An Overview of Contributions for Nose Landing Gear Configuration – BANC-III Workshop

by

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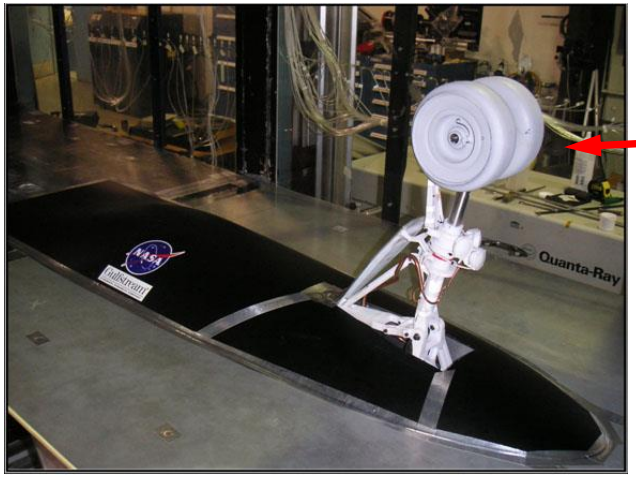
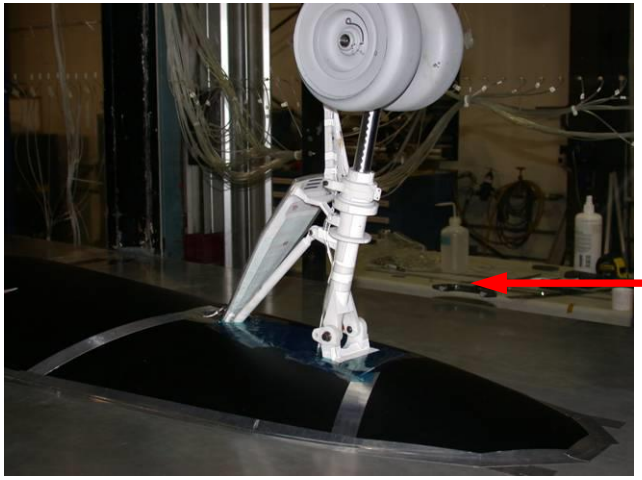
21st AIAA/CEAS Aeroacoustics Conference

22-26 June 2015, Dallas, Texas

Background – Gulfstream Aircraft Nose Landing Gear Model



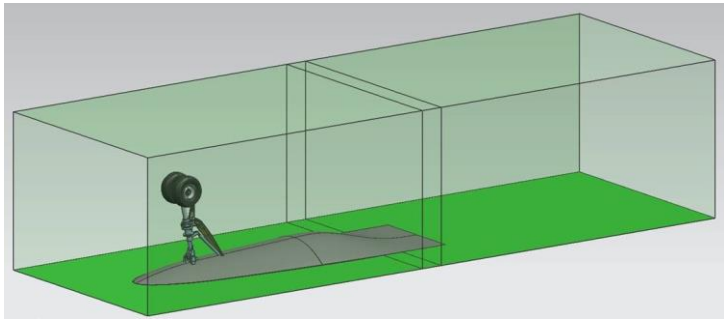


- High-Fidelity, 25% Scale
- Lower Fuselage Section
- Correct Gear Cavity Geometry
- 16 Dynamic Pressure Transducers (1 Roving)
- ~123 Static Pressure Ports
- Removable Components
  - Hydraulic, Electrical Lines
  - Steering Mechanism
  - Light Cluster
  - Can Seal Gear Cavity
  - All Above ⇨ Partially dressed model (simplified gear)

Baseline open configuration for benchmarking aeroacoustic Simulations

Background – Available Database Nose Gear Test Series (2007-2009)

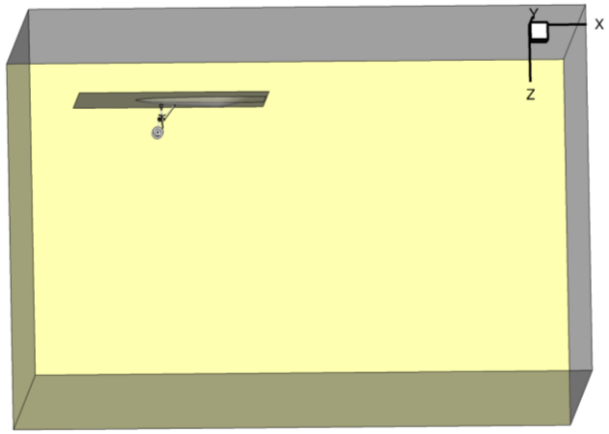
- **NASA Langley Basic Aerodynamic Research Tunnel (BART)**
  - Closed-wall tunnel (Open-Circuit)
  - 28” x 40” x 10’ test section
  - Steady and unsteady pressures, PIV
  - Test M = 0.12, 0.145, **0.166**



Track A

- **Univ. of Florida Acoustic Flow Facility (UFAFF)**
  - Open tunnel within a 100 Hz anechoic room
  - 29” x 44” x 72” test section
  - Acoustic measurements (phased Array, individual microphones)
  - Steady and unsteady pressures
  - Test M = 0.145, **0.166**, 0.189

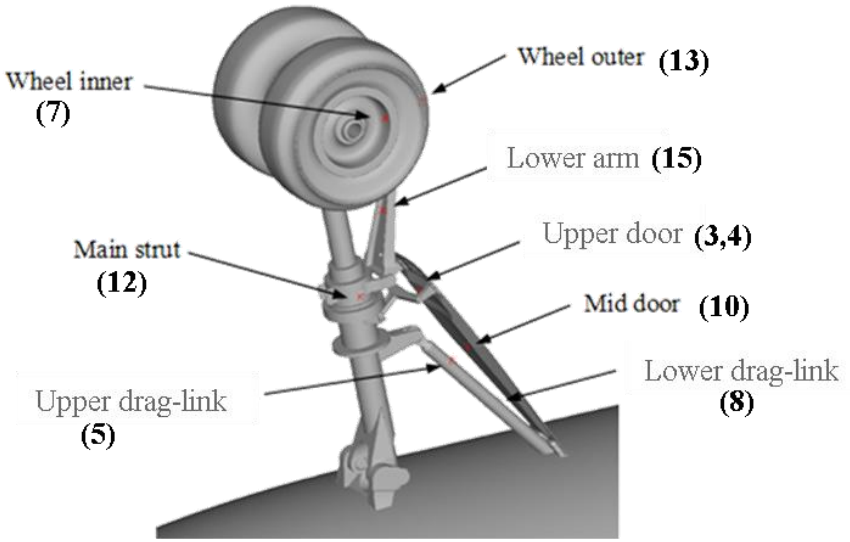
Gulfstream®
A GENERAL DYNAMICS COMPANY



Track B

Data Reporting for BANC-III

- **Not as stringent as previous workshop**
- **Code to Code comparisons**
  - Integrated forces (C_x and C_z)
  - Steady pressure distribution on select subcomponents
  - Cp'_{rms} value from nine surface sensors (400Hz – 10 kHz integration)
  - Surface pressure spectra
  - Velocity profiles at select locations
  - Farfield noise at few microphone locations in flyover direction



Comparison Summary

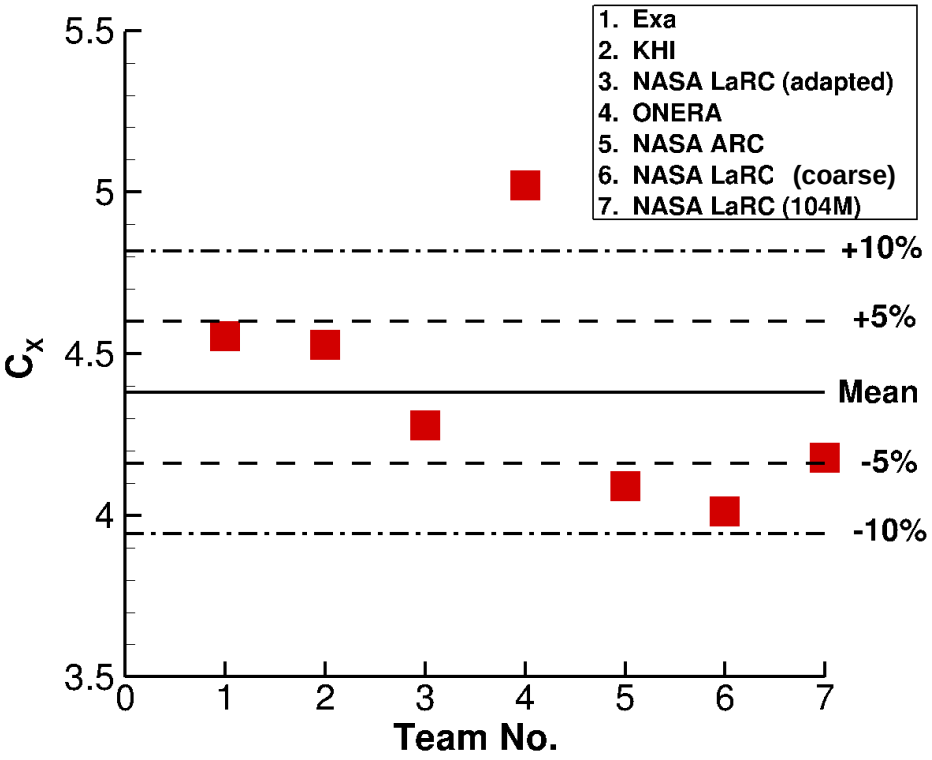
- **Five independent groups (teams) provided results**
- **Seven distinct datasets (five new) used in comparison**
  - Force coefficients in X and Z directions
  - Cp' rms values for nine sensor locations
  - Surface pressure spectra at nine sensors
  - Farfield noise at five microphone locations in flyover direction
- **Comparison of line profiles not performed**

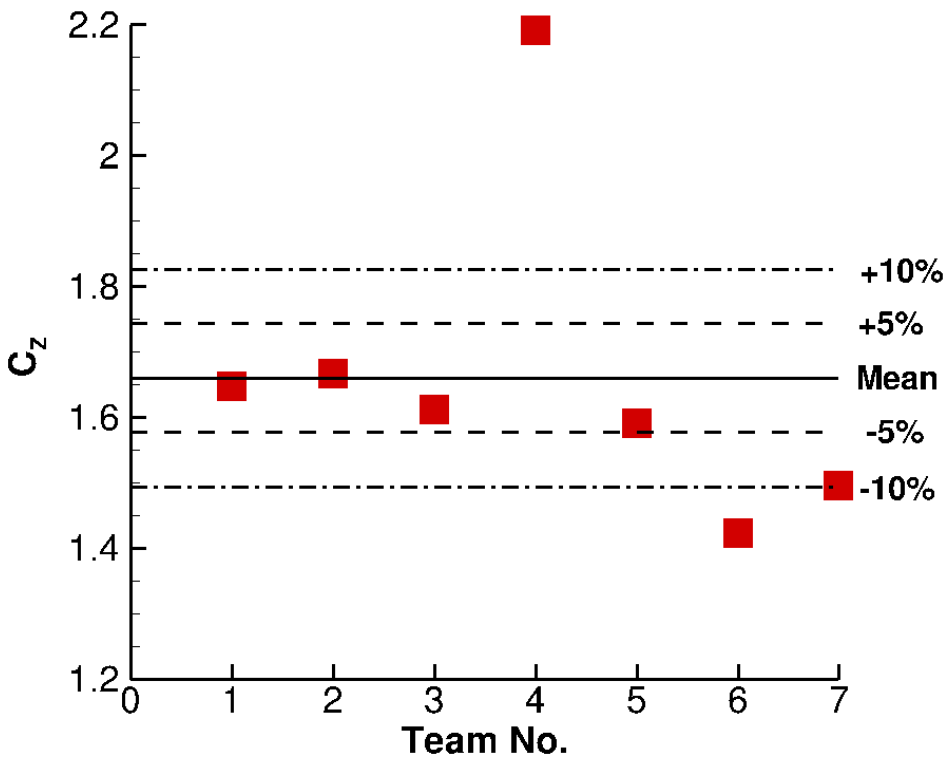
Contributions to PDCC-NLG

Entity	Solver Attributes			Solution Attributes			
	Name	Type	Numerical Scheme	Turbulence Model	Grid element count	Δt Sim. time*	Cores/ physical time
EXA	PowerFLOW	LBM Structured	D3Q19 LBM	LBM-VLES/ RNG k-ε+swirl	369.2M voxels 30M surfels	0.1604 μs 0.024s/0.2s	576/8 days
KHI	Cflow	Comp. N-S Unstructured hybrid+AMR	2nd order 2nd order	DDES/ S-A	36.5M cells 635K surf. elem.	2.94 μs 0.206s	128/29 days
NASA LaRC (adapted)	FUN3D	URANS Unstructured mixed element	2nd order 2nd order	MDDES/ S-A	58M cells 1.0M surf. elem.	4.92 μs 0.148s/0.30s	
ONERA	CEDRE	Comp. N-S Unstructured	2nd order Implicit 1st order	ZDES/ k-ω SST	70M cells 850K surf. elem.	1.0 μs 0.06s/0.102s	480/18 days
NASA ARC	LAVA	URANS Structured/ unstructured	2nd order 2nd order	DDES/ S-A			
NASA LaRC (Coarse**)	FUN3D	URANS Unstructured mixed element	2nd order 2nd order	MDDES/ S-A	24M cells 1.1M surf. elem.	4.92 μs 0.148s/0.30s	
NASA LaRC (104M)	FUN3D	URANS Unstructured mixed element	2nd order 2nd order	MDDES/ S-A	104M cells 2.7M surf. elem.	4.92 μs 0.148s/0.30s	

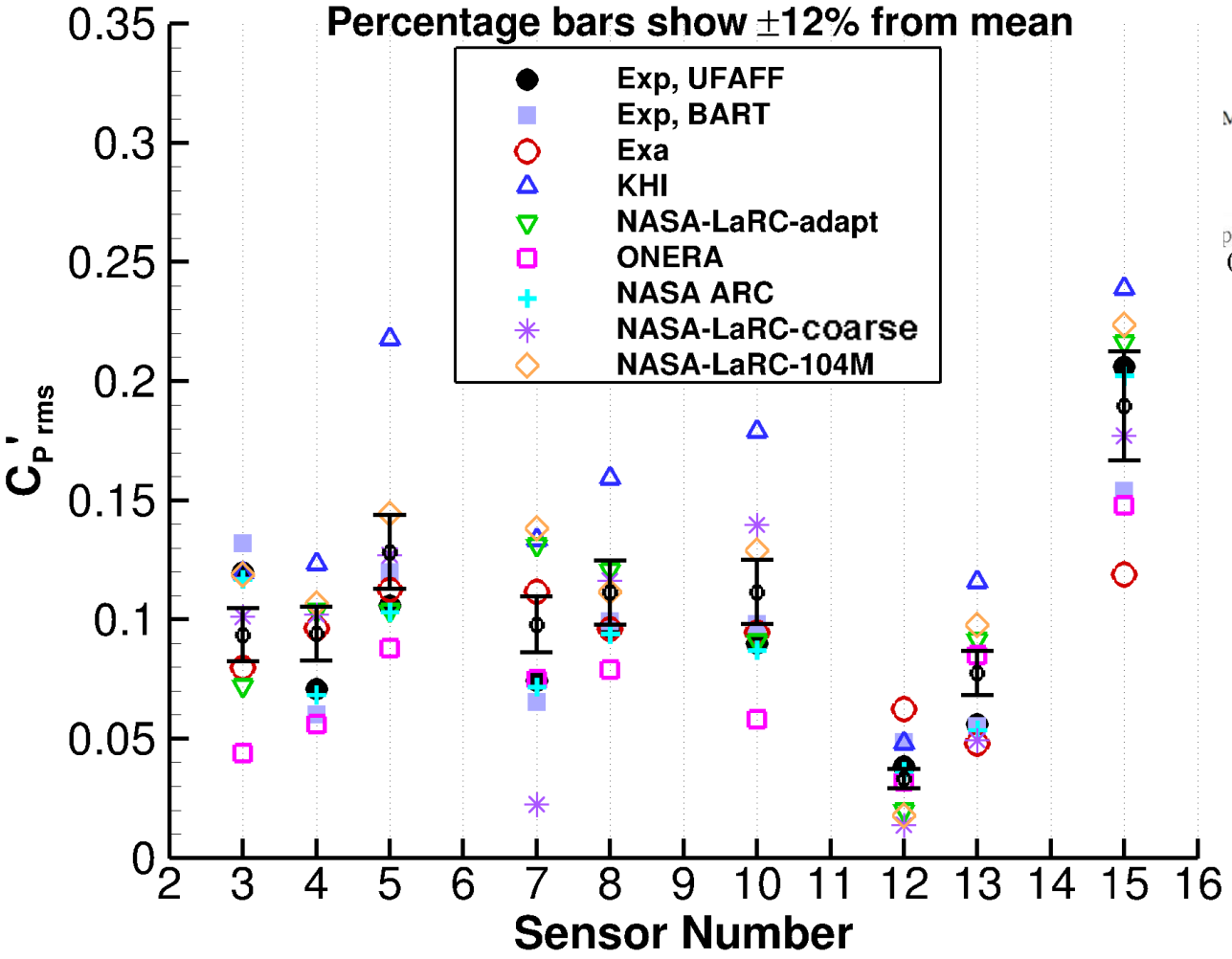
* Transient/sampling
** Initial effort

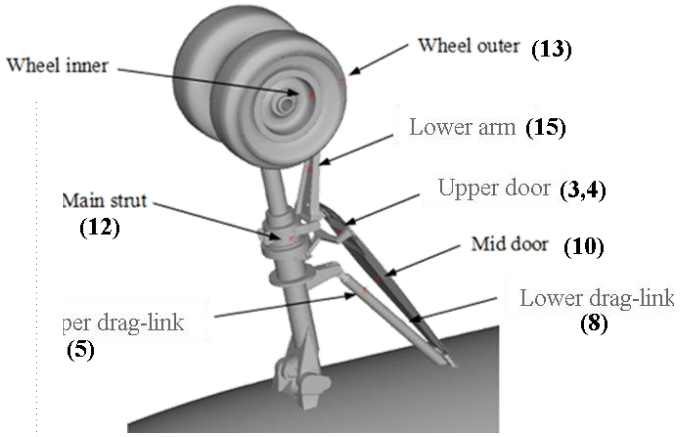
Integrated Forces (Coefficients)



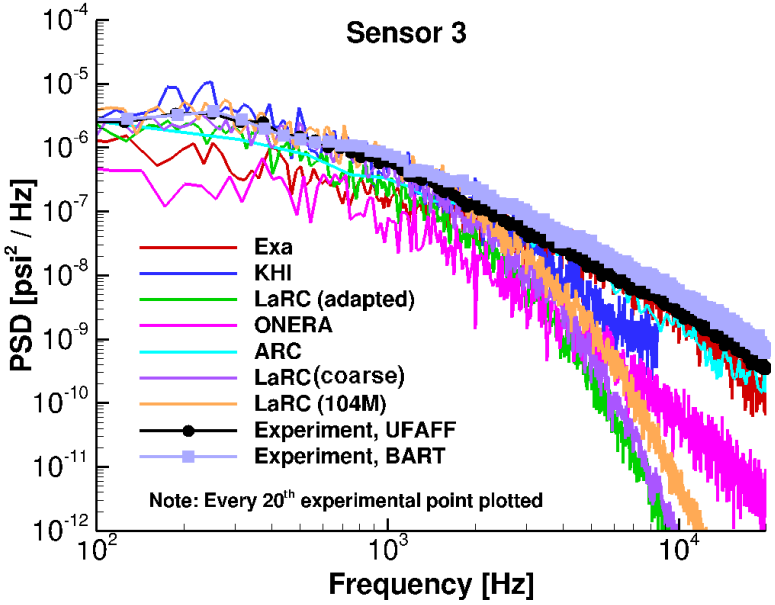


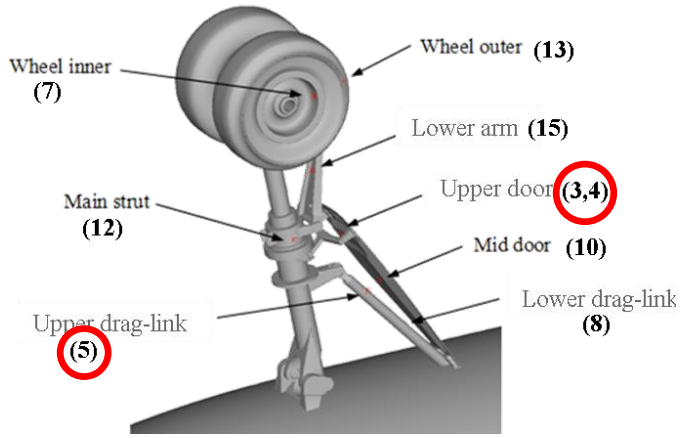
RMS Pressure Levels at Sensor Locations

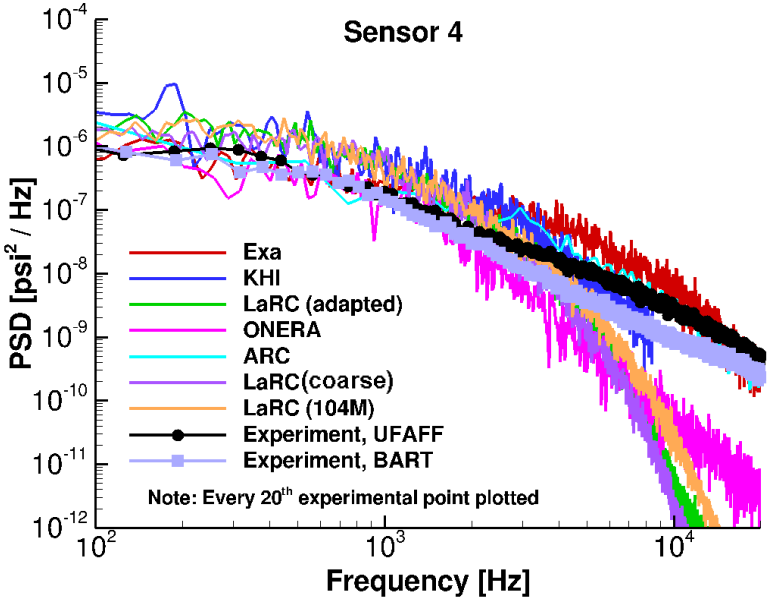


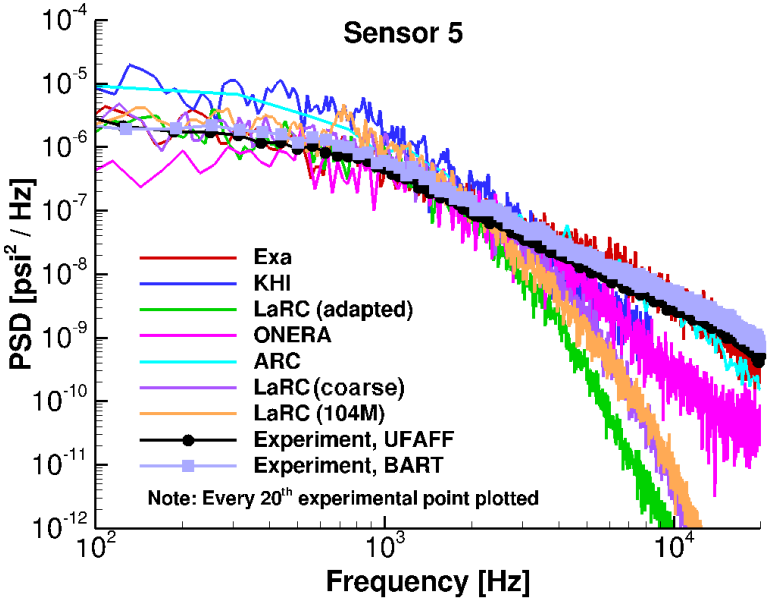


Surface Pressure Spectra at Sensor Locations









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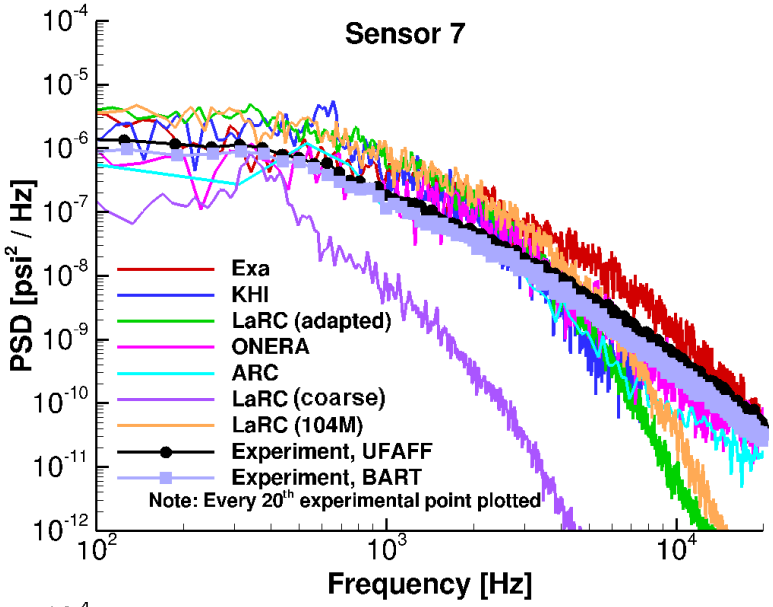

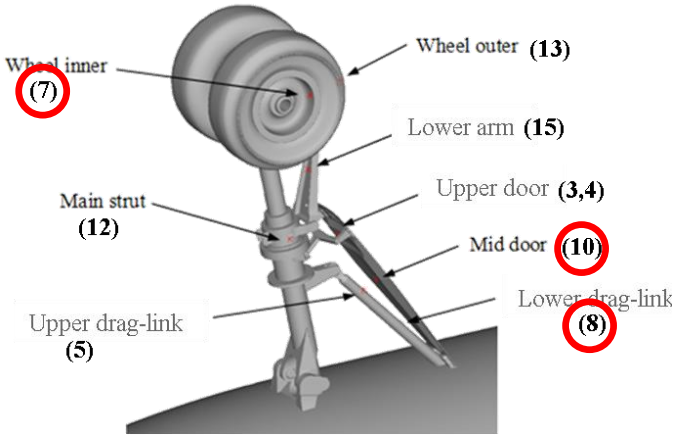

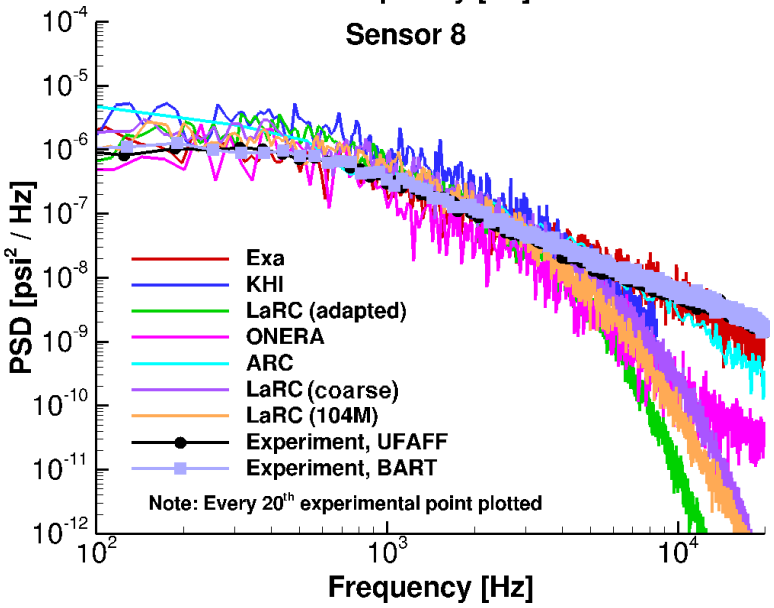

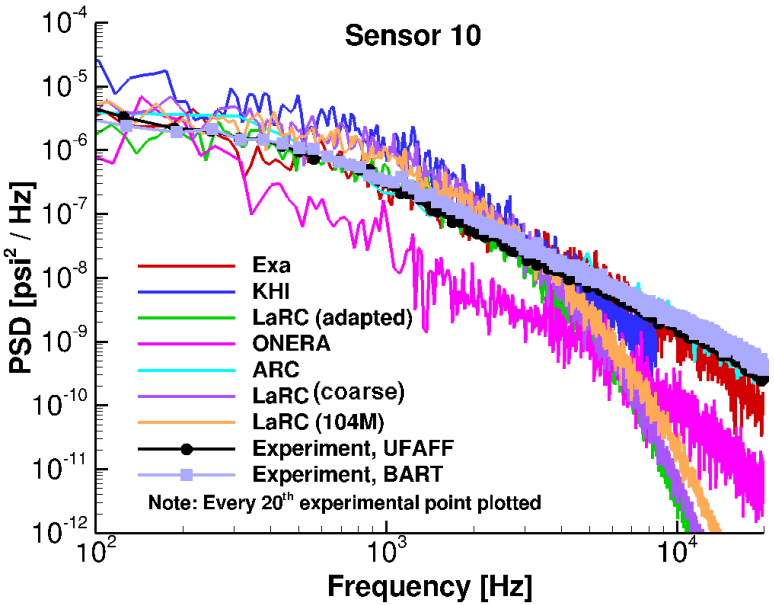

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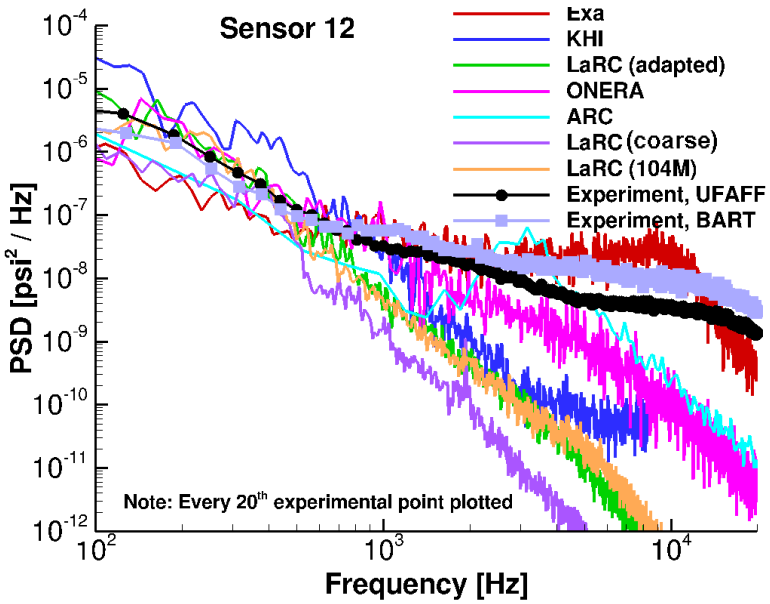
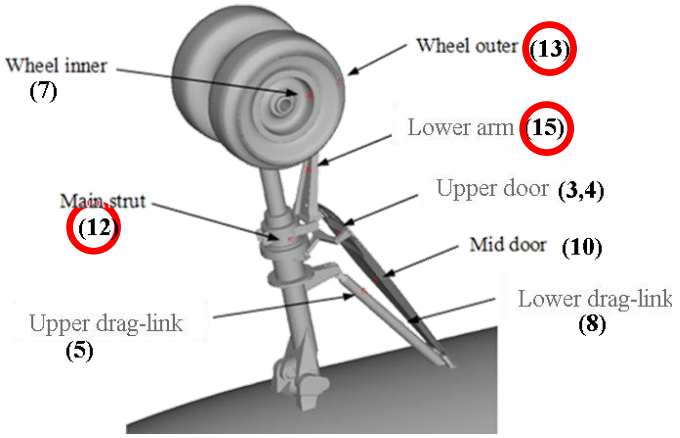
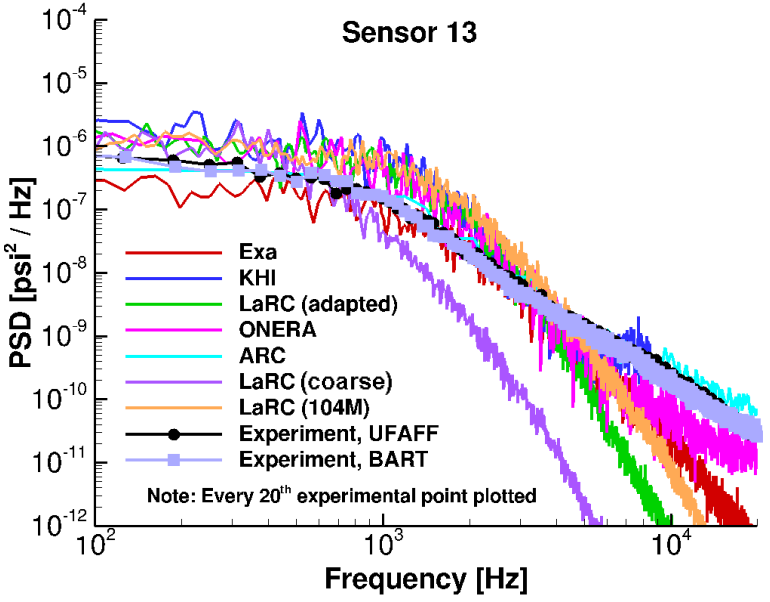
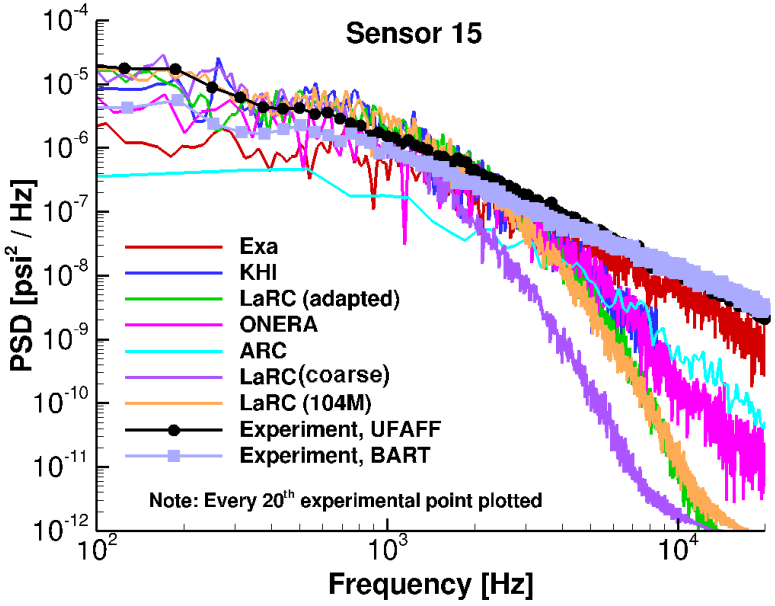
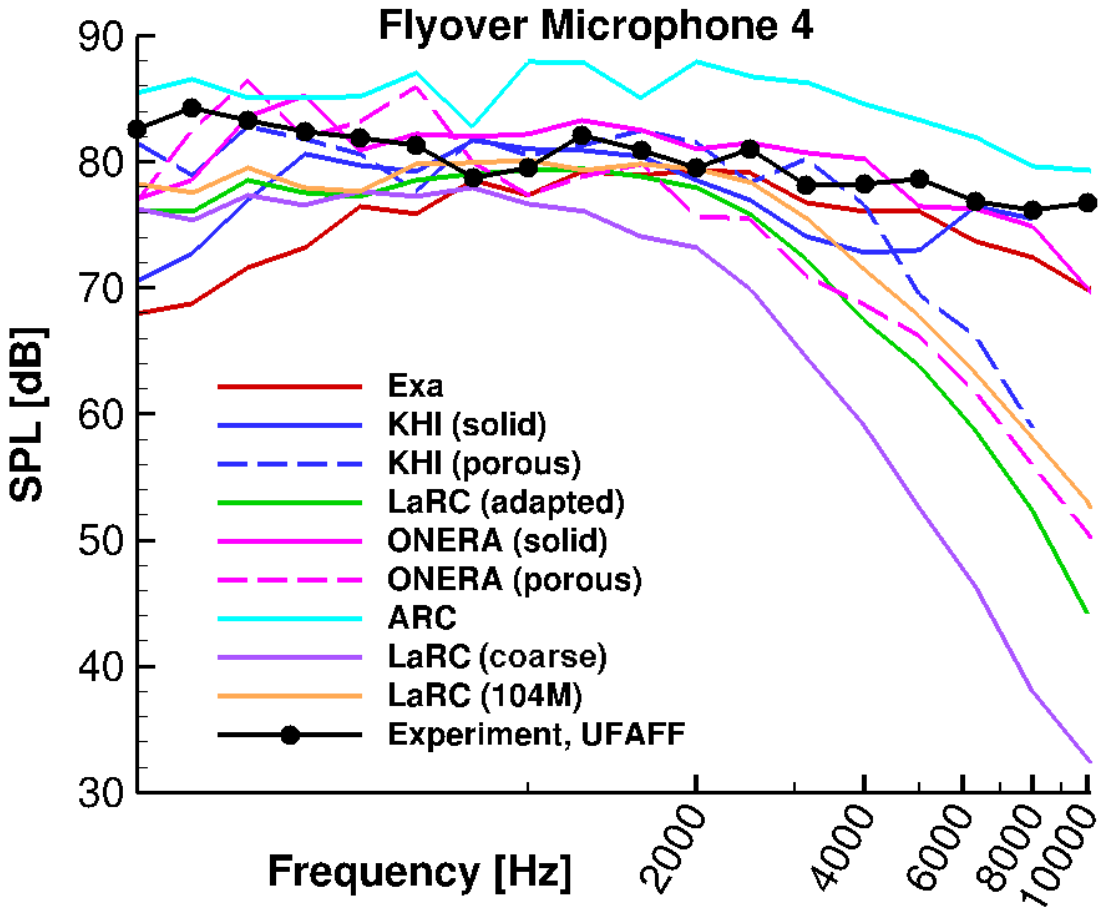


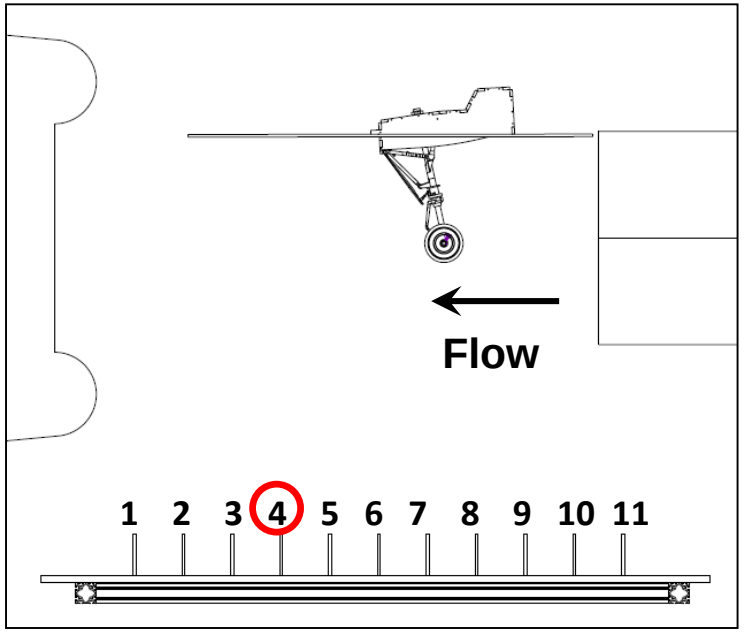






Farfield Noise Comparison





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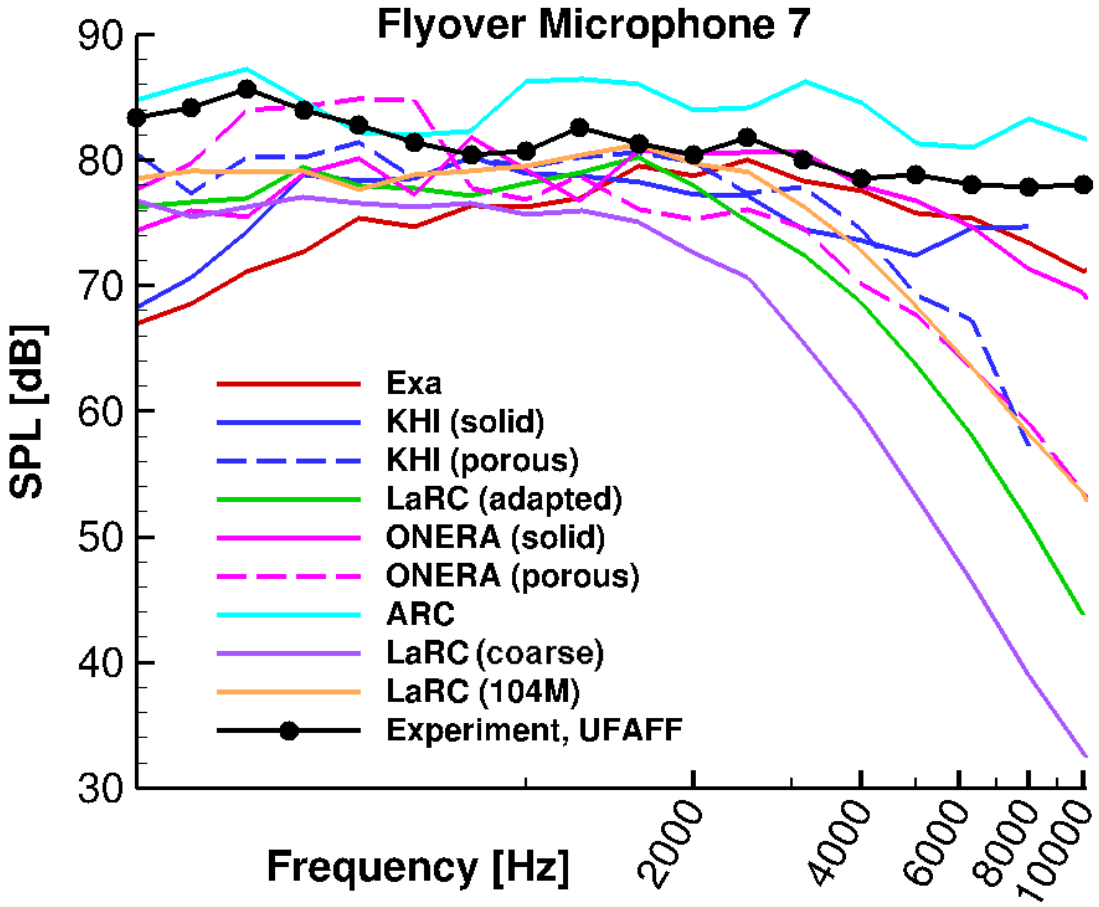
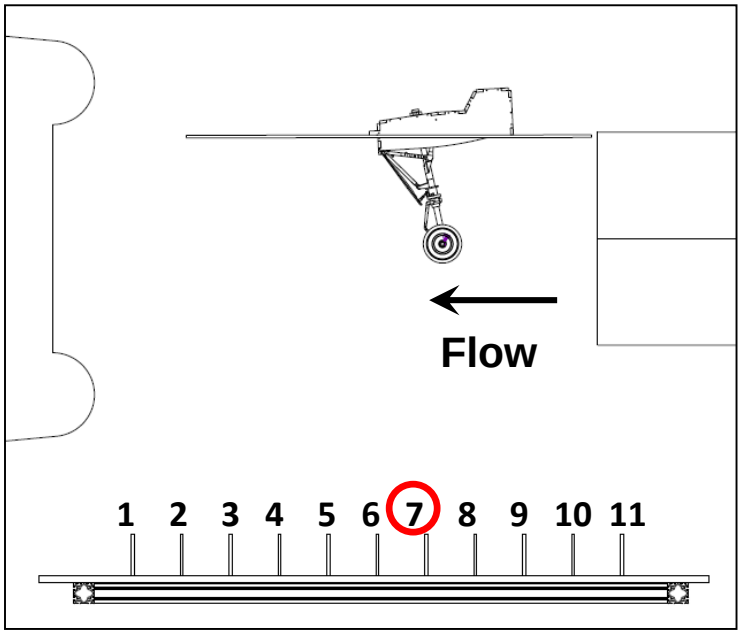


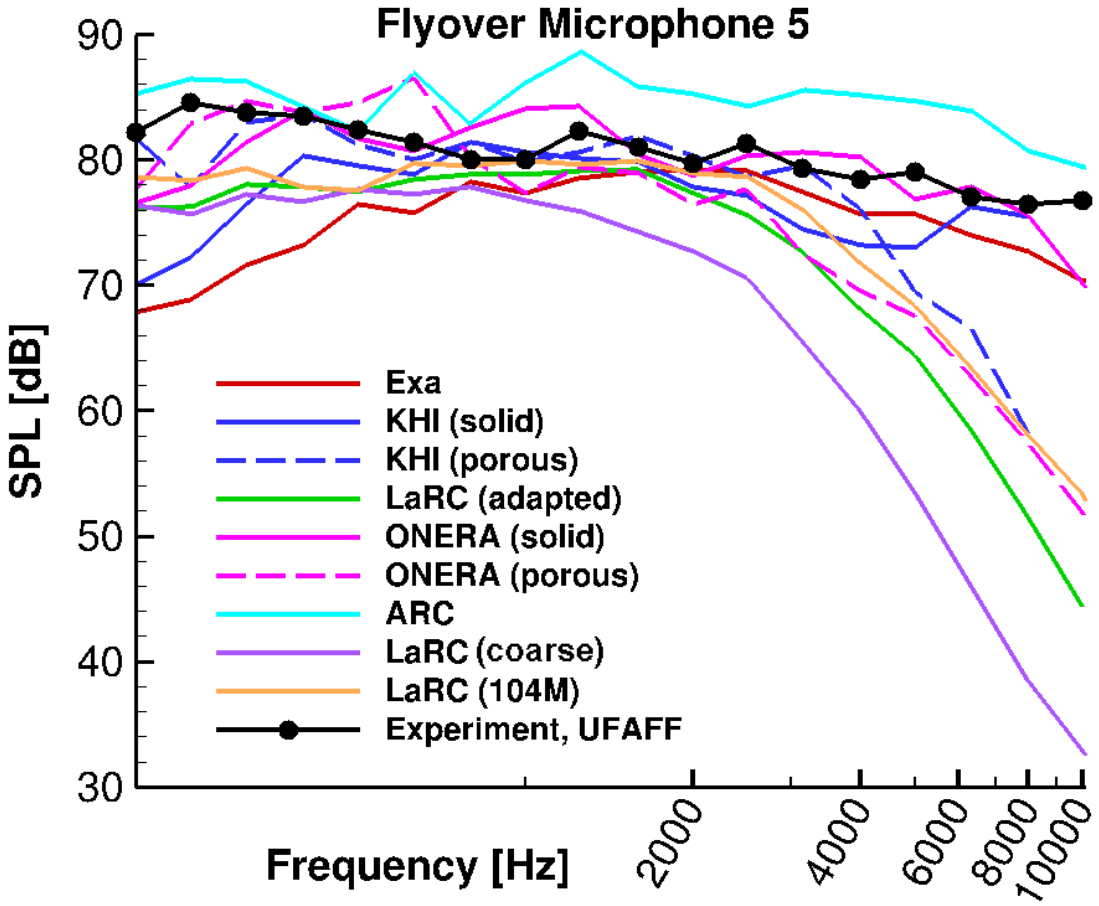


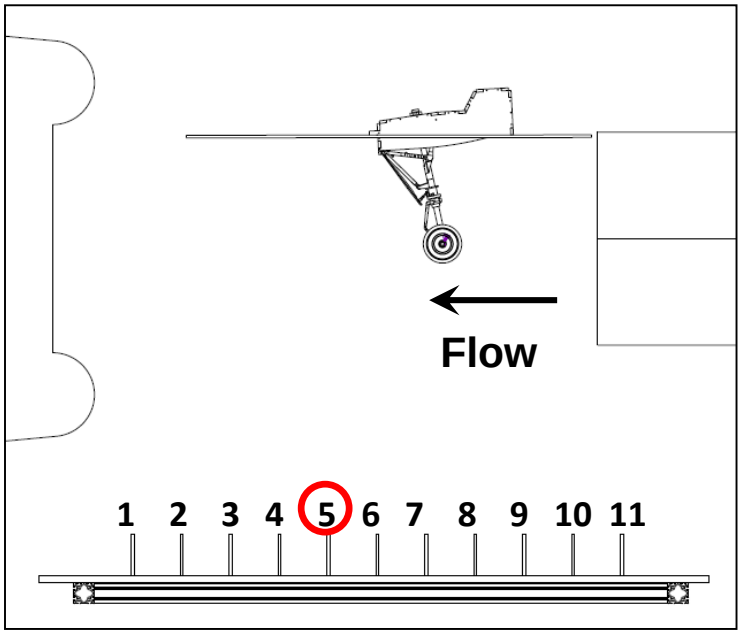
Summary

- Code-to-code comparison of force coefficients showed relatively consistent trends and levels
- Significant variation in computed Cp'rms values was observed among flow solvers and relative to measured values
- Some Cp'rms values seemed to be inconsistent with associated spectra
- Computations attempted to capture high-frequency behavior
- Farfield noise comparison showed fair agreement
- Computed farfield noise requires further scrutiny

Backup Slides

Farfield Noise Comparison





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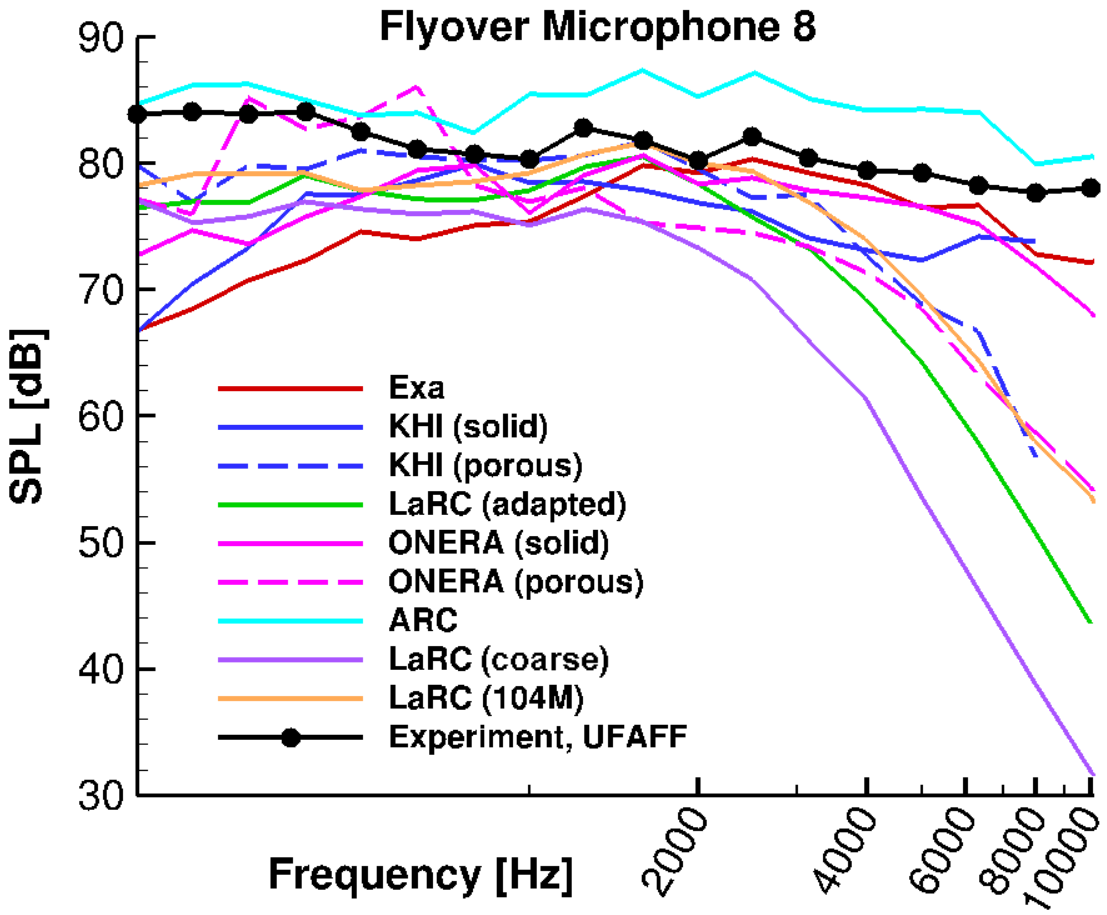

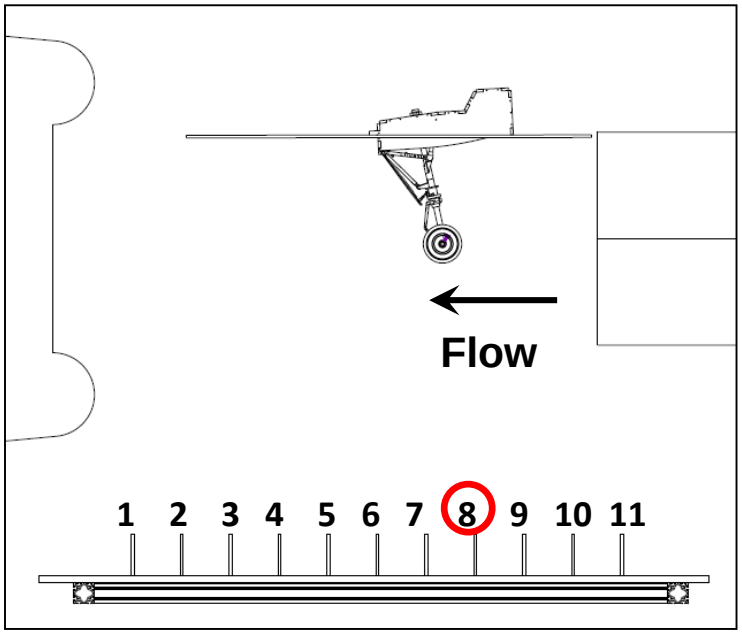

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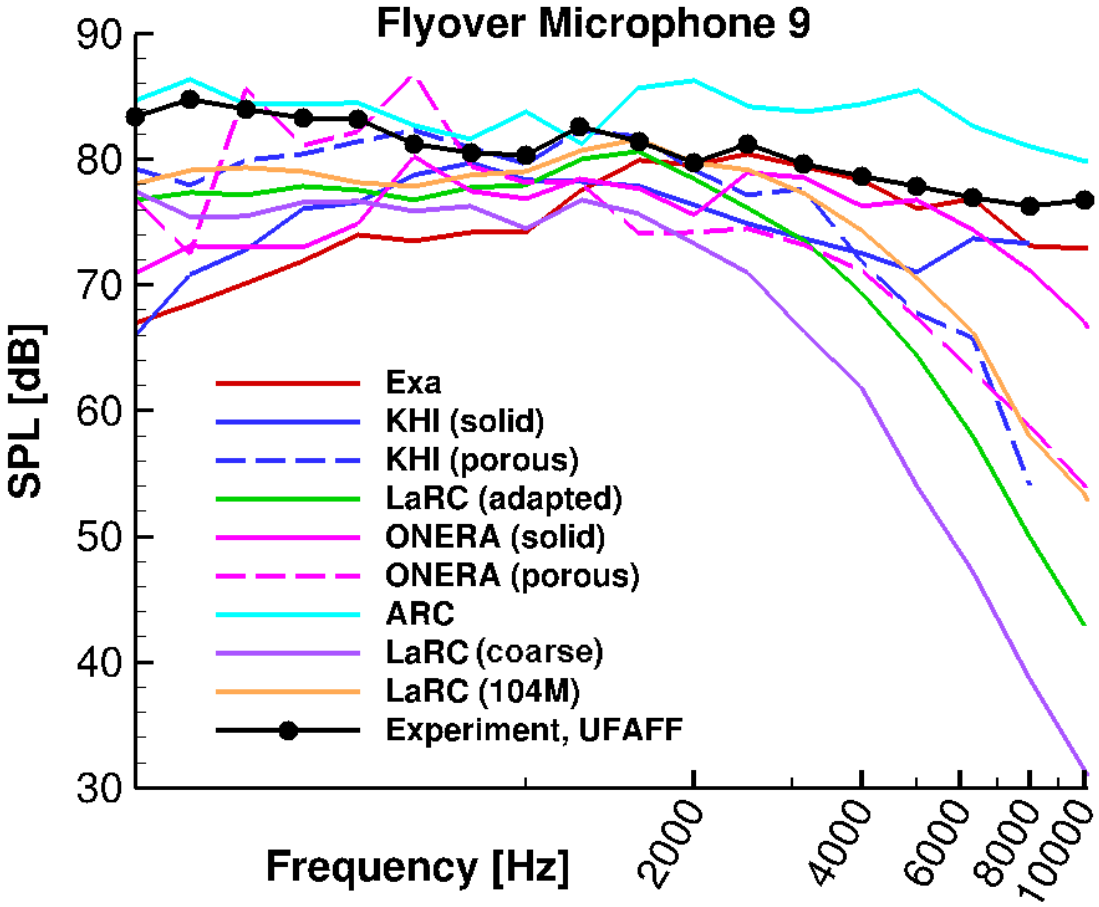

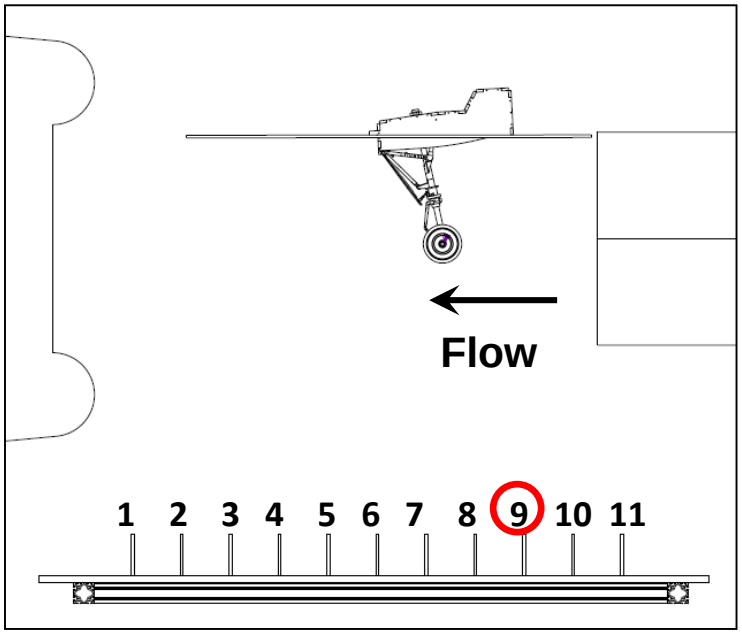

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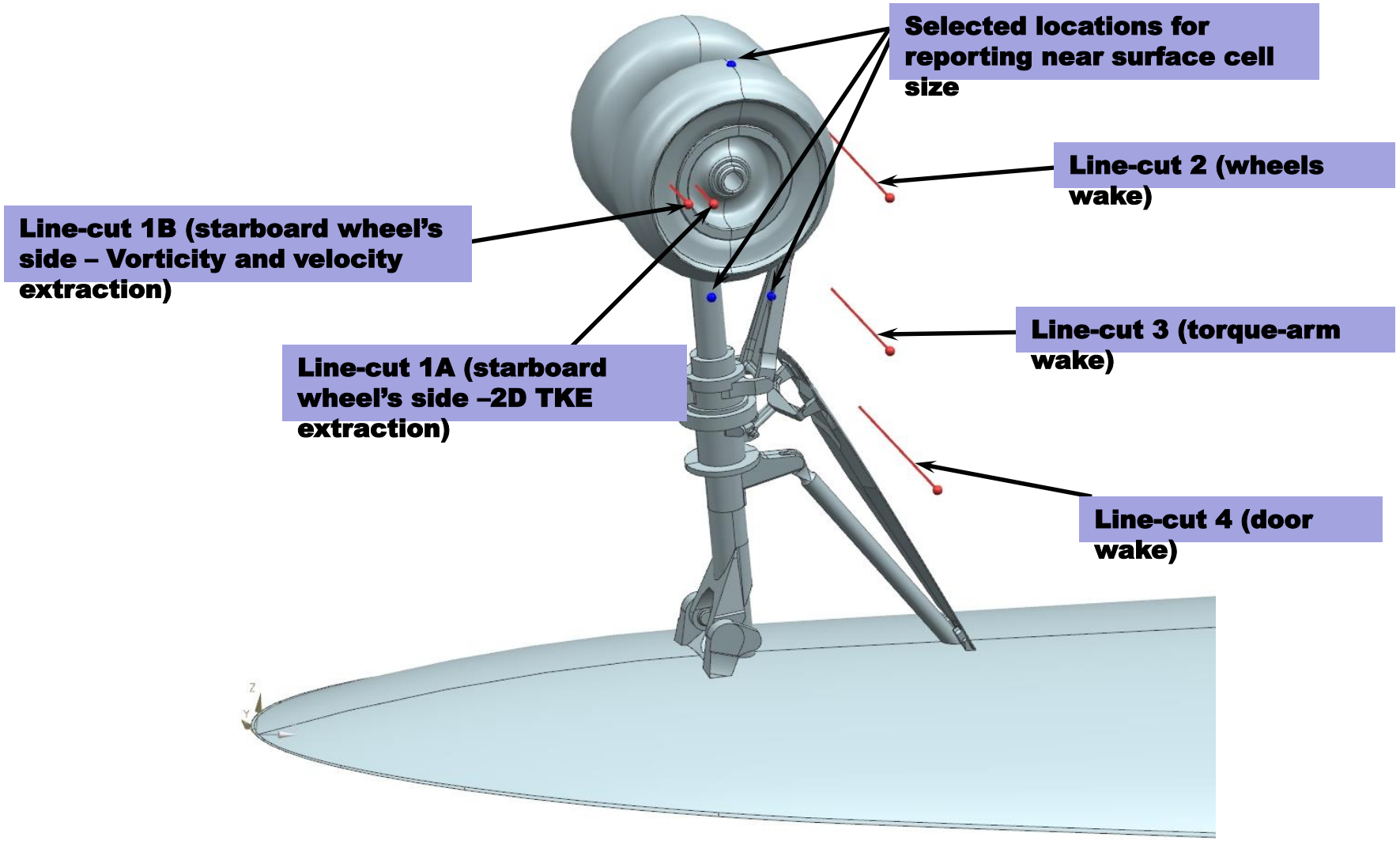
** Initial effort

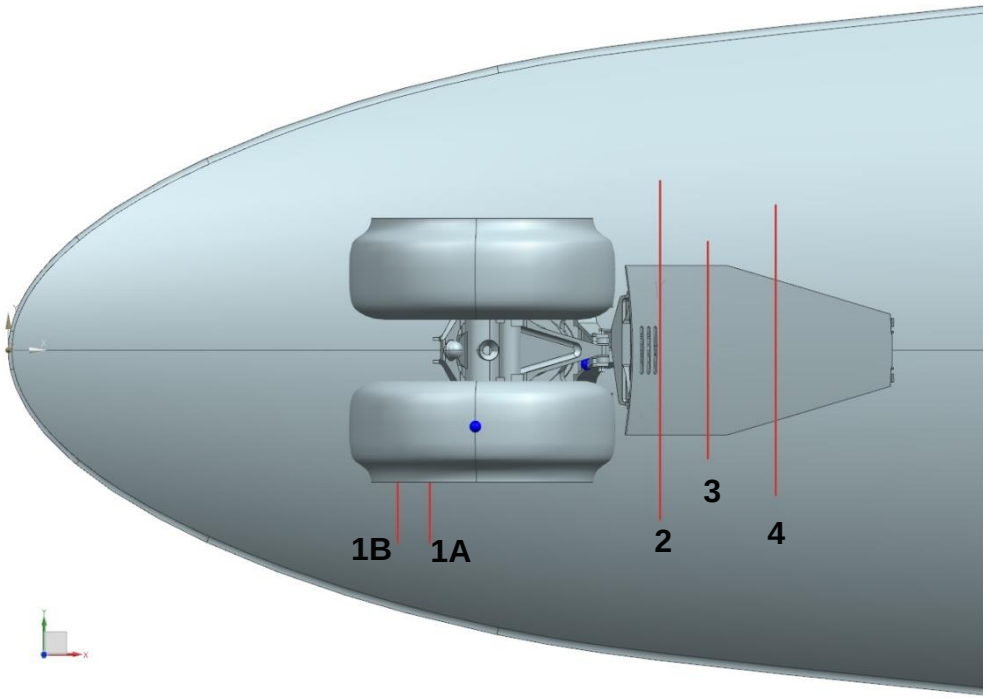
Line Cut Locations

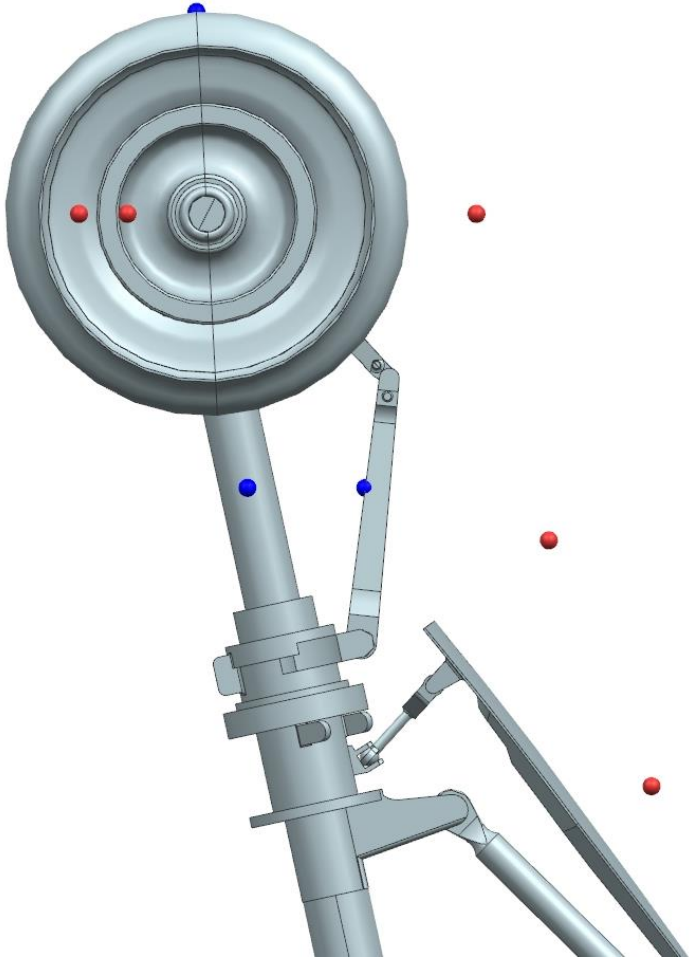


Note: red dots indicate the starting point of the line-cuts

Line Cut Locations

- **Blue spheres correspond to selected locations for reporting near surface cell size**
- **Red spheres and lines highlight location and orientation of the line cuts**





Extracted Flow Quantities

Line-cut 2 (wheels wake)