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An Overview of ASME V&V 20: Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer

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ABSTRACT

An overview of the new ASME V&V 20 Standard [1] is presented. The objective of V&V 20 is the specification of a verification and validation approach that quantifies the degree of accuracy inferred from the comparison of a simulation solution and appropriate experimental data. The approach, first proposed in [2], uses the concepts from experimental uncertainty analysis [3-5] to consider the errors and uncertainties in both the solution and the data. The scope of V&V 20 is the quantification of the degree of accuracy of simulation of a specified validation variable at a specified validation point for cases in which the conditions of the actual experiment are simulated. Consideration of solution accuracy at points within a domain other than the validation points, for example interpolation/extrapolation in a domain of validation, is beyond the scope.

The definitions of verification and validation used are consistent with those used in previously published guides and texts on V&V [6-8]. The concepts and definitions for error and uncertainty used differ from those in the previously published guides, however, in that the concepts and definitions from internationally-accepted experimental uncertainty standards [3, 4] are used.

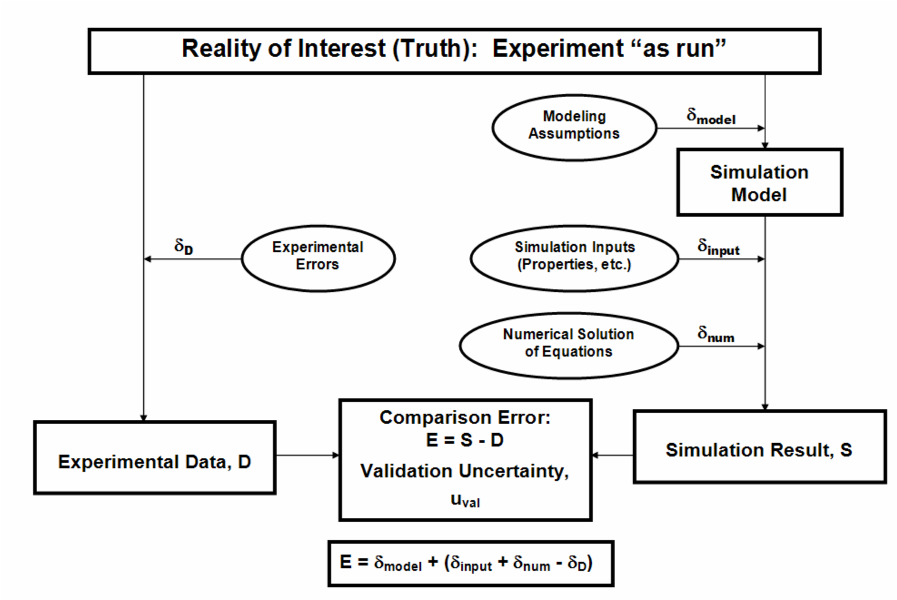

Figure 1 Overview of the V&V 20 approach with sources of error (δ) in ovals.

The schematic shown in Figure 1 illustrates the approach and some of the nomenclature used. The error in the experimental result D is δ_D, and errors in the simulation result S are: δ_{model} due to modeling assumptions and approximations; δ_{num} due to the numerical solution of the equations; and δ_{input} due to errors in the simulation input parameters. The validation metrics used are the validation comparison error E and the validation uncertainty u_{val}, which is the standard uncertainty [3-5] that characterizes an interval which includes the combination of errors ($\delta_{num} + \delta_{input} - \delta_D$).

The validation uncertainty u_{val} is composed of contributions from the standard uncertainties u_{num}, u_{input}, and u_D. The uncertainty u_{num} is estimated as a result of code and solution verification procedures [9]. The contribution of the combination of u_{input} and u_D is determined by propagation of input uncertainties and experimental uncertainties [3-5] using either a sensitivity coefficient approach or a Monte Carlo (sampling) approach and taking into account the correlation effects of shared variables in S and D and multiple measured variables possibly sharing identical elemental error sources.

An interval which contains δ_{model} is characterized by $E \pm u_{val}$. If an error distribution is assumed, an interval which contains δ_{model} with a given level of confidence is characterized by $E \pm ku_{val}$, where k is the coverage factor [3-5].

Examples of application of the V&V 20 approach will be discussed for cases in which the validation variable D: (1) is directly measured, (2) is determined from a data reduction equation that combines multiple measured variables, and (3) is determined using an inverse heat conduction model that itself introduces a modeling error $\delta_{D,model}$.

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