

Automation of the Uncertainty Quantification Process Based on Probability Boxes with DAKOTA

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ABSTRACT

Computational Fluid Dynamics (CFD) has been used extensively to fill critical testing gaps present in scramjet engine research and development. The heavy reliance on CFD is driven by several factors that include:

- difficulties with replicating hypersonic conditions in ground test facilities for sufficient periods of time
- obstacles with utilizing advanced diagnostics in the harsh scramjet flow environments
- lack of facilities large enough to test full-scale engines, other than possibly missile applications

To date, while the use of CFD is prevalent, very few efforts have been undertaken that truly attempt to document all (or even most) of the sources of uncertainty in the simulations. Instead, the current state-of-the-art relies heavily on the experience of the CFD practitioner to estimate the uncertainty associated with their simulations through simple sensitivity studies or subject matter expertise. This practice will have to be replaced with a formal uncertainty quantification (UQ) process if CFD is to play an expanded role in the design research and engineering community, test and evaluation community, and ultimately certification for flight. This is especially true for hypersonic air-breathing propulsion systems due to the environment, scale, and duration limitations of ground test facilities. Accounting for uncertainties in a formal manner is a tedious process. Moreover, the typical CFD practitioner is not likely to be familiar with formal UQ methods. Hence, a major obstacle that has prevented the adoption of UQ methods in the engineering design and development cycle is the lack of a tool set to automate most (if not all) of the UQ work flow. Towards this end, the SANDIA package DAKOTA (which has been developed to drive both UQ and optimization processes) will be tightly wrapped around the VULCAN-CFD code to automate the uncertainty quantification process. The automated process will be applied to an isolator turbulence model validation exercise that has previously been documented using a manual approach to the UQ process. Hence, the focus of this paper will be documenting the level to which automation can hide the UQ process details from the CFD practitioner rather than the UQ method itself.