What Is
PIRT

V&V/UQ and Credibility Processes Team

This "What Is" will:

- Provide you with an understanding of PIRT and why it is critical to create and use it
- Help you understand the structure and the terminology of a PIRT
- Help you identify who should be involved in creating a PIRT

Prerequisite reading: What Is CompSim Credibility; What Is Verification and Validation (V&V)

A Phenomena Identification and Ranking Table, or PIRT, provides a structured approach to identify and prioritize the important physical phenomena in an engineering application. A PIRT is developed through expert opinion for a particular intended use. The intended use is specific to the application driver, technical issue, scenario, and analysis objective, such as the performance or safety of a nuclear reactor.

Defining key physical phenomena and ranking importance is the primary function of a PIRT. A secondary function is to further assess the adequacy and gaps in the simulation capabilities, and available experimental data in an expanded PIRT (as shown in Figure 1). Developing an expanded PIRT involves ranking and aligning application requirements with associated physics and materials model development, simulation code development and verification, validation, and uncertainty quantification activities. The expanded PIRT is a necessary step for computational simulation planning.

The PIRT process originated from needs in the U. S. nuclear power industry for high consequence modeling and simulation. As discussed in Wilson, 1998, the PIRT process was devised to identify important physical phenomena in nuclear reactor performance and subsequently to support the use of computational modeling in safety analyses.

Construction of a PIRT is a necessary condition for the development of the PCMM (*Predictive Capability Maturity Model*).

During the PIRT development, information is gathered from project teams, subject matter experts, application analysts, code developers, experimentalists, and Validation and Verification (V&V) specialists. An initial elicitation from all subject matter experts builds consensus in the technical community by soliciting and accommodating a broad spectrum of perspectives. The PIRT is a living document that evolves as modeling and experimental activities progress and information is gained during the analysis and validation process.

When material models represent a significant part of an application analysis, you may use a Material Identification and Ranking Table (MIRT) to separately organize the material behavior assessment. A MIRT, however, should only be viewed as a sub-element of the PIRT, especially when conducting a priority assessment where equal consideration of all phenomena from both the PIRT and the MIRT is necessary.

		Adequacy for Intended Use			
Phenomena	***Importance***	**Math Model**	**Code**	**Validation**	**Model Parameter**
Phenomena 1	H	H	M	L	L
Phenomena 2	M	H	M	L	L
Phenomena 3	L	H	M	L	L

Figure 1. A recommended template for an expanded PIRT, including relevant physical phenomena, their importance ranking, and adequacy of current technical capabilities for a specified analysis.

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Why should you create a PIRT?

The PIRT is used to define the application requirements in terms of the relative importance of the physical phenomena for the intended use. Developing a PIRT helps ensure that all important physical phenomena are taken into account in an application analysis.

Expanding the PIRT helps facilitate computational simulation planning and ensure that limited resources (budget, people, and time) are focused on the activities that are believed to have the greatest impact on the predictive capability for the intended application.

The PIRT process helps bridge the gap between application requirements and math models, discretized models, code capabilities, and verification and validation requirements. The goal of a PIRT is to ensure both sufficiency and efficiency of the computational capabilities. Sufficiency is provided through a process of consensus building by expert elicitation for an intended application. Efficiency is provided through prioritization of the phenomena and gap analysis of the simulation and experimental capabilities.

Assessing the importance of the phenomena and the adequacy of the technical capabilities used in an application analysis is a critical first step in establishing the credibility of a computational simulation prediction.

What is the structure of the PIRT?

The structure of the expanded PIRT includes three main elements (refer to Figure 1):

1. A row for each identified phenomena relevant to the intended application.
2. A column for ranking the importance of the identified phenomena using a low, medium, and high scale.
3. Additional columns for the assessment of adequacy of the current simulation capability, using a low, medium, and high scale, relative to the phenomena.

Prioritization is derived from the *importance* ranking of the phenomena relative to application requirements and the *adequacy* ranking is derived by scoring the mathematical models, material models, code capabilities (including code verification), and validation (including solution verification and uncertainty quantification) for the intended use. Note that once low priority phenomena have been identified, there is typically no need to further evaluate the adequacy and gaps of the capability elements. Detailed descriptions of the importance and adequacy rankings definitions can be found in the "How To PIRT" document.

What is a PIRT gap assessment?

A gap assessment can be visually indicated by color coding the PIRT elements with green, yellow, red, and blue cells. Gaps are defined as shortcomings between the importance level and the adequacy of the current capability elements. Green is assigned when the adequacy is at the same or higher level as the importance level, and implies that the current capability element is sufficiently adequate for the intended use, with no known deficiencies. Yellow is assigned when the adequacy is one level below the importance level, and implies that the current capability element is partially adequate for the intended use, with some known deficiencies. Red is assigned when the adequacy is two levels below the importance level, and implies that the current capability element is insufficient and not adequate for the intended use. Blue is assigned to the adequacy columns for phenomena whose importance is currently unknown, independent of the adequacy ranking of the individual capability elements. The color coding aids in prioritization of gaps that should be addressed; that is, resources should first be focused on red and then yellow, while green requires no new resources.

After the gaps have been identified in the PIRT, a mitigation strategy for addressing the inadequacies should be developed. This may include acceptance of the inadequacy, workarounds, or other documented strategies. For large multi-year projects, this may take the form of a Verification and Validation modeling and simulation plan (V&V plan). If time and/or cost prevent additional development or experiments from being conducted in critical areas, then the risk of using approximate models with limited data, verification, and/or validation should be noted.

A PIRT evolves with continuous reassessment and improvement. At any point in time, it provides the best available assessment of the current understanding of the engineering/physics problem being addressed. As work is being conducted, gaps may be closed, one or more mistakes may be revealed, missing elements may appear, or the originally stated priorities may be adjusted. Therefore, a PIRT should be revisited periodically and updated.

PIRT Connection to Validation Hierarchy

A validation hierarchy provides a structured approach to validate physics models using a "bottom up" process that starts with unit-level physics and simple hardware, continues up to coupled physics and more specialized hardware, then to more integrated physics and sub-system hardware, and finally to complete physics and system hardware. This approach can be implemented in applications where sufficient resources and relevant experimental data are available at each level to perform a validation assessment.

In some mechanics applications where the fidelity of the physics models and/or supporting experimental data is limited, a calibration approach at top levels in the hierarchy is employed. For such applications, calibration of sub-models typically occurs at the system and sub-system levels, depending on the model fidelity and the availability of experimental data at each level.

The PIRT describes phenomena that occur throughout the hierarchy, and includes a validation assessment of how well the math models represent the phenomena at lower levels in the hierarchy. When a calibration approach is employed, PIRT construction remains the same. The calibration step is simply captured in the adequacy assessment of the model parameters and should reflect whether relevant experimental data is available to calibrate the model parameters, followed by a validation assessment of how well the calibrated models capture the physical response.

PIRT Definitions

- **Phenomena** are physical features or behaviors of an engineering analysis that are relevant to the intended application.
- **Math Model** is a physical, conceptual, or phenomenological model that is defined using precise mathematical equations. Math model adequacy represents the pedigree, completeness, and relevance of the math model form for the application.
- **Code** represents the computational modeling and simulation capabilities used in an engineering analysis. Code adequacy represents the status and quality (code verification) of the math model implementation.
- **Validation** is the process of determining the accuracy of a computational simulation to represent the real world as approximated by experimental data. Validation adequacy represents the rigor (solution verification and uncertainty quantification) used in quantifying the math model accuracy and the relevance of the validation comparison for the application.
- **Model Parameter** refers to parameters or functions in the physics or material models that are typically experimentally determined. Model parameter adequacy represents the pedigree, completeness, and relevance of the model parameter values or functions for the application.
- **Code Verification** is the process of determining that the computational model accurately represents the underlying mathematical model and its solution.
- **Solution Verification** is the process of quantifying the numerical error in the computational

simulation due to spatial discretization, temporal discretization, stochastic resolution, and iterative convergence.

- **Uncertainty Quantification** is the process of characterizing all relevant uncertainties in a model and of quantifying their effect on a quantity of interest.

Where do you get more information?

A "How To PIRT" document (SAND2016-6465 TR) is available that provides detailed information for constructing a PIRT. V&V/UQ Portal, https://rails-rn-prod.sandia.gov/vvuq/pirt

Wilson, G. E. and Boyack, B. E., "The role of the PIRT process in experiments, code development and code applications associated with reactor safety analysis," (1998), Nuclear Engineering Design, Vol. 186, p. 23-37.

Who should you contact for help?

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