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Risk Informing the Commercial Nuclear Enterprise

Promise of a Discipline: Reliability and Risk in Theory and in Practice
University of Maryland

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How our Business is Risk-Informed

I. Managing Risk to the Business

II. Managing the Risk of Normal Plant Operation

III. Defining Extreme External Events

IV. Risk-Informed Lessons for External Events

V. The Path Forward



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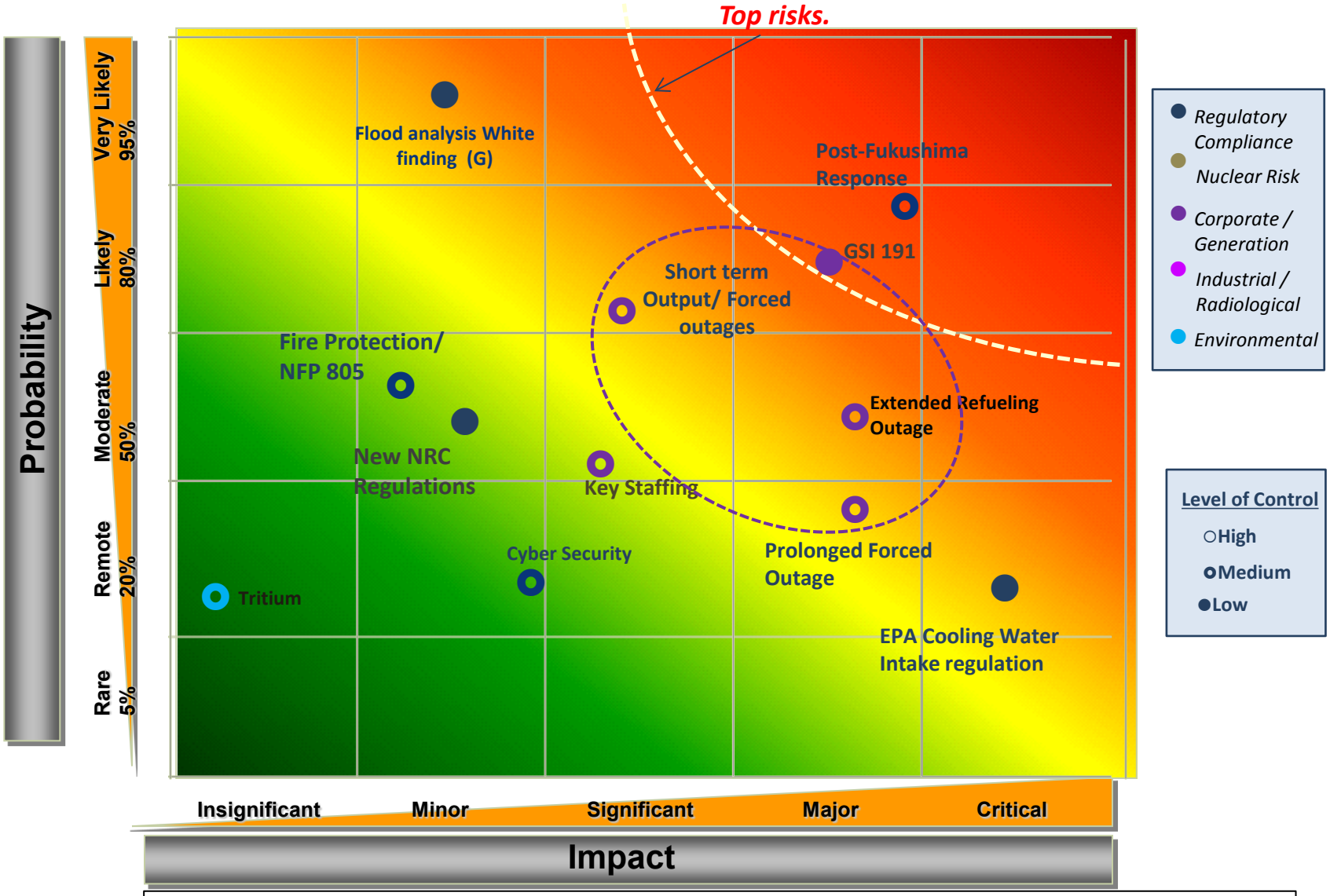
I. Managing Risk to the Business

- Each CENG nuclear plant and the corporate office maintains a risk “Heat Map”
  - An easy-to-read summary of the risks associated with a business unit
  - A method for communicating the risks being managed
- ‘Delphi Method’ for forecasting risk is used - experts come together to perform periodic assessments of Company risks
  - Subjective (non-analytical) probability and impact assessment of each risk
  - Identifies mitigating actions




Operating Fleet Heat Map (example)



Significant risks from site maps grouped / assigned based on significance to fleet

Heat Map Risk Table (example)

Issue	Risk	Category	Impact	Probability	Level of Control	Mitigation
Fukushima Response	High cost of studies, modifications, uncertainty of outcomes. Impact on emergency planning	Regulatory	Major	Likely	Medium	Active engagement with industry and NRC
EPA 316b Rule, Clean Water Act	Potential for significant modifications to intake structures at NY and MD sites	Regulatory	Critical	Remote	Low	Industry proposing alternatives to federal and state EPA
Key Staffing	High rate of retirements over next ten years, loss of expertise/talent	Corporate	Significant	Moderate	Medium	Implement Knowledge Transfer and Retention program




II. Managing Risk during Normal Operations

- Plant-specific PRAs model core damage and large early release frequency
- Risk impact of scheduled maintenance, plant evolutions, and system outages are analyzed
- Four risk levels used to communicate to plant staff and set controls

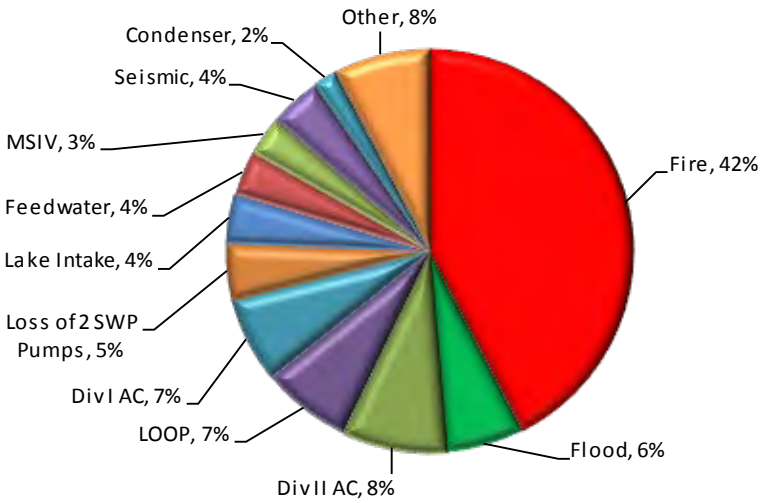
GREEN	ORANGE
YELLOW	RED

- Pre-established risk mitigation measures applied as higher risk conditions are entered

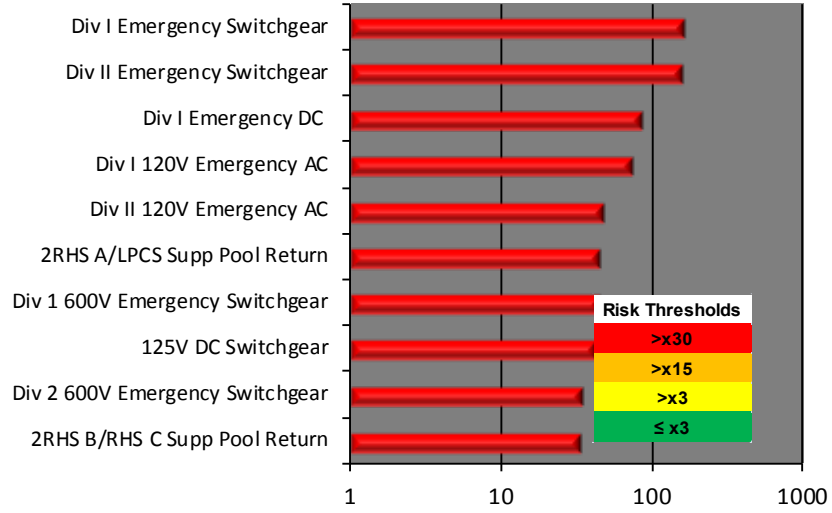



Example Plant PRA Risk

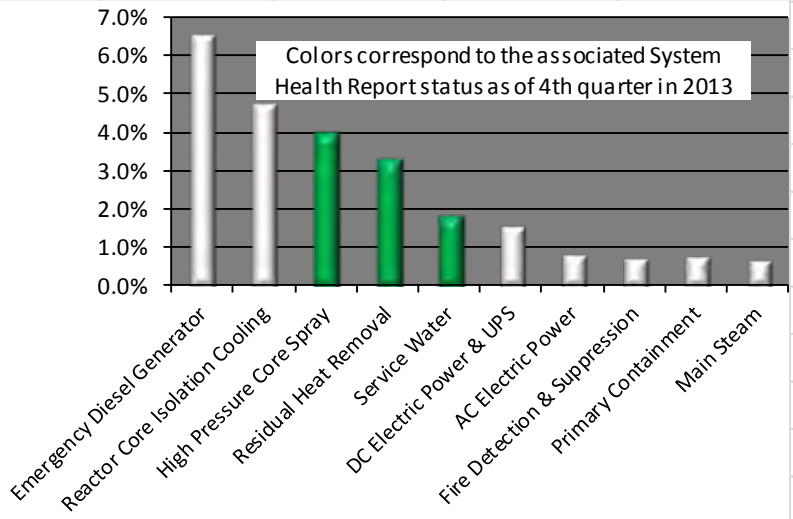
Initiating Event Distribution



Potential Risk Increase Factor for Key Equipment



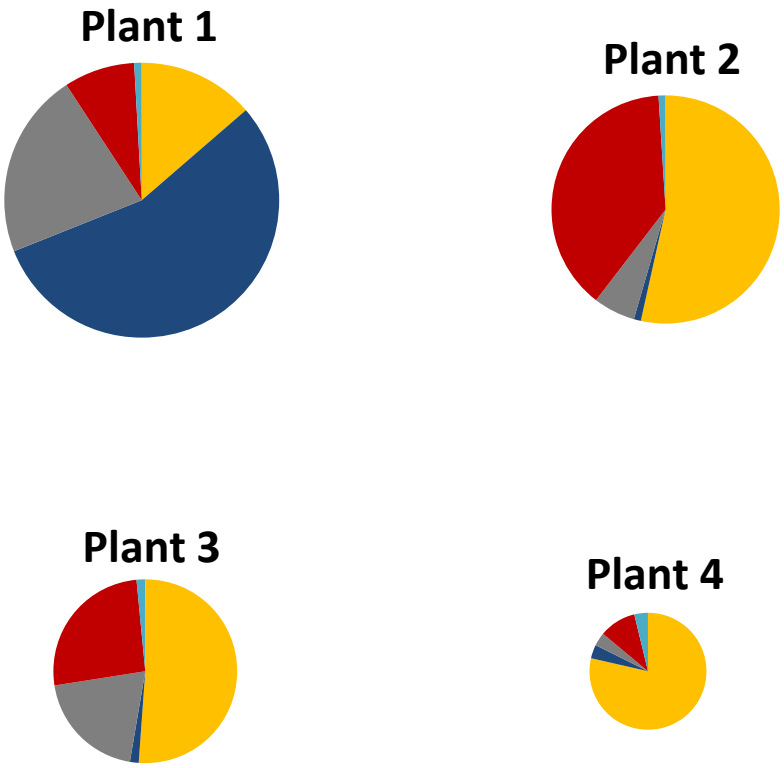
System Percentage Contribution to CDF



Key Operator Actions

%CDF	Description
30%	Respond to Control Room Fire
15%	Control Service Water and Open Room Doors (HVAC)
9%	Align Containment Heat Removal
4%	Vent PC (Air or Div I AC lost)
3%	Isolate SW Header Flood in RB
3%	Control Level to Prevent Boron Washout
2%	Align RHR During ATWS
2%	Align Fire Water for EDG Cooling
2%	Manually Depressurize (Transient)
1%	Vent PC (Local Actions including use of Port. Powerpack)

Hypothetical PRA Risk Planetary Charts



- Every Plant is Unique – design, internal / external events
- Risk insights are gained by comparing plant risk profiles
  - ✓ Physical Modifications
  - ✓ Protective Barriers
  - ✓ Procedures
  - ✓ Operator Response Times
  - ✓ Maintenance Practices
  - ✓ Housekeeping

III. Defining Extreme External Events

- Original plant design for external events (security, seismic, flood, fire) based on regulations and best state of knowledge of risk at time of licensing
- Industry understanding of risk has been highly dynamic
  - 1975 Browns Ferry fire
  - 2001 terrorist attacks
  - 2011 Japan earthquake and tsunami (Fukushima)
- Evolving risk insights from new data creates constant “churn” in design and operation of our plants
  - Fire: industrial fire code - to - “Appendix R” - to - NFPA 805
  - Revised design basis security threat, robust defenses, cyber
  - Post-Fukushima reassessment of earthquake frequency and intensity for central and eastern US plants (NRC GSI-199)
  - Post-Fukushima reassessment of design basis flood/frequency



IV. Risk-informed Lessons for External Events

- The uncertainties are real and unavoidable
  - Extrapolation from internal event modeling experience is not applicable to other models
  - Reliance on numerical mean values is not sufficient
  - Data supporting rare events may have large uncertainty (e.g., floods)
- Undue focus on numerical outcomes leads to a reduced emphasis on important insights
- Adding conservatism in PRA is not an antidote, it can significantly distort sound risk-informed decision-making



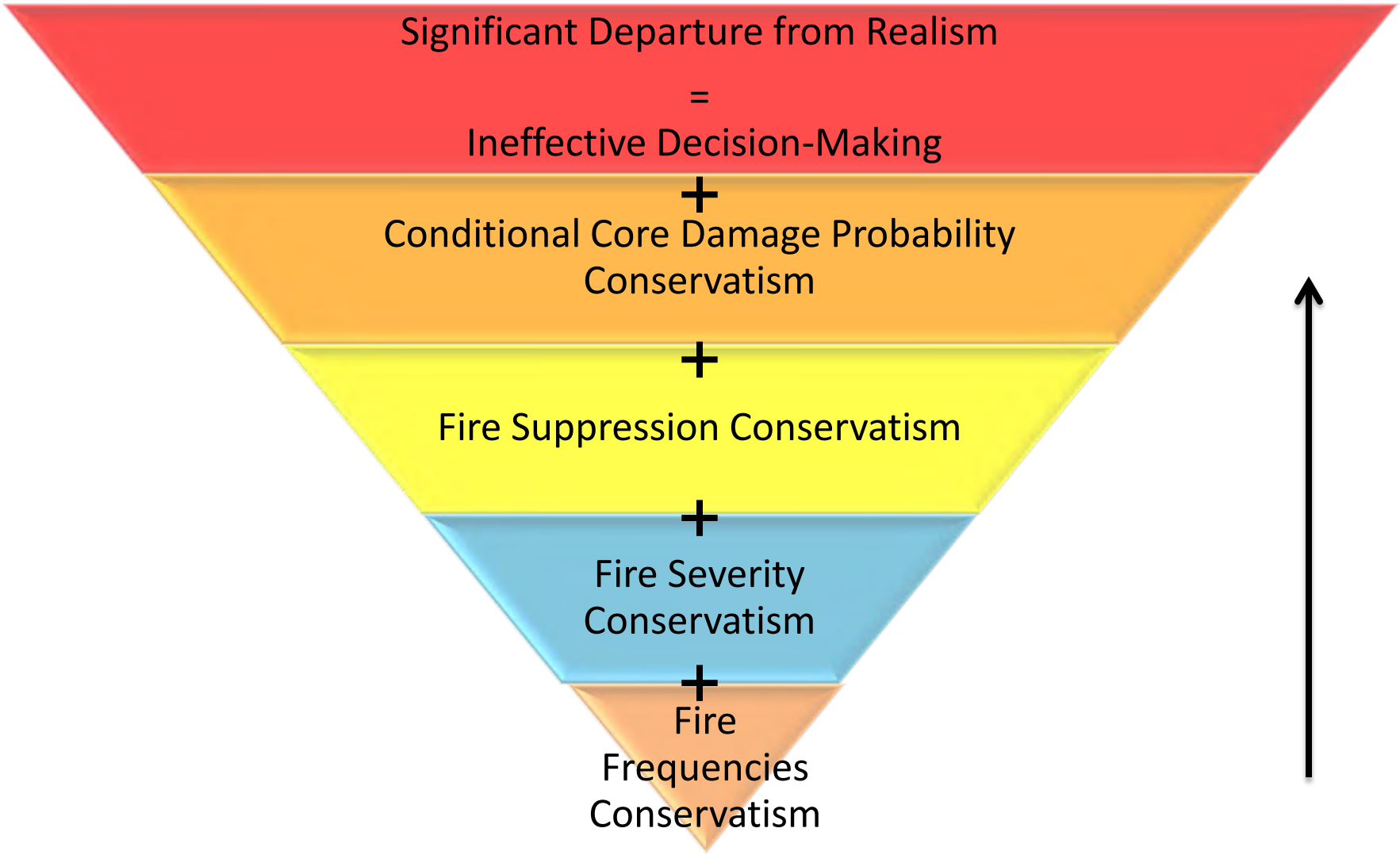

Case in Point

NFPA-805 FPRA Challenge:

- Deterministic PRA mentality distorts risk perspective
  - Conservatisms added at every major step of the process to "bound" uncertainties
- Results do not match operating experience benchmarks
  - Risk-significant fires over-predicted
  - Fires with significant spurious operations over-predicted
- Outcome: Disproportionately large resources spent on model refinements and plant modifications




Large Conservatism in Fire PRA Building Blocks



Compounding conservatism reduces effectiveness of decision making tool

V. The Path Forward

Objective	Proposed Actions	
	Industry	NRC
Gain a more complete and balanced understanding of important risk contributors	Continue development of more realistic and complete plant-specific PRAs	Move away from imbedding conservatism in PRA models - Starts with fire PRA
Clarify risk-informed decision-making process that can deal with uncertainties	Propose a practical integrated decision-making process	Adapt/adopt a practical integrated decision-making process consistent with RG 1.174
Educate decision-making stakeholders on risk-informed decision-making	Provide focused PRA training to industry staff and decision-makers	Provide focused PRA training to NRC staff and decision-makers
Develop technical resources to support better risk-informed understanding	Expand EPRI/OG commitment to training and technology	Expand training on truly risk-informed decision-making



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Key Takeaway

- PRA has added tremendous value to the Nuclear Industry allowing us to operate plants safer.
- Addressing very low probability / high consequence events can be as important as addressing high probability / high consequence events.
- Challenges remain with the tools:
  - Risk insights are masked by over conservatism or deterministic approach – back to basics.
  - Uncertainty matters – what can we do to address and reduce uncertainty?



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