Airframe Noise Reduction Status and Plans

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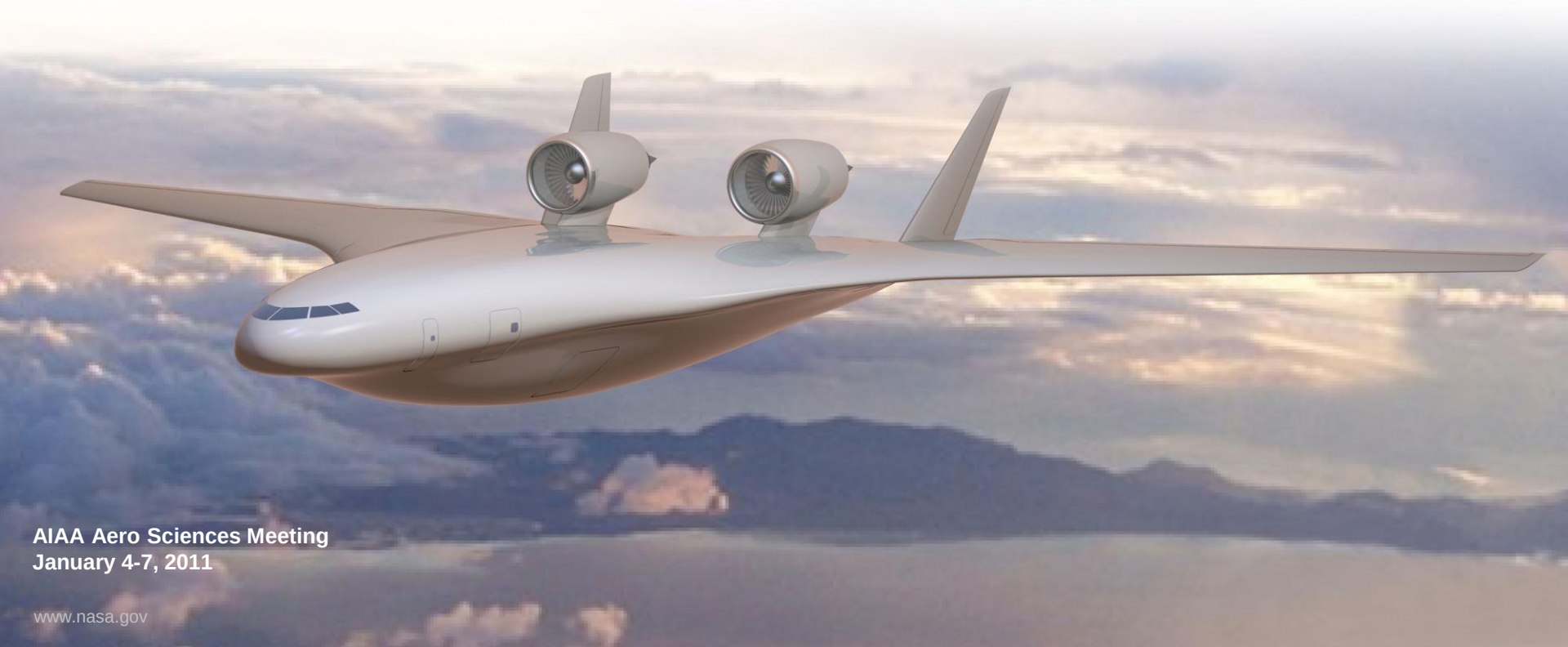


AIAA Aero Sciences Meeting
January 4-7, 2011

Airframe Noise

- Non-propulsive
- Most important during approach
- Broadband and noncompact
- Under-carriage and high-lift devices are prominent airframe noise sources
- Potentially large payoff from reducing airframe noise

NASA-Gulfstream Partnership

Objectives

- Mitigate radiated airframe noise during aircraft landing
- Develop effective noise reduction (NR) concepts applicable to current and future generations of civil transport

Execution Plan

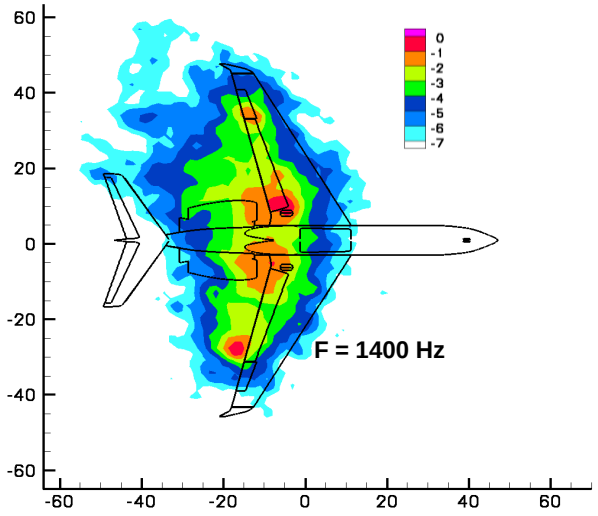
- Utilize flight tests, wind-tunnel experiments, and computational simulations to generate a comprehensive aerodynamic and acoustic database to:
  - » Identify and quantify the prominent airframe noise sources
  - » Better understand the principles of airframe noise generation
  - » Improve airframe noise prediction tools
  - » Establish Reynolds number, geometric fidelity, and installation effects
  - » Develop efficient noise reduction concepts
- Evaluate the most promising noise reduction concepts in a realistic environment

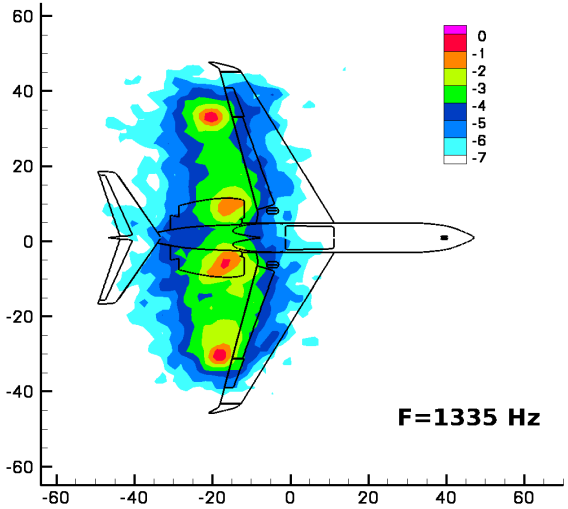
NASA-Gulfstream Airframe Noise Flight Test (2006)

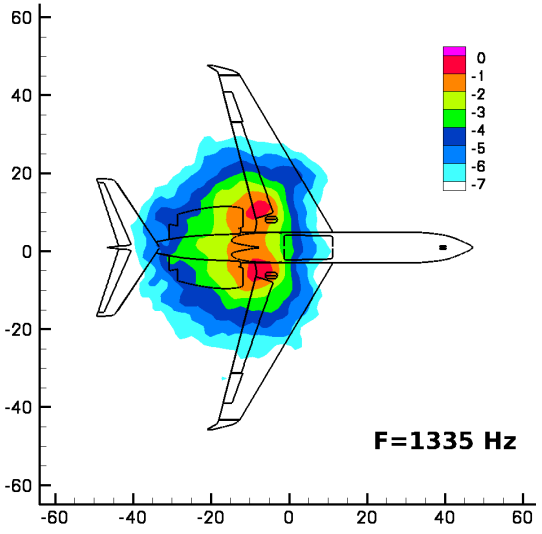
Main Gear and Flaps only

Flaps only

Main Gear only



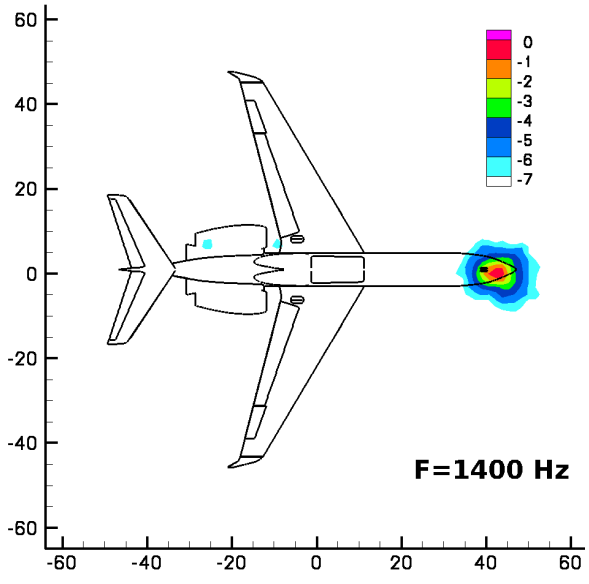




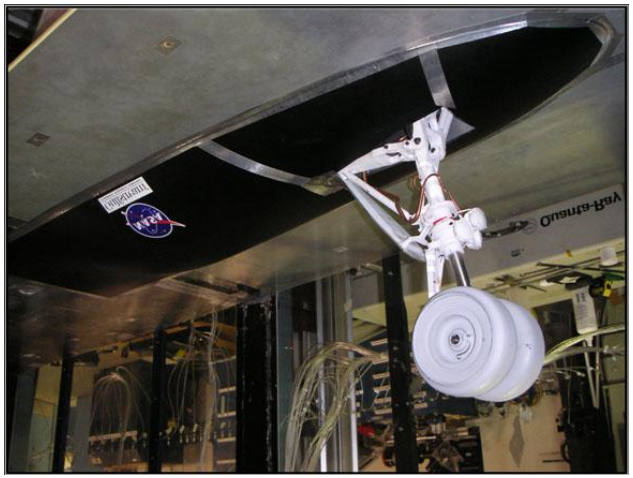
Nose Landing Gear

Acoustic Flight Test (2006)

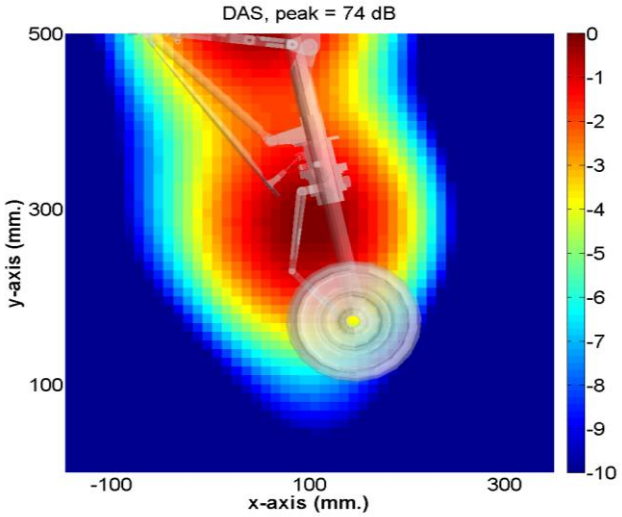
Nose Gear only



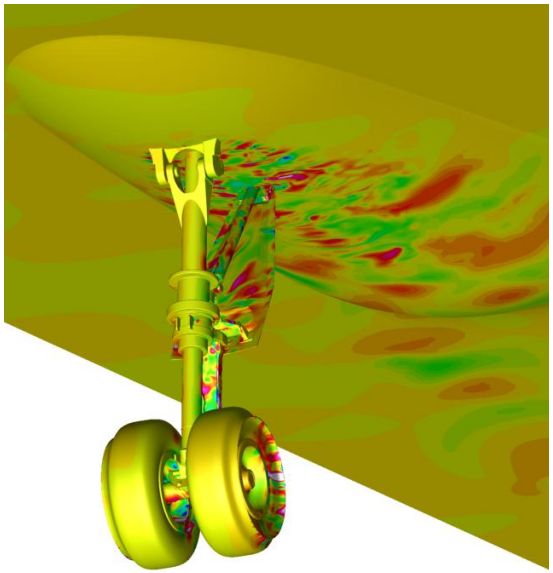
25% Scale Model tests (2007-2010)

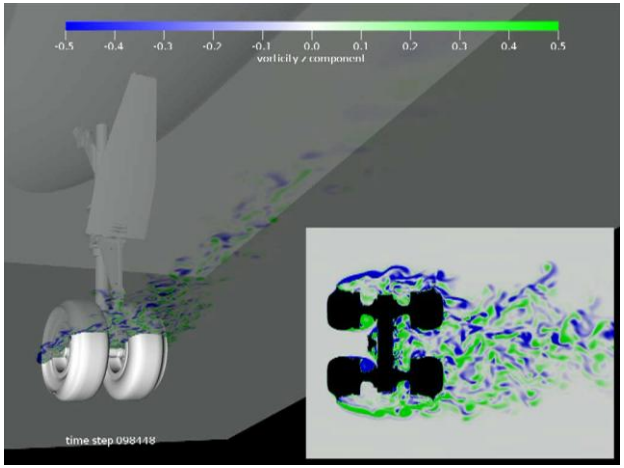


Acoustic measurements
University of Florida



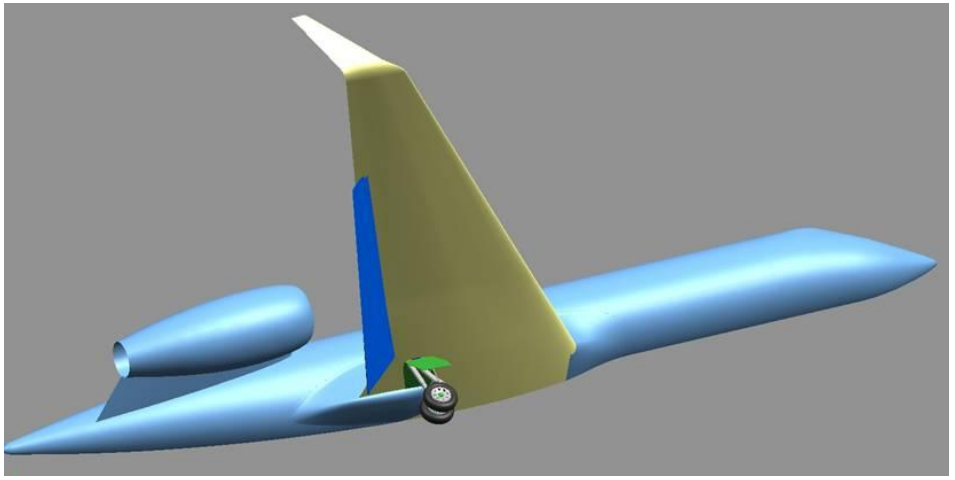
Unsteady Simulations (ongoing)

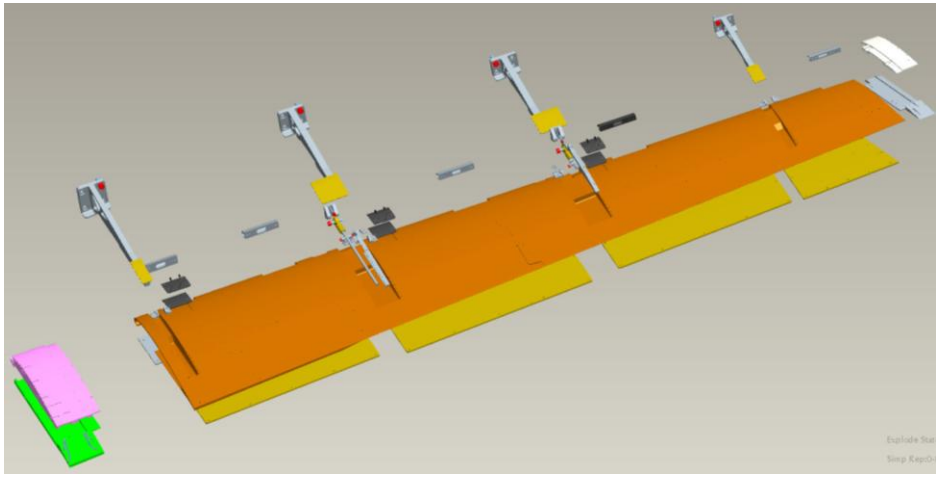


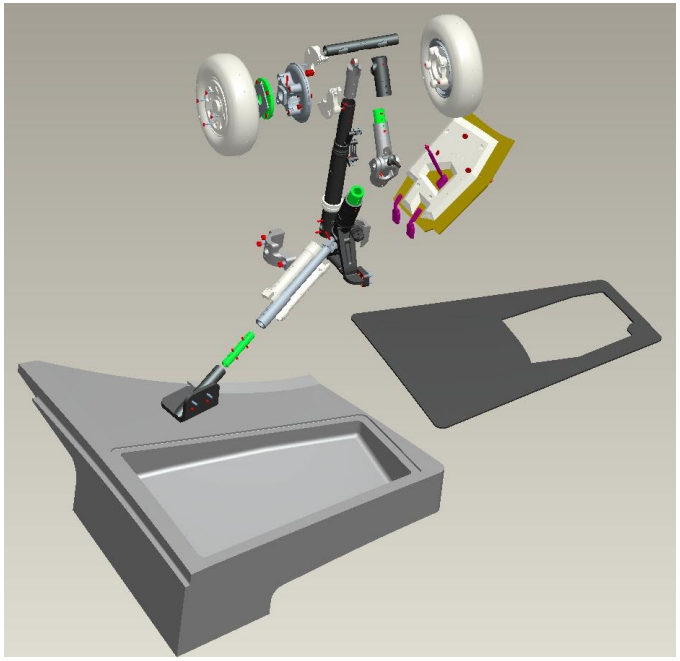


Semi-Span G550 Model

- High fidelity model
  - 18% of full-scale
  - Geometric details captured
  - Fully metric
- Heavily instrumented
  - 750 steady pressure ports
  - 68 unsteady pressure sensors
  - 14 accelerometers
- Model delivered on 9-24-10

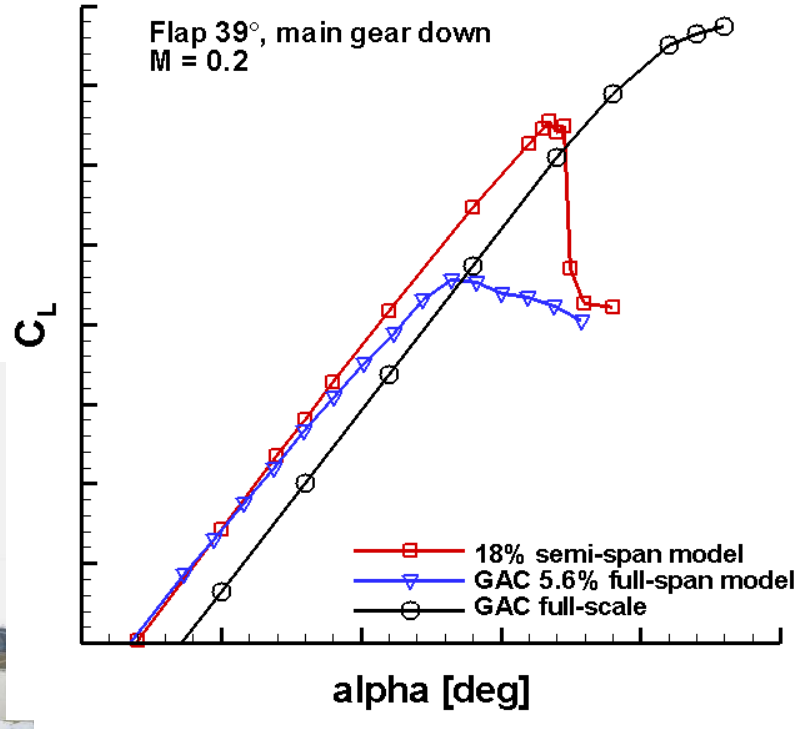






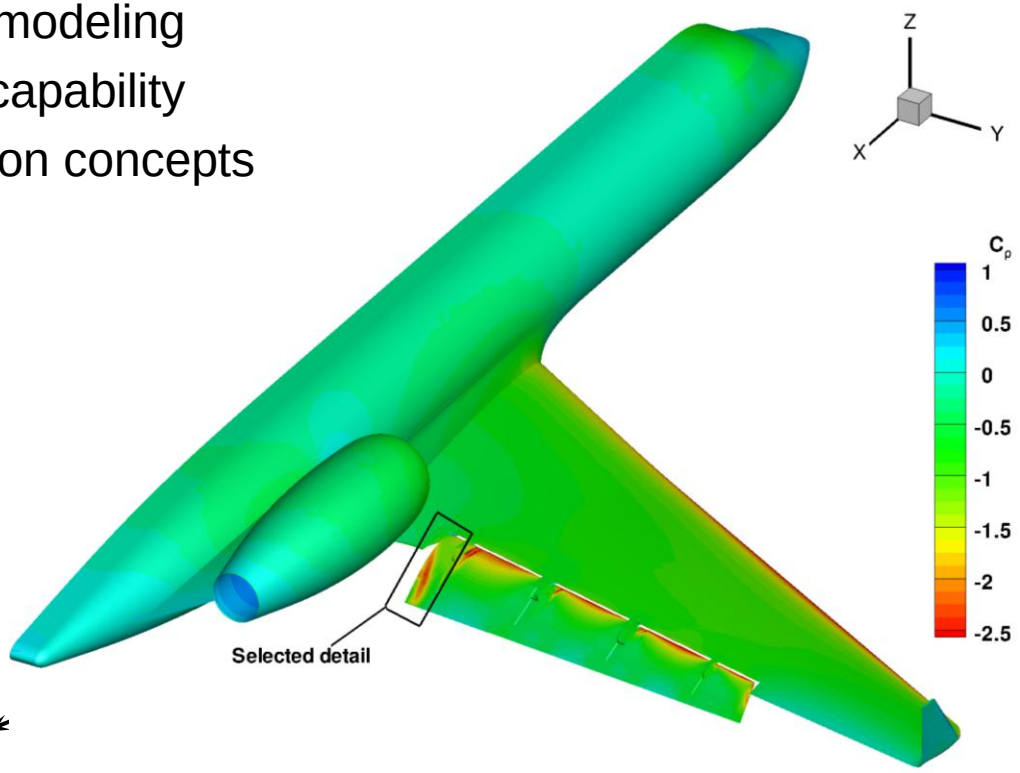
First Entry in Langley 14x22 Tunnel: Aerodynamic Test

- Aerodynamic testing began on 10-13-10
- Testing ended on 11-18-10
- First entry was focused on
  - Global forces (Lift and drag)
  - Steady and unsteady surface pressures
  - Overall aerodynamic characteristics
- Full analysis of measured data ongoing

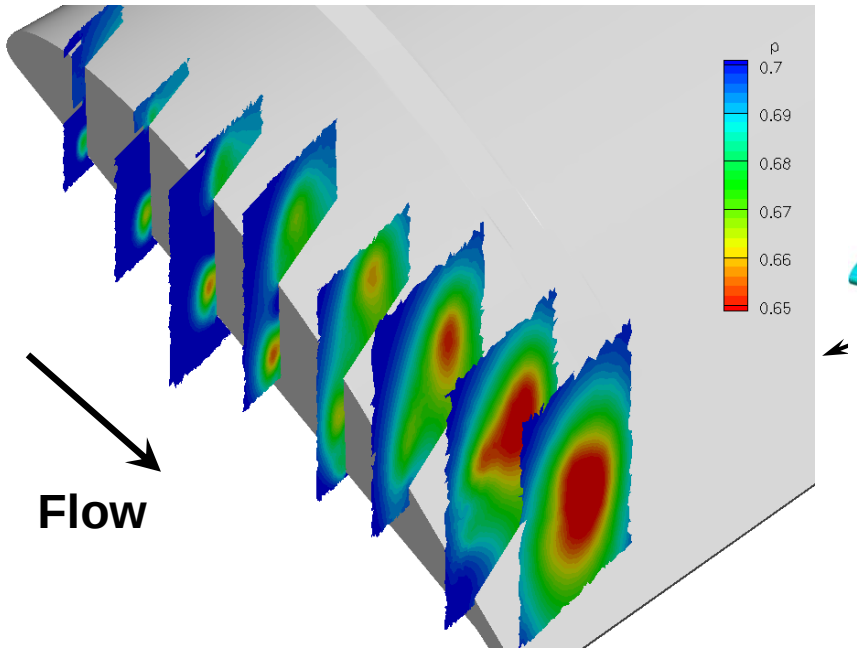


High-Fidelity Computational Simulations

- Provide insight on the nature of noise sources
- Guide physics based noise source modeling
- Advance airframe noise prediction capability
- Develop and evaluate noise reduction concepts

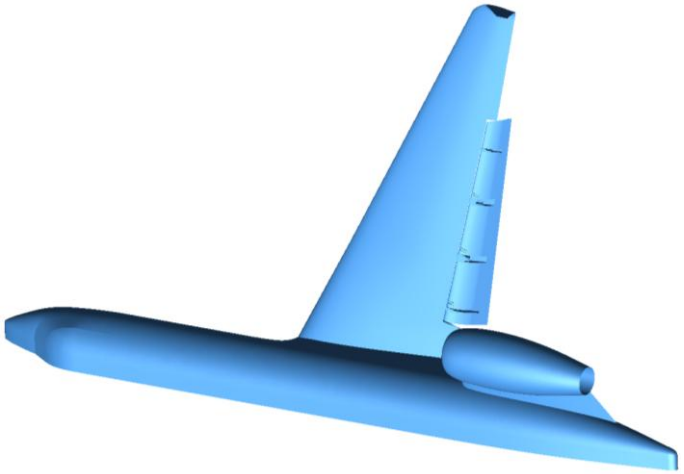


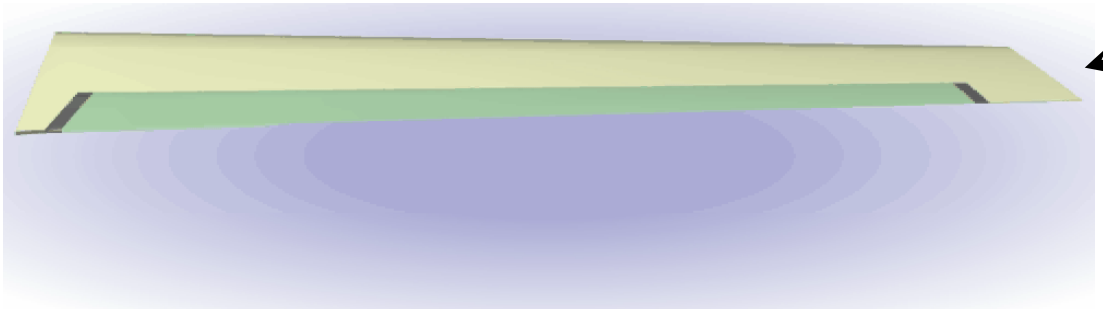
Flap Inboard Edge

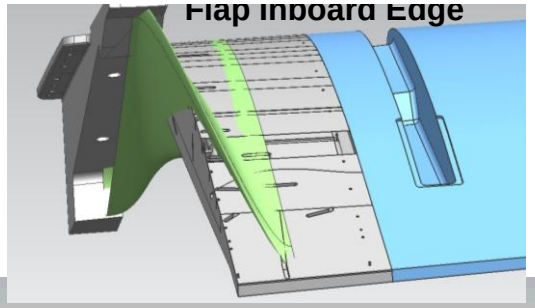


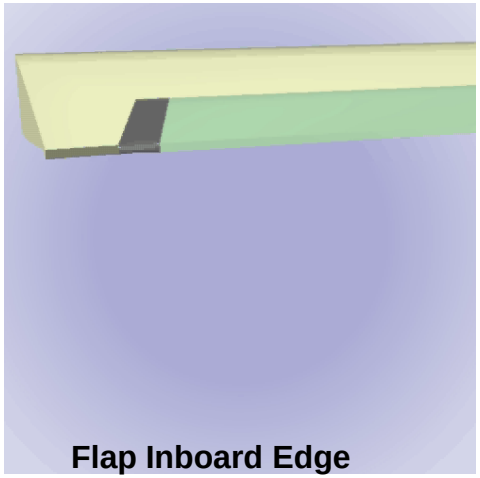
Noise Reduction Effort (Flap)

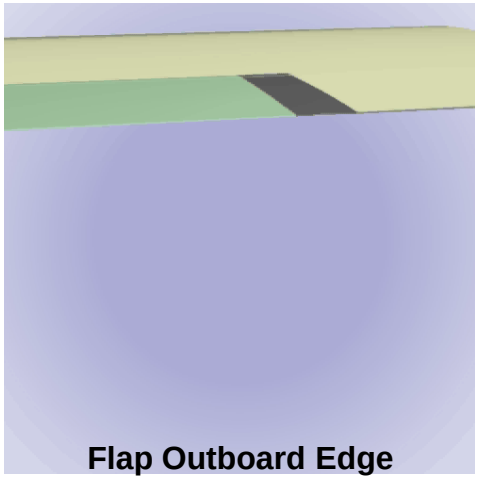
- **FLEX**ible **S**ide-**E**dge **L**ink (**FLEXSEL**)
- FLEXSEL is different than Continuous Moldline Link
- Concept developed by a multi-disciplinary team at NASA Langley
- Effectiveness of concept to be validated/evaluated via simulations and testing

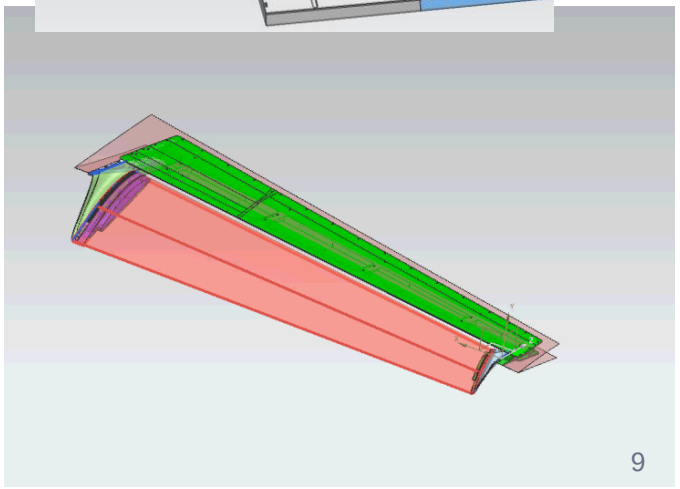






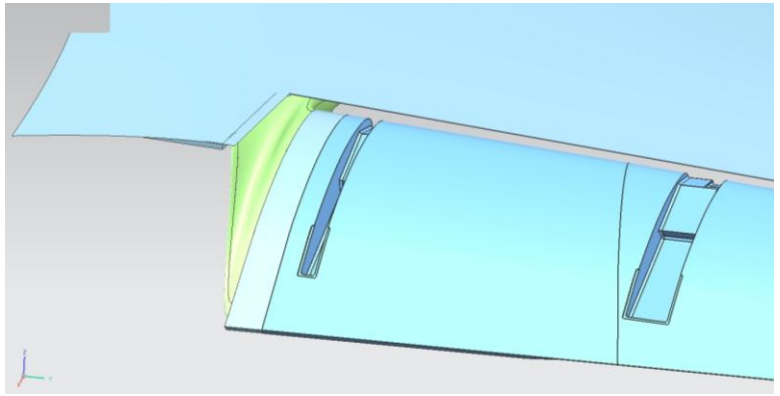


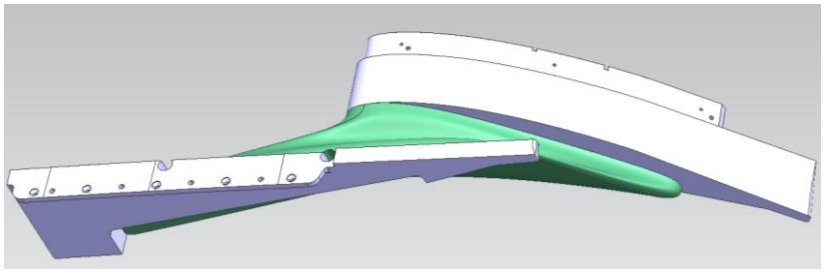


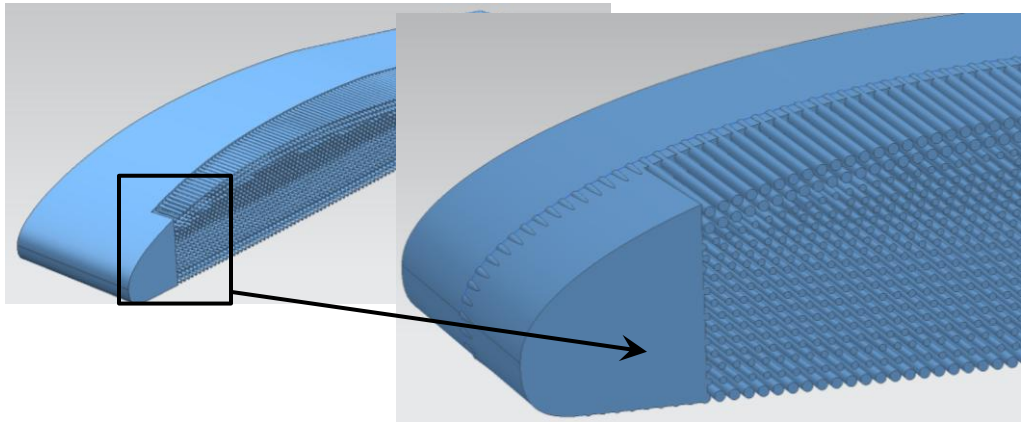


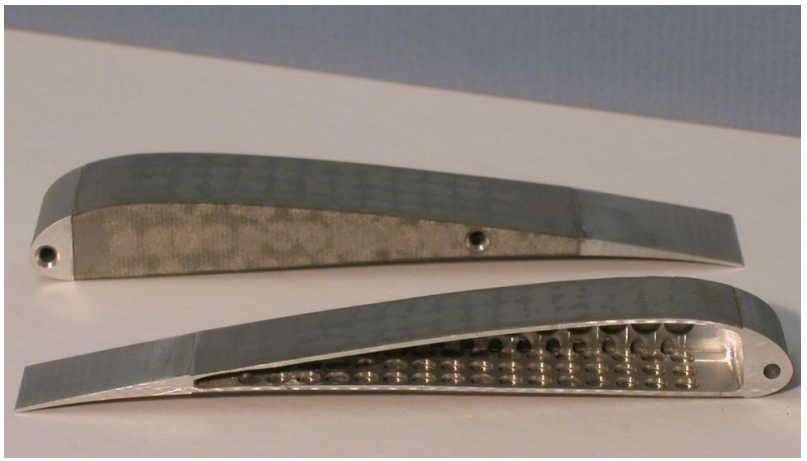
Noise Reduction Effort (Flap)

- Additional concepts to be tested:
  - Various shapes of FLEXSEL
  - Porous tip
  - Extended or locally reacting liners
  - Metallic rods
  - Others

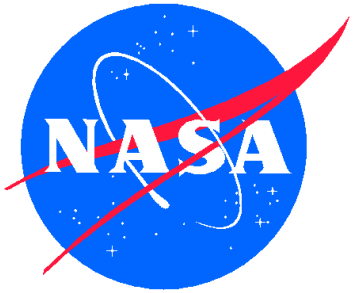








Noise Reduction Effort (Main Landing Gear)



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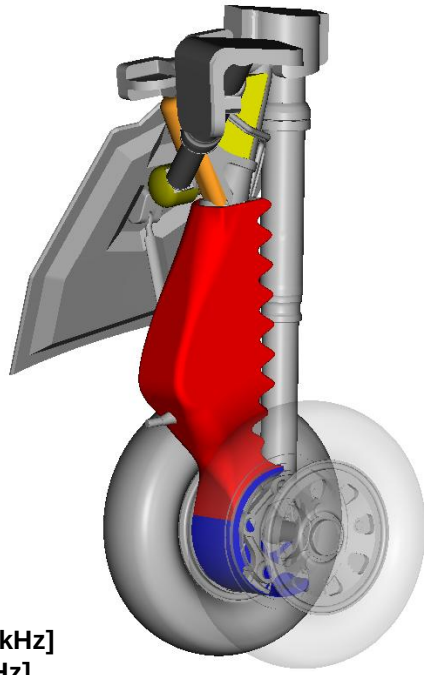
Additional Partners:

GOODRICH

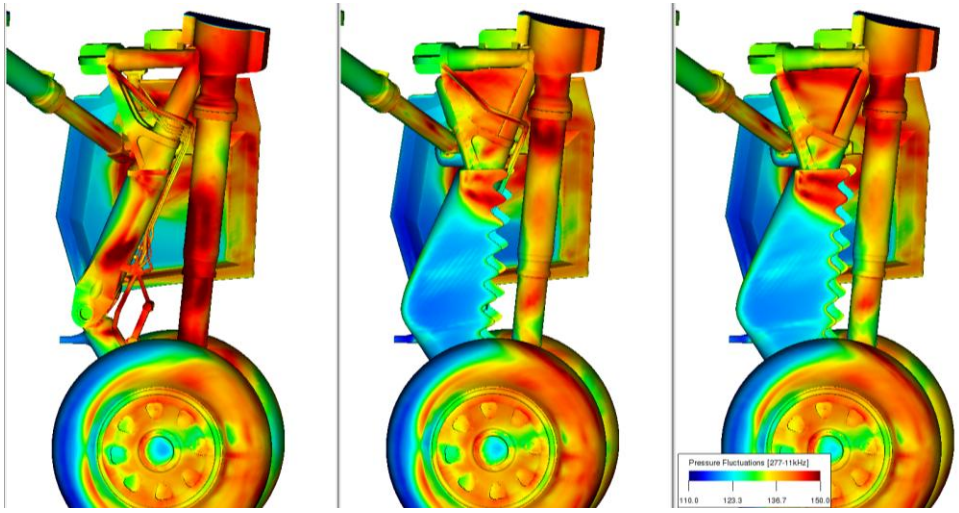
Exa

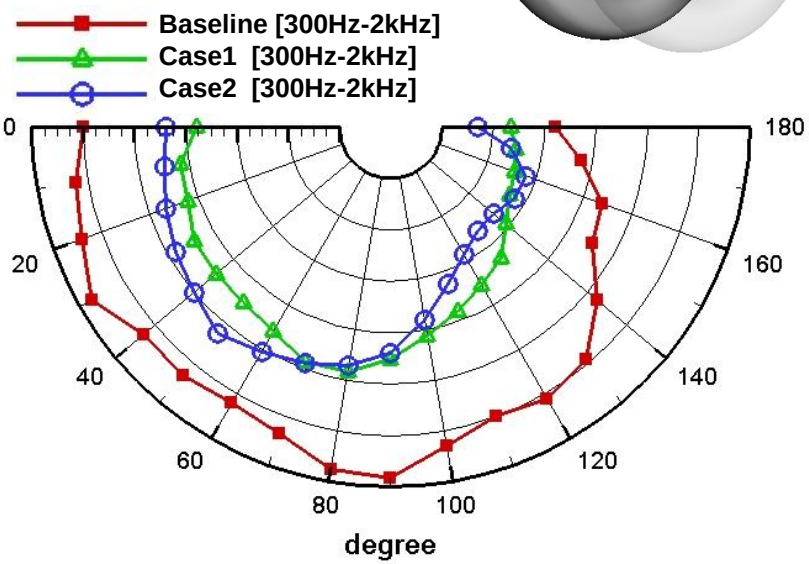
Noise Reduction Effort (Main Landing Gear)

- Collective effort (NASA, Goodrich, Gulfstream, and Exa)
- Use of high-fidelity simulations as a design tool
- Concept development and refinement solely based on simulations
- NASA is to build and instrument the quiet gear design with funding from Goodrich (under way)
- Isolated quiet main gear design to be tested at VA Tech during April-May 2011 (validation of design methodology)
- Quiet main gear to be installed on the 18% G550 model and tested in Langley 14x22 tunnel during September 2011 (validation of concept in a relevant environment)



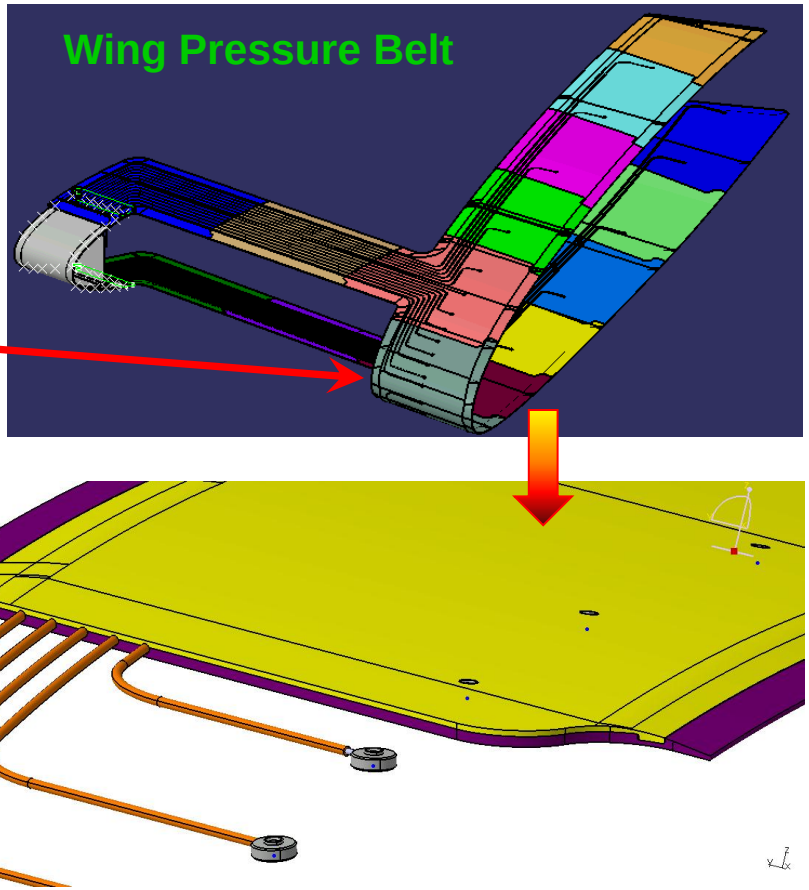
Baseline **Case 1** **Case 2**





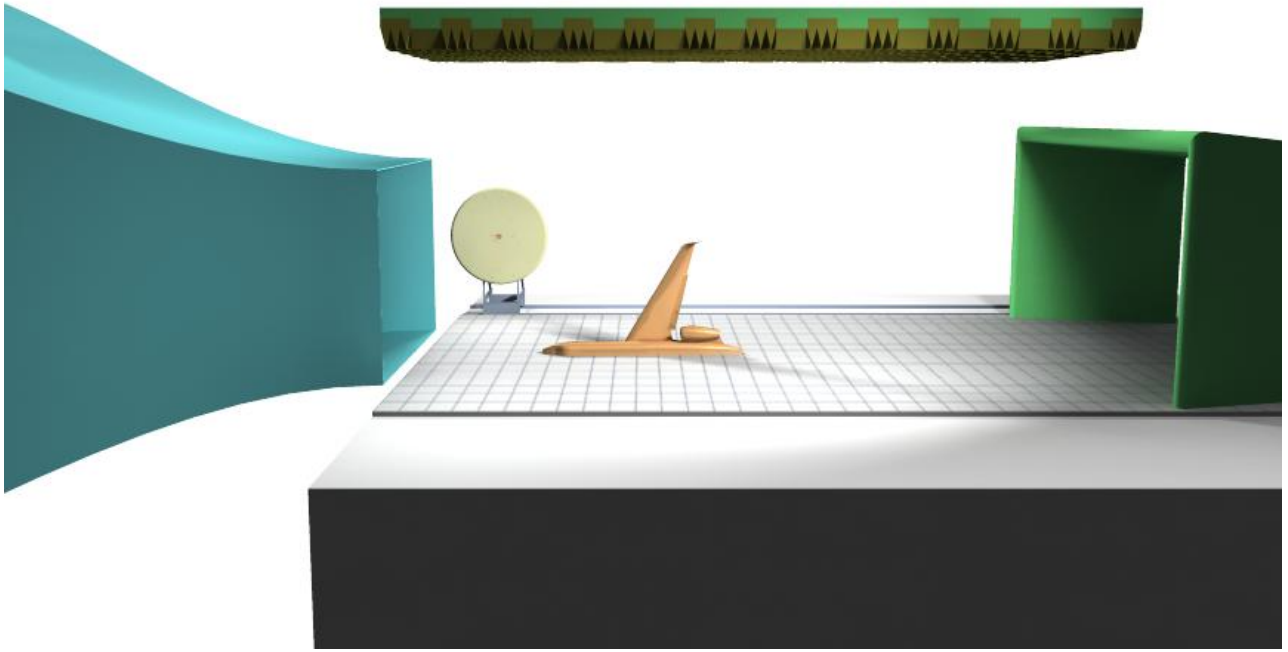
Planned Tests in 2011

- Aerodynamic flight test (G550 aircraft)
  - To be executed during spring 2011
  - Acquire steady surface pressures on wing and flap
  - Acquire unsteady surface pressures at flap edges, nose and main landing gear
  - Establish Reynolds number, geometric, and installation effects

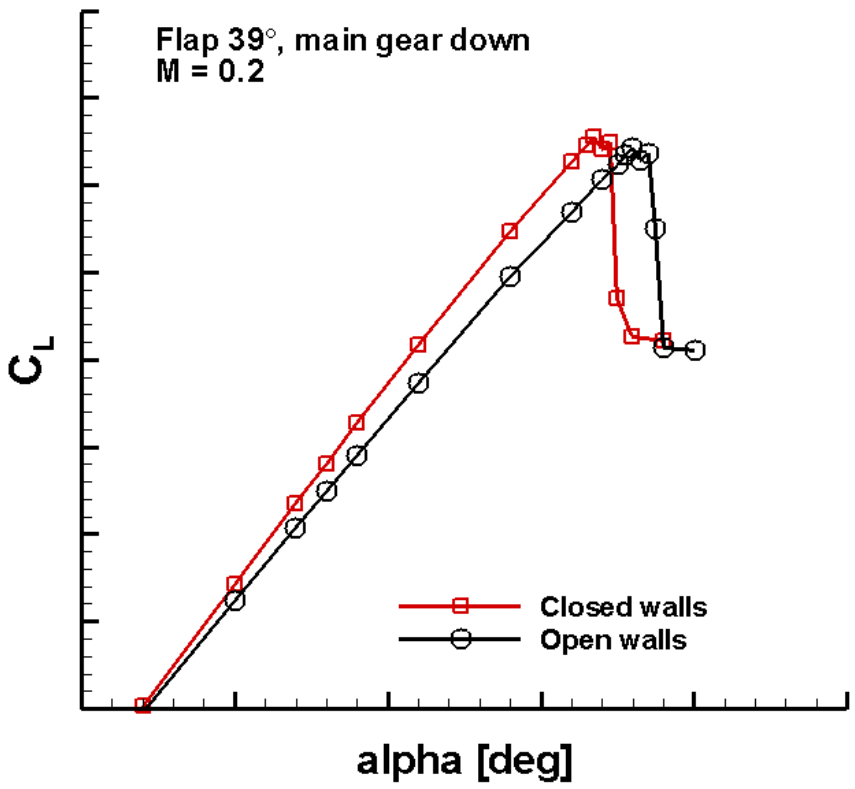


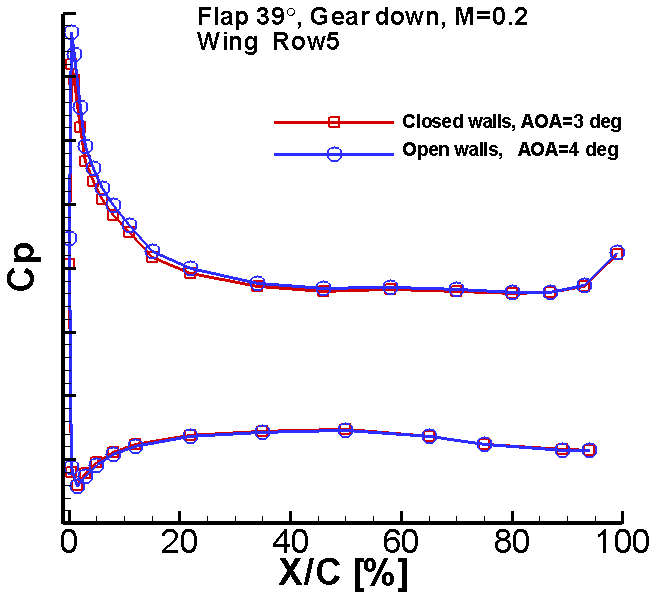
Planned Tests in 2011

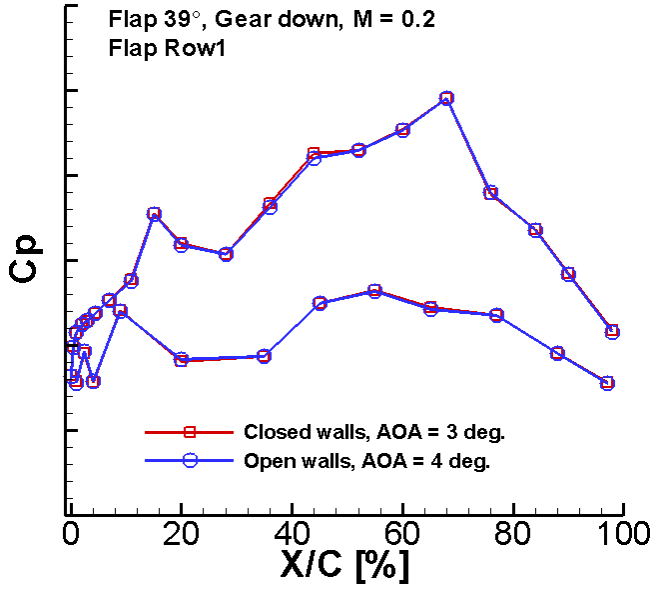
- Second entry in Langley 14x22 tunnel
- This entry is dedicated to:
  - Limited repetition of aerodynamic measurements
  - Acoustic: Microphone array and free-field microphones
  - Off-surface flow: PIV
- Extensive evaluation of noise reduction concepts
  - Flap side-edges
  - Main landing gear
  - Gear-flap interaction



Closed Walls vs Open Walls Aerodynamics

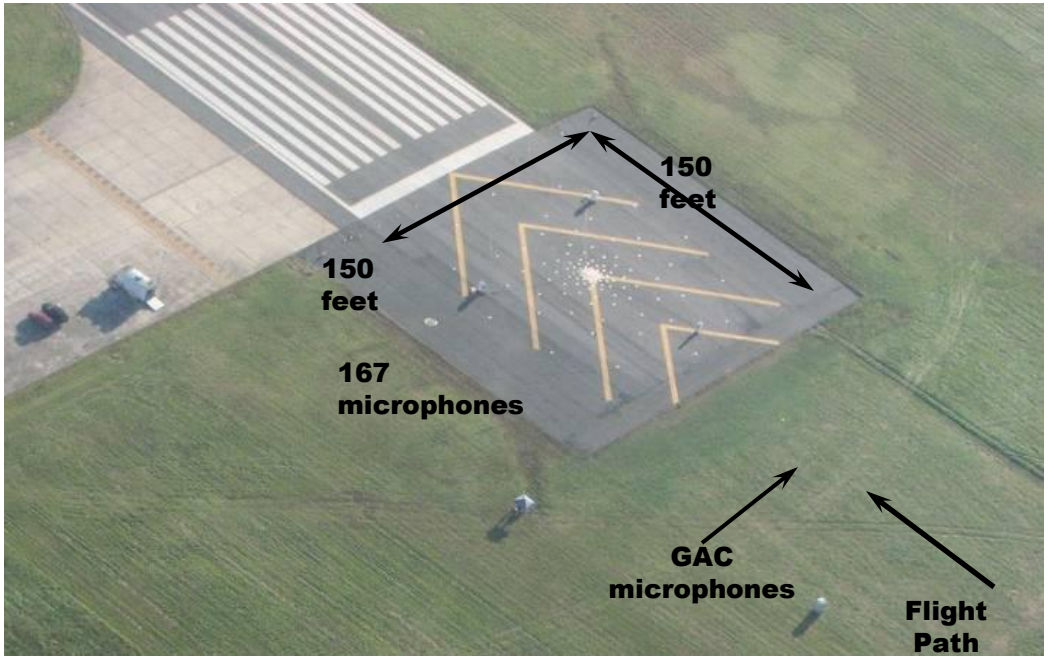






Future Tests Beyond 2011

- Acoustic flight test: to be conducted during 2013 or 2014
- Down-select the most promising noise reduction technologies from 18% model tests and computational aeroacoustic analysis for flight testing
  - Which concepts to be tested based on collective decision by partners and available funding
  - Conduct flyover noise tests similar to 2006 airframe noise tests at Wallops
  - Determine the efficacy of the developed concepts in suppressing airframe noise



Summary

- An ambitious partnership program focused on airframe noise research has been established and is being executed systematically
- The aim of the partnership effort is to generate/acquire a high-quality airframe noise database that would guide the development of
  - Better noise source models
  - Efficient computational tools with predictive capabilities
  - Viable noise reduction concepts
- Delivery and aerodynamic testing of the 18% semi-span G550 model constitute the initial critical steps toward achieving these goals

Backup Slides

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