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RIC 2010

Development of the Extremely Low Probability of Rupture (xLPR) Assessment Tool

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NRC/RES/DE/CIB

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Introduction

- 10 CFR 50 Appendix A General Design Criteria (GDC) 4 requires that primary piping systems exhibit an extremely low probability of rupture in order to exclude dynamic effects associated with postulated pipe ruptures from the design basis

- Deterministic Leak-Before-Break (LBB) methodology, as described in NRC Standard Review Plan (SRP) 3.6.3, was developed to meet this goal

- In recent years, probabilistic analysis has matured to provide the flexibility in evaluating a wide variety of materials, degradation mechanisms, application of mitigation techniques, and the influence of inspection

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Motivation

- Systems approved for LBB have experienced degradation mechanisms such as stress corrosion cracking. The SRP was developed prior to the advent of this operating experience

- xLPR, which is a modular-based probabilistic computer code, will explicitly model the degradation, the mitigation strategies (such as weld overlays) and the influence of inspection technology on pipe failure frequency

- The xLPR program represents an NRC/industry co-operative process to develop a robust probabilistic software tool to improve design and regulatory decision making

Objectives of NRC Sponsored Research

- Develop a robust methodology for evaluating reactor coolant system piping failure/rupture probabilities
- Select appropriate, technically sound input data and models to produce best-estimate output results with quantified uncertainty
- Develop a computational software tool that applies the input data and models and appropriately treats epistemic and aleatory uncertainties
- Verify, validate, benchmark and document the software tool to enable its use in support of design and regulatory decisions by both industry and NRC

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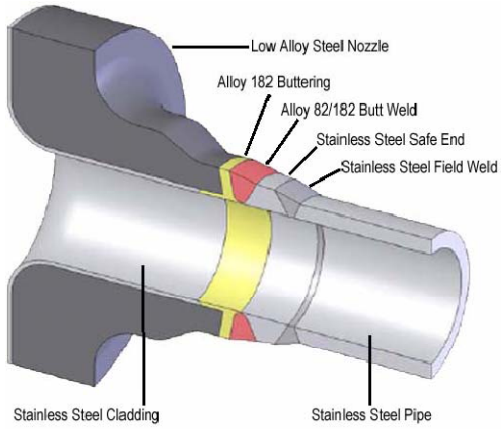
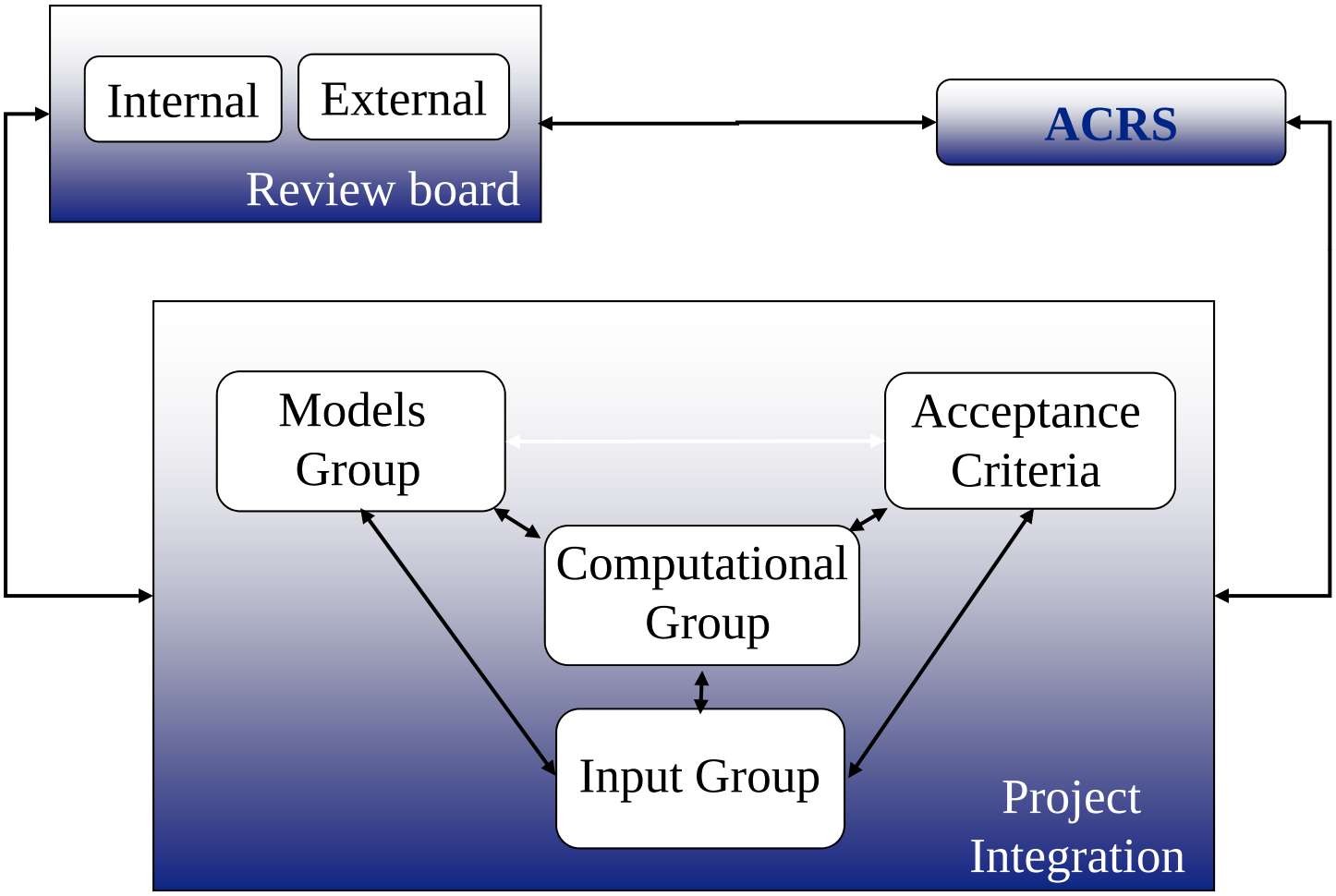
Current Research Efforts - xLPR Pilot Study

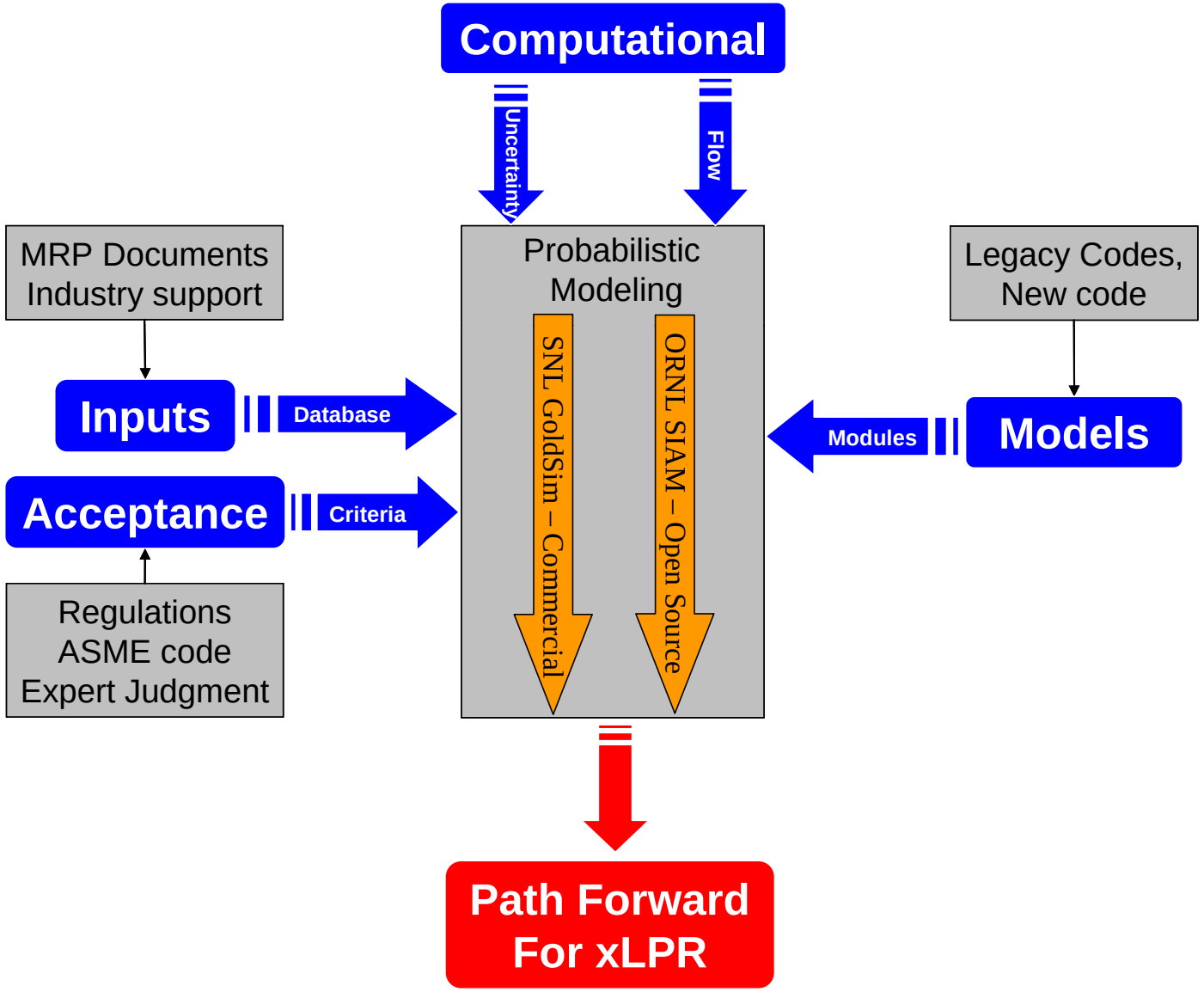


- Intended to demonstrate feasibility of the proposed NRC-industry cooperative process and the probabilistic framework
- Develop an initial assessment tool for dissimilar metal pressurizer surge nozzle welds, accounting for weld residual stresses and PWSCC
- Provide order-of-magnitude estimates of piping rupture probabilities and identify areas requiring more focused attention in the long-term study

Code Group Structure



Pilot Study Structure



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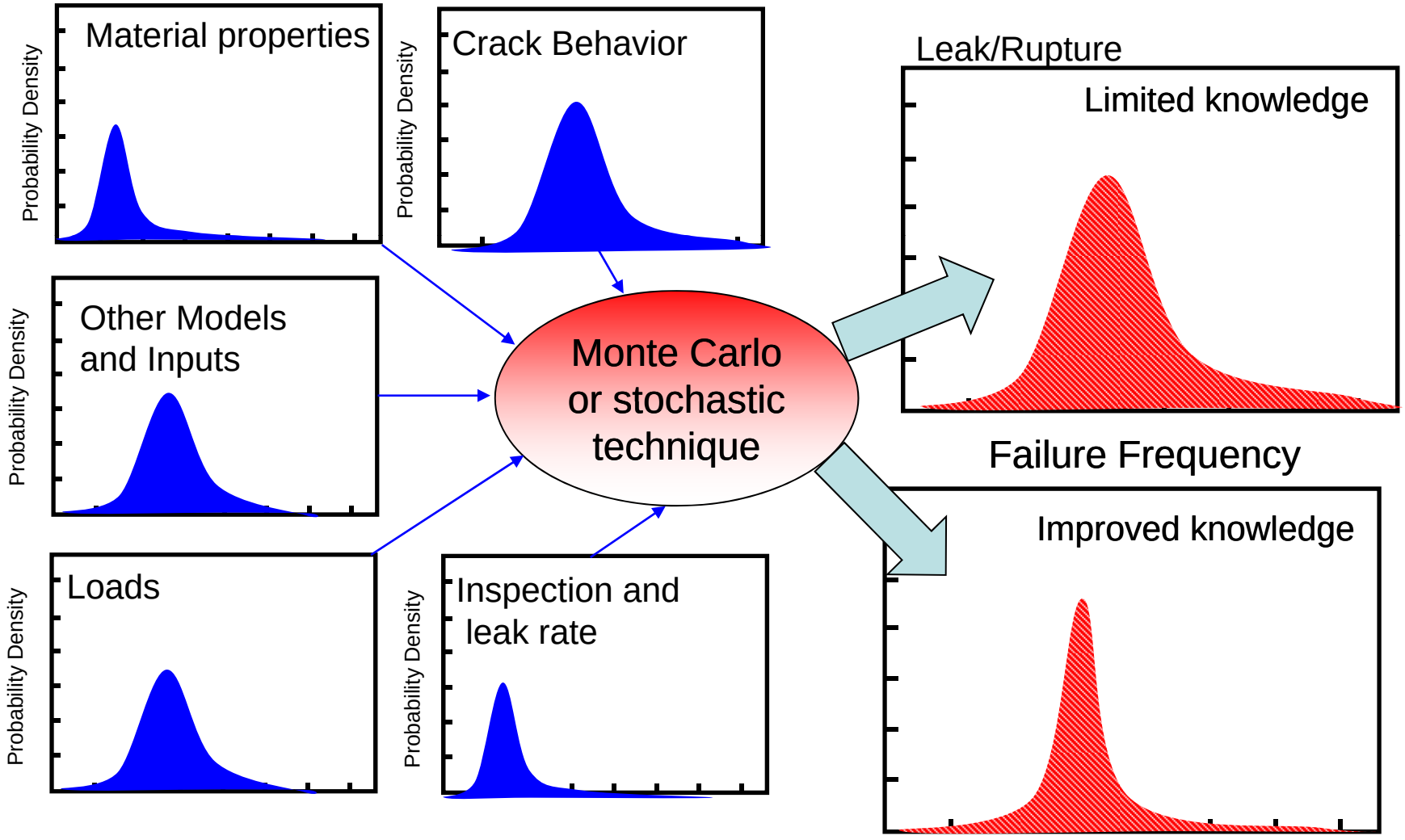
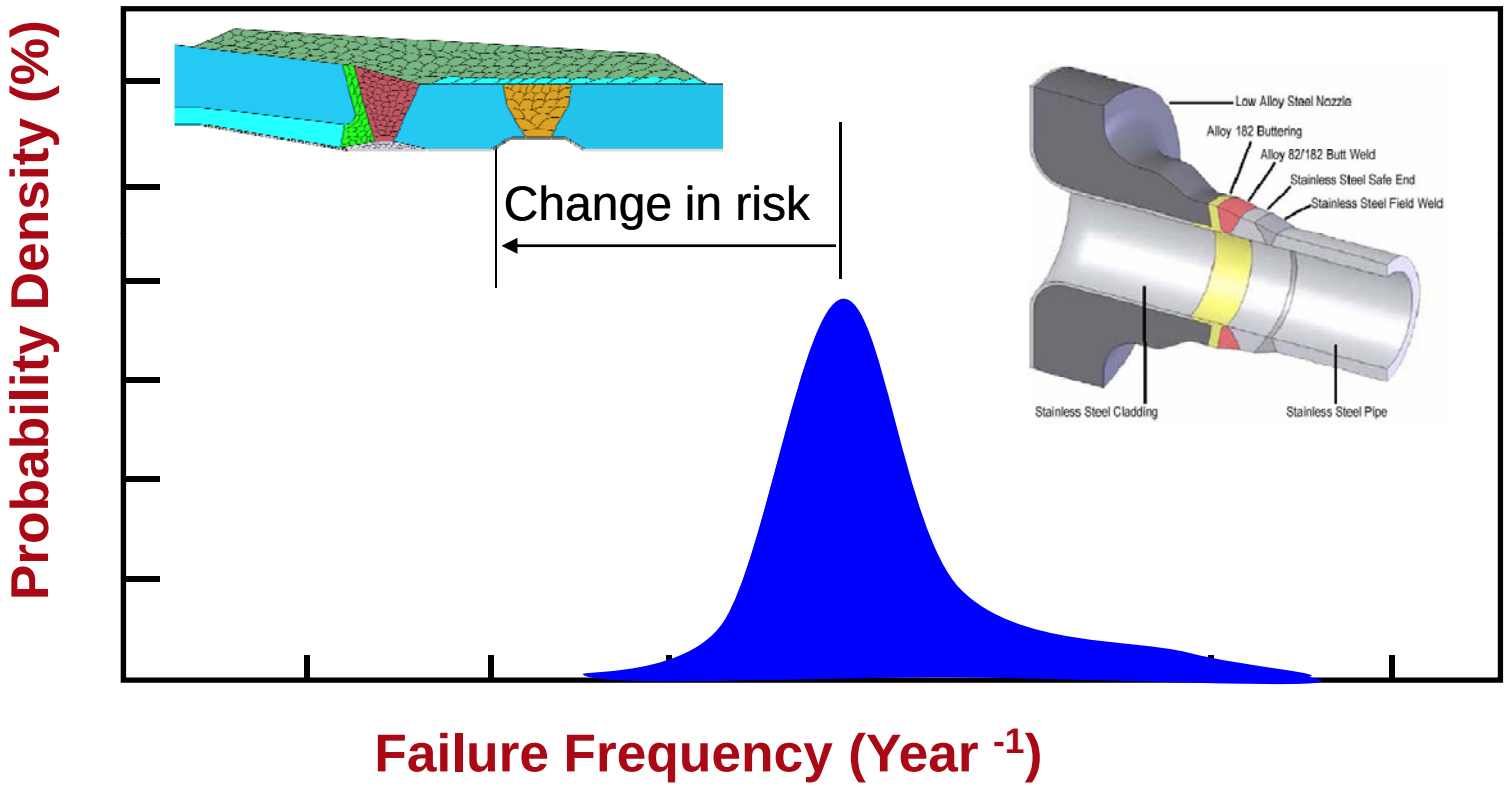
xLPR Process



Using xLPR


Probability Density (%)
Change in risk
Low Alloy Steel Nozzle
Alloy 182 Buttering
Alloy 82/182 Butt Weld
Stainless Steel Safe End
Stainless Steel Field Weld
Stainless Steel Cladding
Stainless Steel Pipe
Failure Frequency (Year -1)

xLPR Timeline

- Cooperative xLPR Research Program through NRC/EPRI MOU Addendum
- Pilot Study Alpha version completed 1st quarter 2010
- Pilot Study Final version complete – 3rd quarter 2010
- xLPR complete – 2012/2013