NOV 19, 2015

Stability and Transition on Flight Vehicles

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ABSTRACT:

The ability to accurately predict and control the transition process from laminar to turbulent flow will provide significant advances in air-vehicle design, with applications ranging from high-altitude long-endurance unmanned aerial vehicles, to energy-efficient transports, to hypersonic systems. The development, validation, and introduction of physics-based approaches for stability and transition prediction will lead to smaller and more manageable uncertainties in the design of vehicles. Moreover, control may be applied for two different reasons. First there is the desire to delay transition, which contributes to aerodynamic heating load reduction and range and/or endurance. A second desire is to encourage transition for enhanced mixing or separation delay, such as over control surfaces and the inlet of a scramjet engine. The most effective strategy for control is to capitalize on the flow physics, identify the relevant instability mechanisms and what affects them, and modulate the most unstable disturbances as they are just beginning to grow. Our team has successfully applied linear and nonlinear parabolized stability equation and global methods to these problems, and also considered the effects of 2-D surface excrescences and formulated a physics-based correlation for forward-facing steps in 3-D boundary layers. Through mechanism identification, verification, and validation activities, several lessons have been learned in applying stability formulations.

BIOGRAPHY:

Helen L. Reed, Ph.D., P.E., holds designations as Regents Professor, Presidential Professor for Teaching Excellence, and Holder of the Edward "Pete" Aldridge '60 Professorship, and is a former Department Head of Aerospace Engineering at Texas A&M University, following faculty appointments at Stanford University and Arizona State University. She is also Co-Founder and Chief Technology Officer for Chandah Space Technologies, a start-up company specializing in small-satellite systems. She received her Ph.D. in Engineering Mechanics from Virginia Tech. Dr. Reed has 38 years of experience in physics-based understanding, prediction, and control of the receptivity, stability, and transition of boundary layers on aerospace vehicles, with applications to high-altitude long-endurance unmanned aerial vehicles, transports, and hypersonic trans-atmospheric vehicles. In parallel she also has 22 years of experience in small-satellite design and operations and student programs. She is a Fellow of the American Institute of Aeronautics & Astronautics (AIAA), the American Physical Society, and the American Society of Mechanical Engineers. She was the recipient of the 2007 J. Leland "Lee" Atwood Award from the American Society for Engineering Education and AIAA. She was also inducted into the Academy of Engineering Excellence and the College of Engineering “Committee of 100” at Virginia Tech. Presently she is a member of the National Research Council’s Aeronautics and Space Engineering Board (ASEB), the Chair of the AIAA Transition Discussion Group, subgroup lead for the NATO AVT ET 136 Technical Team: “Hypersonic Boundary Layer Transition Prediction”, and a consultant to the Institute for Defense Analysis.