Advanced IR System For Supersonic Boundary Layer Transition Flight Experiment

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Agenda

• Introduction
• Large scale test preview
• Hardware Upgrades
• Qualification Flight Test
• Results
• Summary
Introduction

• Supersonic Boundary Layer Transition (SBLT) test supercedes Supersonic Natural Laminar Flow (SSNLF) test (1999 - 2002)
  • SBLT Phase 0
    – Existing SSNLF Phase II test article and camera pod
      • Baseline 15° and 30° LE sweep
      • LE roughness (trip dots) 15° LE sweep to assess sensitivity
    – Flight qualify/demonstrate new state-of-the-art IR camera
      • L-3 CMI 640 NC
    – Flight qualify/demonstrate new state-of-the-art digital video recorder
      • Digital Design Corp. (DDC) VADR-1
  • SBLT Phase I, II
    – New large-scale test article
    – High Reynold’s number flight test
Supersonics - Experimental Capabilities

SSNLF (1999-2002)

SSNLF Phase I Test Article and IR Camera Pod

Digital 30° LE M~1.6
Phase II

Analog 15° LE M~1.8
Phase I

End of insulated region
Beginning of insulated region
Flow

Sub-surface Tooling Marks
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.010 x .25 in Trips

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Supersonics - Experimental Capabilities
Centerline Instrumented Pylon (CLIP)

- Modified F-15 pylon for SBLT and related tests
  - Removed bomb rack (MAU-12) which provides for additional vertical clearance and instrumentation pass through
  - Outfitted with large splitter plate to better shield from aircraft boundary layer and disturbances
  - Removed unneeded internals and replaced with instrumentation suite
    - Pressure modules
    - Lag tank
    - Signal conditioning cards
    - PCM encoder
    - Other instrumentation as needed
  - Extended leading edge provided better aero and additional room for instrumentation
CLIP Instrumentation
Supersonic Boundary Layer Transition Flight Test

• Designed new test articles utilizing CLIP to further understanding of boundary layer transition at high Reynolds number supersonic conditions
  – Strong back design that can accept multiple test surfaces
  – Flow calibration probes on non-test side (left)
  – Flat Plate test surface
  – Laminar flow test surface with mixed transition zone

• Utilize advanced F-15B infrared (IR) system
  – Right side aircraft forward armament rail (right side is test side)
  – Detect and characterize transition
  – Determine surface temperatures with surface RTD benchmarks
Test Article Assembly

Front View Cross-Section

Bottom View Cross-Section

Exploded Assembly
SBLT Flat Plate Test Article Mockup
SBLT Phase 0

- IR camera pod
- Centerline Pylon
- SSNLF Phase II Test Article
IR Camera System

• Infrared Camera
  – L3 Cincinnati 640 x 512 NC
  – Mid-wave (3 to 5 micron spectral range)
  – 640 x 512 Indium-Antimonide (InSb) focal plane array (FPA)
  – 16-bit digital and RS-170 analog output

• Pod Optics
  – 13 mm lens
  – Single fold mirror
  – Coated silicon window

• Previous Camera
  – Raytheon Radiance HS
  – Mid-wave
  – 256 x 256 InSb FPA
  – 12-bit digital and NTSC analog
Digital Video Recorders

- 1st / 2nd Generation Recorders
  - “Home Grown” using off the shelf PC parts and ruggedized
  - Assembled by PVP Advanced EO Systems
  - Recorded from high speed parallel connection (10ft max)
  - Maximum 17GB data capacity (2nd gen)
  - Mounted on isolation tray with shock mounts
  - Limited success due to high vibration level in bay beneath inlet where recorder was located (due to distance criteria)
Digital Video Recorders

• 3rd Generation Recorder
  – Digital Design Corp. VADR-1 unit
  – Records from high speed serial connection
    • allows remote location from camera (currently > 50 ft)
  – 120 GB capacity (maximum 288 GB+)
  – Designed for rugged applications
    • such as high speed maneuvering aircraft
  – Completed successful trial on test aircraft

Installed in aircraft

Back/Top

Front/Bottom

3rd Generation Recorder
F-15B Test Bed In Flight
Supersonic Accel with 30° LE
Supersonic Accel with 15° LE
Digital False Color Image
30° LE, M~1.72

Transition Front

Flow

Relative
Temp

Hot

Cold

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Supersonics - Experimental Capabilities
Digital False Color Image
15° LE, M~1.76, LE trips added

Transition Front

Flow

Relative Temp
Hot
Cold
SUMMARY

• Infrared thermography is a preferred method investigating transition in flight
  – Global and non-intrusive
  – Can also be used to visualize and characterize other fluid mechanic phenomena such as shock impingement, separation etc.

• F-15 based system was updated with new camera and digital video recorder
  – To support high Reynolds number transition tests

• Digital Recording improves image quality and analysis capability
  – Allows for accurate quantitative (temperature) measurements
  – Greater enhancement through image processing allows analysis of smaller scale phenomena