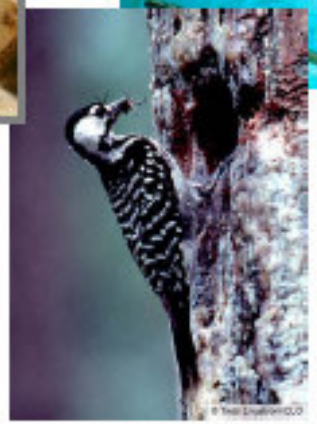
Nano Risk Assessment: In Search of Frameworks

Igor Linkov
Research Scientist
US Army Engineer Research and Development Center, Concord, MA
617-233-9869, ilinkov@yahoo.com

U.S. Army Engineer Research and Development Center

- Warfighter Support
- Military Installations/Environmental Quality
- Civil Works – Water Resources



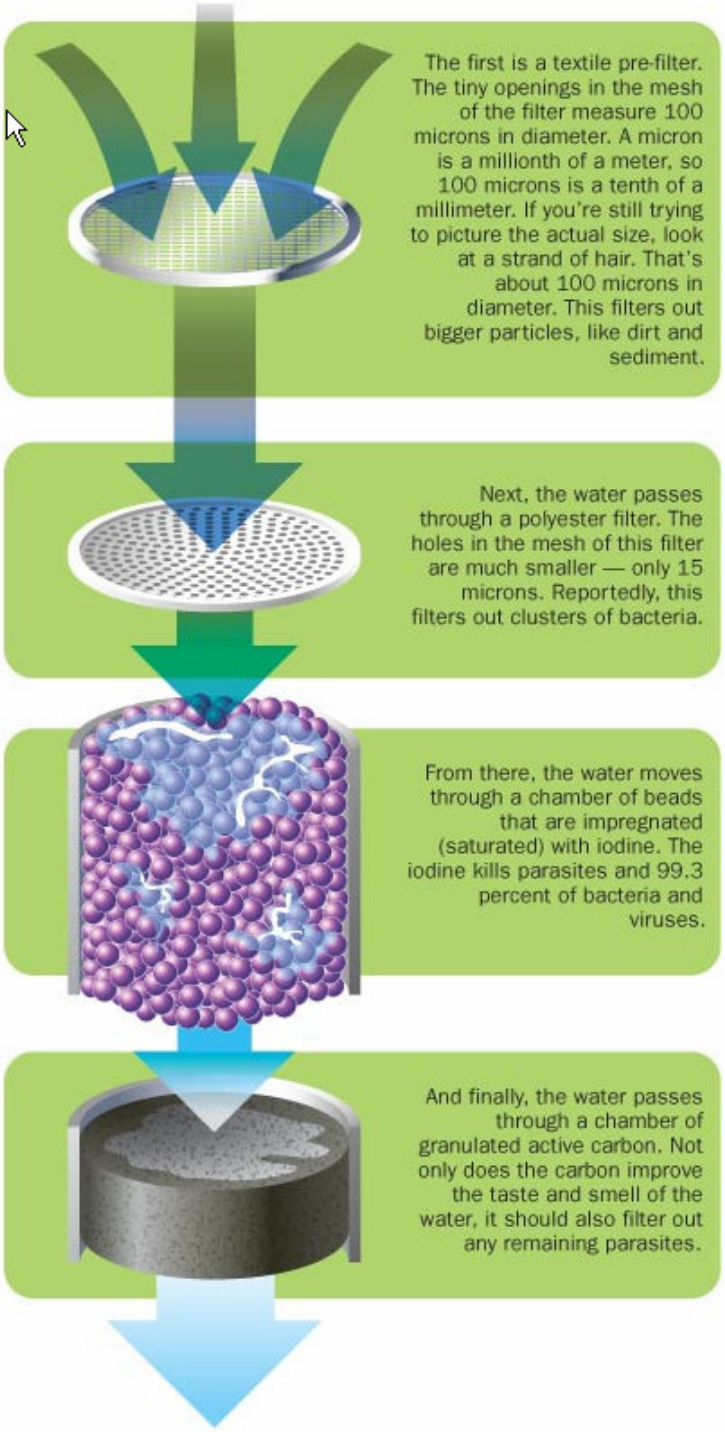

Major program on nano risk assessment (ecotox and life cycle)

Nano Revolution?

About 600 products, example: LifeStraw

Reduces bacteria by at least 6 log10 (99.9999%) and viruses by about 2.0 log10 (99%)

Cost: ~$2, Good for 1yr (700 L of water)

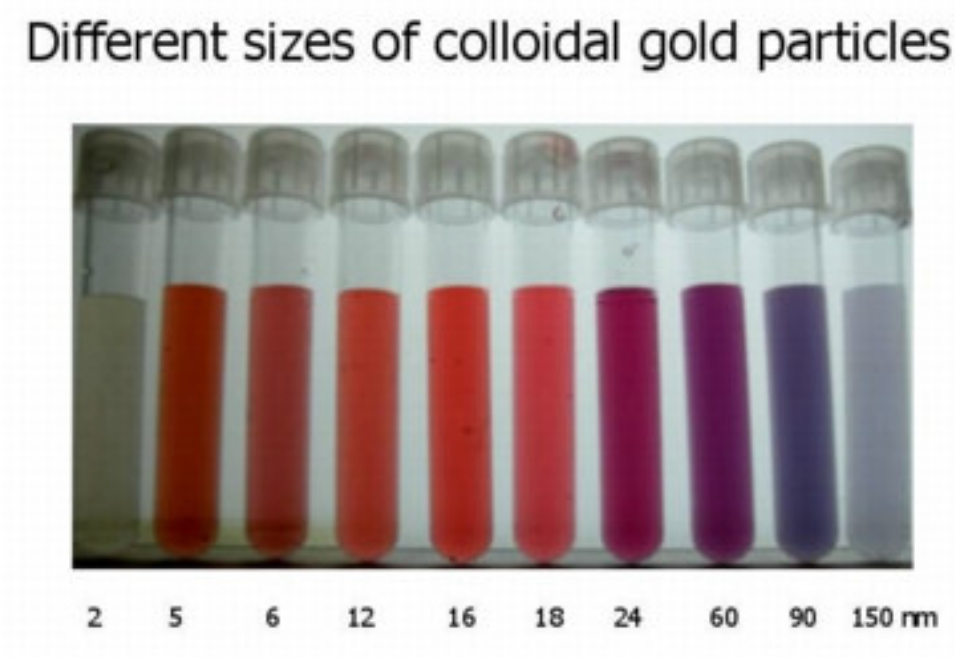


Current Risk Assessment

"Silver is present in LifeStraw-treated water at concentrations ranging from low (<25 ppm) to high (up to 200 ppm) in effluents collected over the intended lifetime of the device (700 L). The average effluent silver concentrations … are below the WHO guideline value and the US EPA MCL of 100 **ppb**."

www.lifestraw.com

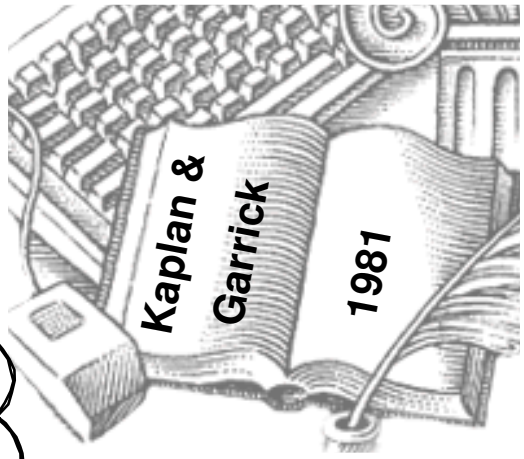
Are Bulk Material Standards Appropriate for Nano?



Risk Assessment Formulation

What can happen (go wrong)?

How likely is it?



What are the consequences?

Need for Risk Assessment
Public Concerns are Increasing

Two types of "correct" risk assessment:

Expert: Risk = Hazard · Exposure · Magnitude · Probability

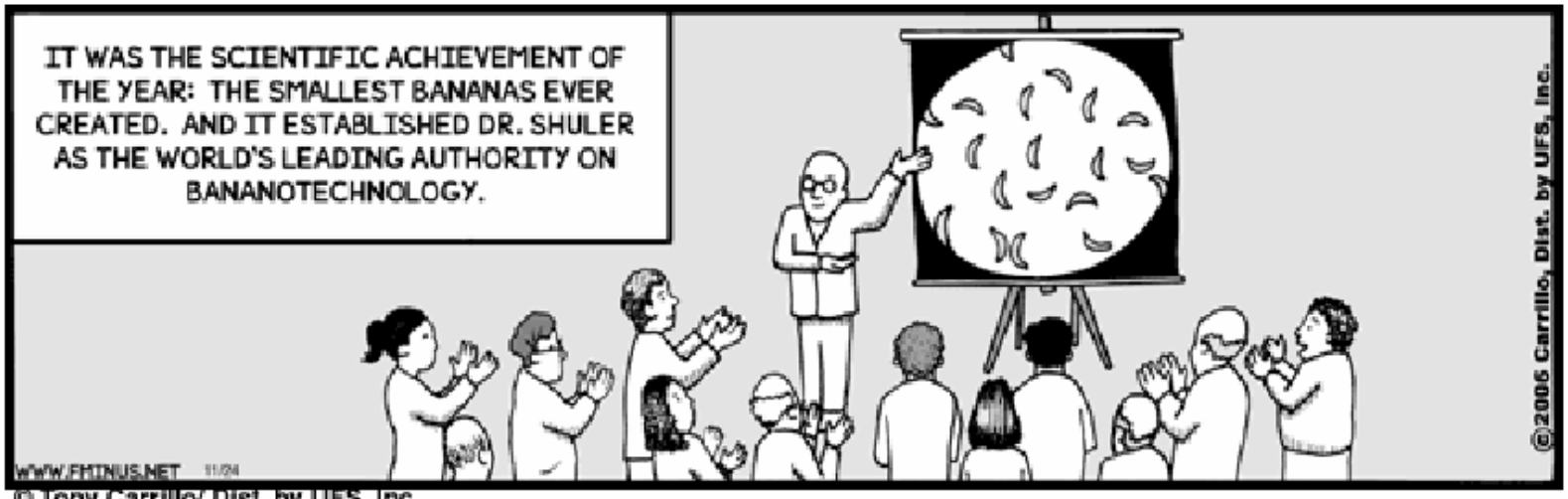
Layperson: Risk = Hazard · Perception

For stakeholders, the root issue is:

fear of becoming a victim to (uncompensated) loss

Core concerns tend to be:

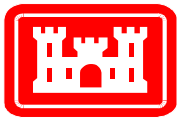
trust, control, process, information and timing.



Comic Strip "F Minus," 11/24/06

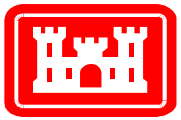
Main Points

1. Relation of pattern, structure-activity and physico-chemical properties of nanoparticles on toxicity and life-cycle risk is widely unknown and available information is fragmented.
2. Challenges of risk assessment and management for situations with a limited knowledge base and high uncertainty and variability require coupling traditional risk assessment with multi-criteria decision analysis (MCDA) and Adaptive Management to support regulatory decision making.
3. Entities engaged in nanotech must consider practical and innovative steps to minimize identified risks while managing proactively for unknowns. Regulatory program should provide value to business by helping focusing on decreasing life-cycle product risk while keeping costs down.

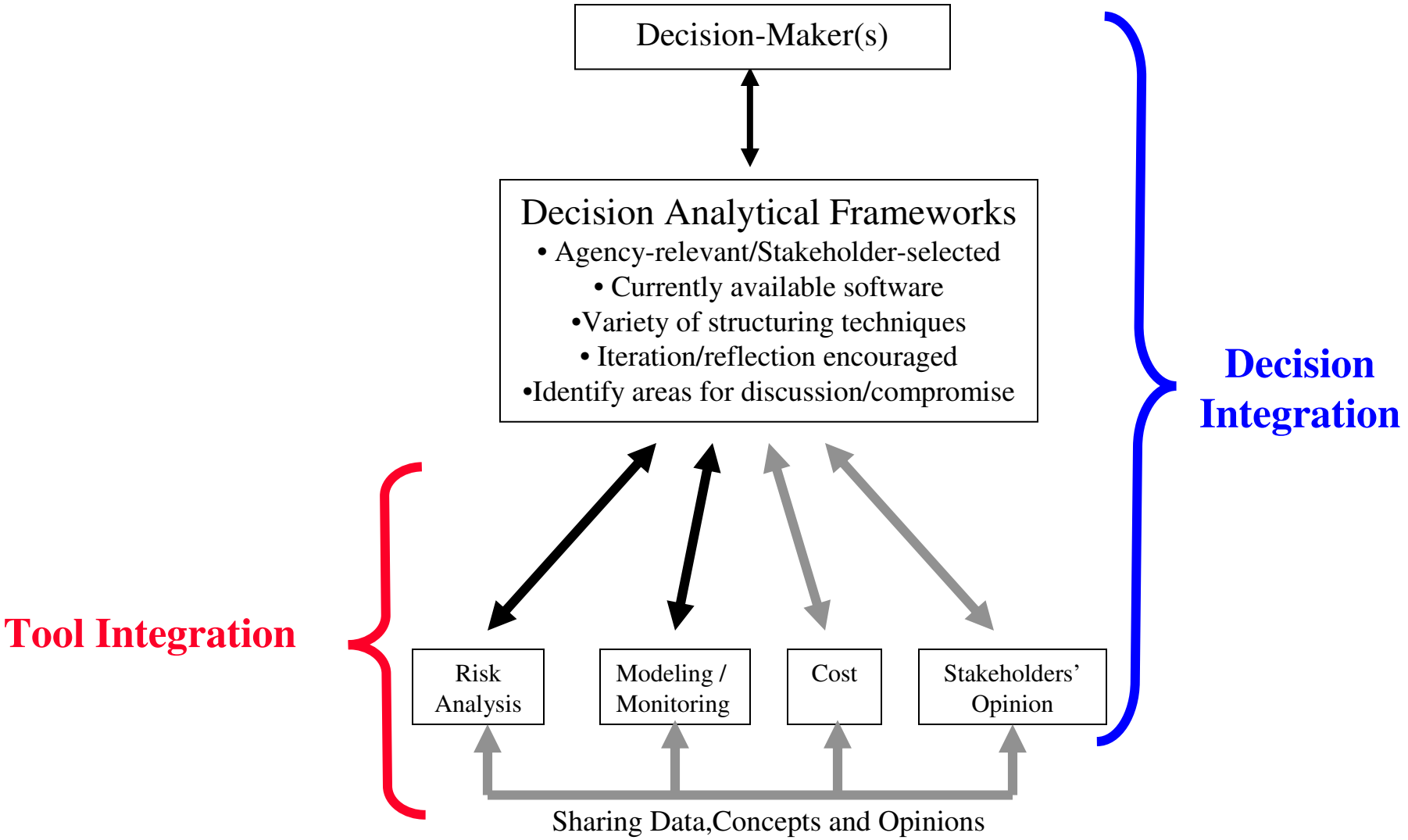


Multi-Criteria Decision Analysis and Tools

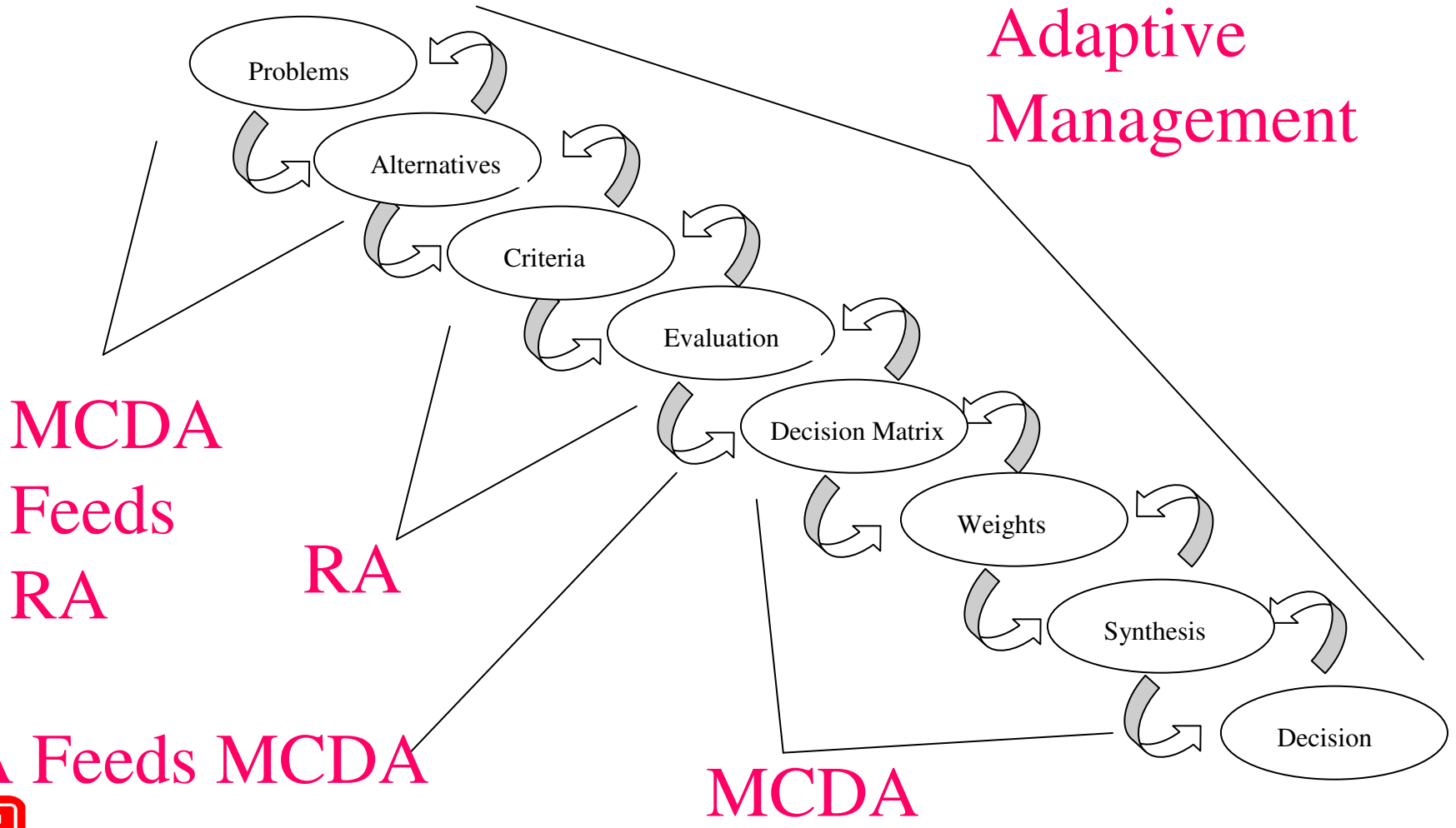
- Multi-Criteria Decision Analysis (MCDA) methods:
  - Evolved as a response to the observed inability of people to effectively analyze multiple streams of dissimilar information
  - Many different MCDA approaches based on different theoretical foundations (or combinations)
- MCDA methods provide a means of integrating various inputs with stakeholder/technical expert values
- MCDA methods provide a means of communicating model/monitoring outputs for regulation, planning and stakeholder understanding
- Risk-based MCDA offers an approach for organizing and integrating varied types of information to perform rankings and to better inform decisions



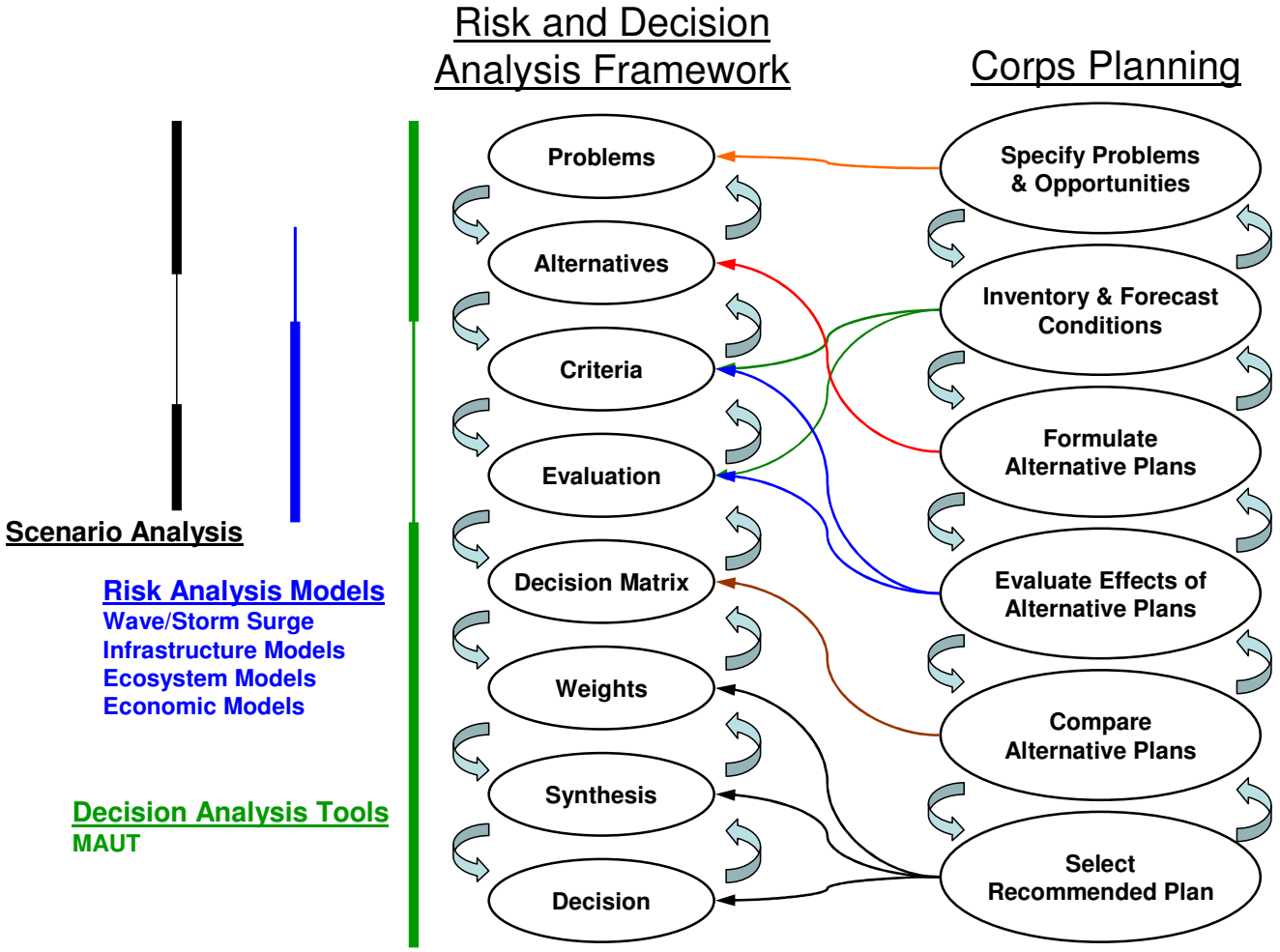
Evolving Decision-Making Processes



How can CRA, MCDA and AM improve the quality and acceptability of decisions?



Risk Informed Decision Framework:
Restoration Planning for Coastal LA and MS



Nanomaterials: Environmental Risks and Benefits and Emerging Consumer Products

NATO Advanced Research Workshop
27-30 April 2008, Portugal

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Contact the ARW Organizers,
Dr. Jeffery Steevens at Jeffery.A.Steevens@us.army.mil
Dr. Igor Linkov, ilinkov@yahoo.com

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SRA

Decision Analysis and
Risk Specialty Group

COPPER

International Copper Association, Ltd.

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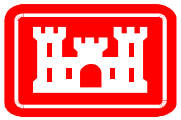

References

- Decision Analysis
  - Trade Off Analysis
    - http://www.iwr.usace.army.mil/iwr/pdf/tradeoff.pdf
  - Beyond Expected Value –
    - http://www.iwr.usace.army.mil/iwr/pdf/02r4bey_exp_val.pdf
  - NATO Workshop on Nano
    - http://www.risk-trace.com/portugal2008
- Papers
  - Linkov, I., Varghese, A., Jamil, S., Seager, T.P., Kiker, G., Bridges, T. (2004). "Multi-Criteria Decision Analysis: Framework for Applications in Remedial Planning For Contaminated Sites". in Linkov, I. And Ramadan, A. eds "Comparative Risk Assessment and Environmental Decision Making" Kluwer, 2004.
  - Kiker, G., Bridges, T., Varghese, A.S., Seager, T.P., and Linkov, I. (2005). Application of multi-criteria decision analysis in environmental management. *Integrated Environmental Assessment and Management* 1 v. 2 49-58.
  - Linkov, I., Satterstrom, K., Kiker, G., Bridges, T., Benjamin, S., Belluck, D. (2006). From Optimization to Adaptation: Shifting Paradigms in Environmental Management and Their Application to Remedial Decisions. *Integrated Environmental Assessment and Management* 2:92-98.
  - Linkov, I., Satterstrom, K., Seager, T.P., Kiker, G., Bridges, T., D. Belluck, A. Meyer (2006). "Multi-Criteria Decision Analysis: Comprehensive Decision Analysis Tool for Risk Management of Contaminated Sediments". *Risk Analysis* 26:61-78
  - Linkov, I., Satterstrom, K., Steevens, J., Ferguson, E, Pleus, R.C. (2007). Multi-criteria Decision Analysis and Nanotechnology *Journal of Nanoparticle Research* 9:543-554.