

Risk-Informed Decision-Making: Sustainable Management of Flood Risks

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Our *Systems*

- Navigation system:
 - locks, dams, channels
- Reservoir system:
 - structures and operating procedures
- Flood risk reduction system:
 - Structural, nonstructural, ecosystem features
- Ecosystem features comprising a restoration project



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Our Decision Problems

- Complexity due to:
 - Nature of the systems we manage
 - Number and diversity of interested and affected parties
- Risk-informed decision making includes approaches for:
 - Resolving risk-decision problems
 - Analyzing relevant uncertainties
 - Informing policymaking, planning and operations



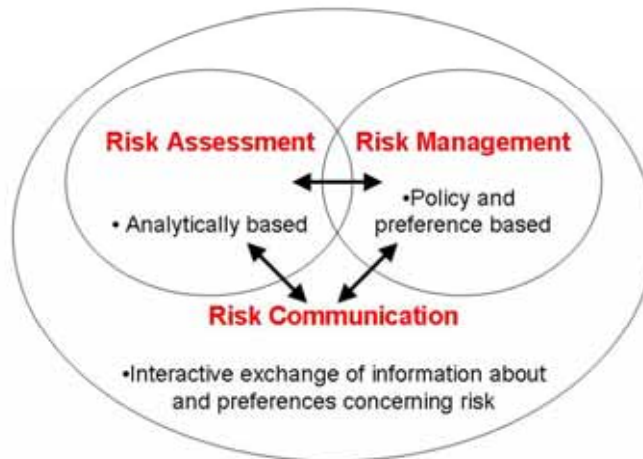
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Risk-Informed

- *Risk analysis*: an approach to developing an understanding of the processes shaping the scope and nature of risks and uncertainties that is sufficient to support decision making
 - What is the risk?
 - Why and how are the risks occurring?
 - What is the uncertainty associated with the risk estimate?
 - How do the management alternatives differ in terms of risk reduction performance?
 - How do we communicate the risks and our strategies for managing those risks?

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Risk Analysis



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Uncertainty, Uncertainty, Uncertainty...

Uncertainty: Lack of certainty

- An important distinction:
 - Making a prediction and
 - Attaching a measure of confidence to that prediction
- Two practical sources of uncertainty
 - Incomplete characterization of the system components
 - Changes in conditions over time that affect the performance of the system

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Risk Assessment Tools

- Range from the qualitative to the quantitative
- Models to describe and forecast the distribution of events
 - Weather models, hydrodynamics and hydrology, contaminant fate and transport, water quality models, etc.
- Data analysis and models to describe the range of consequences
 - Human health and safety, economics, ecology, etc.
- Approaches for evaluating uncertainties
 - Scenario analysis
 - Quantitative, probabilistic methods

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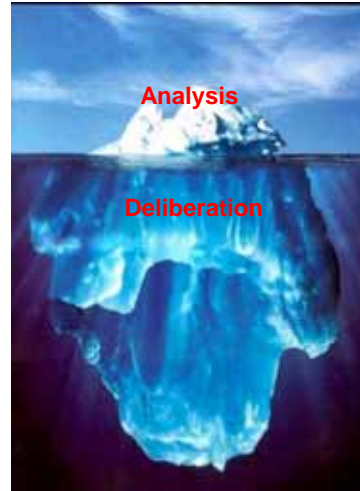
The Multidimensional Nature of Risk

- Two aspects
 - Diverse nature of the outcomes of interest
 - Could include: human health and safety, economics, environmental impacts, affects on social systems, etc.
 - Human dimensions
 - Human responses to risk are a function of human values, risk perceptions and risk attitudes

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An Analytic-Deliberative Process

- Risk analysis produces, uses and disseminates technical information
- Deliberation is used to develop understanding to support decisions
 - Deliberation will determine:
 - How the problem is conceptualized
 - How the problem is analyzed
 - What constitutes a successful solution



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Katrina: A “Big” Event

- Landfall 0610, 29 August 2005
- Category 3
 - 125 mph sustained winds
 - 24-28 ft. max surge
- 1,836 deaths
- \$100B in damages
- 100 mcy of debris



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Congressional Direction for LaCPR

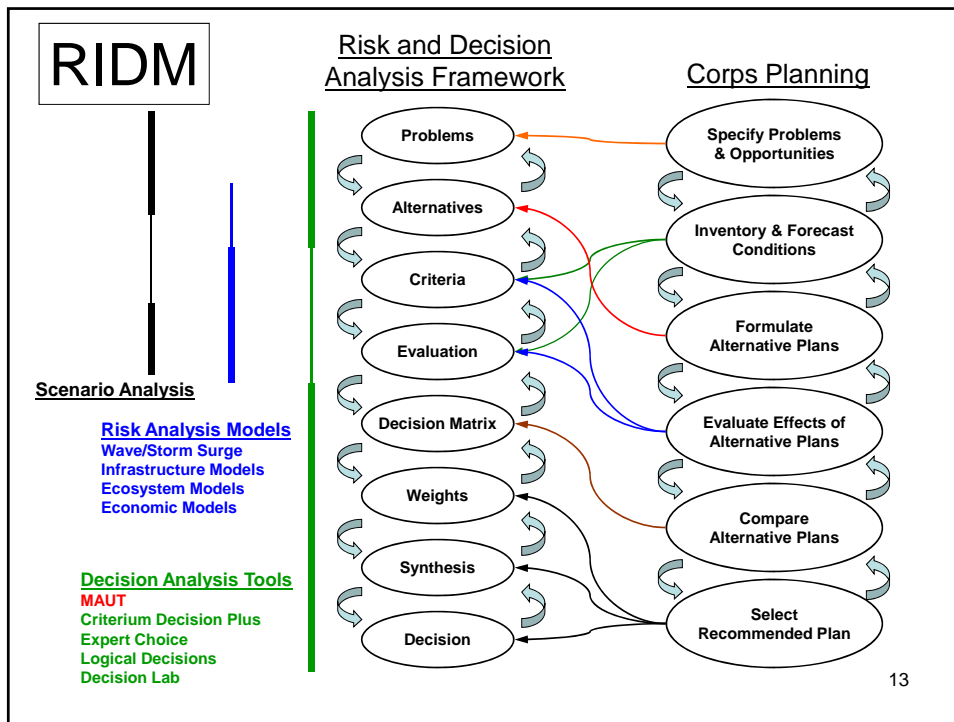
- Comprehensive hurricane protection analysis and design
- Full range of flood control, coastal restoration, and hurricane protection measures
- Storm surge equivalent to a “Category 5” hurricane
- Exclusive of normal policy considerations
- Preliminary Technical Report within 6 months
- Final Technical Report within 24 months
- Reports on component areas for authorization as soon as practicable
- Close coordination with the State of Louisiana

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Risk-informed decision making as applied to post-Katrina planning

- Broader than traditional NED analysis
- Solidly founded upon the Corps’ planning process
- Incorporate risk and uncertainty information into the decision process
- “Simply and clearly show to decision makers and the public the risks, costs, and consequences of...” plans
 - Provides the means to score and rank plans
- Promote transparency in decision making
- Provide a structure and process that facilitates interaction with partners and stakeholders
 - Promote understanding, credibility and legitimacy
- Facilitate adaptive management

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Scenario Analysis

- Consider future uncertainties through scenario analysis
- Scenarios represent combinations of assumptions or future conditions
 - Example conditions for coastal flooding scenarios:
 - Sea level rise/subsidence rates
 - Future economic and development patterns
- Scenarios used to evaluate the robustness of potential plans of action

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LACPR Scenarios

| | | Relative Sea Level Rise | |
|-------------------------------|--|-------------------------|----------|
| | | (Lower) | (Higher) |
| Pattern of Development | High employment / dispersed population | $k = 1$ | $k = 2$ |
| | BAU employment / compact population | $k = 3$ | $k = 4$ |

Multi-Criteria Decision Analysis

- An approach for structuring and analyzing decision problems
- Emphasis given to:
 - Defining the problem
 - Establishing explicit objectives
 - Defining metrics for evaluating alternative solutions/plans
 - Incorporating human values and risk attitudes
 - Through weighting and utility functions
 - Ranking plans based on quantitative scores derived from metrics
 - Using multi-attribute utility theory

LaCPR Objectives and Metrics

Planning Objectives

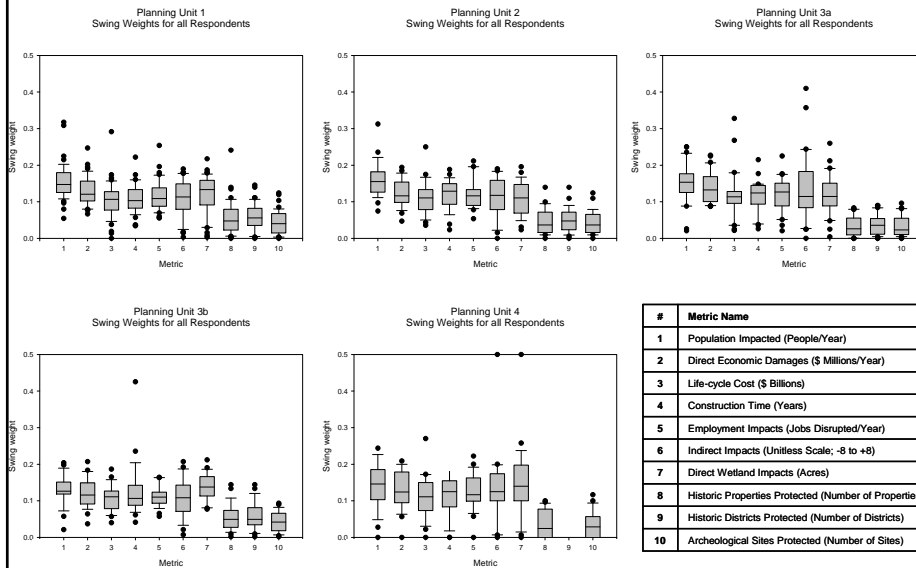
- Reduce risk to public safety from catastrophic storm inundation
- Reduce damages from catastrophic storm inundation
- Promote a sustainable ecosystem
- Restore and sustain diverse fish and wildlife habitats, and
- Sustain the unique heritage of coastal Louisiana by protecting historic sites and supporting traditional cultures

Risk Metrics

- National Economic Development
 - Residual damages
 - Life-cycle costs (Implementation, O&M)
 - Construction time
- Regional Economic Development
 - Regional Economic Development (jobs, income, regional output)
- Environmental Quality
 - Spatial integrity
 - Wetlands restored and/or protected
 - Direct impacts
 - Indirect impacts
 - Historical properties protected
 - Archeological properties protected
- Other Social Effects
 - Residual population impacted
 - Historical districts protected

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Distribution of Swing Weights Across Planning Units



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Plan Rankings

PU-1: A

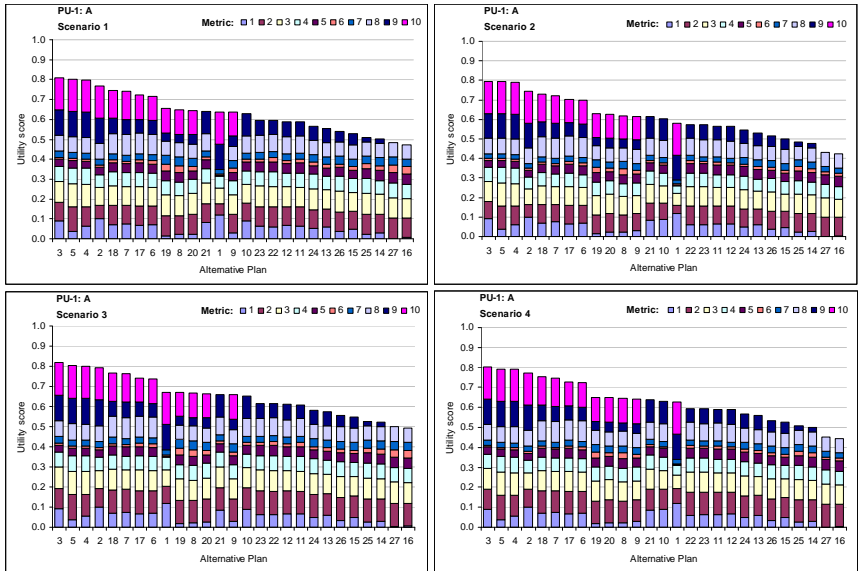
| Plan | Plan Code | Utility |
|------|-------------------|---------|
| 3 | PJ1-NS-100 | 0.825 |
| 5 | PJ1-NS-1000 | 0.822 |
| 4 | PJ1-NS-400 | 0.700 |
| 2 | PJ1-R2 | 0.707 |
| 18 | PJ1-C-HL-a-100-3 | 0.747 |
| 7 | PJ1-HL-a-100-3 | 0.740 |
| 17 | PJ1-C-HL-a-100-2 | 0.721 |
| 6 | PJ1-HL-a-100-2 | 0.715 |
| 19 | PJ1-C-HL-b-400-2 | 0.654 |
| 8 | PJ1-HL-b-400-2 | 0.646 |
| 20 | PJ1-C-HL-b-400-3 | 0.646 |
| 21 | PJ1-C-LP-a-100-1 | 0.641 |
| 1 | PJ1-0 | 0.628 |
| 9 | PJ1-HL-b-400-3 | 0.627 |
| 10 | PJ1-LP-a-100-1 | 0.630 |
| 23 | PJ1-C-LP-a-100-3 | 0.565 |
| 22 | PJ1-C-LP-a-100-2 | 0.565 |
| 12 | PJ1-LP-a-100-3 | 0.588 |
| 11 | PJ1-LP-a-100-2 | 0.588 |
| 24 | PJ1-C-LP-b-1000-1 | 0.564 |
| 13 | PJ1-LP-b-400-1 | 0.553 |
| 26 | PJ1-C-LP-b-1000-1 | 0.541 |
| 15 | PJ1-LP-b-400-1 | 0.529 |
| 25 | PJ1-C-LP-b-1000-2 | 0.510 |
| 14 | PJ1-LP-b-400-2 | 0.561 |
| 27 | PJ1-C-LP-b-1000-2 | 0.452 |
| 16 | PJ1-LP-b-1000-2 | 0.474 |

Table of Top Ranked Plans: PU1, Scenario 1

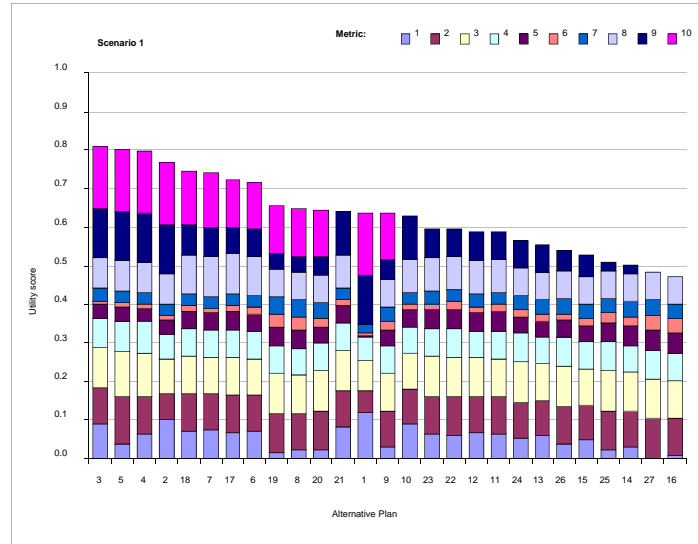
| PLAN CODE Frequency | Rank Based on Swing Weights | | | | | Total |
|------------------------|-----------------------------|----|----|----|----|-------|
| | 1 | 2 | 3 | 4 | 5 | |
| PJ1-C-HL-a-100-2 | 0 | 0 | 0 | 0 | 5 | 5 |
| PJ1-C-HL-a-100-3 | 0 | 0 | 0 | 10 | 28 | 38 |
| PJ1-C-HL-b-400-2 | 1 | 0 | 0 | 3 | 0 | 4 |
| PJ1-C-LP-a-100-1 | 0 | 0 | 0 | 3 | 1 | 4 |
| PJ1-C-LP-a-100-2 | 0 | 0 | 0 | 0 | 1 | 1 |
| PJ1-C-LP-b-1000-2 | 0 | 0 | 1 | 0 | 0 | 1 |
| PJ1-HL-a-100-2 | 0 | 0 | 0 | 0 | 0 | 0 |
| PJ1-HL-a-100-3 | 0 | 0 | 0 | 1 | 2 | 3 |
| PJ1-HL-b-400-2 | 0 | 1 | 0 | 0 | 2 | 3 |
| PJ1-LP-b-1000-2 | 0 | 0 | 0 | 1 | 0 | 1 |
| PJ1-NS-100 | 16 | 13 | 15 | 0 | 0 | 44 |
| PJ1-NS-1000 | 28 | 6 | 7 | 2 | 0 | 43 |
| PJ1-NS-400 | 0 | 23 | 21 | 0 | 0 | 44 |
| PJ1-R2 | 0 | 2 | 1 | 25 | 6 | 34 |
| Total | 45 | 45 | 45 | 45 | 45 | 225 |

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Example LACPR Rankings



Example LACPR Rankings



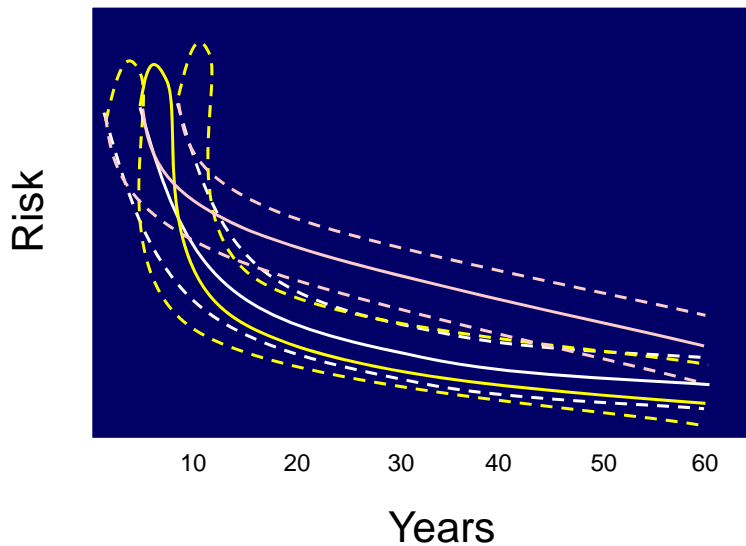
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Example Optimal Decisions by Scenario

| PU-1 | Relative Sea-level Rise | |
|------------------------|-------------------------|------------|
| | Lower | Higher |
| Pattern of Development | | |
| High/Dispersed | PU1-NS-100 | PU1-NS-100 |
| BAU/Compact | PU1-NS-400 | PU1-NS-400 |

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Risk Reduction Comparison



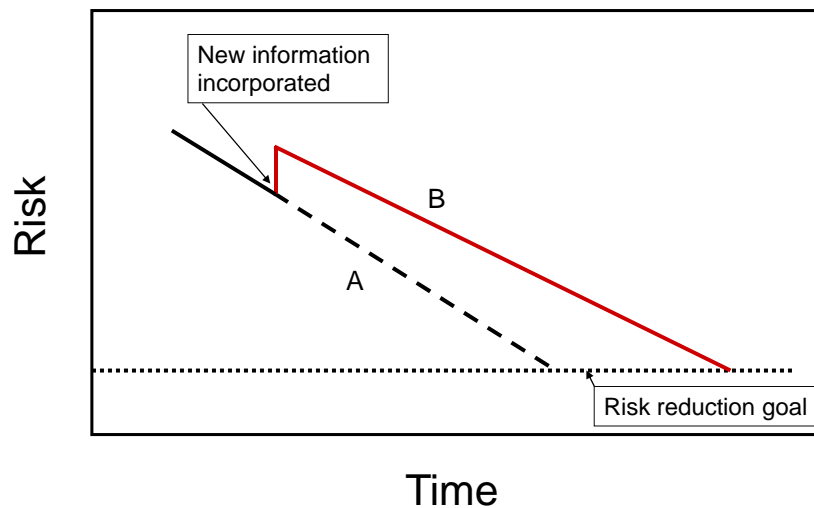
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Adaptive Management

- Uncertainty is inherent to planning, design, construction, and O&M
- Adaptive management requires a framework for collecting and using information that results from:
 - Implementing a plan
 - Monitoring the performance of the plan
 - Learning
- The RIDM provides a suitable approach

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Risk Reduction Trajectories



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Conclusions

- There are clear benefits to be gained by advancing the use of formal risk and decision analysis methods:
 - Opportunities to explore trade-offs among diverse objectives
 - The ability to distinguish science and engineering inputs to a decision from values associated with objectives
 - Means for exploring the implications of uncertainty and the value of reducing it
 - Providing a quantitative framework to implement adaptive management
- However, efforts to apply these approaches will confront a number of practical issues related to the following:
 - Under-estimating the level of effort required to accomplish effective deliberation through the use of decision analysis
 - Determining who can/should be involved in value/preference elicitation
 - Intolerance for transparency in decision-making
 - The misconception that decision analysis is a substitute for an actual decision

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