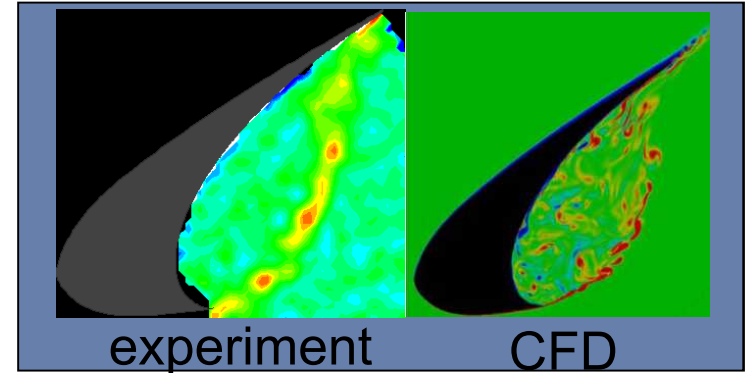
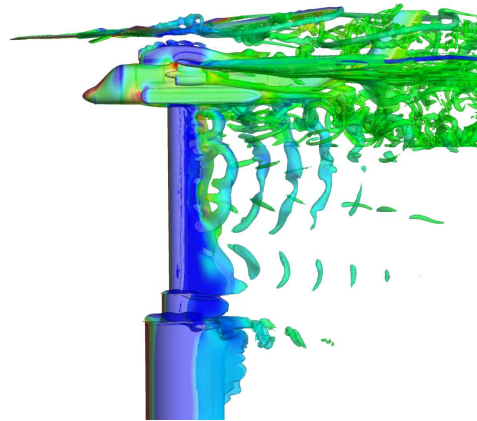
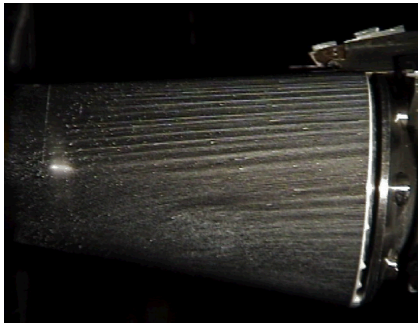




Flow Physics and Control Branch



Catherine McGinley

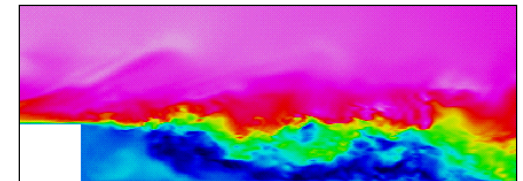
Research and Technology Directorate
NASA Langley Research Center

March 1, 2010



Fundamental Aerodynamics

- Themes:
 - Investigate fundamental physics of boundary layers; separation, turbulence, and transition across the speed regime
 - Develop tools to discover and model the underlying physical processes of fluids
 - Advanced experimental instrumentation and facilities
 - Advanced numerical simulation and modeling tools
 - Develop flow control mechanisms for high lift systems, separated flows, vortical flows, laminar & turbulent drag reduction, boundary-layer ingesting inlets, etc.
 - Investigate the fluid physics of unsteady flow fields associated with the generation and mitigation of noise sources



Example: Cavity Mode/Tonal Control



NASA Fundamental Aeronautics Program

- **Hypersonics**

- Fundamental research in all disciplines to **enable very-high speed flight** (for airbreathing launch vehicles) and **re-entry into planetary atmospheres**
- High-temperature materials, thermal protection systems, airbreathing propulsion, aero-thermodynamics, multi-disciplinary analysis and design, GNC, experimental capabilities



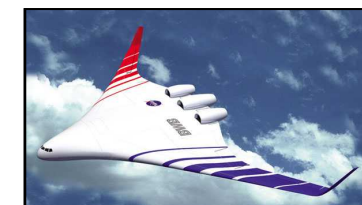
- **Supersonics**

- **Eliminate environmental and performance barriers** that prevent **practical supersonic vehicles** (cruise efficiency, noise and emissions, vehicle integration and control)
- Supersonic deceleration technology for **Entry, Descent, and Landing** into Mars



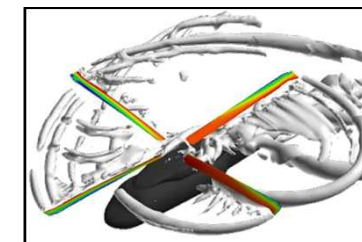
- **Subsonic Fixed Wing (SFW)**

- Develop revolutionary technologies and aircraft concepts with highly **improved performance** while satisfying **strict noise and emission constraints**
- Focus on **enabling technologies**: acoustics predictions, propulsion / combustion, system integration, high-lift concepts, lightweight and strong materials, GNC



- **Subsonic Rotary Wing (SRW)**

- Improve **civil potential of rotary wing vehicles** (vs fixed wing) while maintaining their unique benefits
- Key **advances** in multiple areas through **innovation** in materials, aeromechanics, flow control, propulsion





FPCB Low Speed Flow Physics Facilities



2 x 3-ft Low Speed Tunnel



Basic Aerodynamics Research Tunnel (BART)



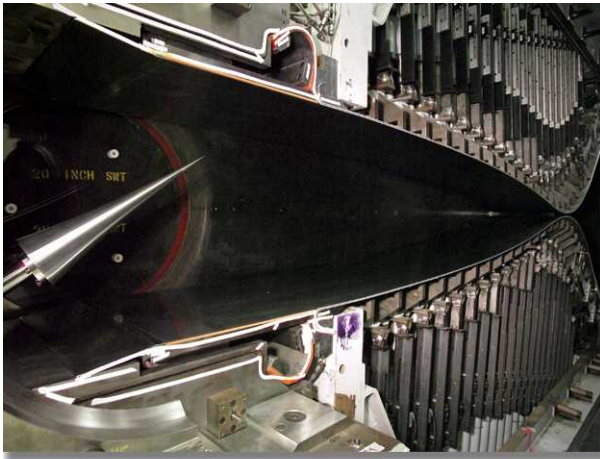
20 x 28-in Low-Speed Tunnel

- 150+ channels high speed DAQ, to 1 MHz
- Hot wires, hot films, pressure probes
- Unsteady pressure transducers, accels, etc.
- High speed PIV, 2D/3D PIV, Large Field PIV
- Laser induced Thermal Anemometry, LV
- Pressure and Temperature Sensitive Paint
- Flow visualization (oils, liquid crystals)
- 1 dSpace, 2 XPC Target Real time control systems



High Speed/Quiet Physics Tunnels

20-in Supersonic Wind Tunnel (SWT)



- *Mach 0.2 - 0.75; 1.4 - 5.0*
- *Only facility to supply low-disturbance “Mars Explorer” airfoil data*
- Also test wherever the physics dictate –
 - 14' x 22', TDT, 0.3m TCT, NTF, ARC 11', flight vehicles
 - TAMU Mach 6 Quiet Tunnel, Princeton Superpipe

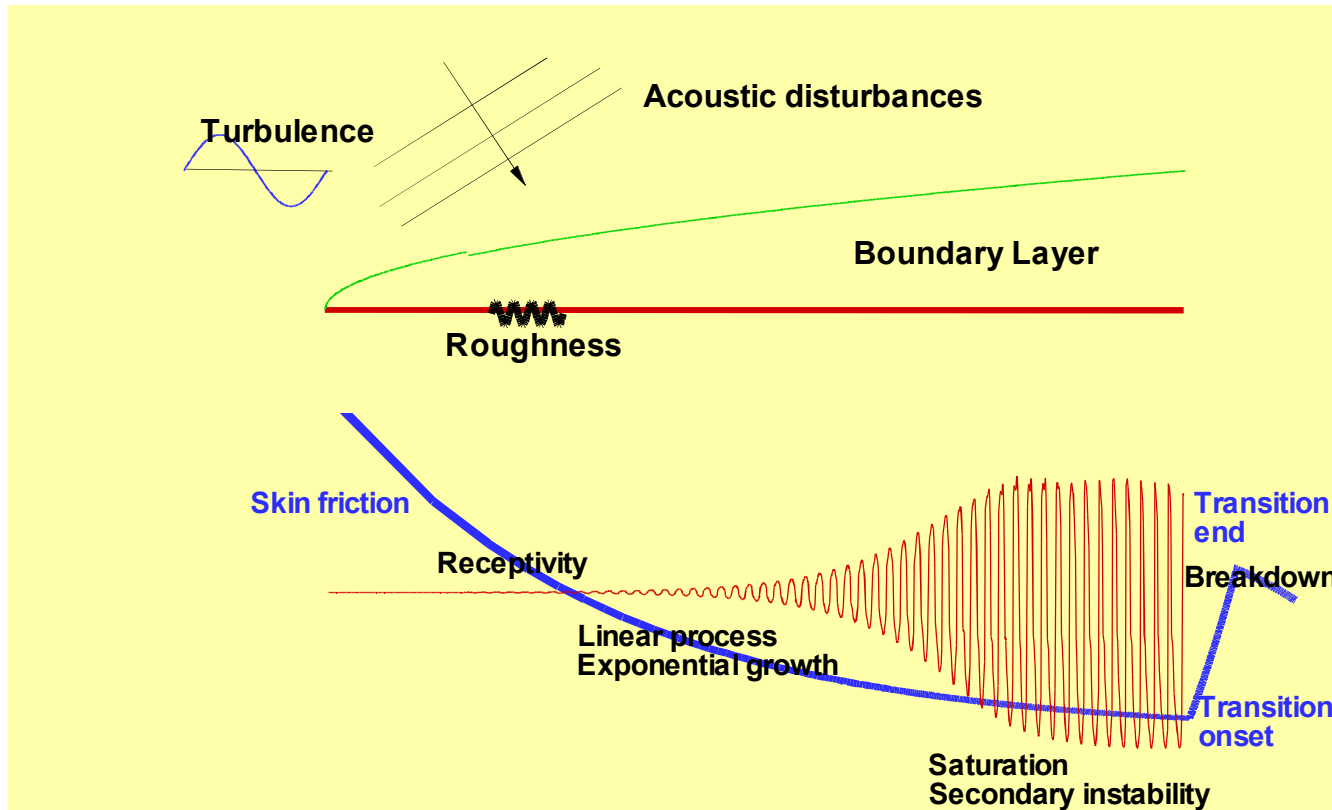
Supersonic Low-Disturbance Tunnel (SLDT)



- *Mach 3.5*
- *First supersonic transition quiet testing capability.*



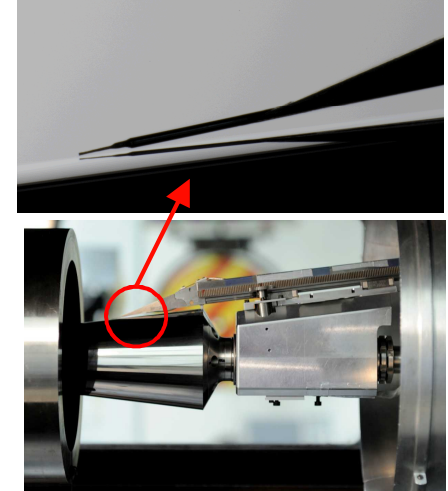
Transition Physics



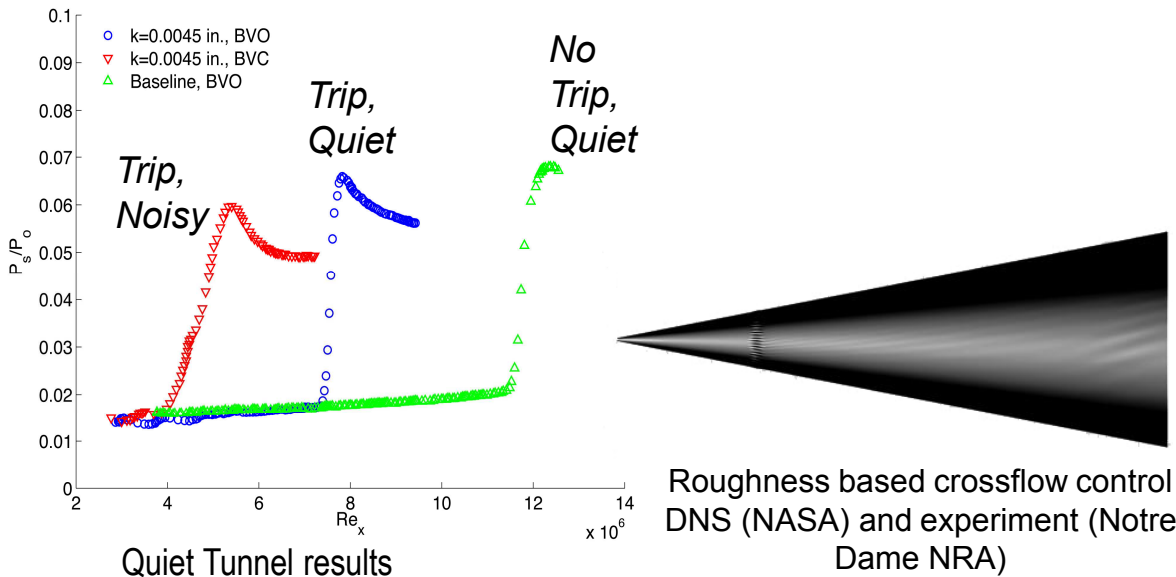
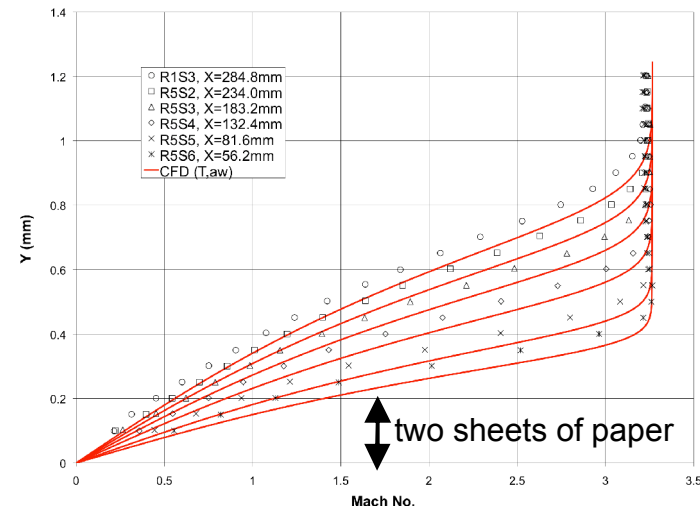


Transition Physics Experiments

- Demonstrate prediction and control of boundary layer transition, natural and with roughness
 - Quantitative measurements of transition mechanisms
 - DNS of supersonic and hypersonic boundary layer receptivity



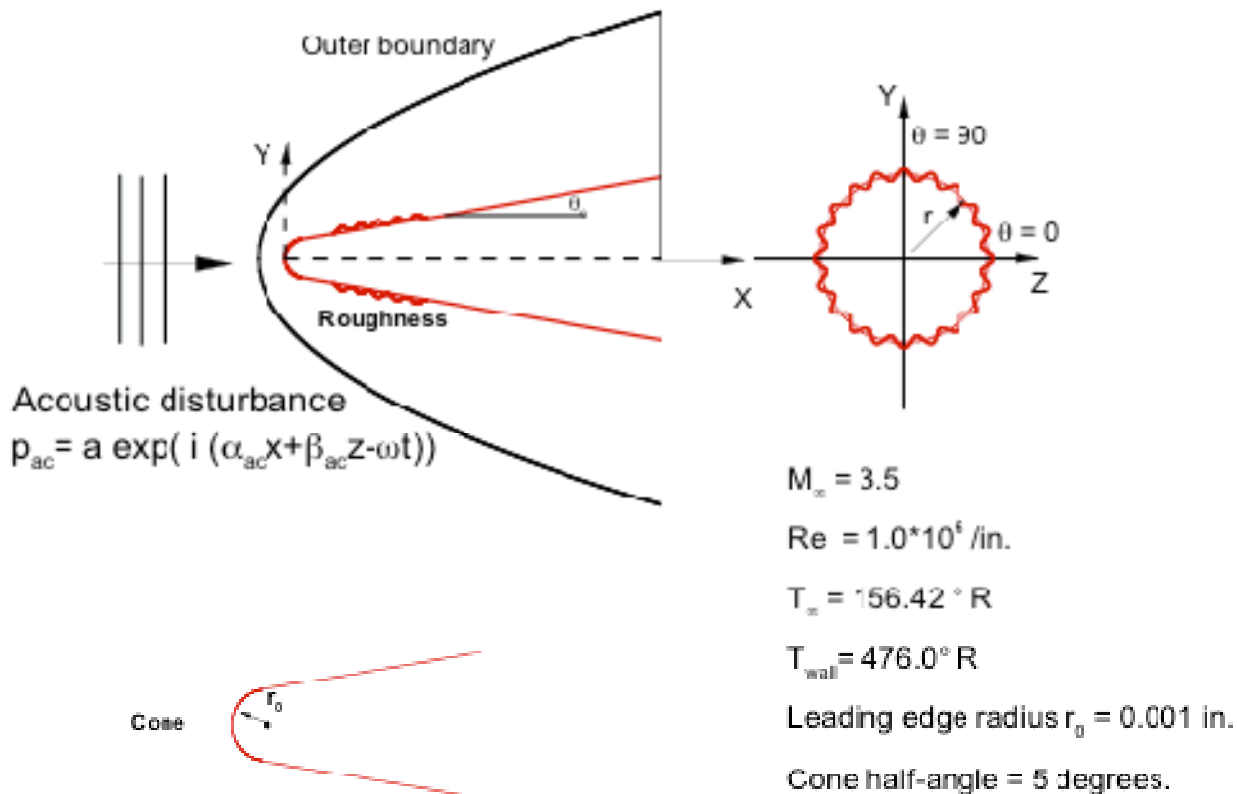
T68 7-deg Cone Checkout BL Pitot Surveys





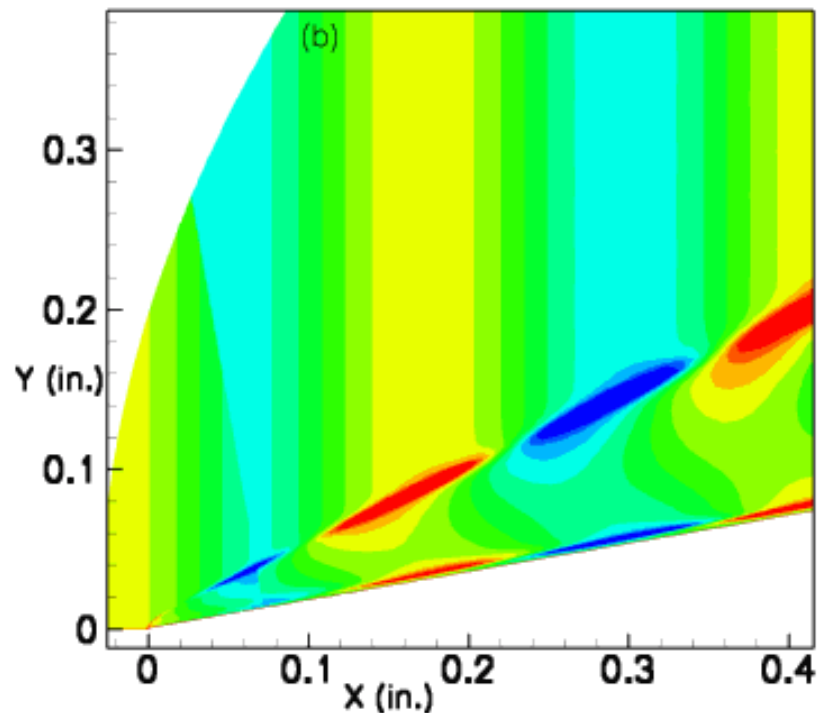
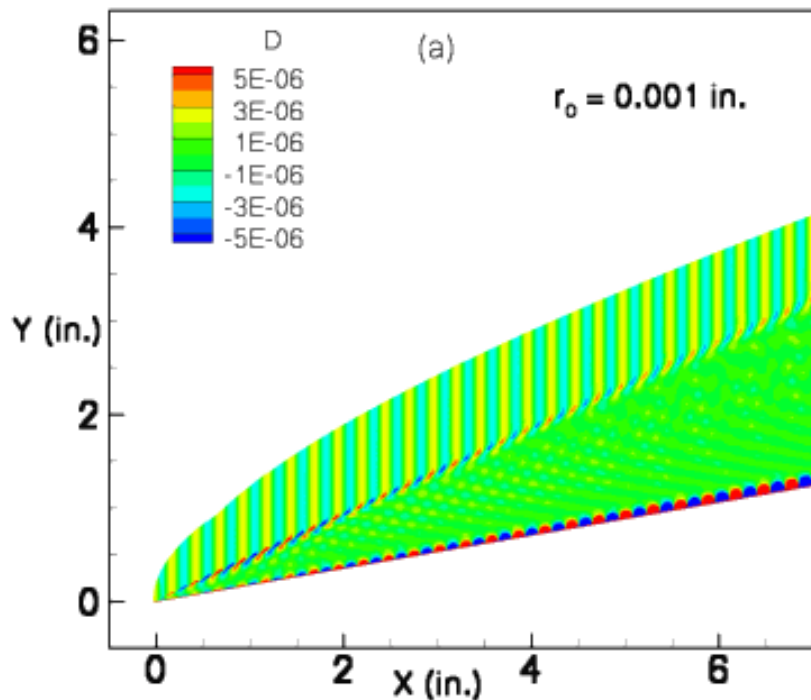
Computational Model

Flow over flat plates, wedges and cones including roughness





DNS Evaluation of Transition Mechanisms

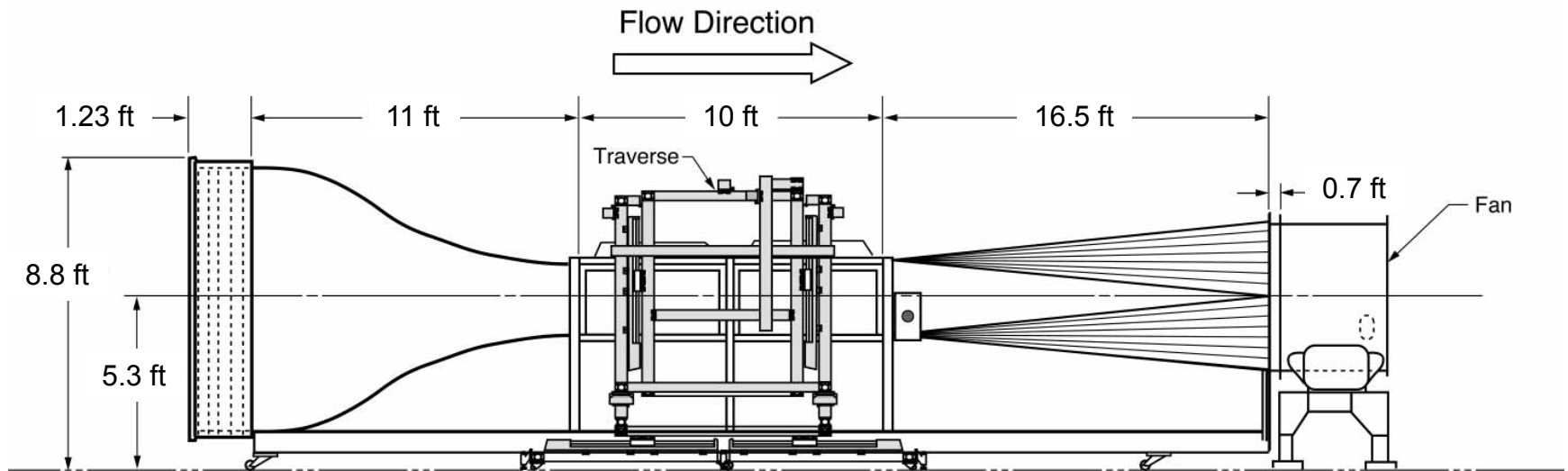


To investigate how the instability waves are generated inside the axi-symmetric supersonic boundary layers and to estimate the receptivity coefficients.

- Three-dimensional plane acoustic waves can interact with the ax-symmetric geometry and can scatter small scale disturbances inside the boundary layer
- Plane acoustic waves can interact with roughness at the surface and can generate the instability waves inside the boundary layer



Basic Aerodynamics Research Tunnel



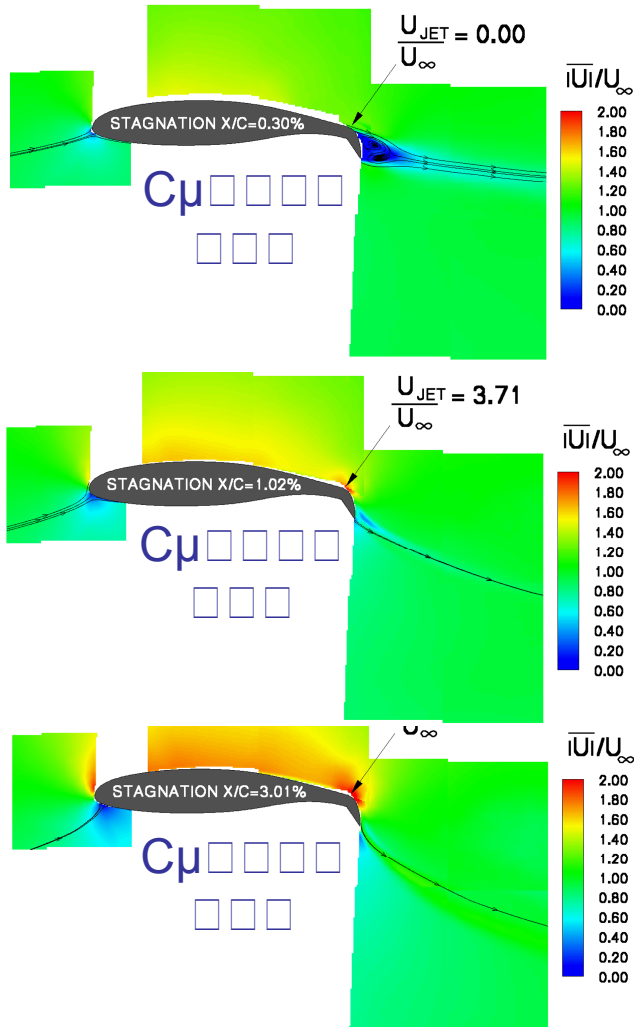
BART Specifications

- Test section: 2.333 ft x 3.333 ft x 10 ft
- Max. Velocity: 185 ft/s
- Max. Re/ft: 1.14×10^6
- Max Mach No: 0.17
- Max. Turbulence Intensity: 0.09%

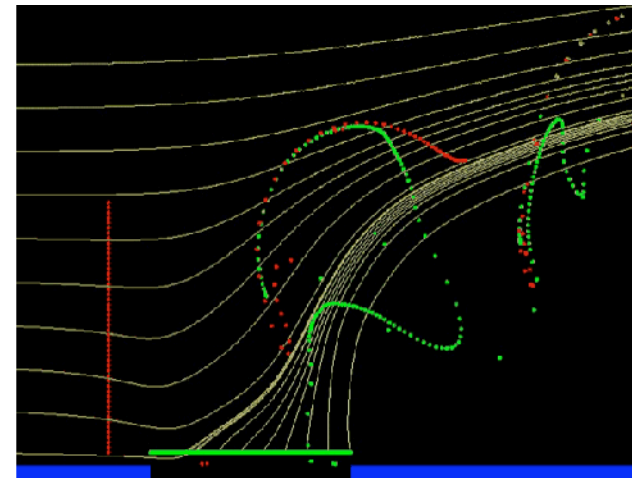


Flow Control – PIV Data

- Streamline characteristics for a internally blown flap



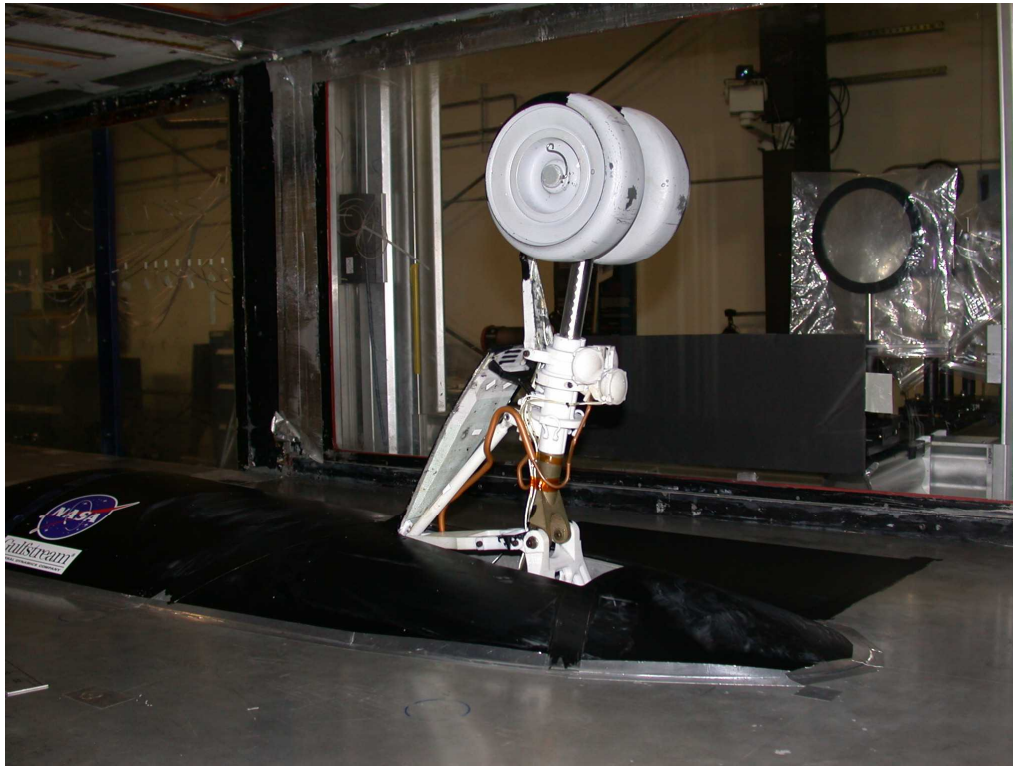
Mean streamlines and particle traces of ZNMF jet in cross-flow





Unsteady Aerodynamics – Landing Gear

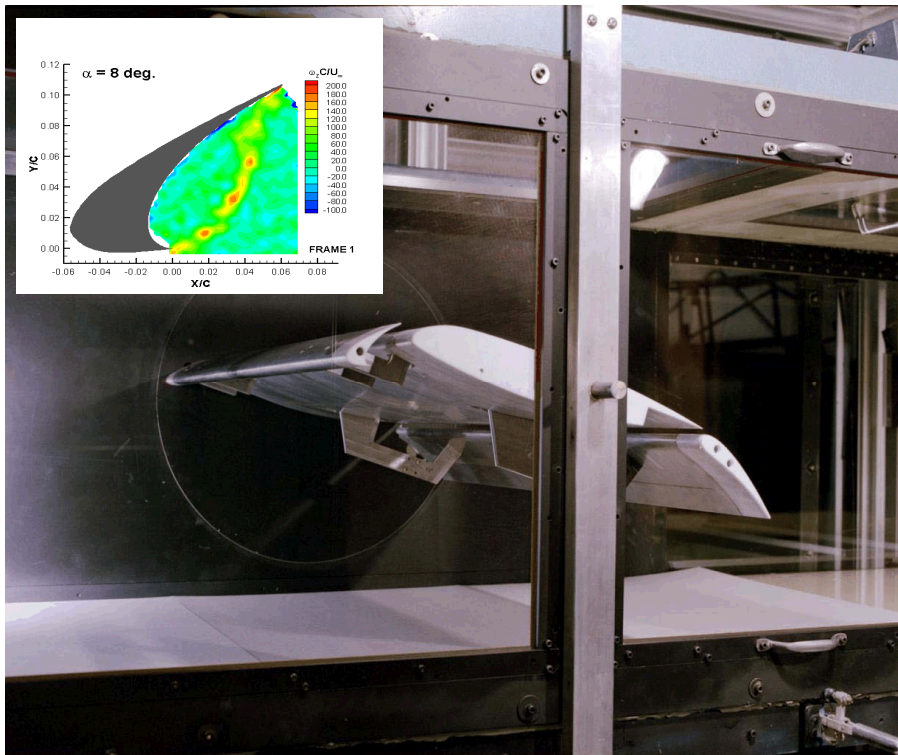
Gulfstream G550 Nose Landing Gear (25%scale)



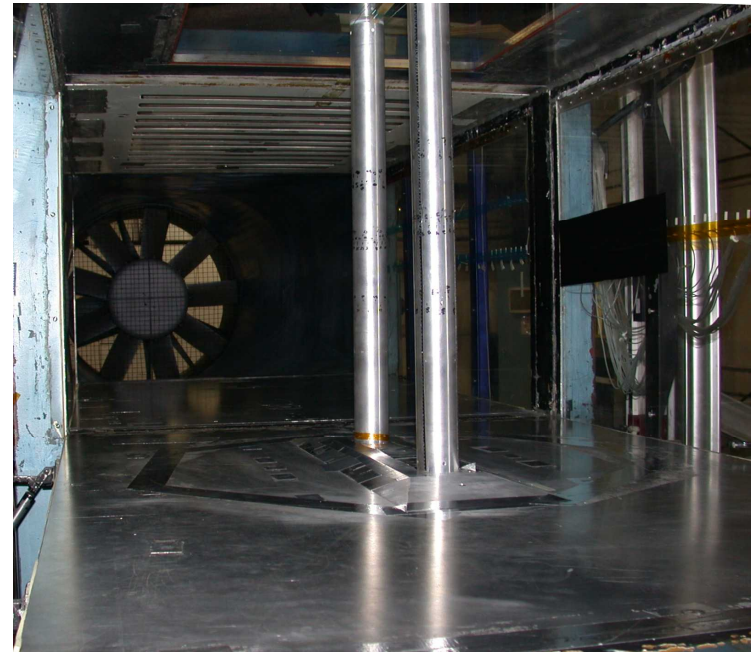


Unsteady Aerodynamics - Fundamental

2-D High-Lift Model



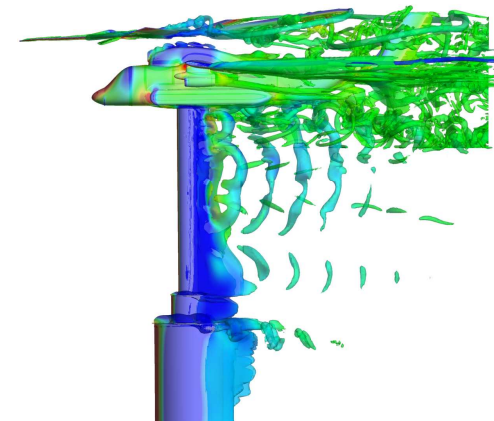
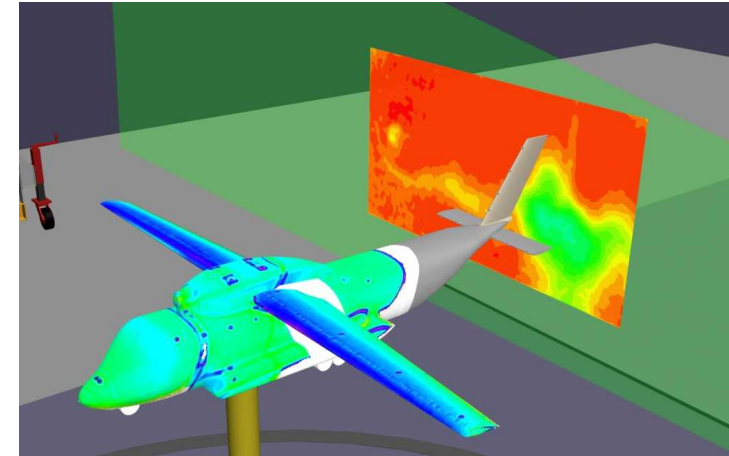
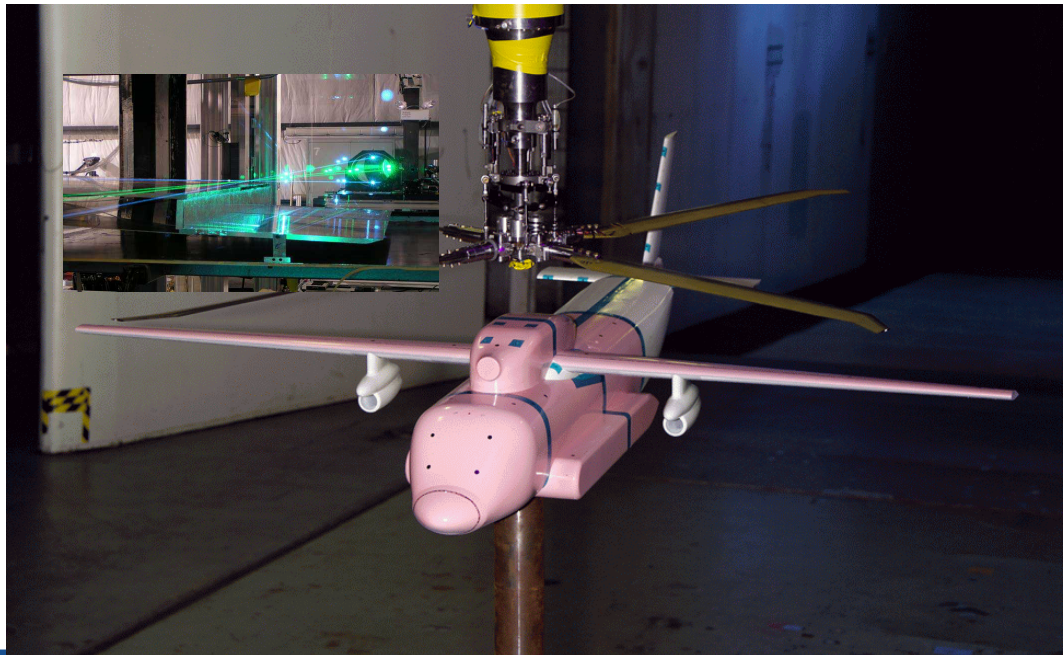
Tandem Cylinders





Rotorcraft Wakes

- Large field of view rotor wake assessments
 - Large field of view Particle Image Velocimetry (LFPIV)
 - Developed for 14' x 22'
 - Designed experiments with OVERFLOW CFD tool
- Blade/fuselage unsteady pressures
 - Unsteady Pressure Sensitive Paint (PSP)





Flow Physics and Control Branch

- FPCB has rich history in advanced analysis techniques for time-dependent fundamental aero research
- History in fundamental research allows us to quickly come to speed on engineering problems