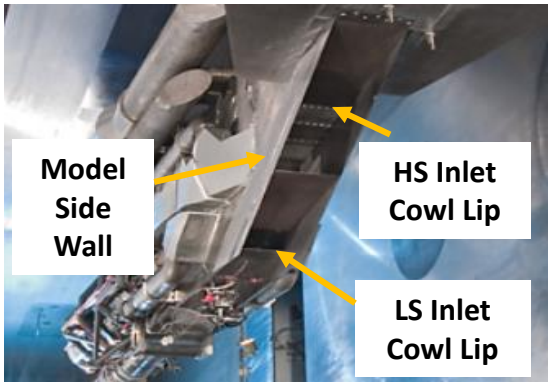
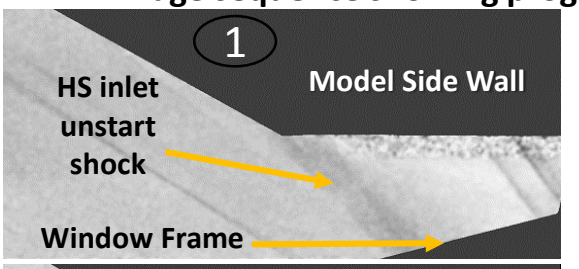
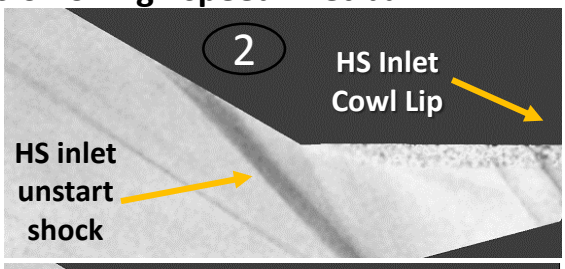
Installed CCE Model

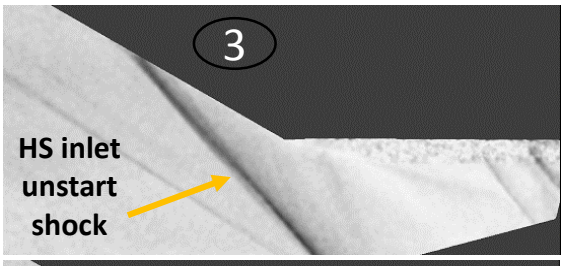


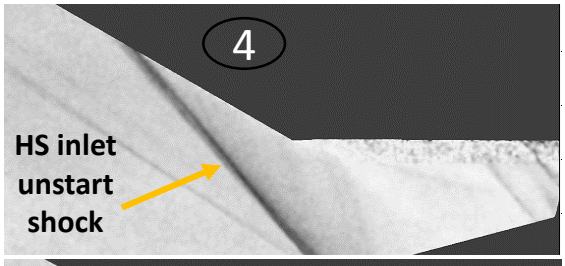
Painted 10'x5' BOS Pattern onto Tunnel Wall

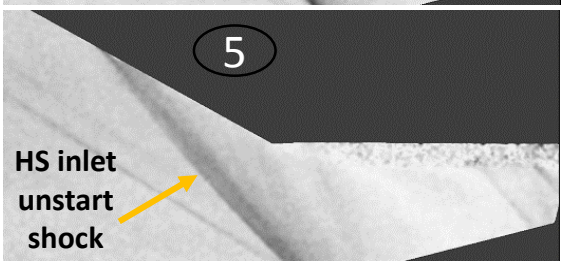
Image sequence showing progression of high speed inlet buzz

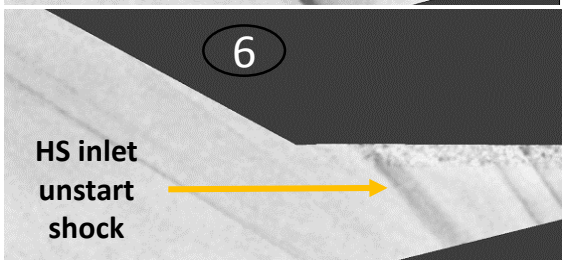












Background-Oriented Schlieren used in a hypersonic inlet test at NASA GRC

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Background Oriented Schlieren (BOS) is a derivative of the classical schlieren technology, which is used to visualize density gradients, such as shock wave structures in a wind tunnel. Changes in refractive index resulting from density gradients cause light rays to bend, resulting in "apparent" motion of a random background pattern. The "apparent" motion of the pattern is determined using cross-correlation algorithms (between no-flow and with-flow image pairs) producing a schlieren-like image. One advantage of BOS is its simplified setup which enables a larger field-of-view (FOV) than traditional schlieren systems. In the present study, BOS was implemented into the Combined Cycle Engine Large-Scale Inlet Mode Transition Experiment (CCE LIMX) in the 10'x10' Supersonic Wind Tunnel at NASA Glenn Research Center. The model hardware for the CCE LIMX accommodates a fully integrated turbine based combined cycle propulsion system. To date, inlet mode transition between turbine and ramjet operation has been successfully demonstrated. High-speed BOS was used to visualize the behavior of the flow structures/shock waves during unsteady inlet unstarts, a phenomenon known as "buzz". Transient video images of inlet buzz were recorded for both the ramjet flow path (high speed inlet) and turbine flow path (low speed inlet). To understand the stability limits of the inlet, operation was pushed to the point of unstart and buzz. BOS was implemented in order to view both inlets simultaneously, since the required FOV was beyond the capability of the current traditional schlieren system. An example of BOS data (Images 1-6) capturing inlet buzz are presented.