DFD09-2009-020008

Abstract for an Invited Paper
for the DFD09 Meeting of
the American Physical Society

Wind Tunnel to Flight: Numerical Simulations of Hypersonic Propulsion Systems[1]

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Uncertainties in the flight conditions and limitations of ground based facilities create inherent difficulties in assessing the performance of hypersonic propulsion systems. We use numerical simulations to investigate the correlation of wind-tunnel measurements (Steelant et al., 2006) and flight data (Hass et al., 2005) for the HyShot vehicle; the objective is to identify potential engine unstart events occurring under different combustion regimes. As a first step we perform simulations corresponding to both reacting and non-reacting conditions in the ground-based facility to validate the numerical tools. Next, we focus on reproducing the flight conditions; a fundamental difficulty is the lack of precise information about the vehicle trajectory. A Bayesian inversion strategy is used to infer the altitude, angle of attack and Mach number from the noisy pressure measurements collected during the flight. The estimated conditions, together with the scatter due to the measurement uncertainty, are then used to study the flow and thermal fields in the combustor. The details of the methods used to characterize the uncertainty in the flow simulations and to perform the Bayesian inversion will also be discussed.

[1]This work is supported by the Department of Energy [National Nuclear Security Administration] under Award Number NA28614.

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