SAND2017-13076PE

Comparison of Methods
xLPR Scenario Analysis & Sensitivity Template

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GOALS OF ANALYSES

- The major cause of differences between to the two analyses has been linked to the differences in the goals

Sandia – Scenario analysis

- ***Comparison*** *of results when* ***several*** *scenarios are considered (Generic plant inputs)*
- *Testing of various levels of probabilities for the response (from high to low)*
- *Checking sampling methodologies implemented in xLPR (SRS, LHS, IS…)*

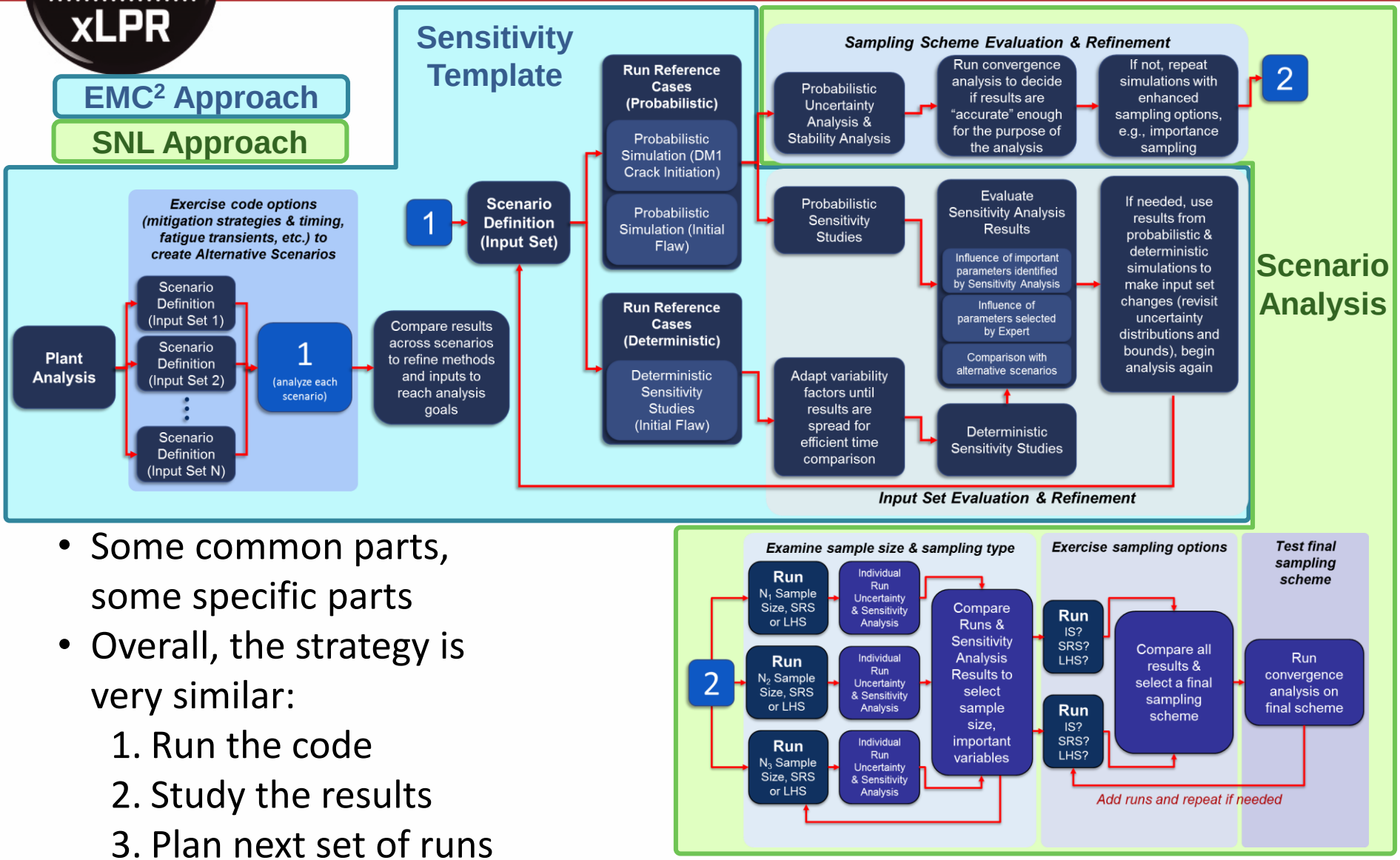
Emc² – Sensitivity studies

- ***Concentration*** *on a specific weld in a specific nuclear power plant (VC Summer and Tsuruga considered so far)*
- *Testing variations (sensitivity studies) from reference scenario (what-if analyses)*
- *Checking understanding of the model (does it match what is expected by experts?)*

ANALYSIS WORKFLOW COMPARISON

EMC² Approach

SNL Approach



- Some common parts, some specific parts
- Overall, the strategy is very similar:
  1. Run the code
  2. Study the results
  3. Plan next set of runs

PROBLEM SET-UP

- Approaches for problem set-up very similar, iterative process used
- Both use inputs based on work by xLPR Inputs Group

Sandia – Scenario analysis

- *Scenarios inputs based on xLPR Inputs Group data*
- *Iterative process – First run a reference case and learn from it to decide which additional runs (if any) are required*
- *Tracking and document each set up and each variation when applied*

Emc² – Sensitivity studies

- *Scenarios inputs based on Inputs Group data*
- *Iterative process – First run a reference case and learn from it to decide which additional runs (if any) are required*
- *Tracking and document each set up and each variation when applied*

xLPR CODE UPDATES

- Small differences in code modifications but overall same strategy
- Differences are due to the type of analysis (large number of scenarios vs. concentration on one scenario)

Sandia – Scenario analysis

- *Saving all scalar inputs that may be uncertain – common implementation can be used to wide range of scenarios*
- *No saving of spatially varying values – reduce amount of data saved – increase speed*
- *Use of extended list of already saved outputs – increase speed – consistency amongst scenarios*
- *Documentation of new elements and impact for QA purposes*

Emc² – Sensitivity studies

- *Saving inputs set to uncertain in input set – reduce the space and increase run speed*
- *Saving first five values for spatially varying parameters – checking of importance of specific value sample spatially*
- *Saving additional outputs depending on the scenario or the sensitivity study considered – fine tuning for each scenario*
- *Documentation of new elements and impact for QA purposes*

SAMPLING STRATEGY

- Sampling strategies differ across both studies
- Importance sampling applied in both analyses

Sandia – Scenario analysis

- *Running many simulations with:*
  - *Different sample sizes (100-10,000 epistemic and 50-100 aleatory)*
  - *Different random seed*
  - *Different sampling strategy*
- *Selection of sampling strategy based on results from set of runs*
- *Use of importance sampling when needed on most influential variables*

Emc² – Sensitivity studies

- *Running reference scenario with always same size (100 epistemic and 25 aleatory)*
- *Iterative update of sampling strategy based on results*
- *Use of importance sampling when needed on most influential variables*

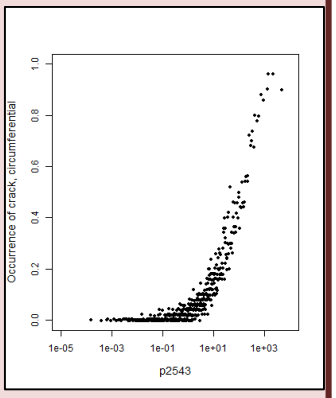
SENSITIVITY ANALYSIS

- Sensitivity analysis approach similar, regression methods vary

Sandia – Scenario analysis

- *Stepwise (rank) regression using standardized rank regression coefficient (SRRC) and final R^2 as indicator*
- *Scatterplots to support visually (and qualitatively) the regression results*

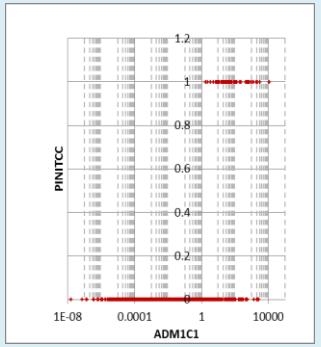
Variable Identifier	Variable Name	SRRC
Probability of Occurrence of Axial Cracks – R^2 = 0.892		
p2543	Multiplier proport. Const. A (DM1)	0.902
p4350	Hoop WRS Pre-mitigation	-0.228
p5103	Log reg. intercept param., beta 0 (axial)	0.064
p5104	Log reg. slope param., beta 1 (axial)	0.050
p1102	Pipe wall thickness	-0.039
Probability of Occurrence of Circumferential Cracks – R^2 = 0.847		
p2543	Multiplier proport. Const. A (DM1)	0.923
p4352	Axial WRS Pre-mitigation	-0.106
p2505	Elastic Modulus, E	-0.049
p9002	Surface Crack Dist Rule Modifier	0.037
p5101	Intercept, B0 (circ)	0.030



Emc² – Sensitivity studies

- *Three regressions (rank regression, recursive partitioning, multi-adaptive regression splines (MARS)) reporting main contribution and conjoint contribution*
- *Scatterplots to support visually (and qualitatively) the regression results*

	Rank Regression			Recursive Partitioning		MARS		Main Contri-bution	Conjoint Contri-bution *
Final R^2	0.15			0.88		0.53			
Input	R^2 inc.	R^2 cont.	SRRC	S_i	T_i	S_i	T_i		
ADM1C1	0.07	0.07	0.07	0.22	0.96	0.22	0.79	0.12	0.48
AMULTDM1	0.11	0.04	0.05	0.03	0.58	0.08	0.10	0.04	0.24
AXIALWRS	0.13	0.02	0.04	0.01	0.24	0.03	0.15	0.01	0.14
FFLAWC2	0.14	0.00	0.02	---	---	0.01	0.11	0.00	0.03
CKB	0.14	0.00	0.01	0.00	0.03	0.00	0.00	0.00	0.01
STHA4	0.14	0.01	0.02	0.00	0.19	0.00	0.14	0.00	0.12
C3MULT	0.14	0.00	-0.02	---	---	0.01	0.20	0.00	0.05
STHC5	0.15	0.00	0.01	---	---	0.01	0.00	0.00	0.00
RPYS	0.14	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.01
TWCDIST	0.15	0.00	-0.01	---	---	---	---	0.00	0.00
EFPY	---	---	---	---	---	0.00	0.00	0.00	0.00
ADM1A1	0.15	0.00	0.01	---	---	0.00	0.02	0.00	0.00
COA4	---	---	---	---	---	0.00	0.03	0.00	0.01
FOIZN	---	---	---	---	---	-0.01	0.00	0.00	0.00
AMD1A2	---	---	---	---	---	0.00	0.00	0.00	0.00
COC5	---	---	---	---	---	0.00	0.00	0.00	0.00

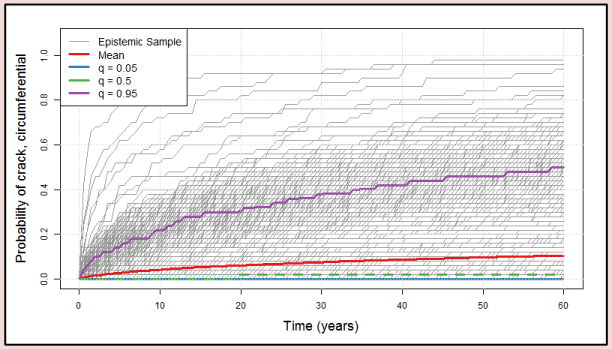


UNCERTAINTY ANALYSIS

- Uncertainty source and quantities of interest differ between studies

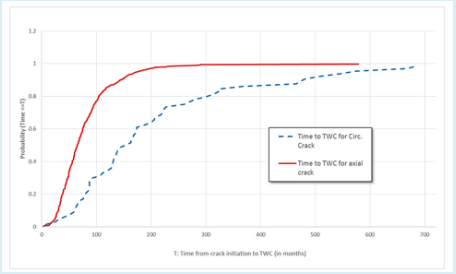
Sandia – Scenario analysis

- *Separation epistemic and aleatory uncertainty*
- *Representation of distribution, mean, and quantiles over probability of occurrences of events*



Emc² – Sensitivity studies

- *Grouped results (focus on mean values at specific time)*
- *Representation of distribution and mean over probability of occurrences of events*



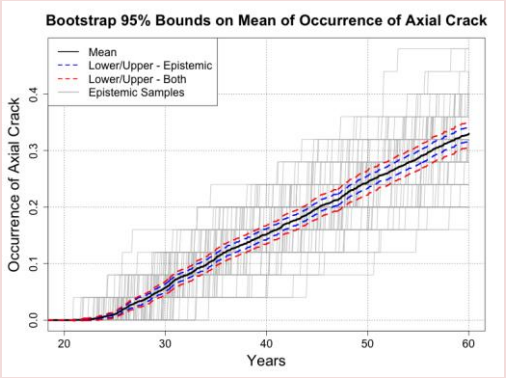
	Initiation circ. crack before 60 yr.	Initiation axial crack before 60 yr.	Leakage of circ. crack before 60 yr	Leakage of axial crack before 60 yr	Rupture
# RLZ[4]	63	345	46	329	42
%	2.5%	13.8%	1.8%	13.2%	1.7%

STABILITY ANALYSIS

- Stability estimated via bootstrap and parametric bounds in both studies
- Sampling loop over which confidence intervals are taken differs

Sandia – Scenario analysis

- *Stability estimated via bootstrap and parametric bounds*
- *Confidence intervals on epistemic only or on both epistemic and aleatory*



Emc² – sensitivity studies

- *Stability estimated via bootstrap and parametric bounds*
- *Confidence intervals on both epistemic and aleatory (over events)*