T653 Infrared Thermography Results

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Background & Objectives

- During Test 638/640, IR thermography was used to verify laminar-turbulent transition on the juncture-flow model configured with the F6 wing geometry (no leading-edge horn)
  - Global images of the upper/lower wing surfaces and the fuselage were obtained
  - In general, the wing leading edge was found to be laminar and there was no leading-edge contamination from the turbulent fuselage boundary layer.
  - Rows of trip dots were placed on the upper & lower wing surfaces to fix the transition location at a percentage of the local chord length
  - Detailed results are reported and discussed in NASA TM-2019-220286

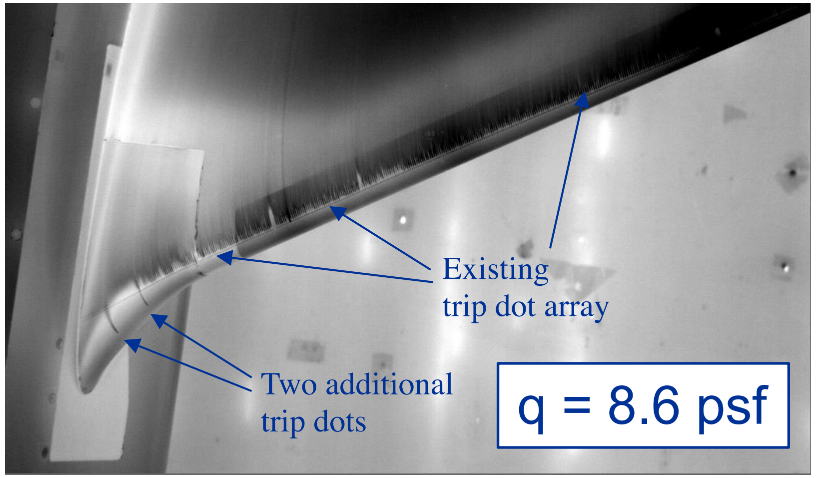
- Due to test time constraints, IR thermography on the F6 wing with the leading-edge horn was not obtained during Test 638

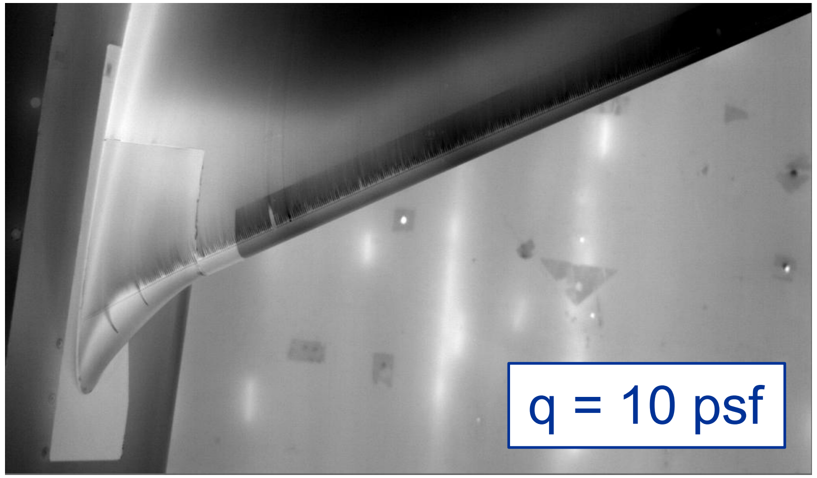
- Since there is uncertainty on the state of the boundary layer on the leading-edge horn of the F6 wing, additional IR images of the wing horn region were acquired during Test 653.

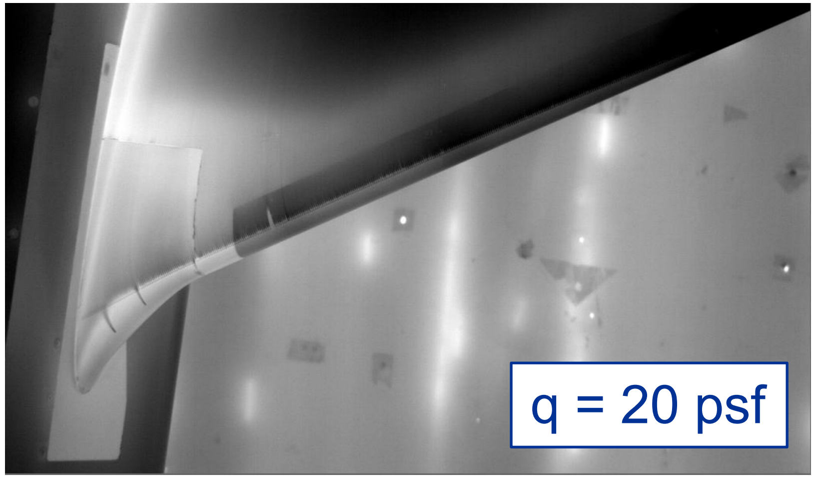
Experimental Setup

- IR camera details
  - Indium Antimonide (InSb) detector that provides temperature meas. in the MWIR range of 3 to 5 μm
  - Detector resolution of 1460 x 852 pixels with a pixel pitch of 14 μm
  - Noise equivalent temperature difference of the detector was less than 25 mK
  - Camera was fitted with a 50 mm, f/4.0 lenses for a cropped view of the wing leading edge region
- IR camera was placed in the tunnel test section ceiling behind a circular cutout, and provided a view of the port wing leading edge horn
- Adjustments to IR image exposure & contrast were made during post processing
- The juncture flow model was painted with a flat black polyurethane paint
  - Provides a low-emissivity surface for the IR thermography and low reflections from IR sources in the test section
  - Provides a modest level of insulation from the aluminum surface of the model (nevertheless, the internal structure of the model is revealed in the IR images, since local heat conduction is influenced by the internal model structure)

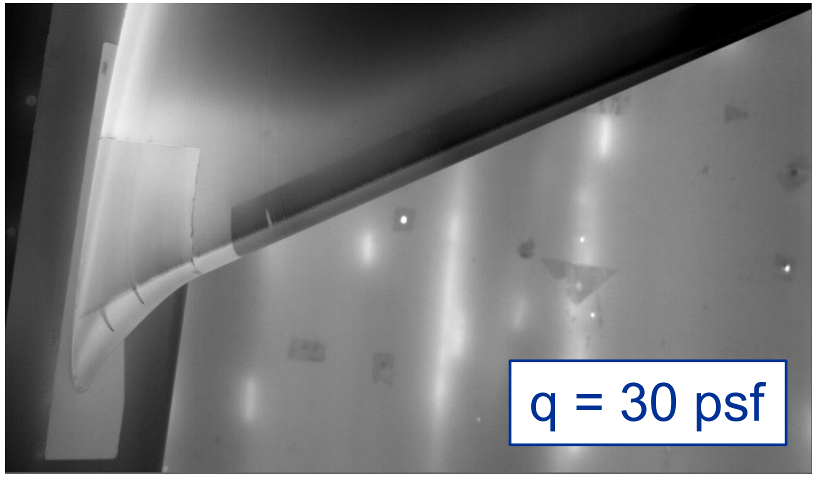
IR Thermography Images: α = 7.5 degrees

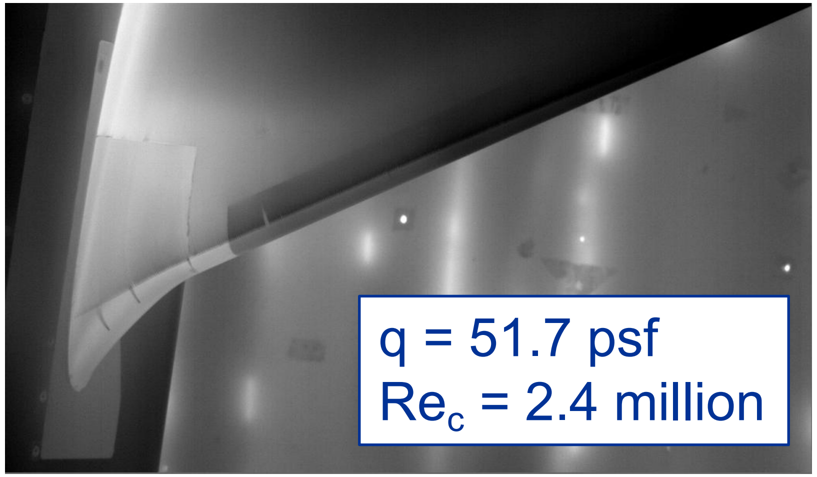




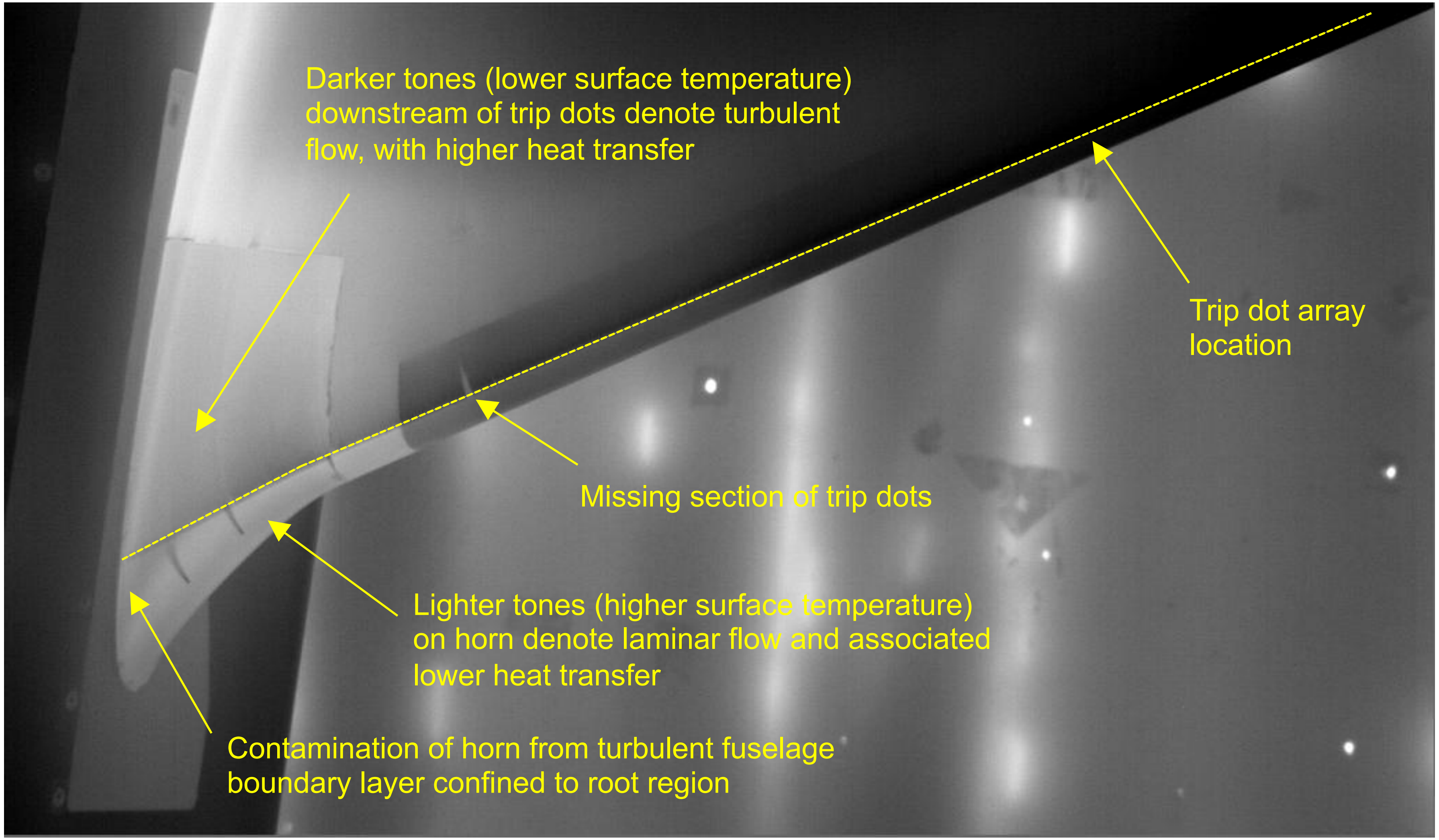


- A sequence of images were acquired as tunnel was ramped up to the nominal chord Reynolds number of 2.4 million
- Two trip dots were placed on the horn to help differentiate tonal levels for laminar and turbulent flow
- In this sequence, the horn was warmer (lighter tones) than the air temperature

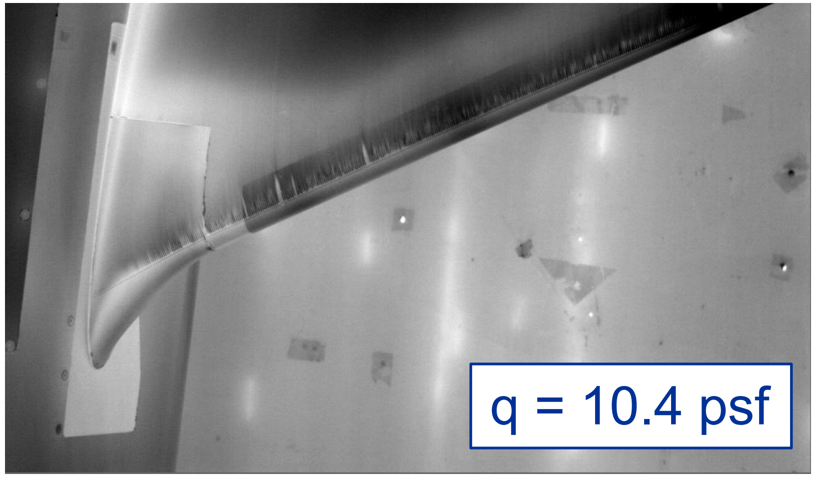


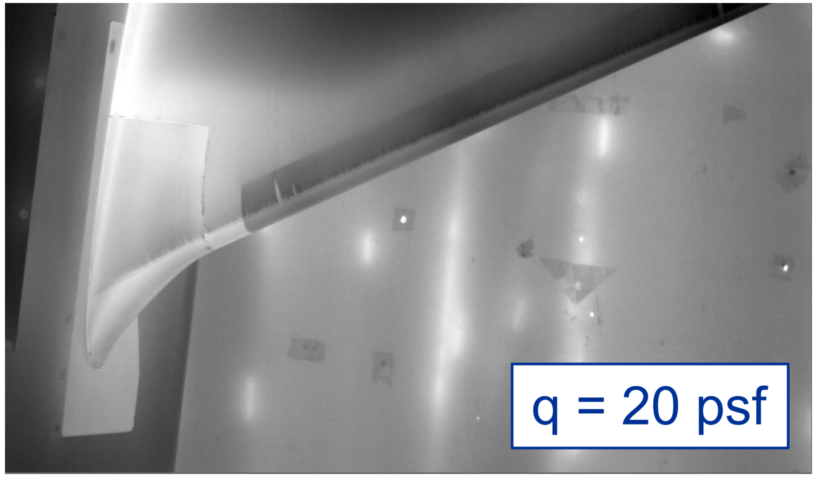


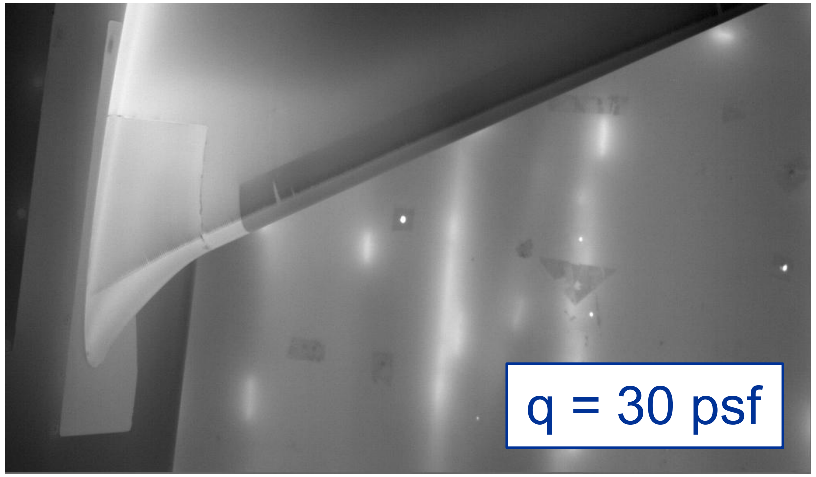
IR Thermography: α = 7.5 deg, Re_c = 2. 4 million



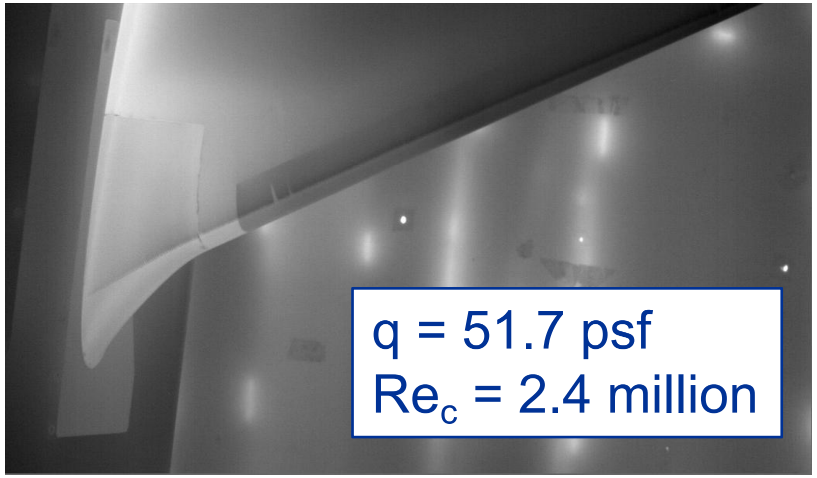
IR Thermography Images: α = 5.0 degrees



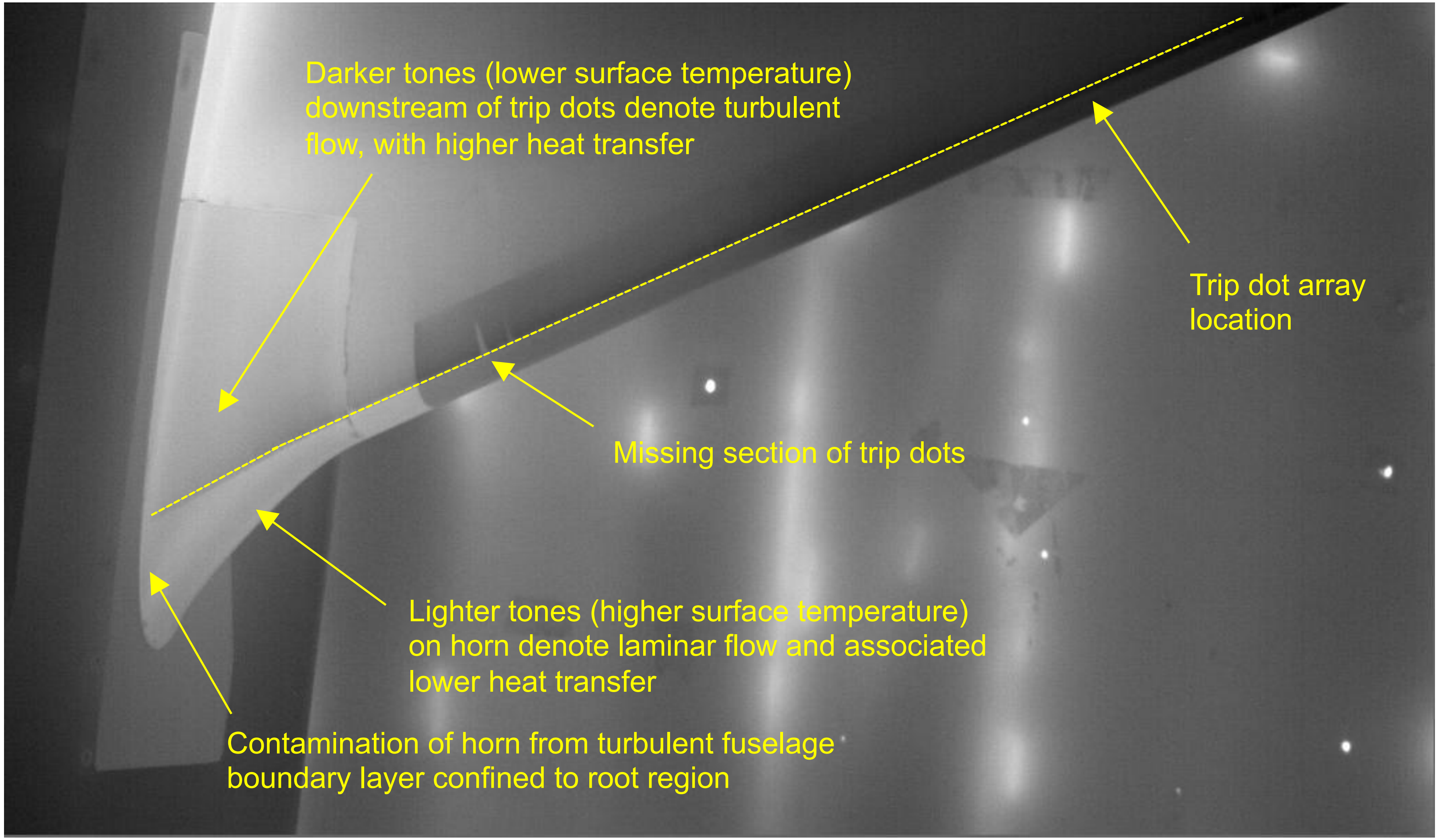




- A sequence of images were acquired as tunnel was ramped up to the nominal chord Reynolds number of 2.4 million
- In this sequence, the horn was warmer (lighter tones) than the air temperature

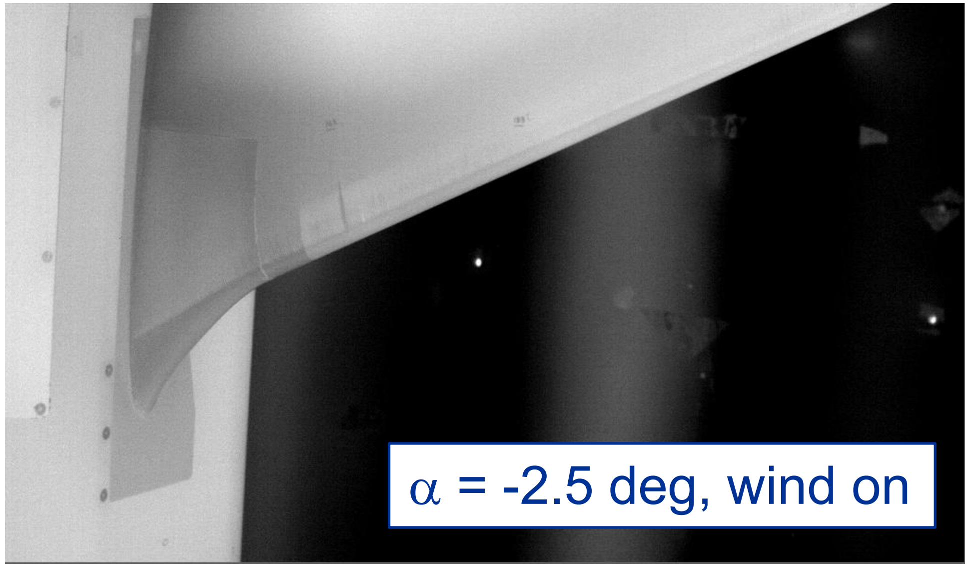


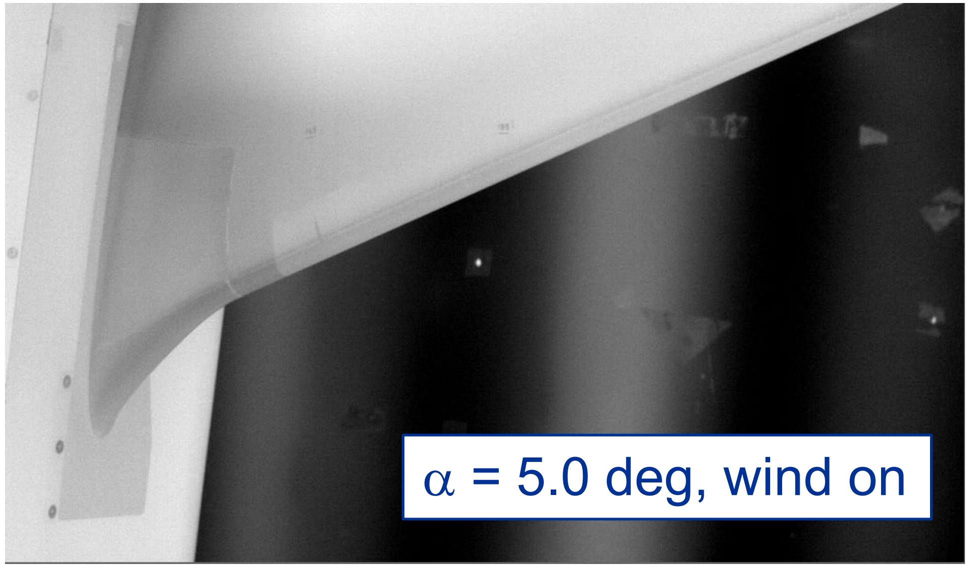
IR Thermography: α = 7.5 deg, Re_c = 2. 4 million

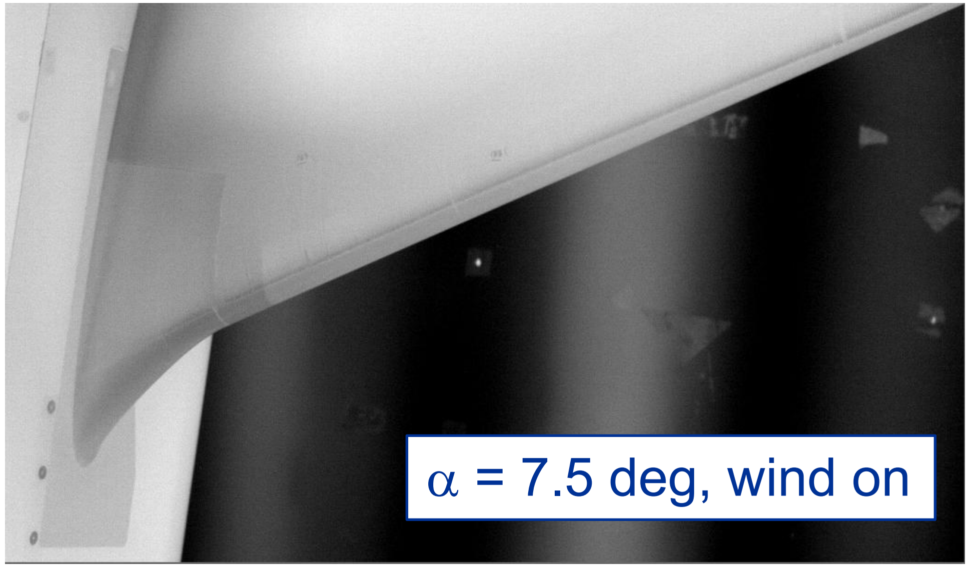


IR Images for Different Angles of Attack: Re_c = 2.4 million

- In this set of IR images, the model surface was cooler than the air temperature.
- Darker tones (cooler temperatures) on the wing leading edge, ahead of the trip dots denote laminar flow







Summary

- IR thermography was used to characterize the boundary layer state on the upper surface of the F6 wing with leading edge horn.

- IR images were acquired at three angles of attack: α = -2.5, 5.0, and 7.5 deg

- In general, the wing leading edge boundary layer appears to be laminar, and transition to turbulent flow is fixed at the trip dot array

- Turbulent flow contamination from the fuselage boundary layer is confined to a wedge-like region on the horn root, upstream of the trip dot array