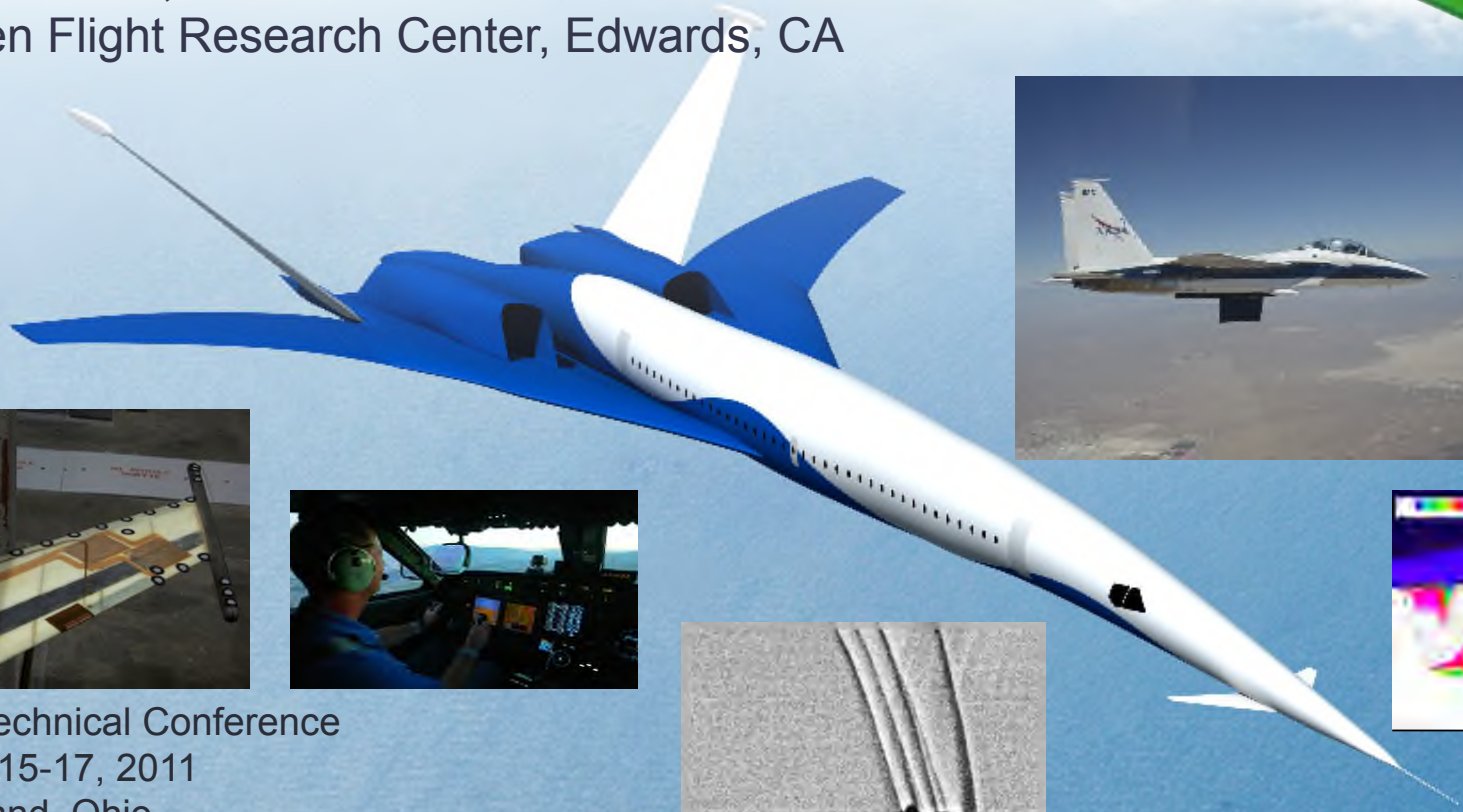
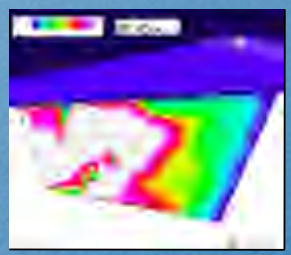
Fundamental Aeronautics Program!

Supersonics Project!

Flight Research and Validation Overview

Daniel Banks, Technical Lead
Dryden Flight Research Center, Edwards, CA





2011 Technical Conference
March 15-17, 2011
Cleveland, Ohio

Agenda!

- FRV Portfolio"
- Task Abstracts"
- Summary Remarks"

Technical Challenge: "
Flight Research and Validation (FRV)!

FRV Objectives:"

•Increase the Technology Readiness Level (TRL) of promising concepts and technologies through research and validation in the flight environment."

•Development of test techniques and testbeds to to more effectively test candidate concepts in flight."

FRV Elements:"

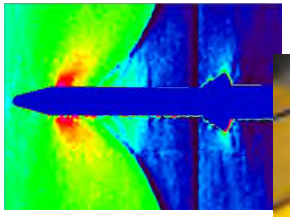
- ! Flight Research"
- ! Flight Test Technique Development"
- ! Testbed Development"

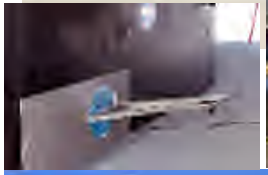
Flight Research and Validation - SUP!

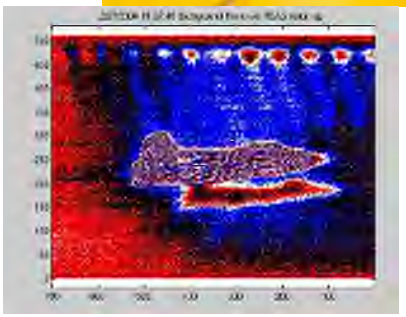
Flight Research:
Large-scale component or fundamental tests conducted at real conditions and representative systems complexity."

Flight Test Technique Development:
Development of hardware and methodology to improve current techniques or produce new techniques for in flight measurement or visualization."

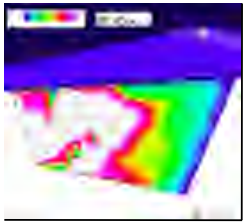
Testbed Development:
Develop new in-flight facilities to perform flight research or test technique development."

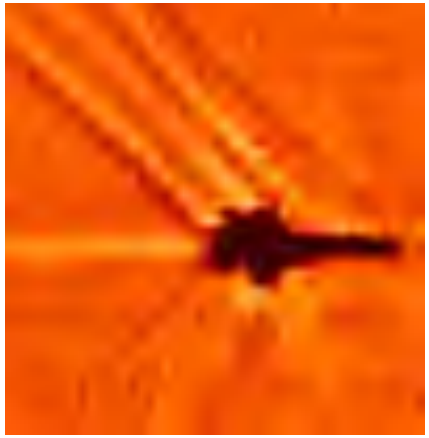






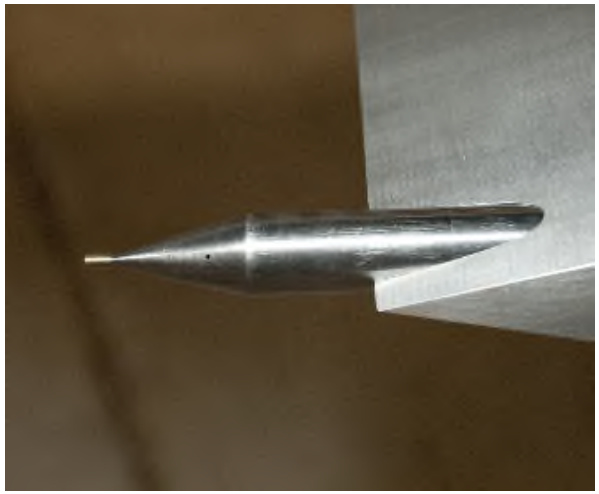
Flight Research and Validation " FY#11 Portfolio!

- **NRA** "
  - Eagle Aero Probes (EAP)"
- **Flight Projects**"
  - Channeled Centerbody Inlet Experiment (CCIE)"
  - Supersonic Boundary Layer Transition Test (SBLT)"
  - External Vision Systems (XVS)"
  - Aeroelastic Test Wing –2 (ATW-2)"
- **Flight Test Technique Development**"
  - In Flight Background Oriented Schlieren (BOS)"
  - Dynamic Inertia Measurement Technique (DIM)"
  - Air-to-Air Schlieren (A2AS)"
  - Advanced In-Flight IR Thermography (AIR-T)"

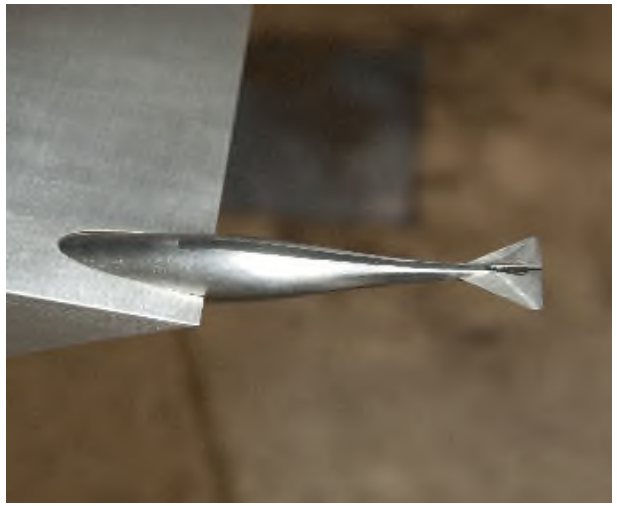


NRA: Eagle Aeronautics – " Wedge and Conical Supersonic Probes!

- High accuracy probes for shock wave characterization"
  - local Mach number, flow angle, total pressure and temperature, static pressure and temperature, velocity and speed sound"
- Conical probe and wedge probe delivered"
- Data algorithms ready for validation"
- Wind tunnel test completed"
- Flight tests in progress"



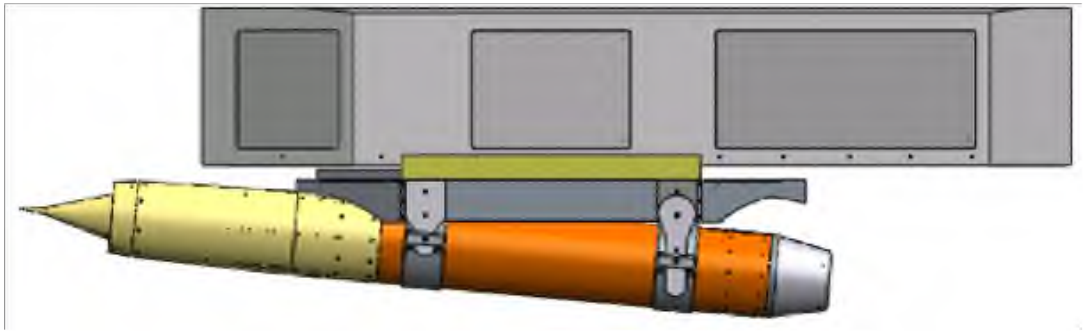
Conical Probe



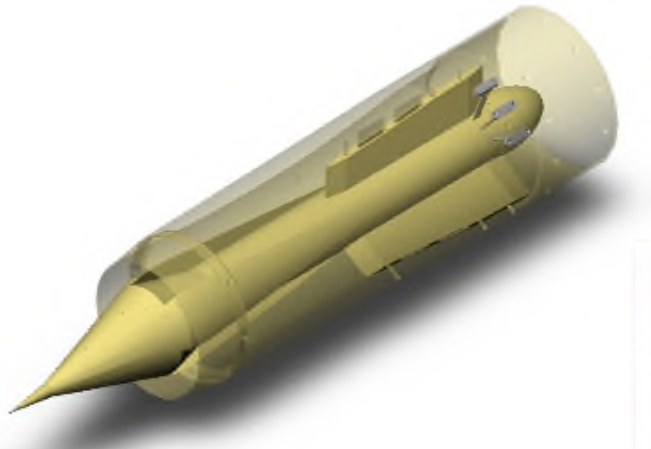
Wedge Probe

Channeled Centerbody Inlet Experiment!

- Biconic supersonic inlet concept developed by Techland Research via a NASA SBIR contract"
  - Inlet design features a unique method of off-design flow matching via movable channels rather than translating centerbody"
- Pressure data will be collected over a series of Mach numbers and mass flow conditions for two fixed geometry inlet configurations and used to determine differences between the two (with emphasis placed on distortion) as well as for comparison to CFD predictions"
- Tests Summer 2011"



CCIE mounted on PFTF assembly



Channeled Centerbody Installed in inlet

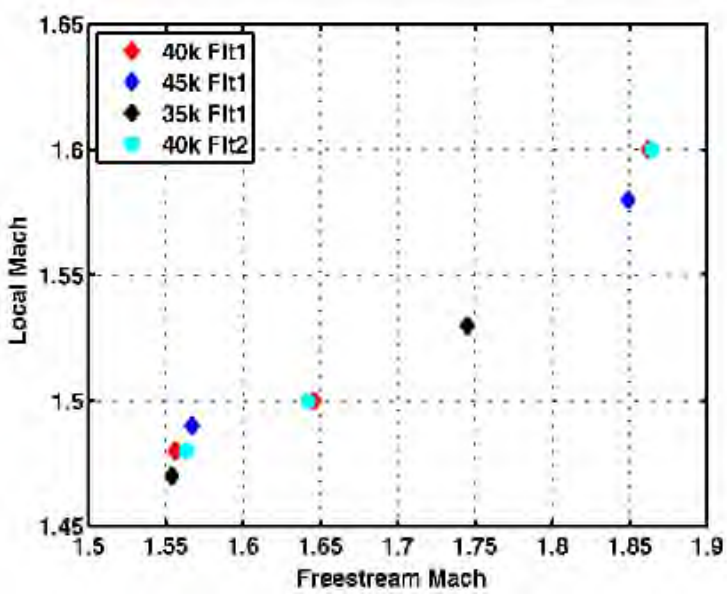
Channeled Centerbody

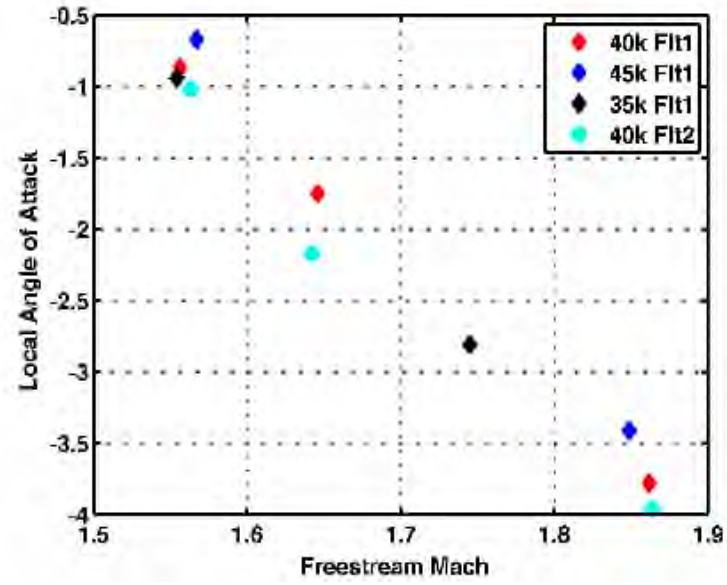
Equivalent Area Smooth Centerbody

Rake Airflow Gauge Experiment"

- ! RAGE consists of a flow-field survey rake, boom, and cone-cylinder assembly"
- ! Flown on F-15B testbed using the Propulsion Flight Test Fixture (PFTF), completed 10/09"
- ! Objective was to determine the local flow properties underneath the F-15B at interface plane of the Channeled Centerbody Inlet Experiment (CCIE)"

NASA DFRC F-15B with PFTF and RAGE





Supersonic Boundary Layer Transition

Objective:"

•Flight research and validation of high Reynolds number transition at supersonic conditions."

Approach:"

•!Flight tests of a flat plate test article for calibration of aircraft underside flow field"

•! Completed August 2010"

•!Design and test of high Re No. laminar flow test article >> Fly 4th quarter FY11"

•! Test article will have 3 discrete regions; TS dominated transition, CF dominated transition, and mixed TS/CF transition"

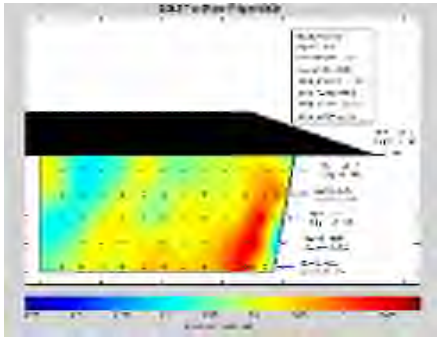
Significance:"

•!Validation of design tools for high Reynolds number transition at 1.0 > M > 2.0"

•!Determination of roughness sensitivity for maintenance of laminar flow at these conditions"

•!Determination of cross flow sensitivity on transition at these conditions '"'

Flat plate test article on F-18

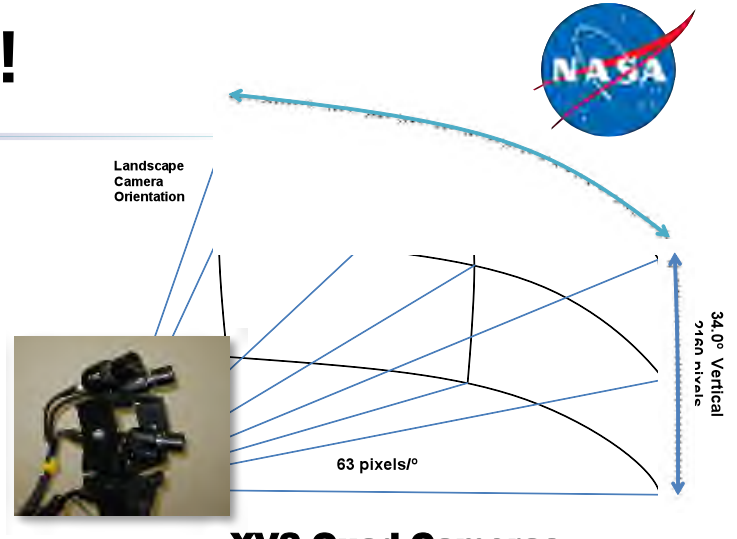


Surface Pressures and Upstream Flow Conditions

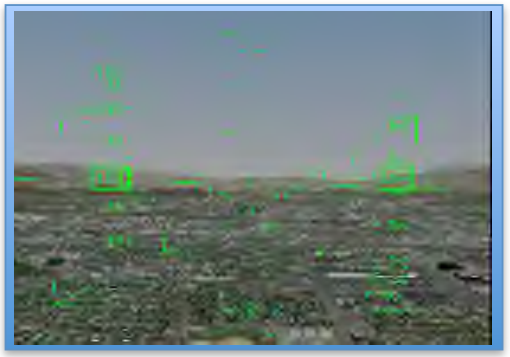
Infrared Thermography showing boundary layer transition

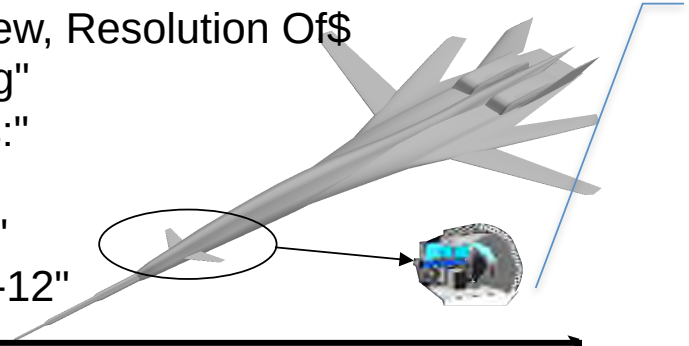
eXternal Vision Systems, XVS!

- Develop eXternal Visibility Systems (XVS) Technology Enabling Replacement of Pilots# Forward View Windows"
  - Display, Sensor, And Associated Systems. "
- Progress"
  - Design Standards Drafted, In Press"
  - Fixed-Base Sim of Field-Of-View (FOV) Requirements Completed"
    - Motion-Base Replication Planned FY11"
  - Lab Testing for Field-of-View, Resolution Of$ XVS Prototypes On-Going"
    - Evaluating Trade-offs:"
      - Latency, FOV, " Resolution, Seams"
  - In-Flight Evaluation, FY11-12"



XVS Quad-Cameras





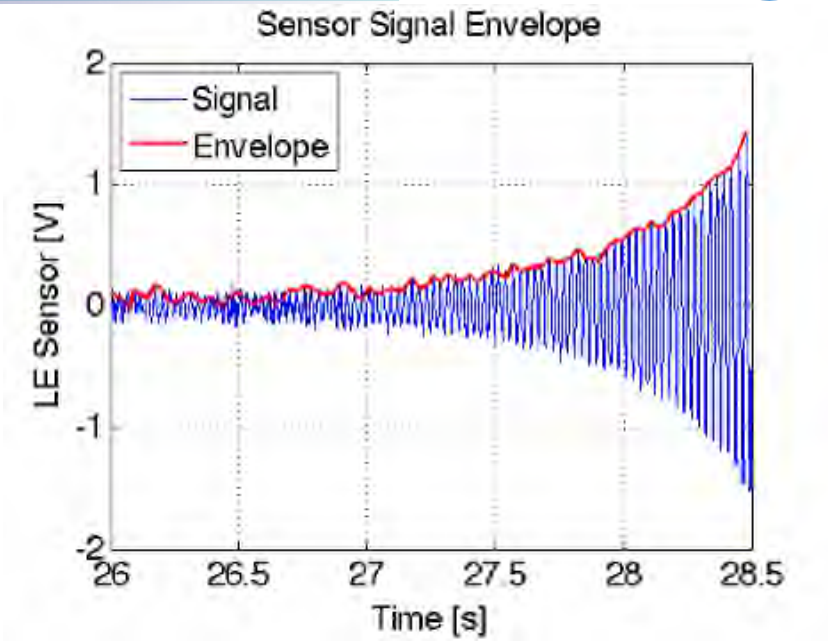
Tiled Array Monitor
3840x2160 Pixels Seamless Display

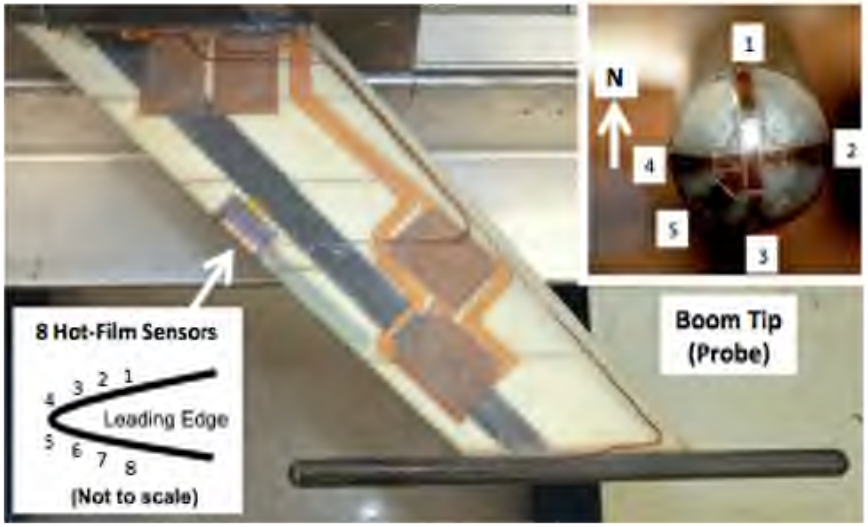
Aeroelastic Test Wing!

Flight tests of a flexible wing with a suite of sensors!

Completed flights in December 2009!

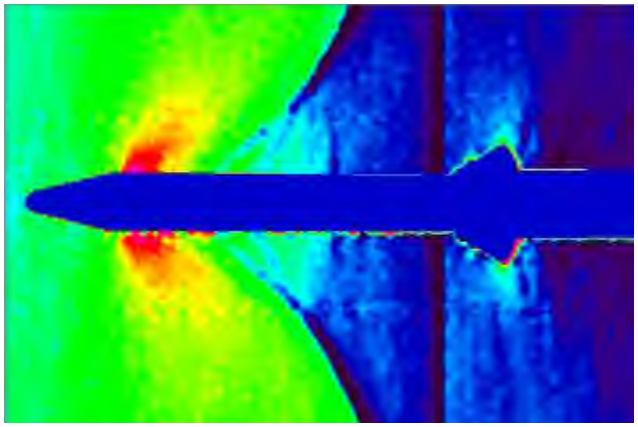
Wing tested up to the onset of flutter!



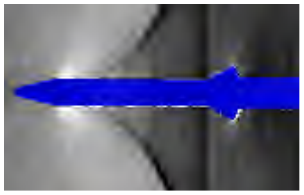


Background Oriented Schlieren!

BOS vs. Real Schlieren, ARC 11-Ft TWT, M=1.05!

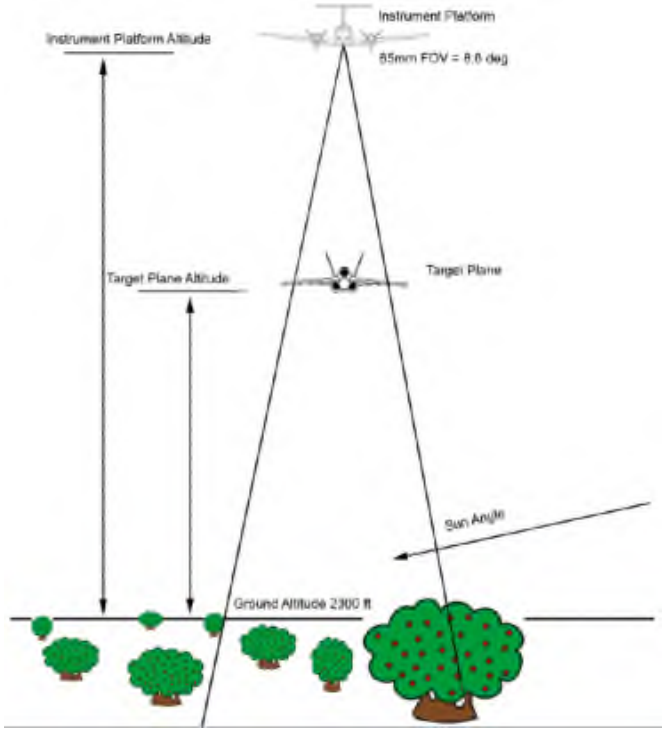


Color Contour
BOS



Gray-scale Contour

Real Schlieren
image



A Synthetic Schlieren technique based on the distortion of known background pattern. In compressible fluids the distortion is caused by changes in the refractive index as a result of density gradients."

Conduct preliminary tests on B-200 King Air with an F-18 target over the desert floor. Flight tests are in progress."

Dynamic Inertia Measurement!

Mass Properties Determination to support Vehicle Flight Dynamics and Control development and verification"

- •!reduce the time and vehicle risk inherent with the measurement of MOIs of full scale atmospheric and space flight vehicles"
- •!enable increased accuracy of measured MOIs "

•Reasonable correlation between analytical and DIM values for most properties. Tests have been completed. Analysis and documentation in progress.

Comparison of Analytical and DIM Values

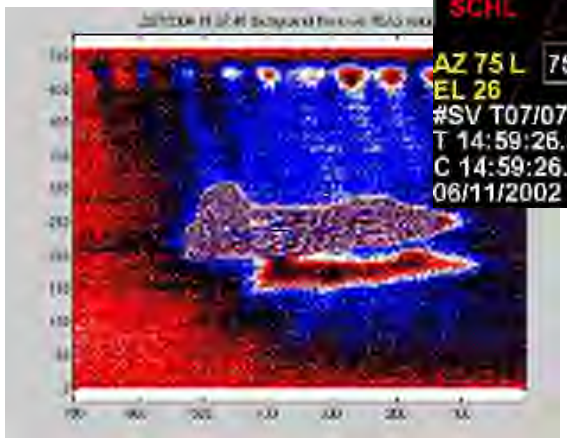
PROPERTY	UNIT	ANALYTICAL VALUE	DIM VALUE	ERROR	ERROR UNIT
Mass	lbs	17386	17331	0.32%	%
x-cg	in	91.17	91.51	-0.34	in
y-cg	in	-0.15	-0.43	0.28	in
z-cg	in	23.18	22.01	1.17	in
Izz	lbs-in^2	9.99E+07	1.08E+08	-7.53%	%
Ixx	lbs-in^2	5.92E+07	6.42E+07	-7.76%	%
Iyy	lbs-in^2	4.75E+07	4.52E+07	5.10%	%

Conventional Testing of Large Test Article !

DIM Testing of Large Test Article!

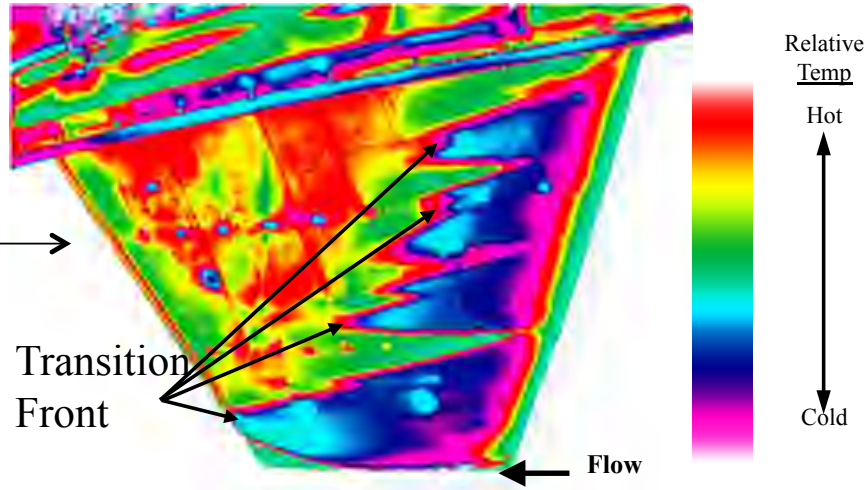
Air-to-Air Schlieren!

- Validation test TBD (3QFY11)
- Obtain high quality Schlieren image with good spatial resolution. Will allow determination of shock location and relative strength in-flight.
- Unique capability to validate shock location and relative strength for sonic boom prediction and MDAO studies.



Advanced IR Thermography!

- Increased capability of in-flight IR thermography systems"
- Obtained high quality (spatial and thermal resolution) analog and digital thermographic images"
- Capability targeted for high Reynolds number in-flight transition tests Q4 FY11"



Validation test result with original test article!

New large chord test fixture (flat plate shown)!

TG-14#s, Sonic Boom Midfield Sensor Platform!

- ! Development as a midfield sonic boom sensor platform"
- ! Provides longer endurance and better station keeping than previously used gliders"

F-15D Testbed Replacement and Support!

- Replacement for F-15B testbed (836)"
- Replacement for one 2-seat F-18 support (852)"
  - Provides higher Mach chase and probing capability"

Summary Remarks!

- Flight Research and Validation (FRV) encompasses flight research, flight test technique development, and testbed development for the Supersonic Project community"
- FRV has a diverse portfolio of ongoing activities"
- FRV is developing capabilities for future endeavors"