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Modeling and Simulation in Long Term Nuclear Plant Operation and Safety

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Fundamental Safety Questions for NPP LTO

As current fleet of operating NPPs ages:

- Can we improve the characterization of plant response to safety significant conditions and events over an extended operating life cycle?
- Can we assess and monitor the impact of plant operational changes and equipment / material aging on safety margins?
- Are the current suites of safety and risk analysis methods / codes adequate to support long term operation?

Need an integrated approach that addresses these issues in a manner that is technically justifiable and cost effective

Need for Modeling and Simulation in NPP LTO

- High costs and lack of experimental infrastructure make life extension based only on empirical data impractical
- Experience from other industries demonstrates cost effectiveness of modeling and simulation to address wide range of issues
- Advances in computational techniques and capability support application to safety and long term operation of NPPs
- Issues to address:
 - Current computer codes were developed more than 30 years ago
 - Bias for complete physical demonstration to resolve and close issues

Significant investment required for application of M&S to NPPs

LTO Issues requiring M&S Contribution

- Possible challenges to successful achievement of long-term operation of current NPP fleet include
 - Technical (RPV embrittlement, concrete degradation, etc.)
 - Economic (obsolescence of components, increased safety expectations of public / regulator, etc.)
 - Human (competition for qualified technical personnel, etc.)
- Operational enhancements to provide:
 - Extended power uprates
 - Higher burnup fuel / lengthened fuel cycles
 - Advanced fuel designs (e.g. SiC cladding)

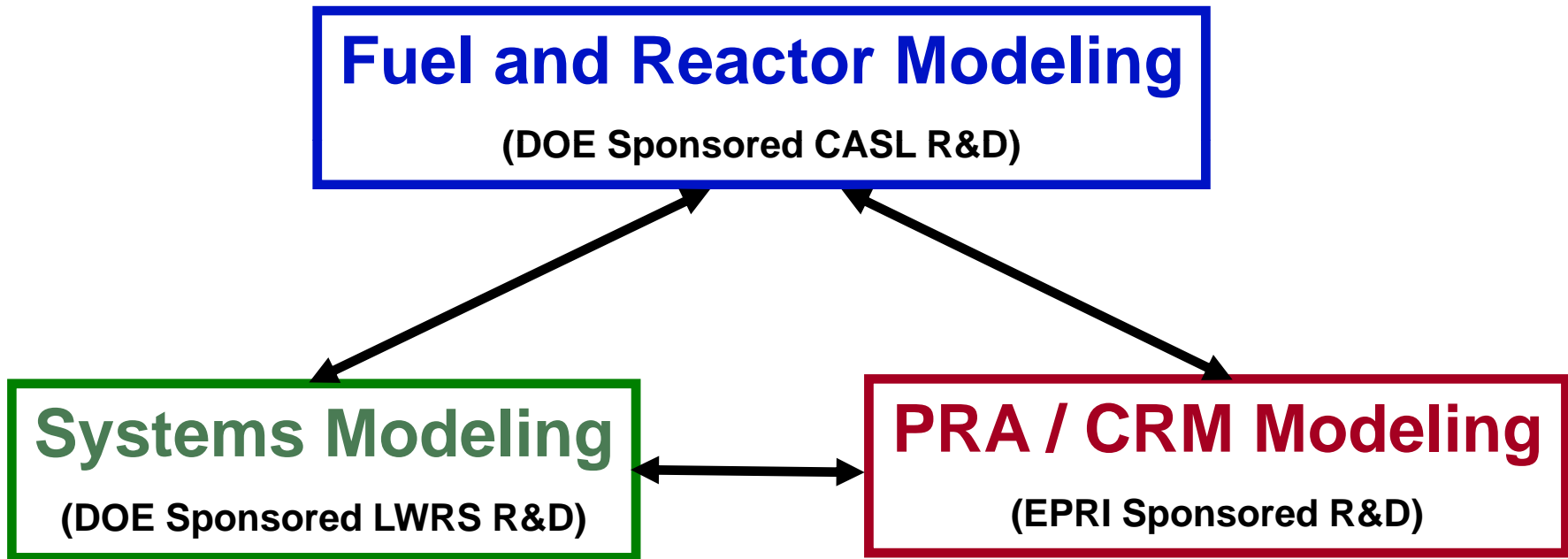
**Coordinated R&D programs (CASL / LWRS / EPRI LTO)
to develop timely cost-effective solutions**

Integrated NPP Safety Analyses for LTO

- Modeling and assessment capability needed to
 - Integrate PRAs with deterministic safety margin evaluations
 - Apply results to investment and operational decision-making
- Application software tools require capability to support advanced analytical methods and modern computational architecture
- Support of plant operations requires capability to perform integrated real-time assessments

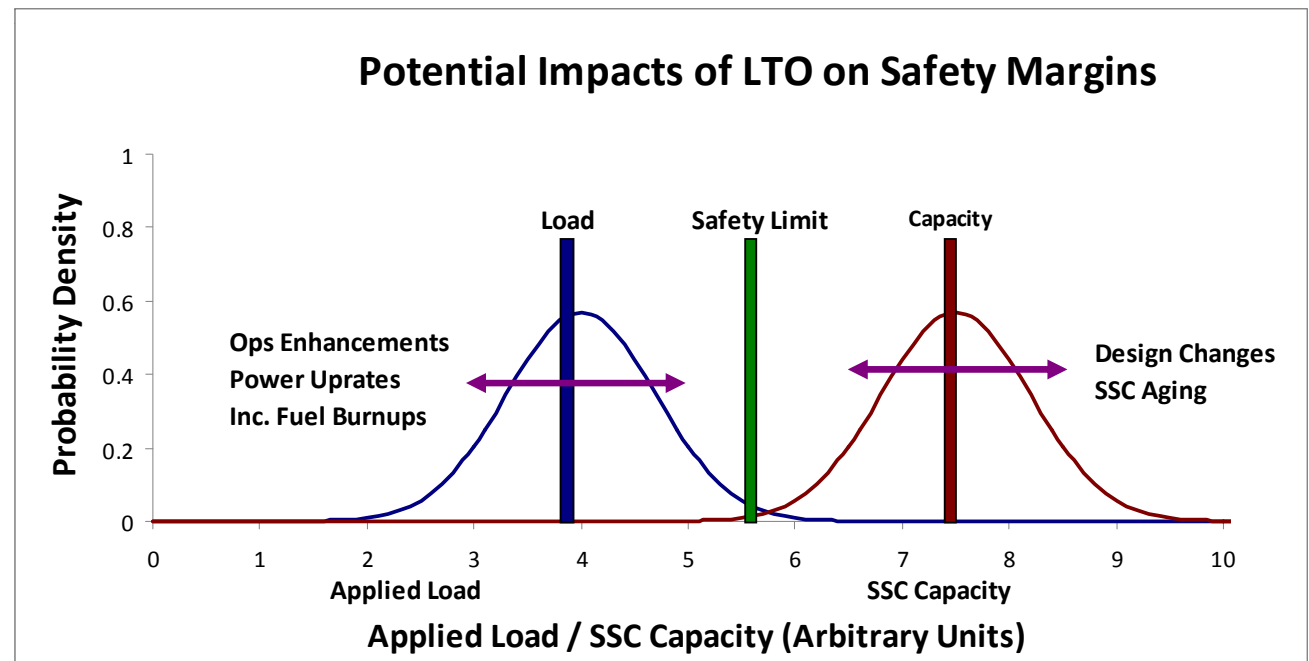
Modeling and simulation provides logical framework for meeting this need

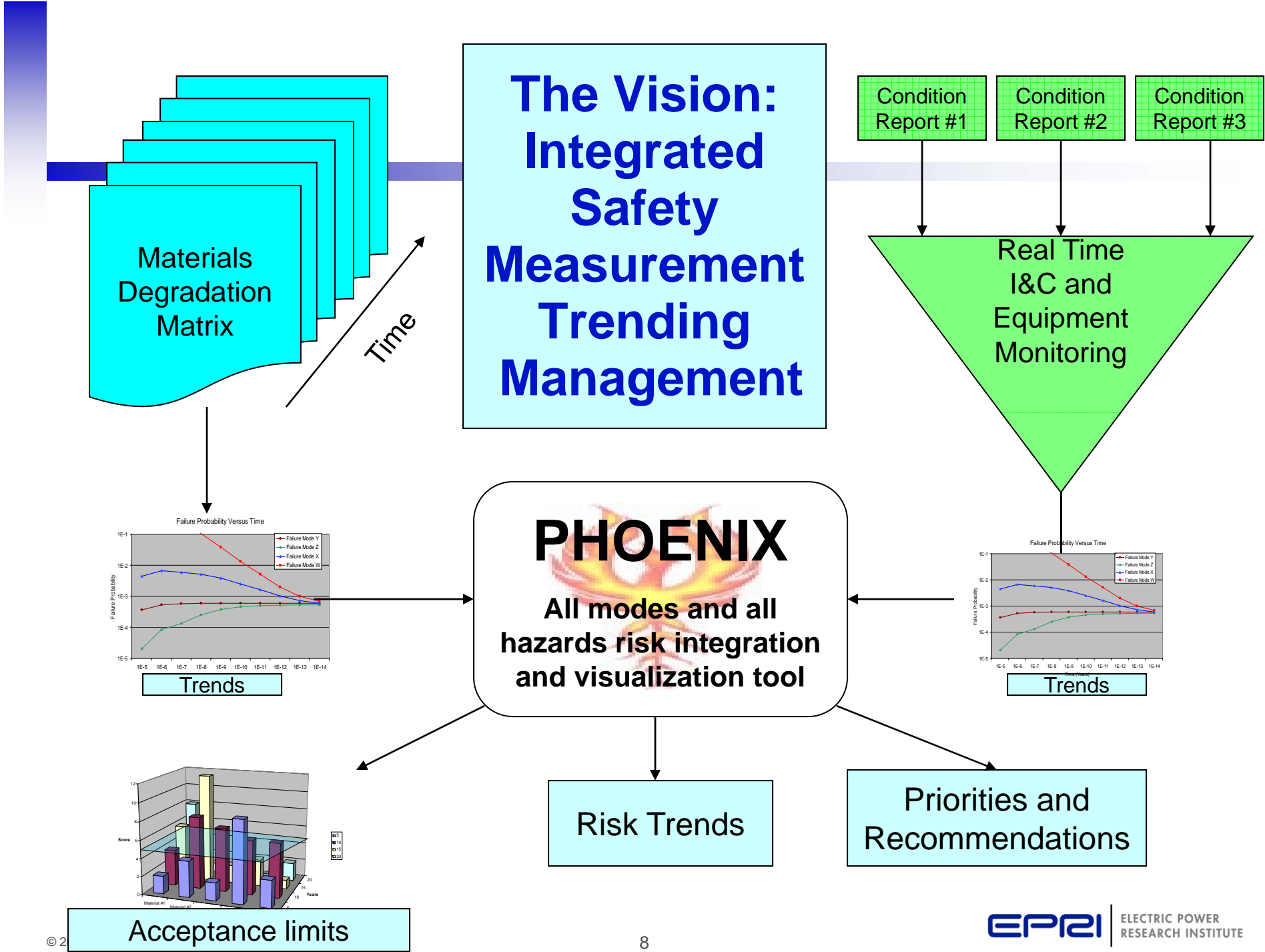
Integrated M&S Research Framework



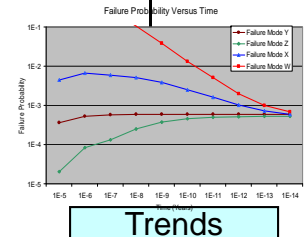
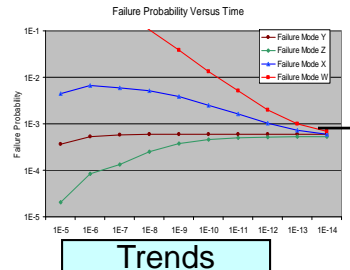
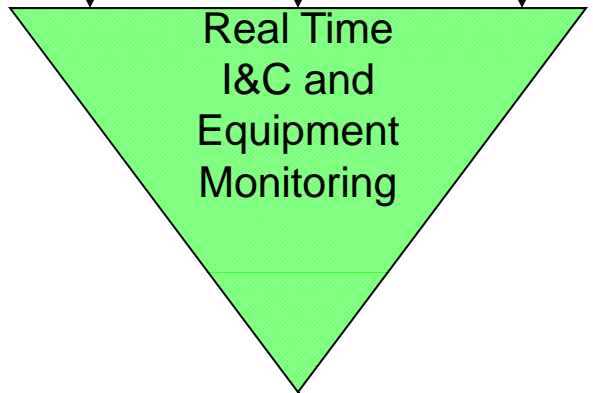
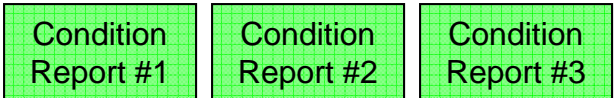
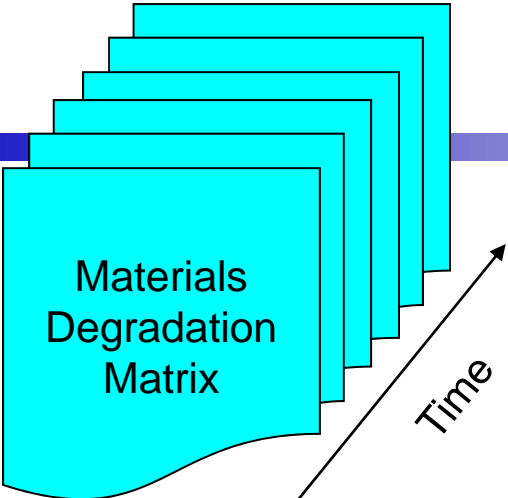
Risk Informed Safety Margin Characterization

- NPP LTO needs a consistent method to enable decision-makers to characterize and evaluate impact on safety margins
- Integrate advances in safety and risk analysis capabilities to characterize margins across broad spectrum of LTO applications / assessments
- Integrate M&S to provide predictive capabilities to evaluate planned changes with high confidence
- Apply advanced visualization capabilities for decision-making support





The Vision: Integrated Safety Measurement Trending Management



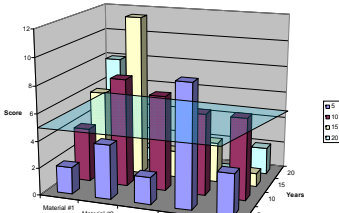
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All modes and all hazards risk integration and visualization tool

Risk Trends

Priorities and Recommendations

Acceptance limits





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