

# Industry / NRC Materials Programs Technical Information Exchange

## PFM Regulatory Guide Update

David Rudland, Senior Technical Advisor, NRR/DNRL  
Patrick Raynaud, Senior Materials Engineer, RES/DE/REB

August 10-11, 2021

---

# Objectives and Disclaimers



The goal of this presentation:

1. Provide an update on the draft PFM Regulatory Guide and Technical Basis

Disclaimers:

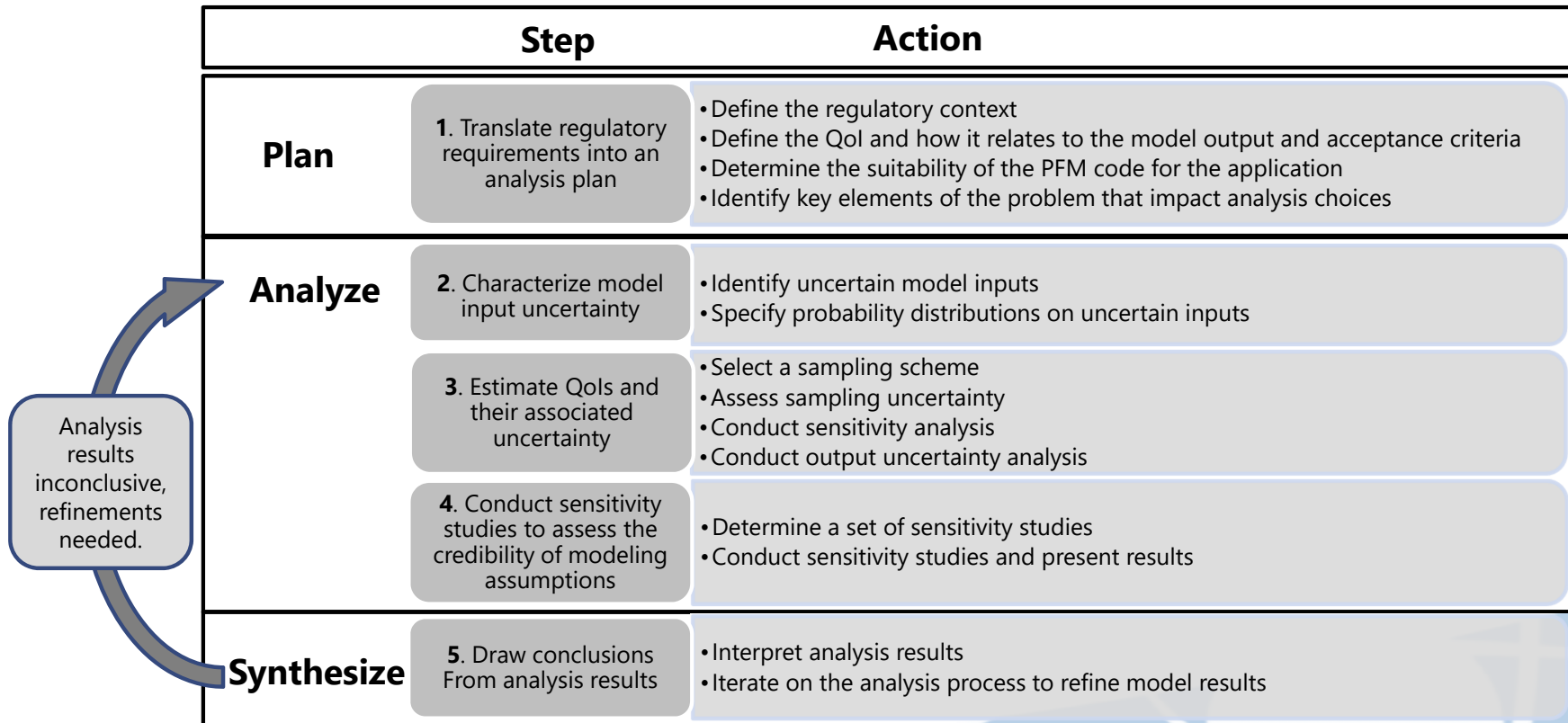
1. All content shown in these slides is pre-decisional and does not represent an official position of the NRC
2. None of the ideas presented here are final
3. This content is not intended to be guidance on what constitutes an acceptable approach for PFM submittals to the NRC

# PFM Guidance Development Documents



- Technical Letter Report on NRC’s preliminary thoughts on increasing confidence in PFM analyses (publicly available in ADAMS at ML18178A431)
- PFM NUREG technical basis
  - NRR review complete
  - Currently continuing internal review
- Draft Regulatory Guide
  - NRR review complete
  - Currently continuing internal review
- Report titled “Application of Probabilistic Analysis Techniques in Probabilistic Fracture Mechanics”
  - Review Complete
  - Will publish after public release of RG and NUREG
- FAVOR Example Study Report
  - Review Complete
  - Will publish after public release of RG and NUREG

# Analytical Steps in a Probabilistic Fracture Mechanics Demonstration



# Detailed Thoughts on a Graded Approach for PFM

- PFM is complex
- The depth and breadth of a PFM analysis might vary widely depending on several factors
- It makes sense to take a graded approach...
  - ...for PFM analyses themselves
  - ...for the level of detail to be presented as part of an evidence package
- General Principles
  - Higher safety significance
  - Higher complexity
  - Higher level of novelty



- Topics Covered
  - Software QA and V&V
  - Models
  - Inputs
  - Uncertainty Propagation
  - Convergence
  - Sensitivity Analyses
  - QoI Uncertainty Characterization
  - Sensitivity Studies

- More analyses, more documentation
- Higher burden to create defensible and rigorous evidence

# PFM Graded Approach

- EPRI proposed minimum requirements for PFM applications and their documentation in EPRI BWRVIP 2019-016 white paper: “Suggested Content for PFM Submittals to the NRC”, ML19241A545
- NRC reviewed the white paper and took EPRI’s recommendations into consideration while developing a graded approach for PFM
- In many cases, NRC proposes to reduce the amount of documentation compared to EPRI’s recommendations
- In some cases, NRC proposes additional documentation
- For each major topic in a PFM application, documentation categories are defined depending on the features of the specific application. **Categories are independent from each other: can be in different categories for different topics**
  - **SQA and V&V**
  - Models
  - **Inputs**
  - Uncertainty propagation
  - Convergence
  - Sensitivity analyses
  - Output uncertainty characterization
  - Sensitivity studies

# Example: Software QA and V&V **DRAFT**



- Safety demonstrations for the NRC usually require that a QA program be in place
- Pre-submittal meetings are very useful to help ensure that everyone agrees on the graded approach path

Category	Description	Graded Approach
<b>QV-1</b>	NRC-approved code	
<b>QV-1A</b>	Exercised within validated range	Demonstrate code applicability within the validated range. Describe features of the specific application where the code is validated and applicable (i.e., areas of known code capability).
<b>QV-1B</b>	Exercised outside of validated range	Provide evidence for the applicability of the code to the specific application with respect to the areas of unknown code capability. Describe features of the specific application where the code has not been previously validated and applied (i.e., areas of unknown code capability).
<b>QV-1C</b>	Modified	Give an SQA summary and V&V description for modified portions of the code. Demonstrate that the code was not “broken” as a result of changes. Make detailed documentation available for further review upon request.
<b>QV-2</b>	Commercial off-the-shelf software designed for the specific purpose of the application	Demonstrate code applicability. Describe the software and its pedigree. Make software and documentation available for review upon request.
<b>QV-3</b>	Custom code	Summarize the SQA program and its implementation. Provide a basic description of the measures for quality assurance, including V&V of the PFM analysis code as applied in the subject report. For very simple applications, possibly provide the source code instead of standardized SQA and V&V. Include separate deterministic fracture mechanics analyses to support other validation results, as appropriate for a given application.

# Example: Inputs **DRAFT**

Category	Graded Approach
I-1D	List input value.
I-1R	List input distribution type and parameters. If applicable, list uncertainty classification (aleatory or epistemic).
I-2D	List input value. If there is a lack of data, justify the use of expert judgment.
I-2R	List input distribution type and parameters. If applicable, list uncertainty classification (aleatory or epistemic). If there is a lack of data, justify the use of expert judgment.
I-3D	List input value. State the rationale for setting the input to a deterministic value. For each deterministic input, give the rationale (method and data) for the selection of its numerical value, along with any known conservatisms in that numerical value and the rationale for such conservatisms. Reference documents that contain the foundation for input choices. Explain the correlations between inputs and how they are modeled, and verify that correlated inputs remain consistent and physically valid. Describe any sensitivity analyses/studies performed to show that the input or its classification does not have a significant effect on the QoI.
I-3R	List input distribution type and parameters. If applicable, list uncertainty classification (aleatory or epistemic). If relevant, classify uncertain inputs as aleatory or epistemic and give the corresponding rationale. For each uncertain input, describe both its distribution parameter values and its distributional form. Give the rationale (method and data) for selecting each distribution, including any known conservatisms in the specified input distributions and the rationale for the conservatism. Detail the distributional fitting method, including interpolation, extrapolation, distribution truncation, and curve fitting. Reference documents that contain the foundation for input choices. Explain the correlations between inputs and how they are modeled, and verify that correlated inputs remain consistent and physically valid. Describe any sensitivity analyses/studies performed to show that the input or its classification does not have a significant effect on the QoI.
I-4D	See I-3D. If there is a lack of data, justify the use of expert judgment.
I-4R	See I-3R. If there is a lack of data, justify the use of expert judgment.

Input Category	Low Knowledge of Input Characteristics		High Knowledge of Input Characteristics	
	Deterministic	Uncertain	Deterministic	Uncertain
High Importance	I-4D	I-4R	I-3D	I-3R
Low Importance	I-2D	I-2R	I-1D	I-1R



# Experience from Recent PFM Submittals



- Several PFM related alternatives have been reviewed. At the time of the recent reviews, details of graded approach were still under development (and are currently under internal review)
- PFM code audit is a useful tool to better understand code details and basis
- The (draft, pre-decisional) PFM guidance...
  - helps the industry prepare submittals that have a consistent level of quality
  - helps the staff understand more complex analyses such as sensitivity analysis and sensitivity studies and their importance in the interpreting the PFM results
  - helps put a framework around the various topics, thus organizing the review

# ACRS Interaction



- Staff briefed ACRS on the PFM Regulatory Guide and associated NUREG on July 20, 2021
  - Joint Subcommittees on Metallurgy & Reactor Fuels and Structural & Seismic Analysis
- Along with the documents, staff discussed the need for PFM guidance and reviewer's perspective of the guidance.
- Brief was well received with many questions from several members.
- Since this was an informational brief, no letter from ACRS is expected.

# Next Steps

- NRC will publish draft regulatory guidance and an accompanying draft technical basis NUREG, both for public comments (August 2021, hopefully)
- NRC will gather public comments on the draft guidance and draft NUREG
- NRC will address all comments received
- Public meetings may take place, if needed
- At least one more ACRS briefing on the topic of PFM and PFM regulatory guidance is expected in the future