Advanced IR System For Supersonic Boundary Layer Transition Flight Experiment

FAP Annual Meeting 2008

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Agenda

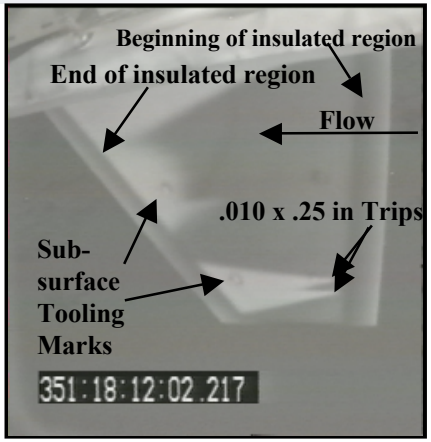
- Introduction
- Large scale test preview
- Hardware Upgrades
- Qualification Flight Test
- Results
- Summary

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

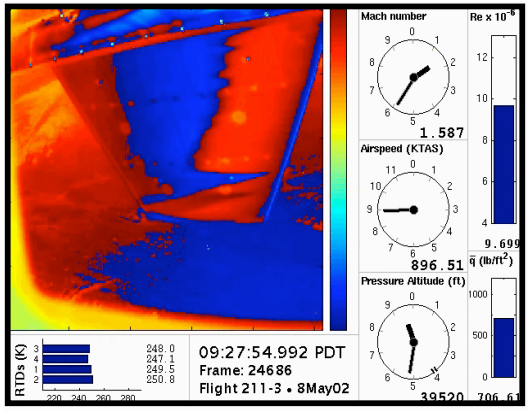
SSNLF (1999-2002)

SSNLF Phase I Test Article and
IR Camera Pod



Analog 15° LE M~1.8

Phase I



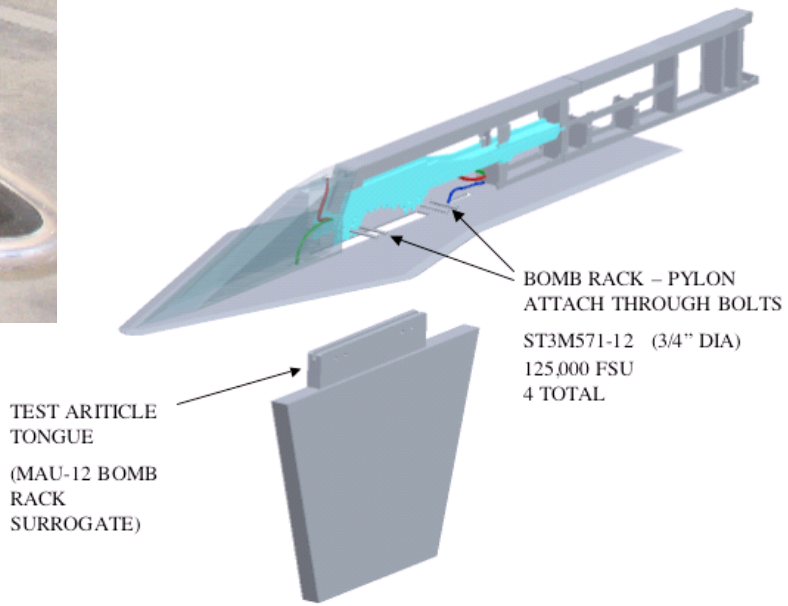
Digital 30° LE M~1.6

Phase II

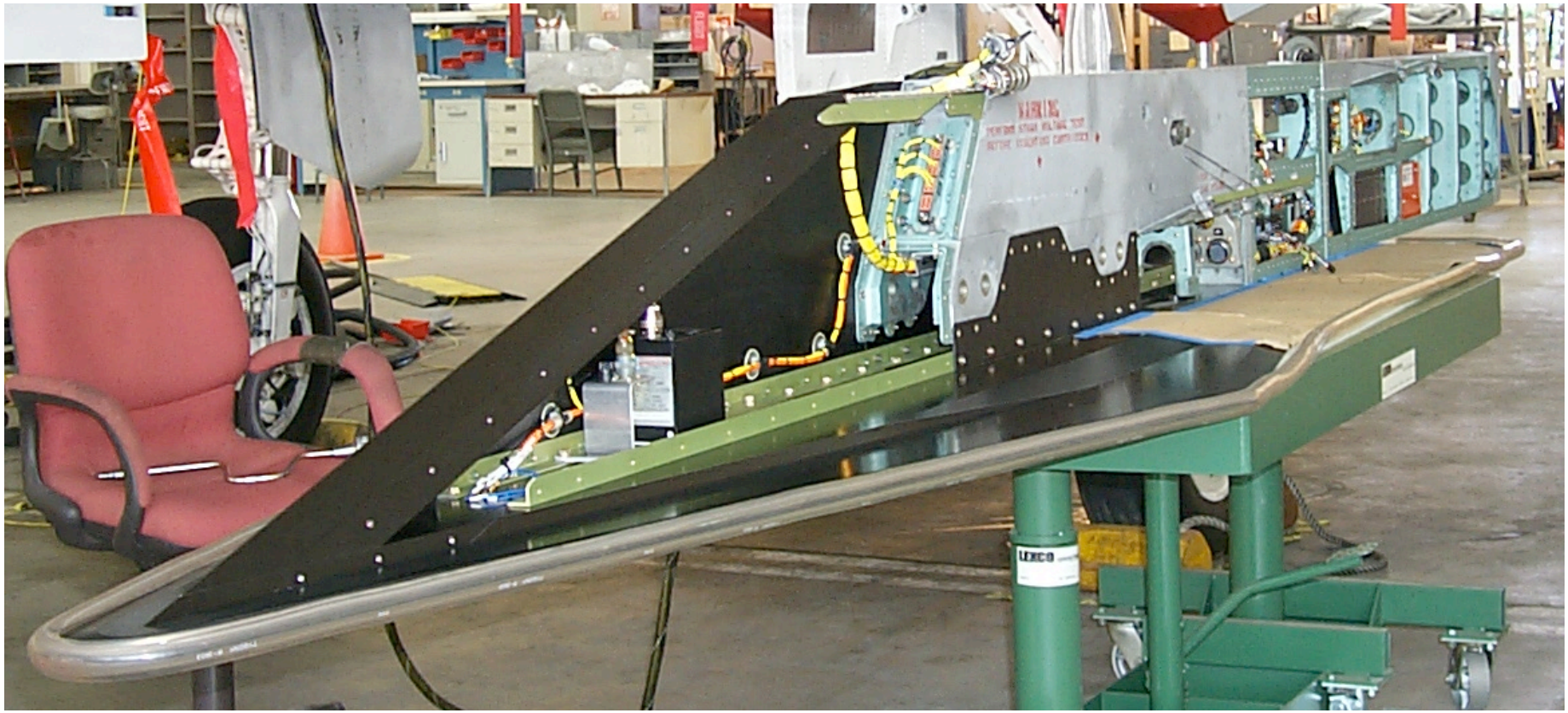
Centerline Instrumented Pylon (CLIP)

- 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

Centerline Instrumented Pylon (CLIP)



CLIP Instrumentation

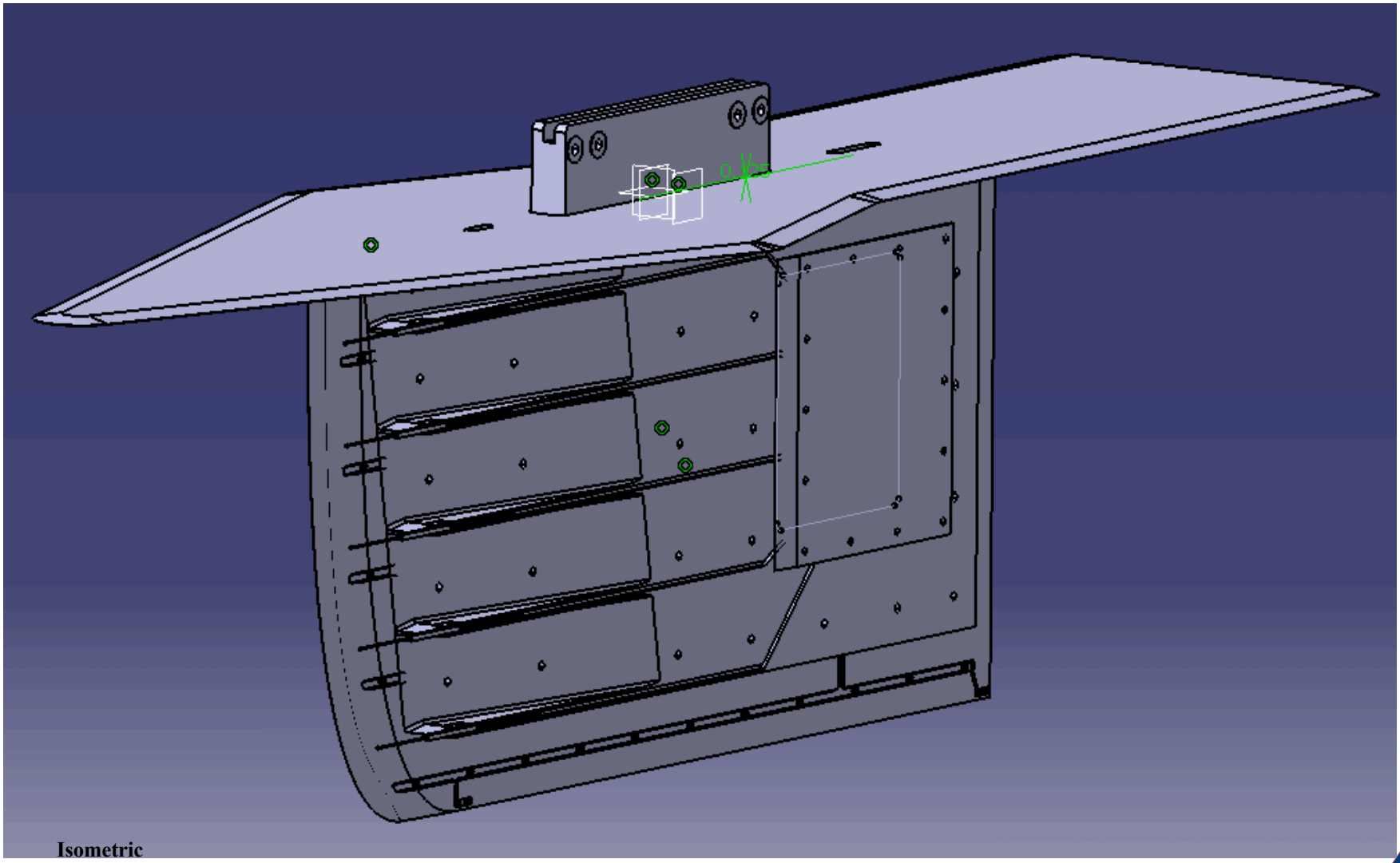


Supersonic Boundary Layer Transition Flight Test

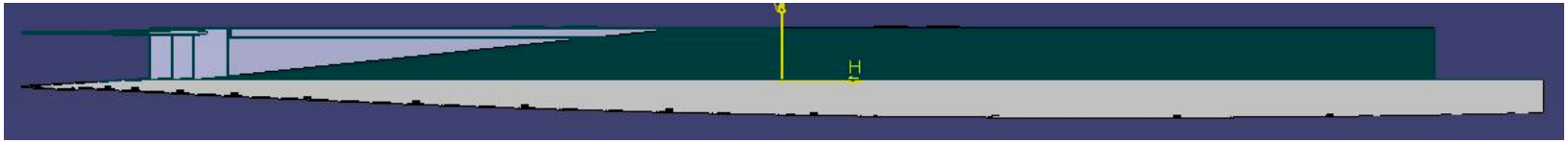
- Designed new test articles utilizing CLIP to further understanding of boundary layer transition at high Reynolds number supersonic conditions
  - Strong back design that can accept multiple test surfaces
  - Flow calibration probes on non-test side (left)
  - Flat Plate test surface
  - Laminar flow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

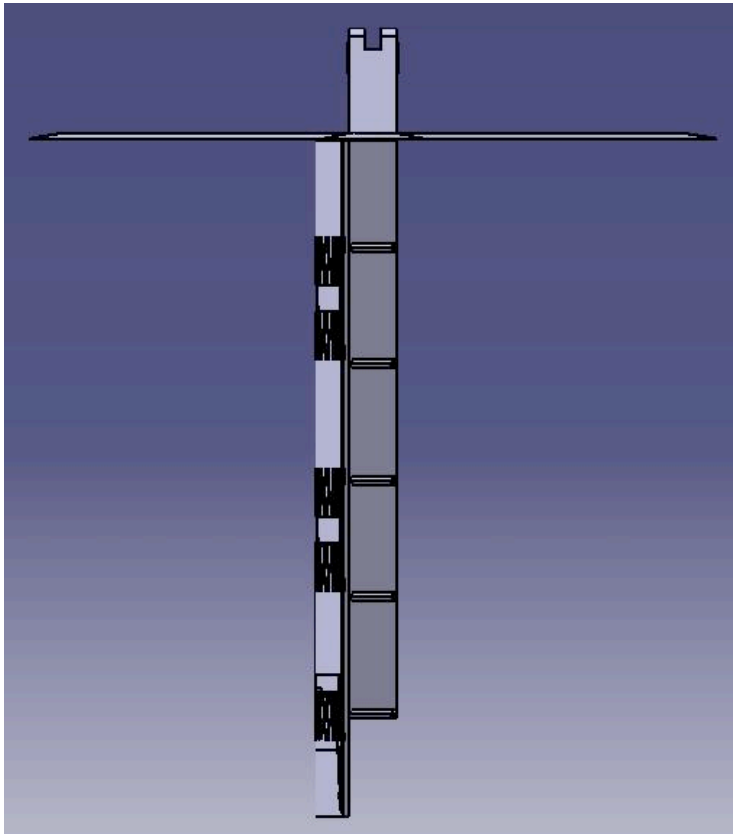
SBLT Laminar Flow Test Article



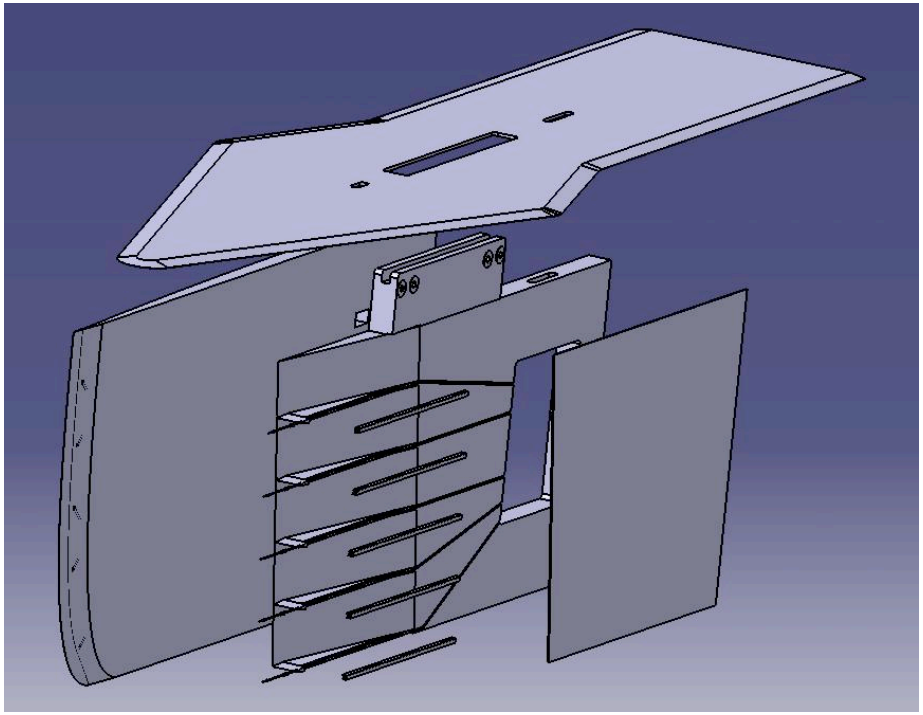
Test Article Assembly



Bottom View Cross-Section

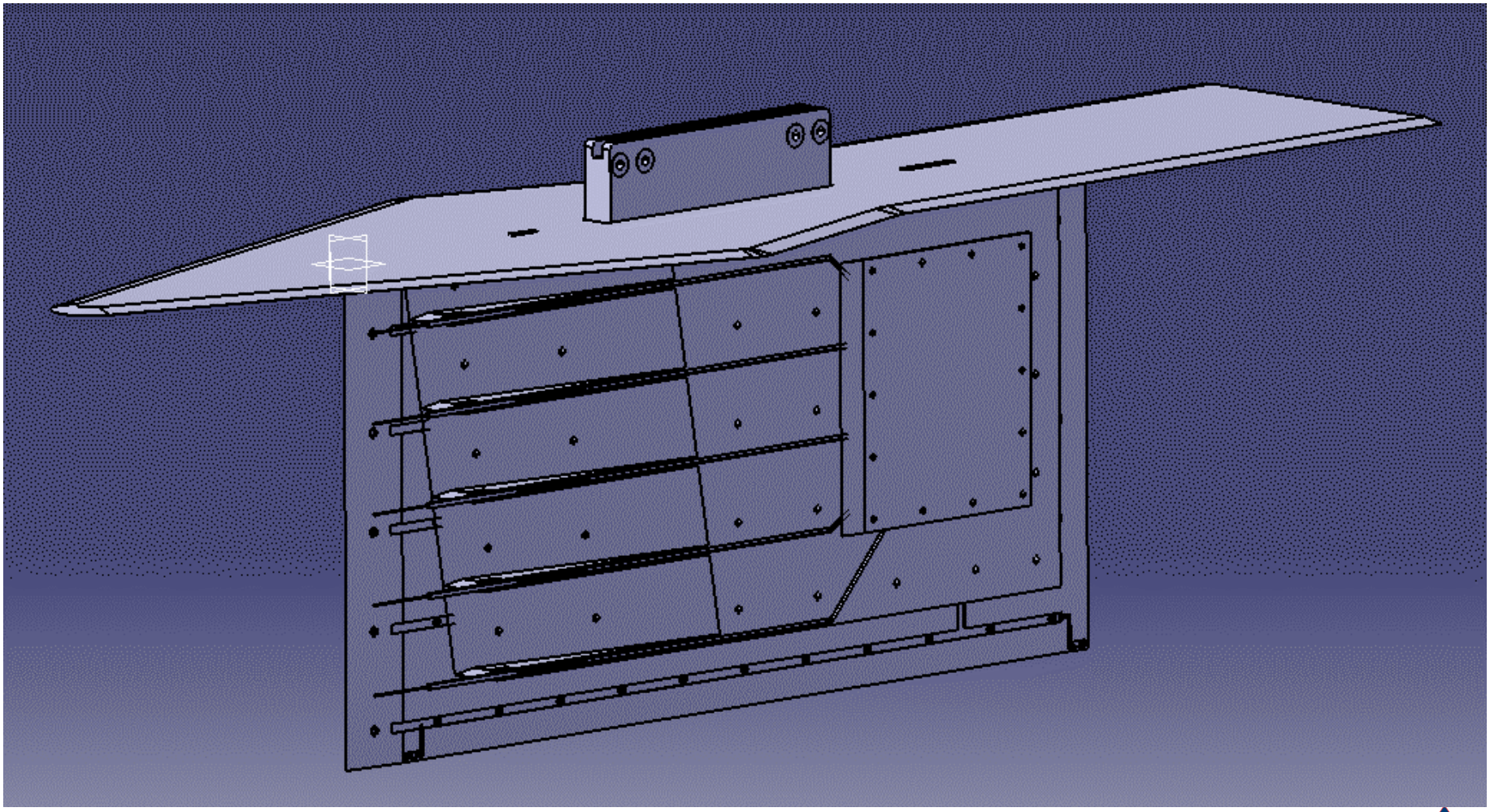


Front View Cross-Section



Exploded Assembly

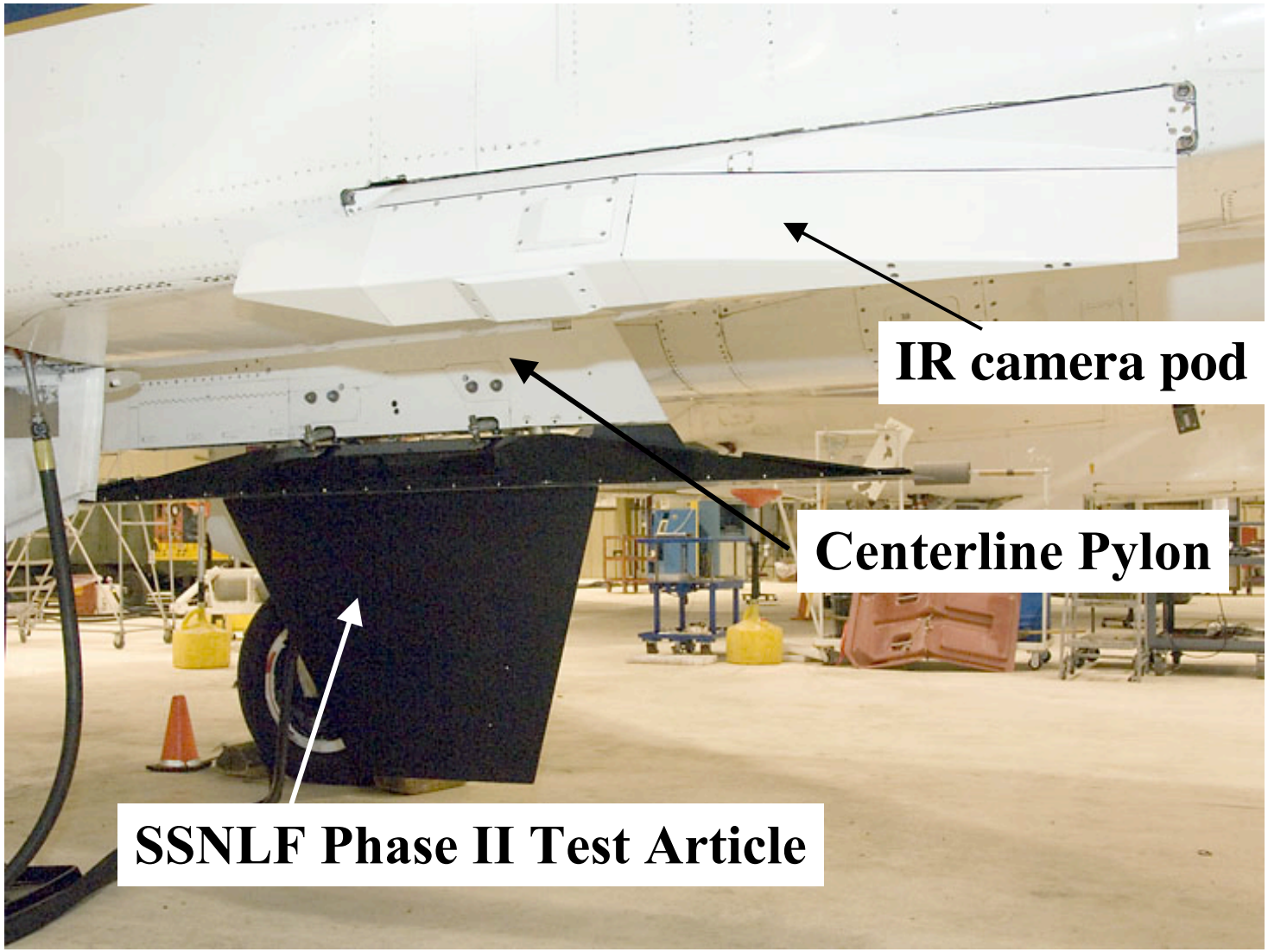
SBLT Flat Plate Test Article



SBLT Flat Plate Test Article Mockup

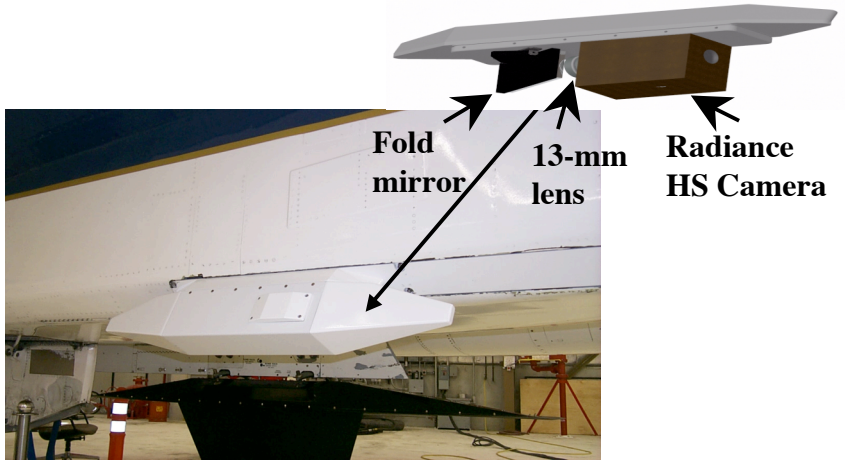
SBLT Flat Plate Mockup

SBLT Phase 0



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



Phase I Camera and Pod

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)

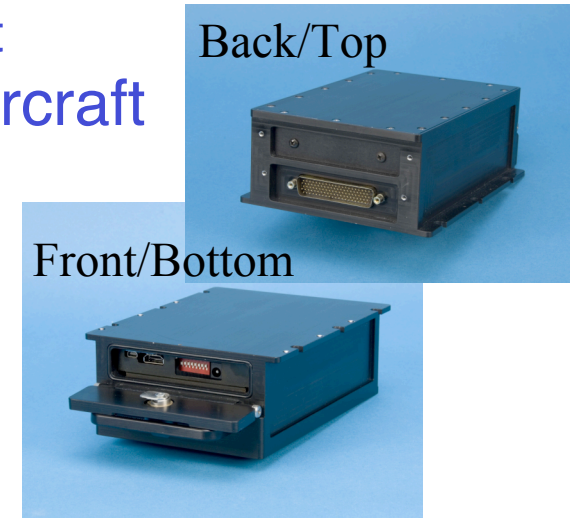
1st Generation Recorder

2nd Generation Recorder

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

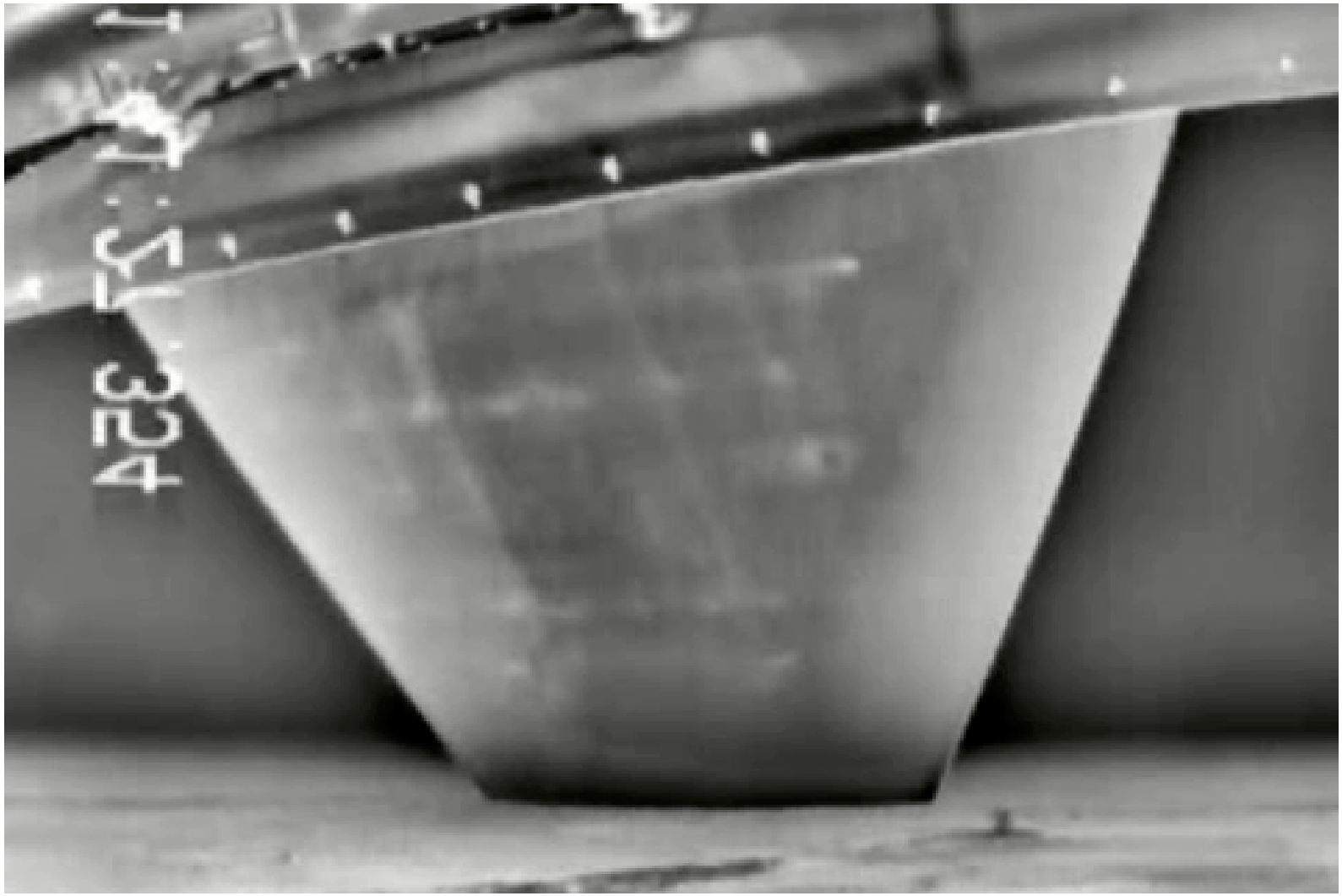
Installed in aircraft



3rd Generation Recorder

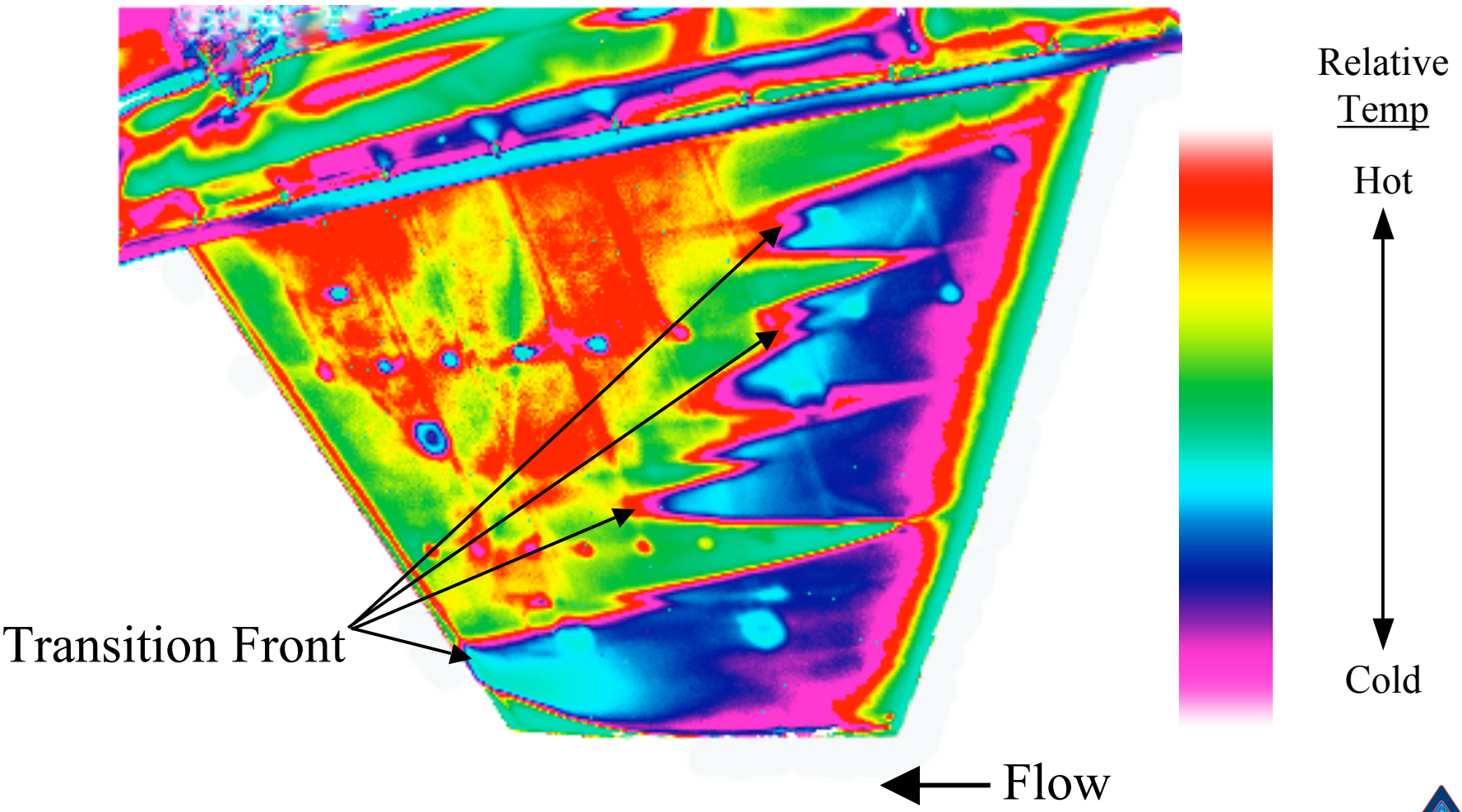
F-15B Test Bed In Flight

Supersonic Accel with 30° LE

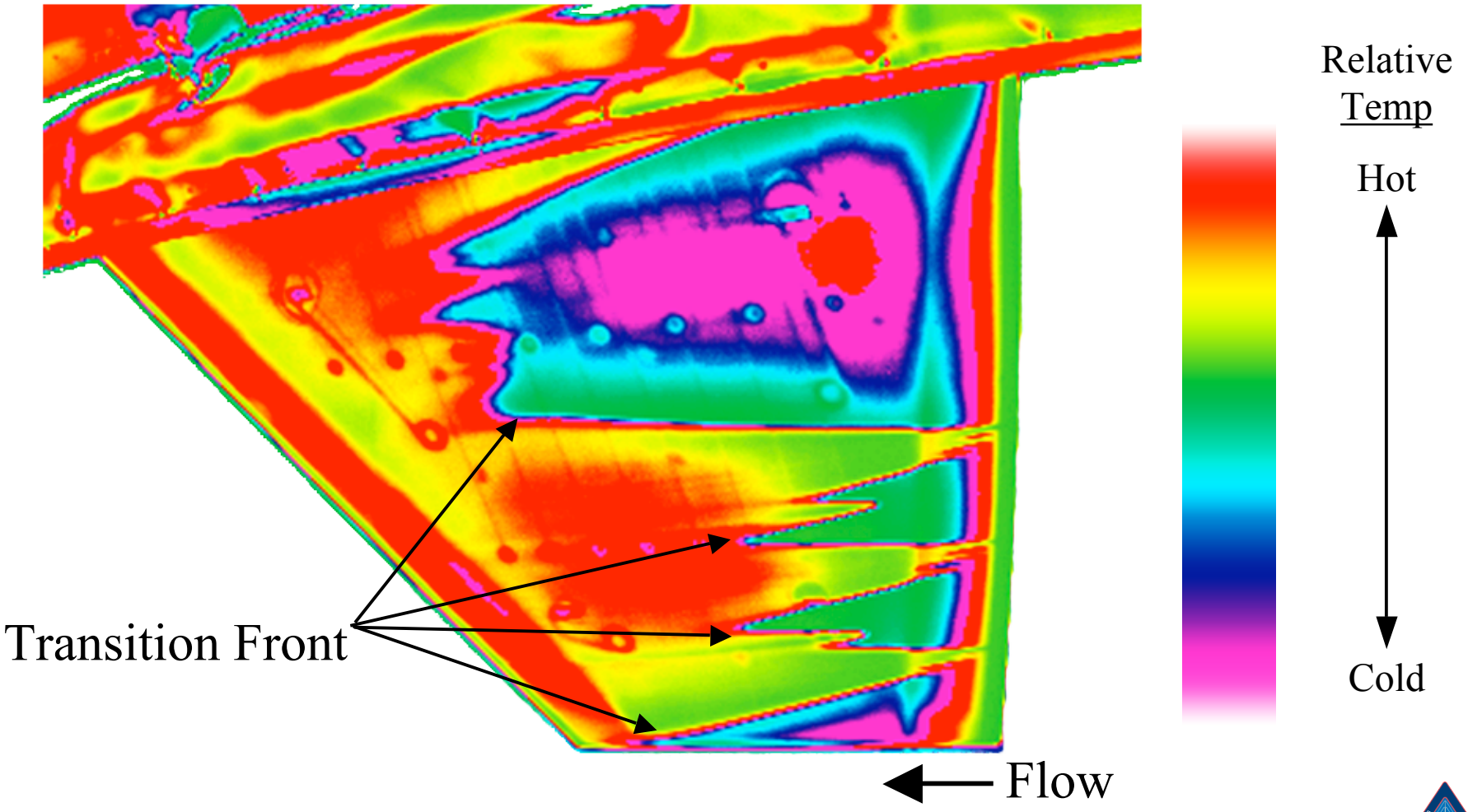


Supersonic Accel with 15° LE

Digital False Color Image
30° LE, M~1.72



Digital False Color Image
15° LE, M~1.76, LE trips added



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