: Benefits (value of damages avoided) B = $\Delta$ cases$_j$ * V**

Which is transformed into present value (PVB) using discount and other parameters supplied by the user.

Cost: samples from present value cost distribution




**Result one "observation" of: Net Present Value as Benefit-Cost PVB-C**

**FERET will obtain many "observations" in the same way with one simulation trial leading to one observation. Typically, FERET is run hundreds of times.**

**FIGURE 19-1.** FERET Conceptual Flow Chart for One Impact of One Pollutant

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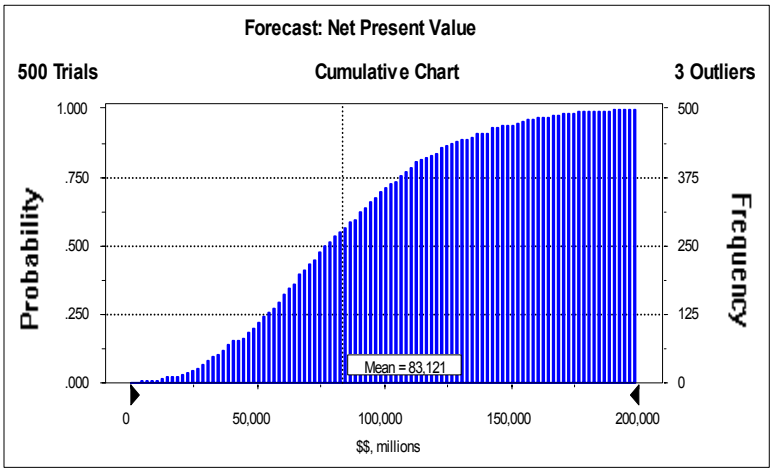
# Benefits and Costs



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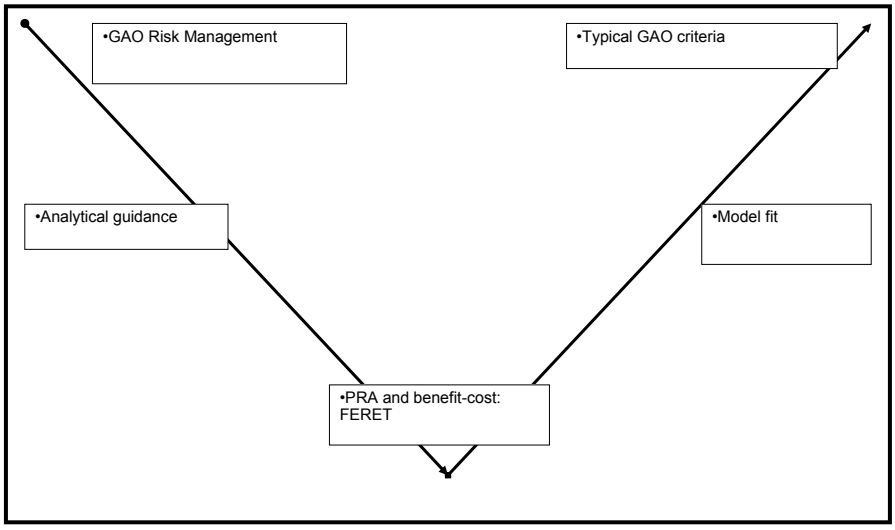

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Initial thinking: Model uncertainty

Given: construction of a PRA with soundly based sources for distribution for parameters

Research question: has pure uncertainty been fully captured? (existing empirical literature on under-estimation of risk.)

Consider NHI=X$\beta$ + $\varepsilon$ and the var(NHI) (NHI=net health impact)

variance component from the conditioning factors (variability mixed with uncertainty) could exist, but the pure error component would typically not

$$Var(NHI|X) = \sigma^2[X(X'X)^{-1}X'+1]$$



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Consider a Bayesian estimate of the goodness of fit based on a subjective estimate of $R^2$

$R^2$ = 1 – SSE/SSTO

With some definitions and algebra:

$$\hat{\sigma}^2 = \left(\frac{1 - R^2}{R^2}\right)\frac{SSR}{N - k}$$

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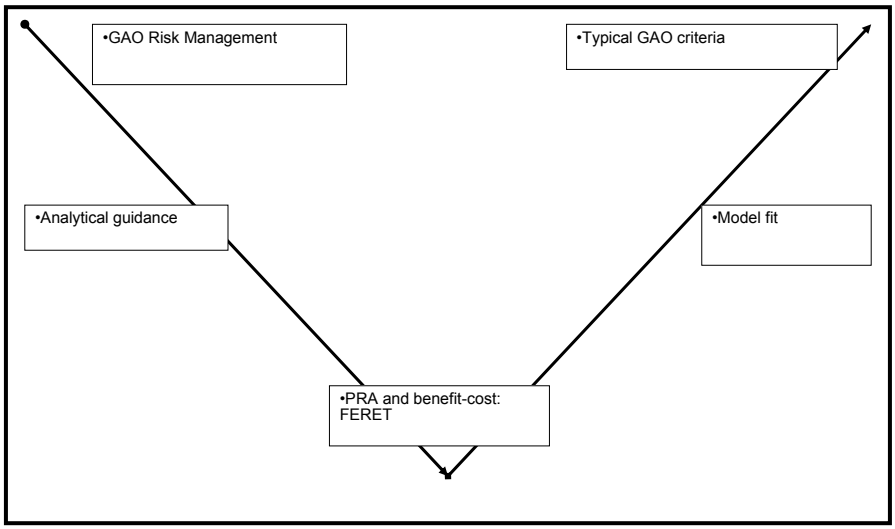
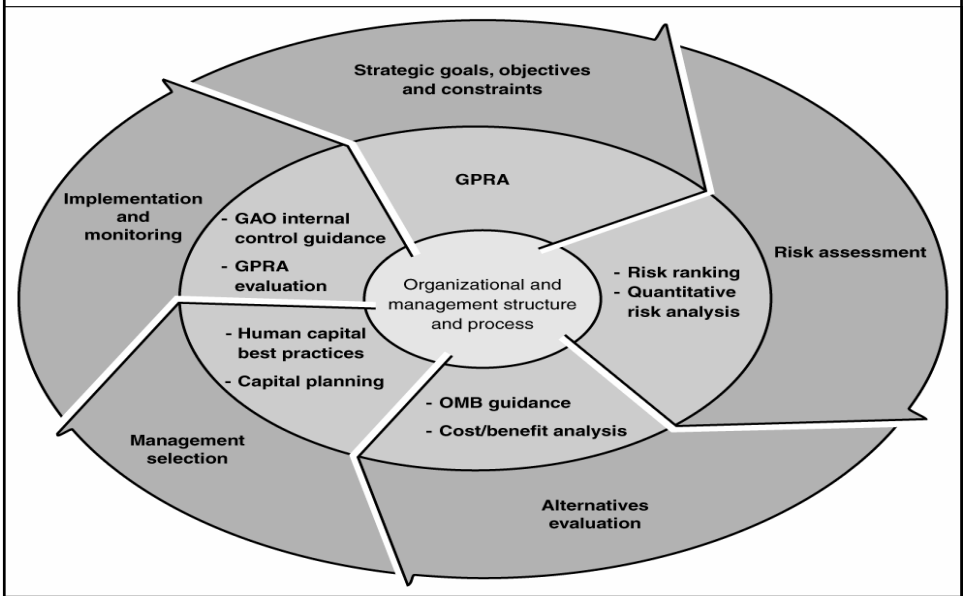





## Cross-cutting Criteria Sources




Source: GAO.