

Title:	Shock-Wave/Boundary-Layer Interaction (SWBLI) Experiments in the Presence of Transition-to-Turbulence on a Flat Plate Model in the NASA LaRC 31-Inch Mach 10 Air Tunnel
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Abstract:

Historically, there have been a limited number of studies involving Transitional Shock-Wave/Boundary-Layer Interactions (XSWBLI) in hypersonic flows, the majority of which have been performed at Mach Numbers of 7.5 and below. Additionally, there have been even fewer such experiments which incorporate non-intrusive and optical diagnostics. NASA Langley Research Center (NASA LaRC), in collaboration with The University of Texas at San Antonio (UTSA) and The University of Tennessee Space Institute (UTSI), is currently planning and preparing for a series of experimental aerodynamic tests using the NASA LaRC 31-inch Mach 10 Air Tunnel. The experiments will primarily focus on studying the dynamics of Shock-Wave/Boundary-Layer Interactions (SWBLI) in the presence of transition (XSWBLI) and turbulence (SWTBLI) on a large, flat plate model at a freestream Mach number of 10. Besides continued interest in understanding the flow at high Mach numbers, executing such tests at Mach 10 avoids some known concerns and will aid in solving new problems. XSWBLI are a highly unsteady phenomena and the generation of XSWBLI at lower Mach numbers can prove to be a significant challenge. This concern will be somewhat mitigated in the Mach 10 flow, as boundary layers become increasingly stabilized, but some difficulty in achieving transition is still expected. Modelling SWBLI in the presence of transitional and turbulent boundary layers has also proven to be difficult, so a high-Mach number experiment which applies non-intrusive and optical diagnostics will aid in solving a unique problem as well as advancing the understanding and characterization of an aerodynamic surface at Mach 10.

The NASA LaRC 31-inch Wind Tunnel incorporates a test section having a cross-section of 31-inches $\times$ 31-inches and provides optical access to the test section via three (3) ultra-violet (UV) transmitting windows on the top, side, and bottom. The Mach 10 operating conditions will consist of pressures (P_0) ranging from 2.4 to 10 MPa (348 to 1,450 psi) at a temperature (T_0) of 1,000 K (1,800 °R). The NASA LaRC 31-inch wind tunnel will deliver 1-minute blow-down runs, of which 30-45 seconds will be consumed to reach the aforementioned test conditions. The pump down time between runs will be approximately 45-60 minutes, which will provide for 6-10 test runs per day over the course of a weeklong entry. The proposed flat plate model will be constructed of stainless steel with geometry consisting of a 10-inch $\times$ 30-inch upper surface and a 2-inch thickness. The model will be designed to support multiple leading-edge inserts in order to examine blunt, round, and sharp leading edges at Mach 10. Adjustments will be made to manage boundary layer thickness as well as the strength and size of the shock interaction region for each test. Measurements and diagnostics will be performed through high-speed schlieren, on-body high-speed pressure transducers, IR thermography, and oil flow visualization.

Hypersonic vehicle applications have and will continue to emerge at the forefront of aerospace. The NASA-UTSA-UTSI team realizes the value of characterizing SWBLI, XSWBLI, and SWTBLI behaviors well beyond single-digit hypersonic Mach numbers. As hypersonic vehicle speed capabilities continue to increase, measurement and diagnostic methods for Mach numbers of 10 and beyond will provide the foundation for a firm understanding of flow field behavior which will directly influence the advancement of technologies towards the design and manufacturing of high-speed aerodynamic surfaces, controls, thermal protection systems, acoustic treatments, and structural components. The use of non-intrusive and optical diagnostic methods in such experimentation is pivotal in developing the visualization and empirical data necessary to advance the aforementioned technology areas.