xLPR Modular Code

Project Status

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June 4, 2014

NRC/EPRI Materials Issue Program
Technical Information Exchange
June 3-5, 2014

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xLPR Outline

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- What is xLPR?
- What have we accomplished?
- What have we learned?
- What's left to be accomplished?
- When will it be done?

xLPR Code

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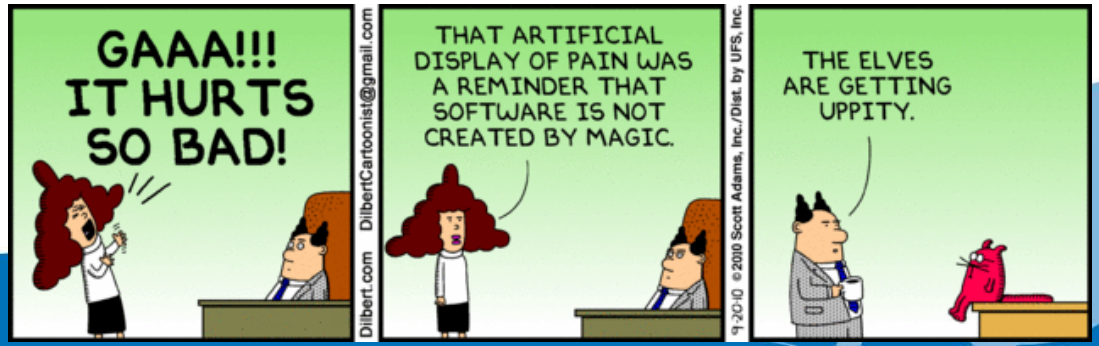
- xLPR is a modular-based probabilistic fracture mechanics code computer code for evaluating the risk of pressure boundary integrity failure

- The code is being developed in a team environment by RES and EPRI through a memorandum of understanding following a detailed QA program

- The current application is for users to directly assess compliance with 10CFR50App-A GDC-4 (LBB)
  - May be applicable to other needs



xLPR Timeline

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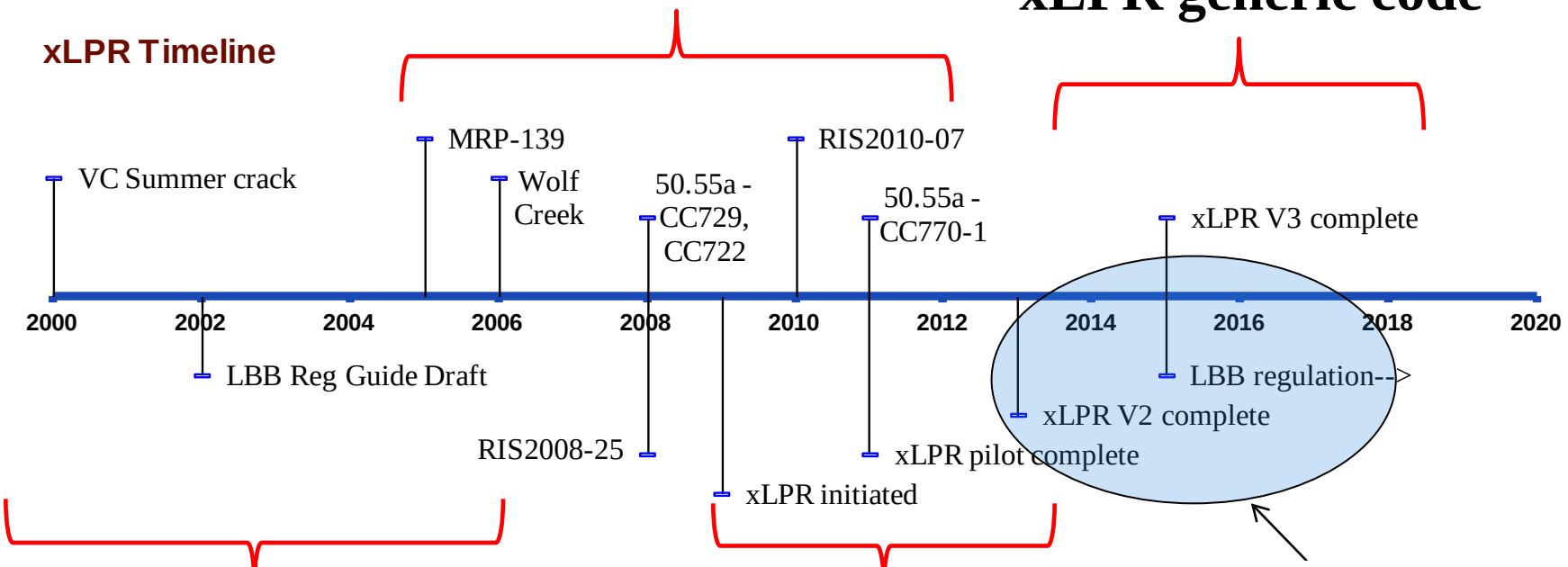
Short term
Mitigation/inspection

Long term
xLPR generic code



PWSCC emergent issue

Medium term
xLPR piping

Sequestration slowed us down a bit – V&V may slow us down more!

xLPR Code Development

Team Members

Code Development Leads
David Rudland – U.S. NRC
Craig Harrington – EPRI

Computational Group
Remi Dingreville– Sandia National Laboratories
Mike McDevitt– EPRI
Cedric Sallaberry – Sandia National Laboratories
Aubrey Eckert– Sandia National Laboratories
Mariner, Paul– Sandia National Laboratories
Patrick Mattie - Sandia National Laboratories
Robert Kurth – Emc2
Dilip Dedhia – Structural Integrity Associates
David Harris– Structural Integrity Associates
Paul Williams – Oak Ridge National Laboratory
Scott Sanborn – PNNL
Ian Miller – GoldSim
Ryan Roper - GoldSim

Inputs Group
Guy DeBoo – Exelon
Gary Stevens – U.S. NRC
Ashok Nana – AREVA NP Inc.
Nathan Palm – Westinghouse

Program Integration Board
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Bruce Bishop – PEAI
Rob Tregoning – U.S. NRC
Jay Collins– U.S. NRC
Ted Sullivan – PNNL

Program Manager
Nate Leech - Demark

Models Group
Marjorie Erickson – PEAI
Eric Focht– U.S. NRC
Mike Benson– U.S. NRC
Mark Kirk – U.S. NRC
Kyle Schmitt – Dominion Engineering
John Broussard– Dominion Engineering
Glenn White– Dominion Engineering
Chris Casarez – Dominion Engineering
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Bud Brust – Emc2
Suresh Kalyanam– Emc2
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Richard Bass – Oak Ridge National Laboratory
Cliff Lange – Structural Integrity Associates
Steven Xu – Kinectrics
Doug Scarth – Kinectrics
Russ Cipolla – Aptech
Mike Hill – UC Davis
Steve Fyfitch – AREVA NP Inc.
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Andrew Cox – Battelle
Lee Fredette – Battelle
Bruce Young – Battelle
Patrick Heasler – PNNL
Mark Dennis - EPRI
Carl Latiolais- EPRI
Thiago Seuaciuc-Osorio- EPRI

QA Group
Nancy Kyle – Theseus
xLPR Team

Cooperative effort between NRC and EPRI through Memorandum of Understanding

xLPR – NRC Intended Use

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- Version 1.0 – Pilot study – Surge nozzle DM weld
  - Demonstrated feasibility
  - Determined appropriate probabilistic framework
  - Developed plan for future version
- **Version 2.0 – Primary piping**
  - Support LBB Regulation Guide development
  - Assess compliance with GDC-4
  - Prioritize future research efforts
- Version 3.0 – Reactor coolant pressure boundary
  - Combine piping with reactor vessel, steam generator, etc.
  - Analyze probability of failure for all coolant pressure boundary components

xLPR Accomplishments

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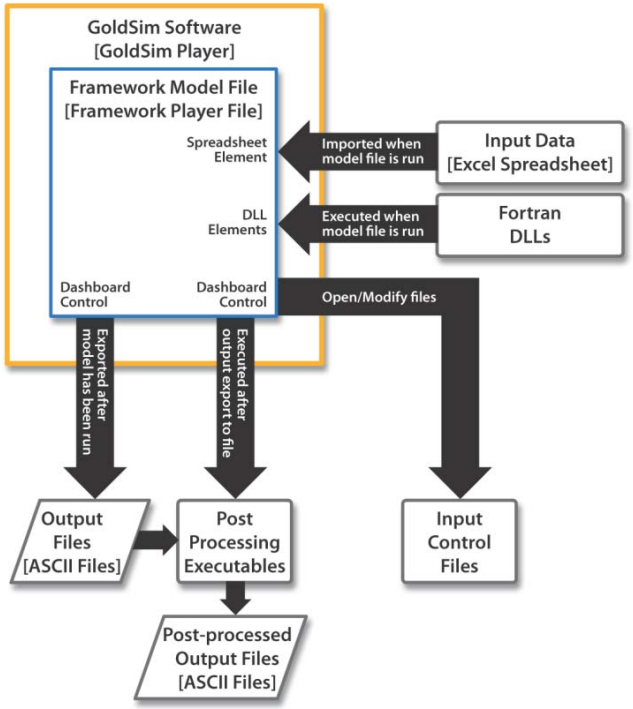
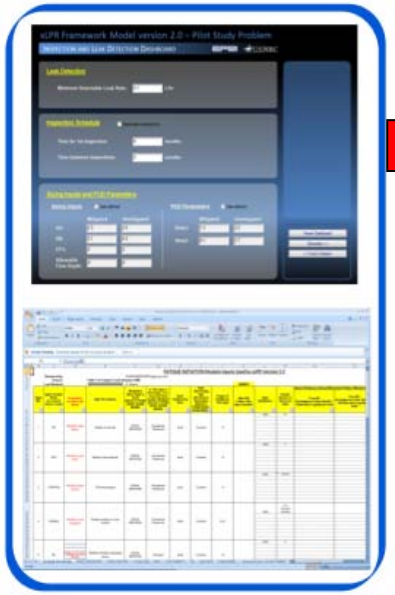
- Pilot study from 2009-2011
  - Developed and assessed xLPR project management structure
  - Determined the appropriate probabilistic framework
  - Assessed the feasibility of developing a modular-based probabilistic fracture mechanics computer code

- Deliverables:
  - xLPR Version 1 – modular-based code limited to PWSCC of a pressurizer surge nozzle developed in team environment
  - Demonstrated ability to predict probability of rupture taking into account mitigation, inspection, leak detection
  - Lessons learned

xLPR V2 Framework

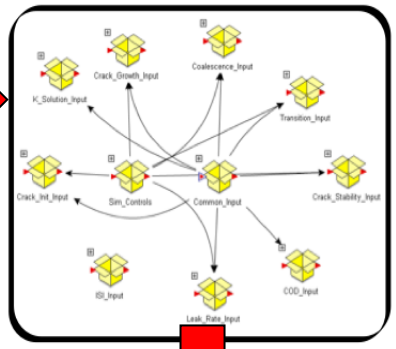


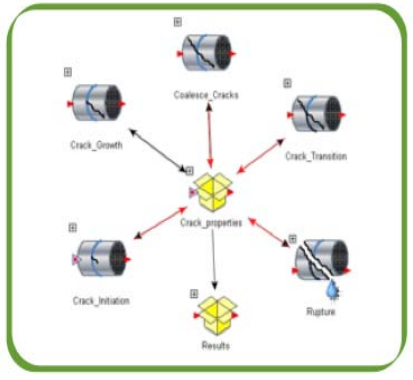
GoldSim software



GUI/Input database

Landing platform





Physical models

This strategy allows for multi-entities to share and work on the framework development in an efficient and parallel manner.

Biggest Challenges
for xLPR Version 2.0
in no particular order

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- SCC initiation
  - Problem is driven by SCC initiation
  - Expert Panel and ACRS engaged
  - All opinions support xLPR design decisions – Must calibrate properly
- Several fracture mechanics details
  - Idealized versus natural growth
  - Restraint of pressure induced bending and system constraint
  - DM weld flaw stability
  - Leak rate determination

Biggest Challenges
for xLPR Version 2.0
in no particular order

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- Code efficiency
  - Use TIFFANY and LEAPOR in Pre-processing for fatigue and leakage
  - Importance sampling – use of adaptive looks promising, but some issues within Goldsim
  - Run times will be slow – still investigating coding efficiencies
- QA
  - QA is time consuming

Biggest Challenges
for xLPR Version 2.0
in no particular order

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- Uncertainty characterization
  - Consistently quantify and characterize uncertainty
  - Will the process always be subjective?? If so, is it reliable for regulatory purposes?
- Complete and proper model and code validation
  - Some models are validated to full scale experiments, some developed from small lab experiments – Do they represent field behavior?
  - How do we (or can we) validate final output?
  - Combine qualitative and quantitative validation?
- BUDGET, MANPOWER and SCHEDULE

Possible Acceptance Criteria

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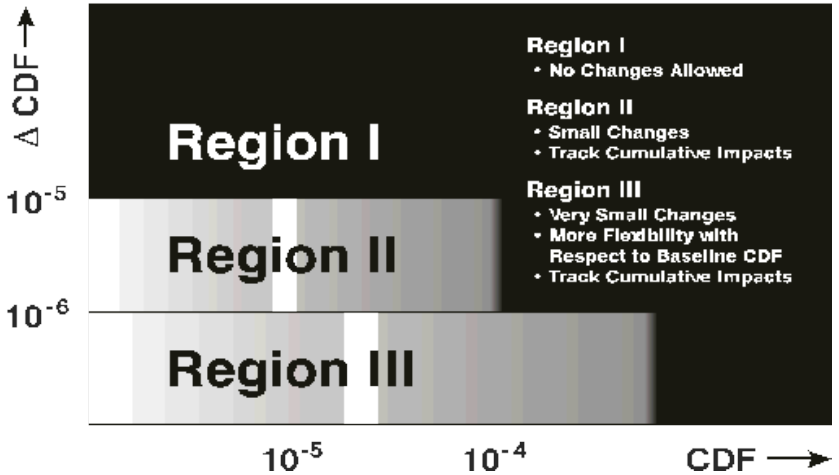
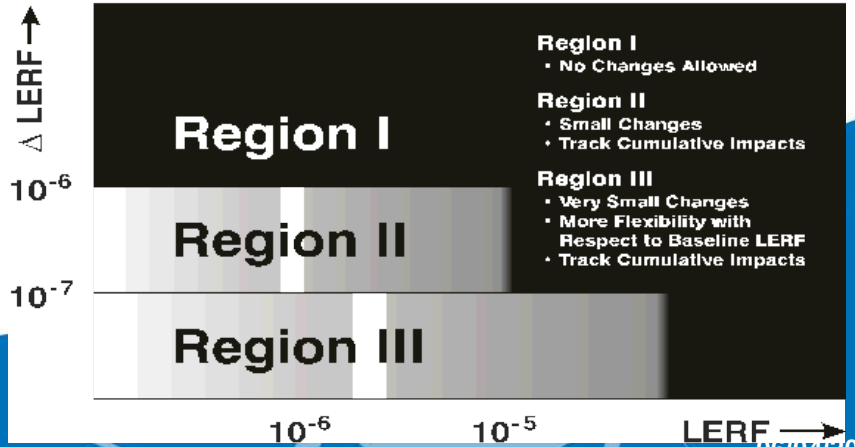
- Office of Nuclear Reactor Regulation (NRR) leading effort to develop xLPR Acceptance criteria
- Regulatory Guide 1.174 provides guidance on
  - Core Damage Frequency (CDF) and ΔCDF
  - Large Early Release Frequency (LERF) and ΔLERF
- Advantage
  - Criteria developed
  - NRC has experience with RG1.174 approach





Issues

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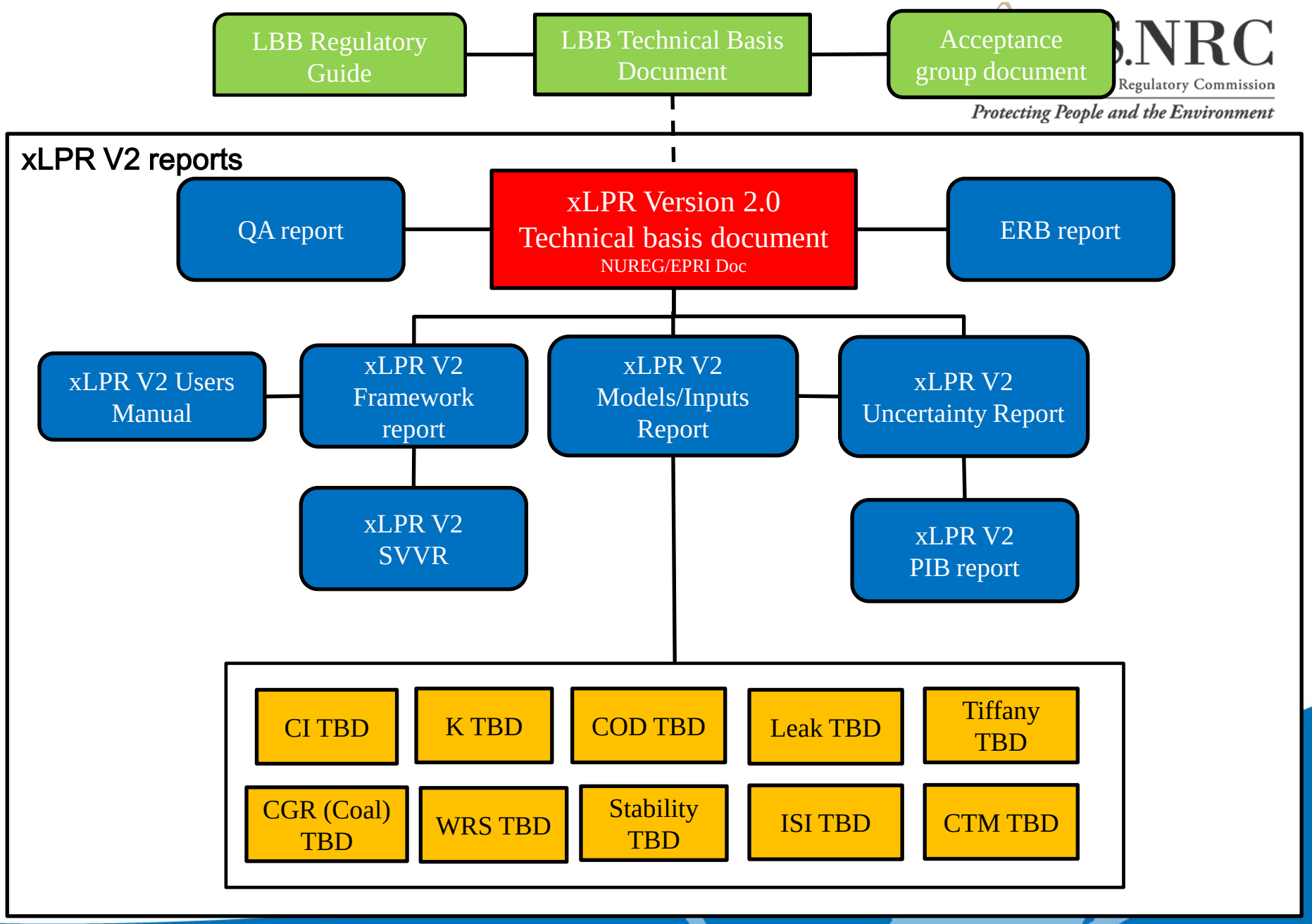
- Use of RG 1.174 predicated on CDF and LERF values from PRA, which assume no dynamic effects from large break. How to estimate these effects for PRA?
- Acceptance group is investigating other options.
- Defense in depth?
- Biggest issue is Regulator Confidence!
  - Technical basis
  - Uncertainty characterization, categorization and propagation key to confidence
  - Validation, validation, validation
- Need to continue open communication to ensure confidence


LBB Regulatory Guide
LBB Technical Basis Document
Acceptance group document
xLPR V2 reports
QA report
xLPR Version 2.0 Technical basis document
NUREG/EPRI Doc
ERB report
xLPR V2 Users Manual
xLPR V2 Framework report
xLPR V2 Models/Inputs Report
xLPR V2 Uncertainty Report
xLPR V2 SVVR
xLPR V2 PIB report
CI TBD
K TBD
COD TBD
Leak TBD
Tiffany TBD
CGR (Coal) TBD
WRS TBD
Stability TBD
ISI TBD
CTM TBD

Path Forward

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- Version 2.0 Development near complete
- Module verification near complete – Model validation underway
- Framework V&V efforts have begun
  - Unit, integration and acceptance plans being developed
- Verified Version 2.0 code complete Sept 2014
- Version 2.0 Code with basic validation complete for release Dec 2014
- Reports complete Spring 2015
- Regulatory Guide for LBB – 2016