Abstract
Laminar to turbulent transition in boundary-layer flows over hypersonic vehicles is accompanied by large increases in skin friction and surface heat flux. Aero-heating uncertainties associated with transition prediction lead to increased weight and, in the worst-case scenario, threaten the structural integrity of the vehicle. Often, transition onset occurs prematurely as a result of discrete 3D protuberances or cavities that represent an inherent aspect of vehicle design and operation. The extensive research performed in support of Space Shuttle Discovery’s Return-To-Flight (RTF) led to a first generation, rapid predictive capability for boundary layer transition due to damage or repair to the thermal protection system. However, the usefulness of such empirical methodology is limited by the significant uncertainty and the fact that it cannot be reliably extrapolated beyond its limited underlying database.

Recent research under the Fundamental Aeronautics Program has led to substantially enhanced understanding of the physical mechanisms responsible for transition due to discrete roughness elements and, furthermore, provided the ingredients towards a next generation, physics based prediction tool. This presentation will outline how the discovery of physical mechanisms related to roughness-induced transition was enabled via a combination of unique capabilities in modeling, simulations, and experiments at the NASA Langley research Center.

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Meelan Choudhari works in the Computational AeroSciences Branch at NASA Langley Research Center, Hampton, VA. His research interests include direct and large-eddy simulations of unsteady flows, asymptotic modeling, hydrodynamic instabilities and laminar-turbulent transition, aeroacoustics, and flow control. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics and currently serves as an Associate Editor of the AIAA Journal. He is also the founding chair of an international working group related to airframe noise and has organized a series of successful workshops related to high fidelity numerical simulations for airframe noise prediction. In the past, he has served as the Chair of AIAA’s Fluid Dynamics Technical committee and also led the Boundary Layer Physics thrust panel that contributed to the National Hypersonic Foundational Research Plan, a national effort to coordinate and roadmap the foundational research in hypersonics.