Verification and Validation in Computational Fluid Dynamics

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As computers get faster, Computational Fluid Dynamics (CFD) will continue to play a growing role in the analysis, design, and optimization of fluid systems. Although often overlooked or ignored, one question that must be addressed is:

how do we know if the simulation results are correct?

Verification and Validation, or V&V, are a formal set of procedures for building confidence in, and determining the limits of applicability of, modeling and simulation. Verification is defined by both AIAA and ASME as the process of assessing the correctness of the computer code and the accuracy of the numerical solution to the given mathematical model of the physics. In other words, making sure the equations are solved correctly. Validation is defined as the process of assessing the accuracy and capability of the mathematical model to simulate the physics of interest. In other words, making sure the correct equations are solved. Three examples will be given of V&V processes applied to problems in CFD:

- hypersonic shock-wave/turbulent boundary layer interactions,
- tractor-trailer aerodynamics, and
- flow through microfibrous materials.

While all three of these examples come from CFD, the V&V principles to be discussed are equally applicable to other disciplines in which partial differential equations must be solved. Examples of broader areas where the V&V principles can be applied include thermal analysis, structural mechanics, structural dynamics, fluid/structure interaction, weather and climate modeling, and astrophysical simulations of stars and galaxies.