Partially-Dressed Cavity-Closed Nose Landing Gear (PDCC-NLG) Problem

Experiment Description and Results

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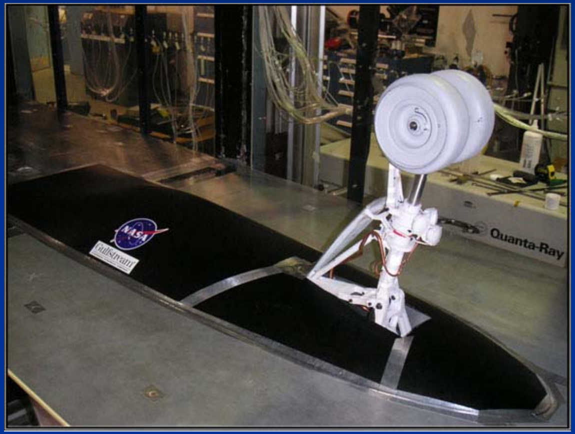
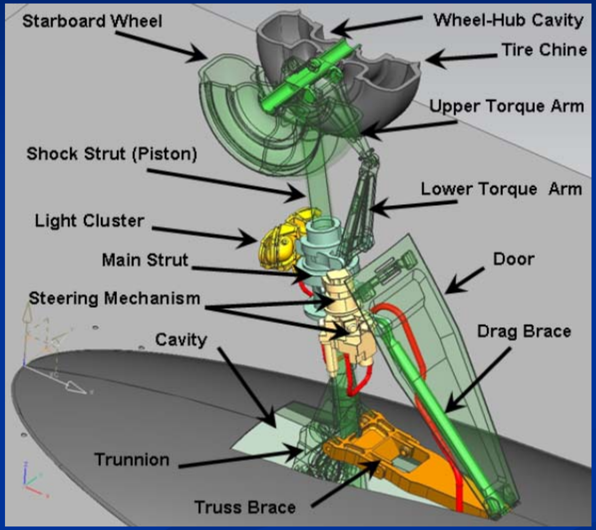
This talk describes the nose landing gear experiments in BART

Background

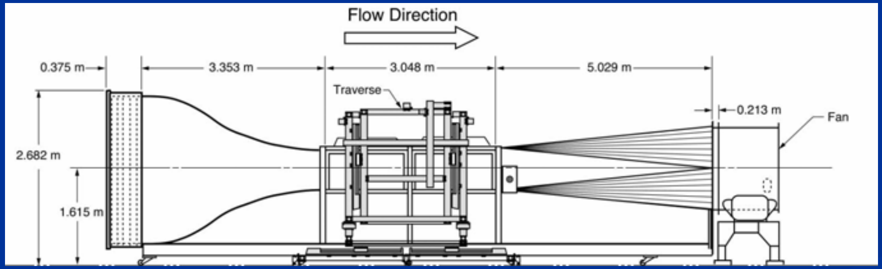


Model

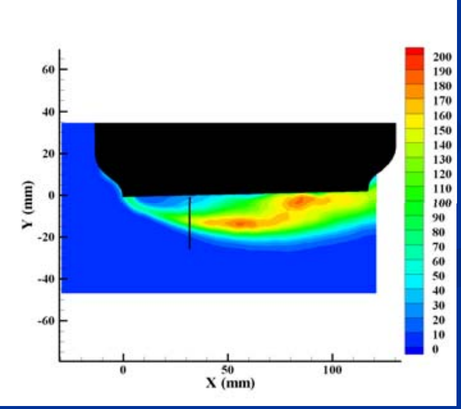


Experiments

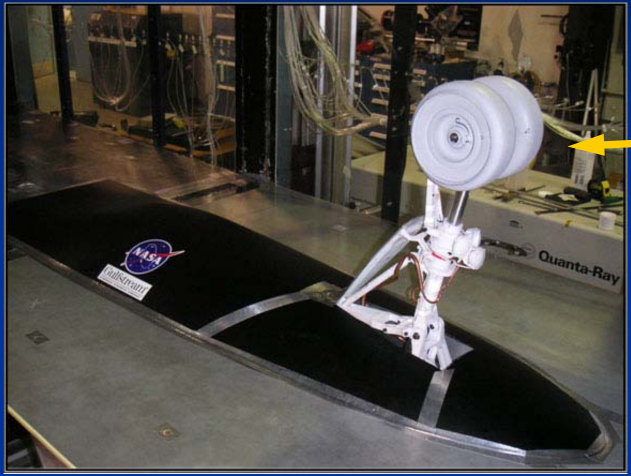
Facility



Data



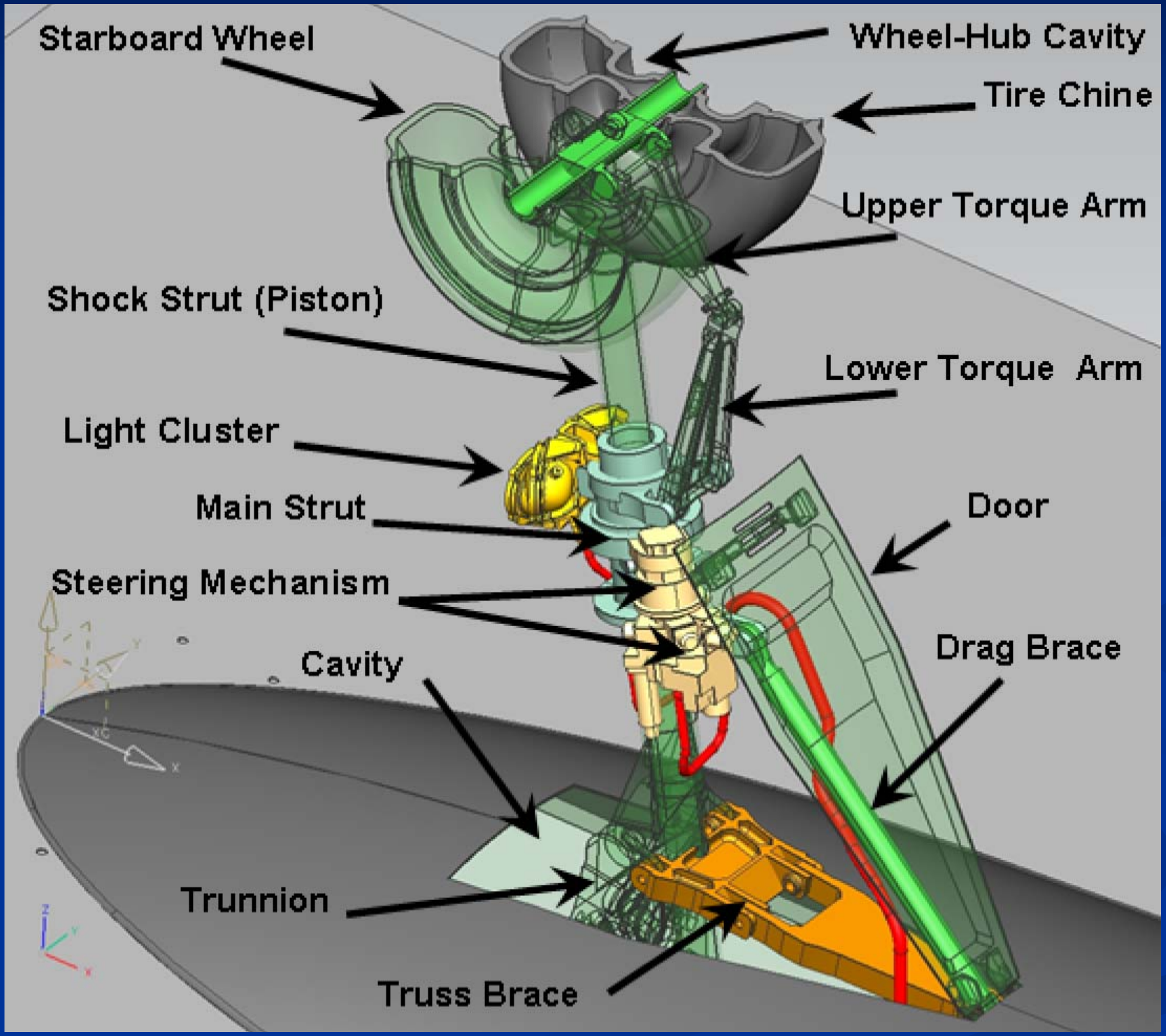
The experimental model was derived from a high-fidelity model of the Gulfstream G550 aircraft NLG



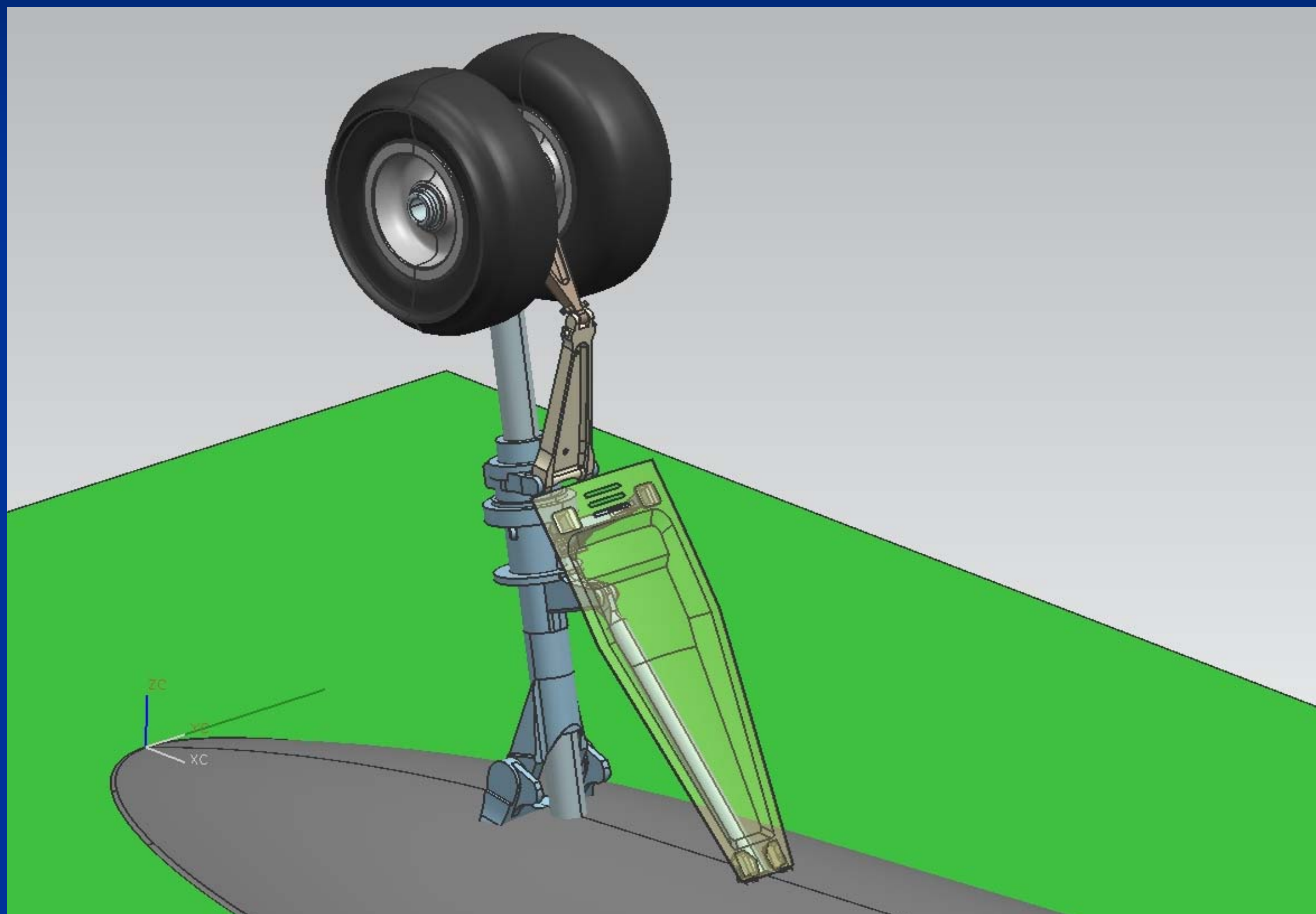
- High-Fidelity, 25% Scale
- Cavity, Lower Fuselage Section
- 16 Dynamic Pressure Transducers (1 Roving/Mobile)
- 120+ Static Pressure Ports
- PDCC => remove…..
  - Hydraulic Lines
  - Steering Mechanism
  - Light Cluster
  - Seal Gear Cavity
  - All Above ⇨ Partially dressed model (simplified gear)

Baseline open geometry configuration for benchmarking aeroacoustic simulations

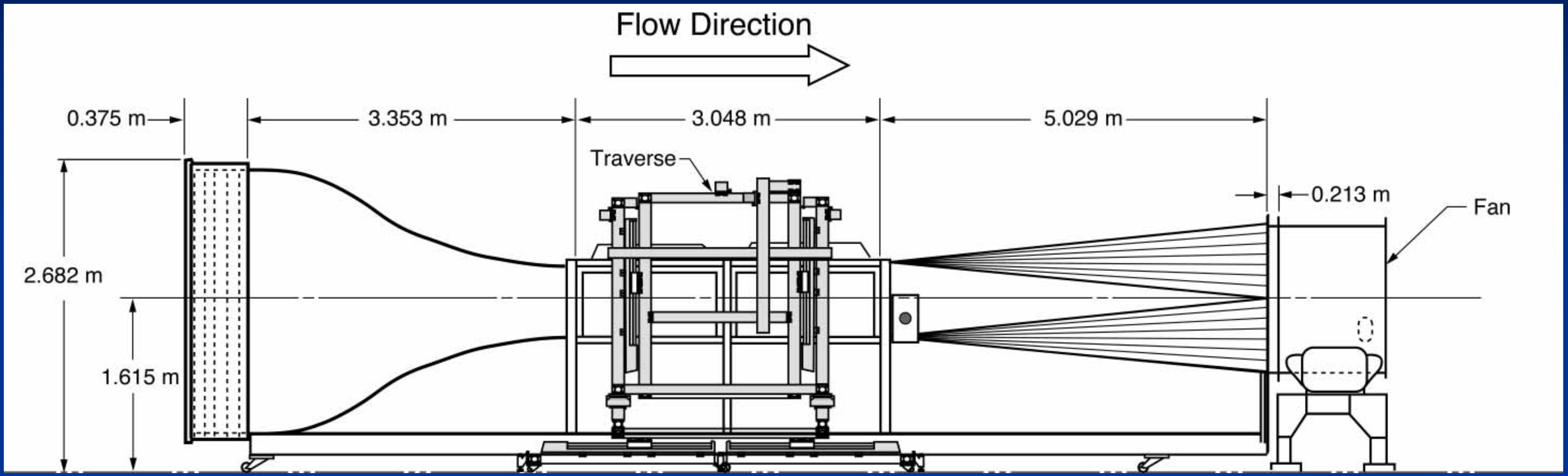
The model component details



Removal of select components produces the PDCC-NLG configuration



The Basic Aerodynamics Research Tunnel (BART) is where the NLG was tested



BART Specifications

Test section: 0.711m x 1.016m x 3.028m

Test Conditions

Velocity: 56.6 m/s

Re/m: 3.832×10^6 ($Re_D = 73{,}000$)

Mach No: 0.166

Turbulence Intensity: 0.077%

$\delta = 0.61''$ (1.55 cm), $\delta^* = 0.086''$ (0.22 cm)

The experimental data in the problem statement consists of steady and unsteady surface pressure and PIV

Steady surface pressures -

Port wheel – two radial rows

Starboard wheel – one circumferential row

Door – five spanwise rows

Fuselage – one streamwise and two spanwise rows

Fluctuating surface pressures -

P_{rms} and PSD – all ten fixed sensors

(mobile sensor at various gear locations can be made available)

p' time history -

- one on port wheel
- one on torque arm
- two on door

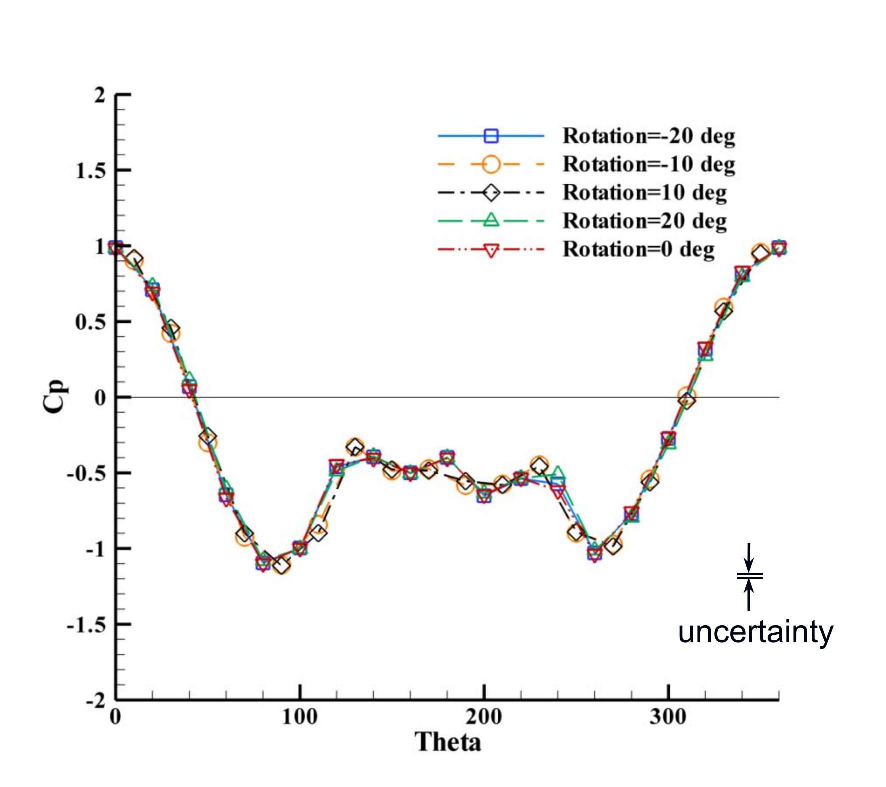
Planar PIV data – multiple planes around the model

The estimated experimental uncertainties are…….

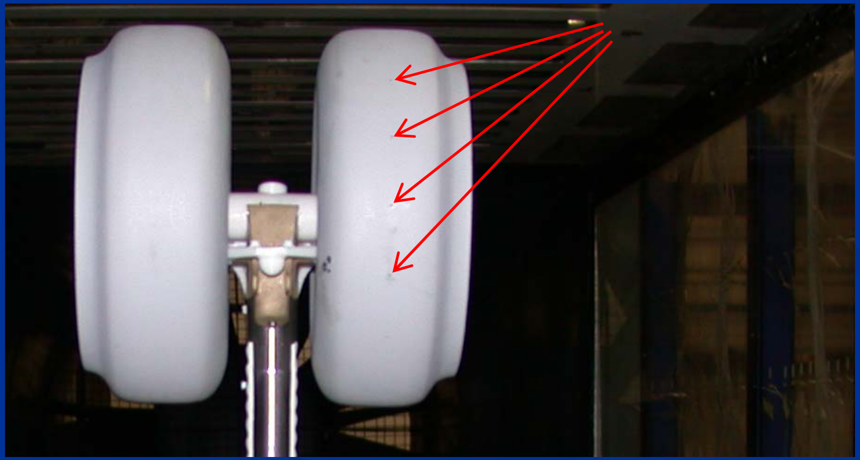
- Steady Cp ~ 0.02
- PIV*: Umean,Vmean ~ 1.4 m/s (2.5 % of U_{inf})
- PIV: Vorticity ~ 729/s
- PIV: TKE ~ 4%
- PSD ~ 10-14%
- Cp'_{rms} ~ 5-7%

* the uncertainty in PIV quantities is based on the system velocity resolution, which relates to the minimum displacement (velocity) the system can measure.

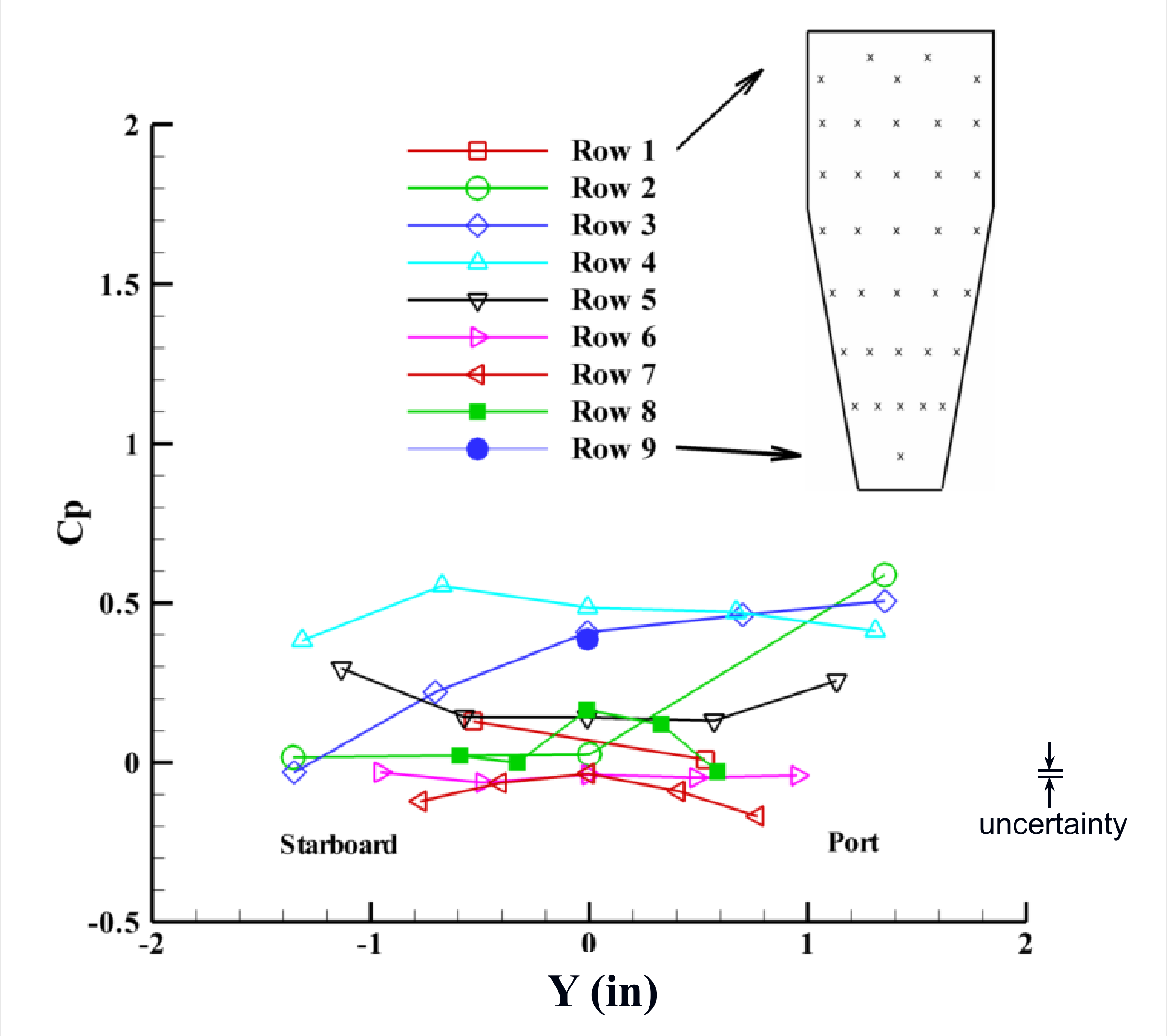
The steady Cp on the starboard wheel was invariant with rotation angle (M=0.166)



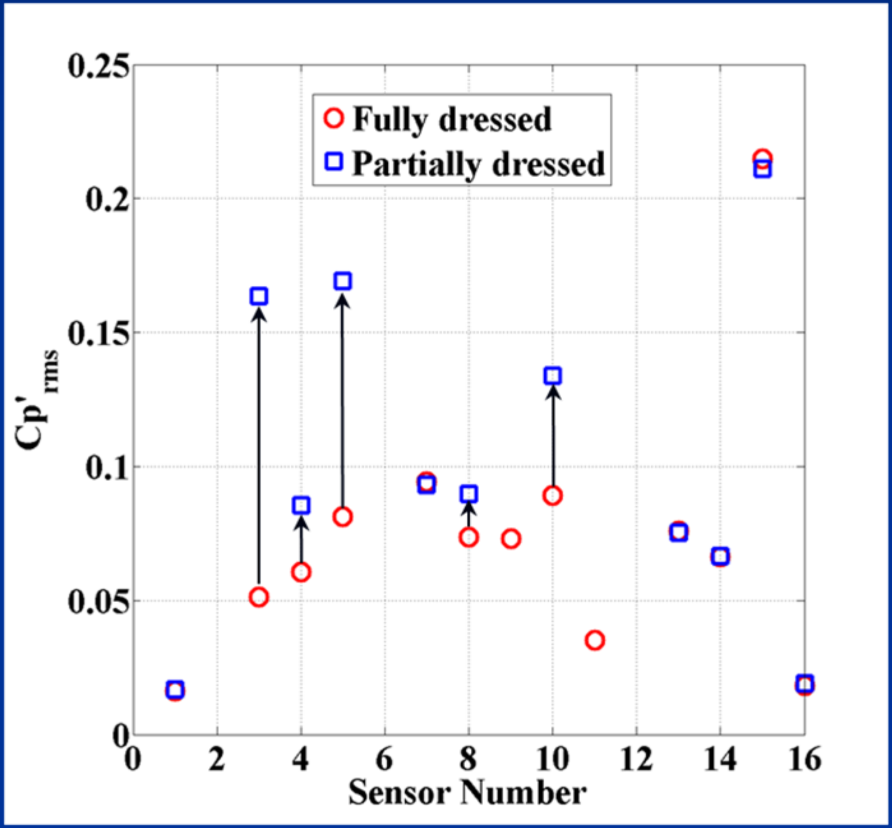
Steady pressure orifices spaced 20 deg

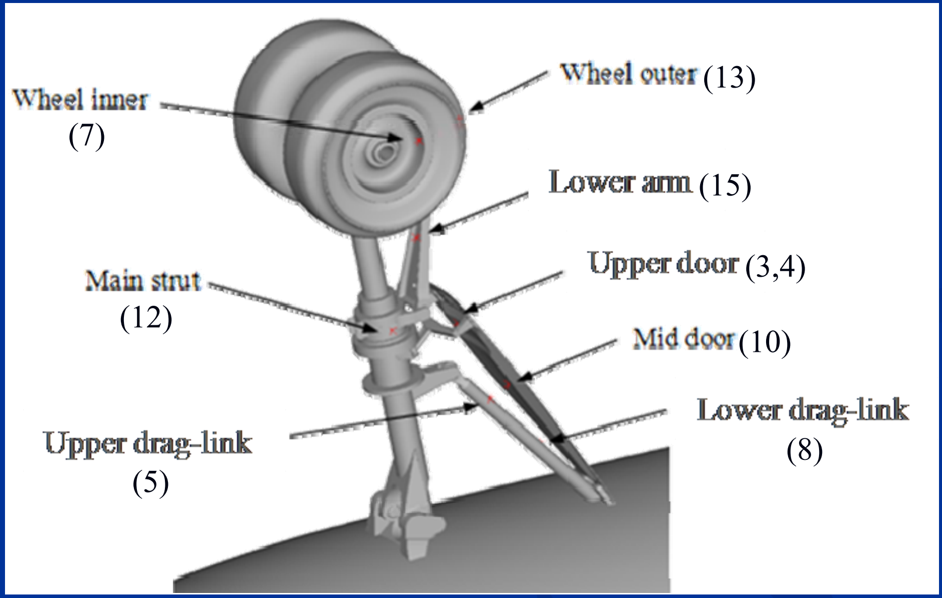


The steady Cp on the door showed mild variation spanwise



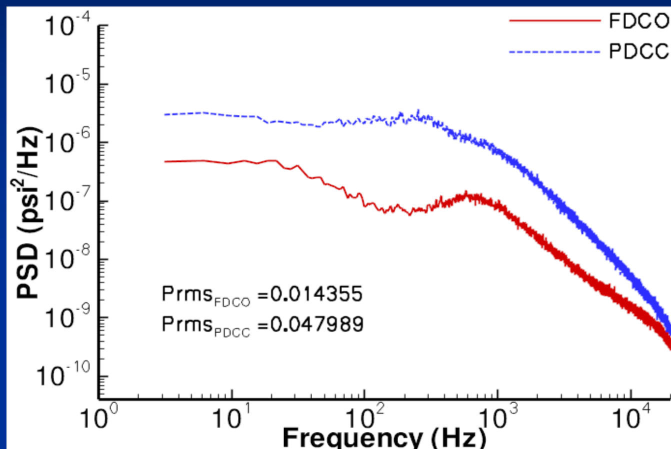
The removal of gear components shows the increase in coefficient of RMS Unsteady Pressure



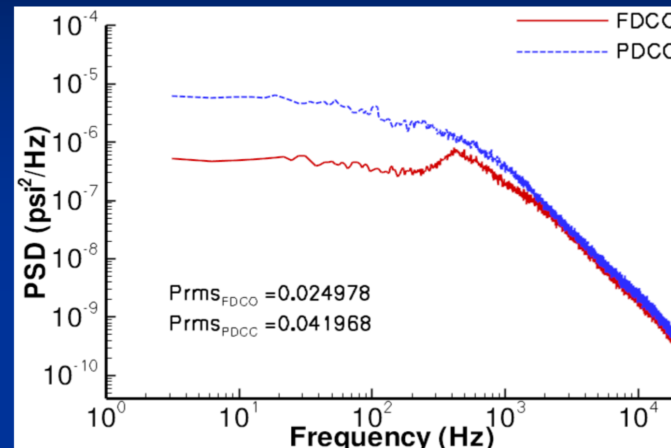


The effect of component removal on PSD is significant for areas of the model in the vicinity of the removed parts

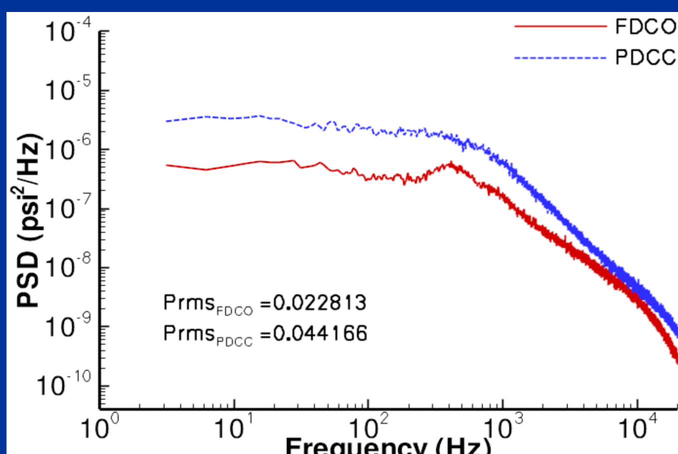
Upper sensor on door



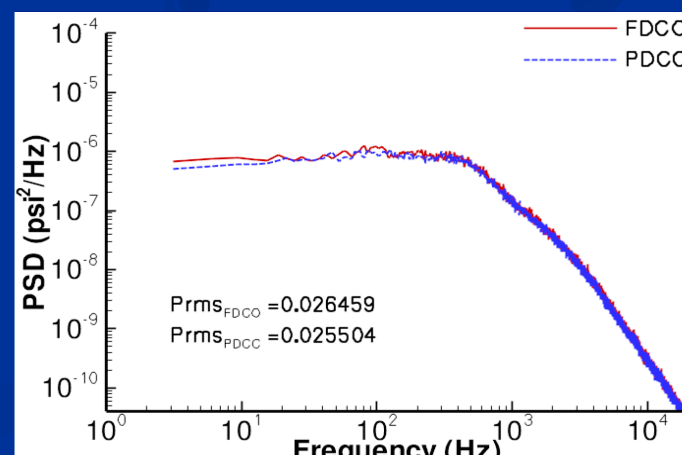
Lower sensor on door



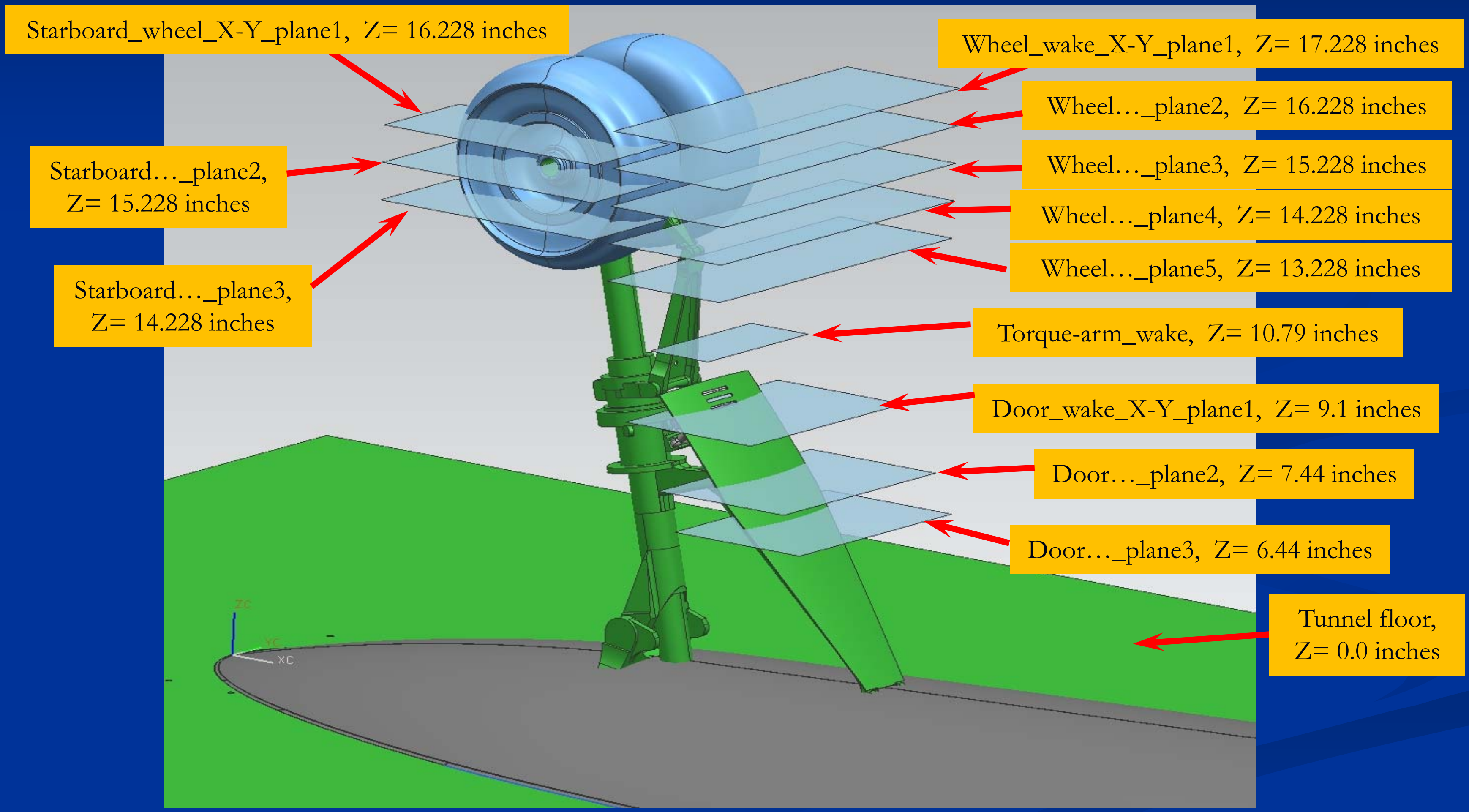
Upper sensor on drag brace



Sensor on back wall of wheel hub



The PIV laser light sheets are shown relative to the model



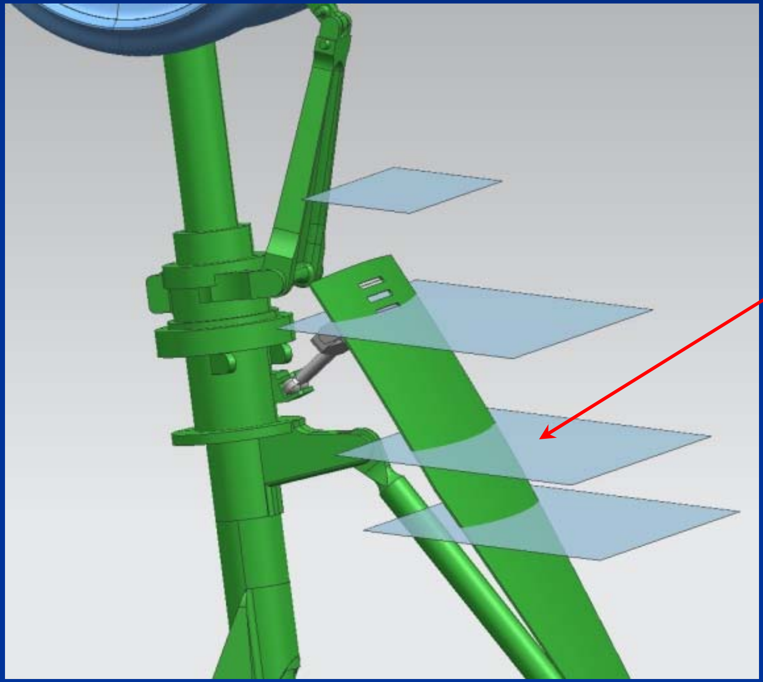
The details of the 2-D PIV system are………

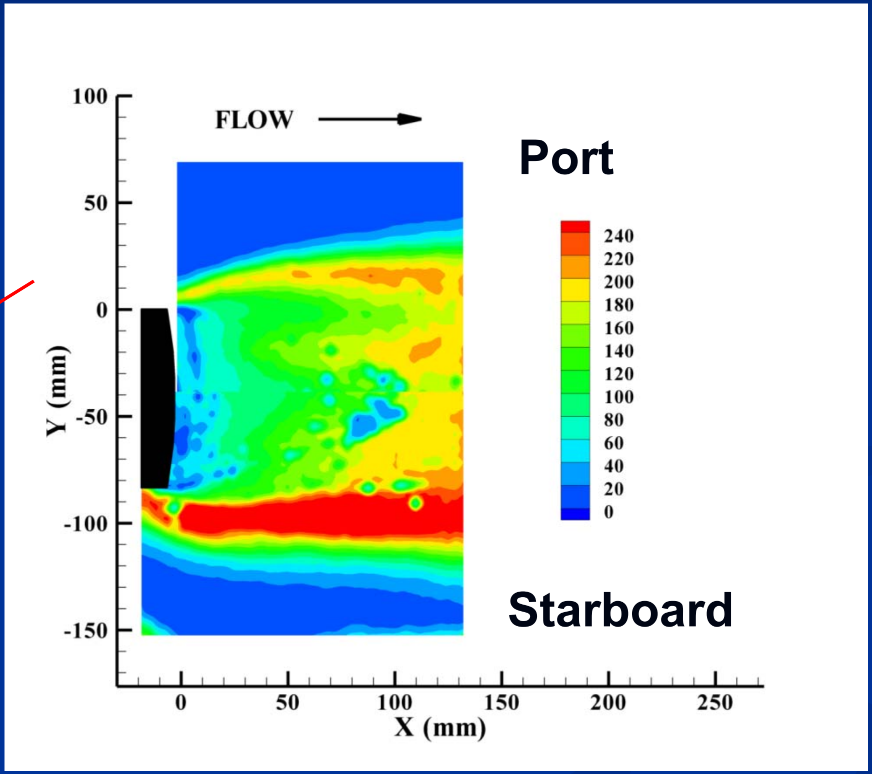
- Lightsheet thickness – 2 mm
- Dual, 220 mJ, Nd-YAG lasers
- Digital camera frame rate – 5 Hz
- Sensor size – 1360X1036 pixels
- Measurement volume –

  - 1.3 mm^2 (50 mm lens, 24X24 interrogation window)

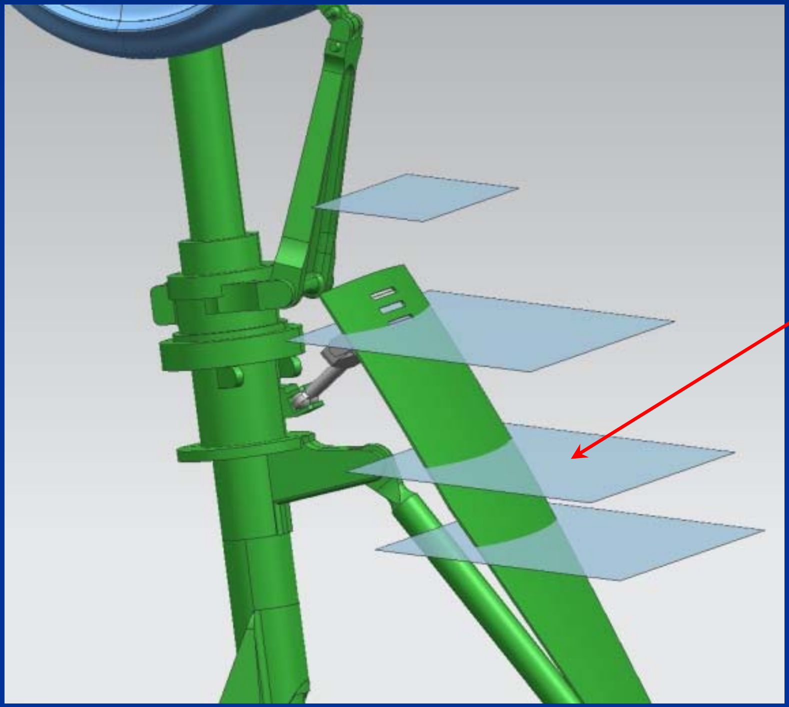
    (0.0175D)
- 50% interrogation window overlap
- Flow seeded by commercial fog generator
- 1000 image pairs per configuration

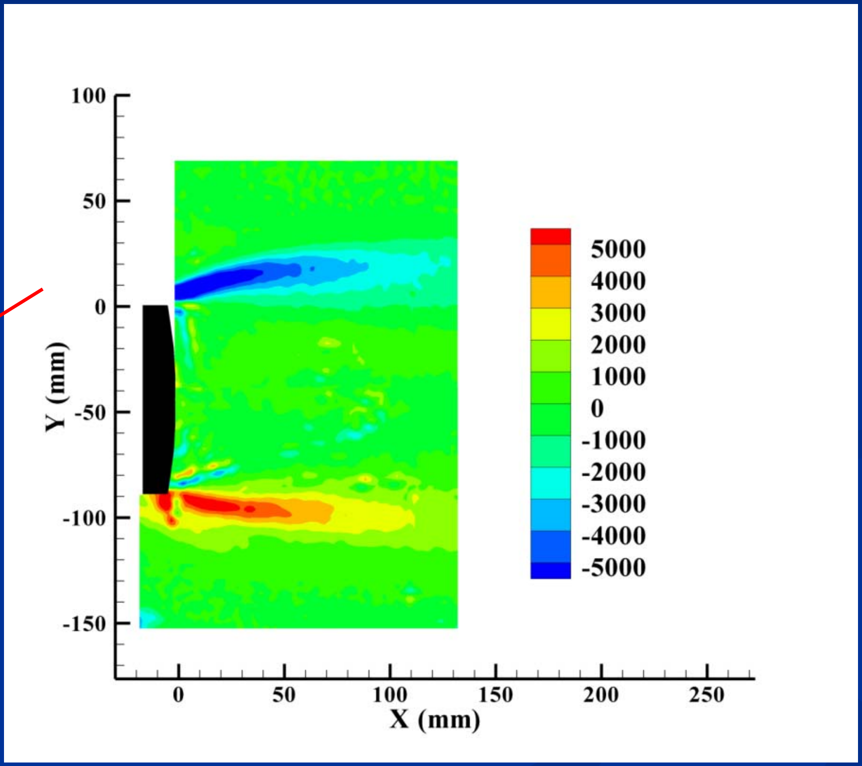
The TKE in plane 2 (behind door) shows the concentration of energy in the shear layers trailing downstream



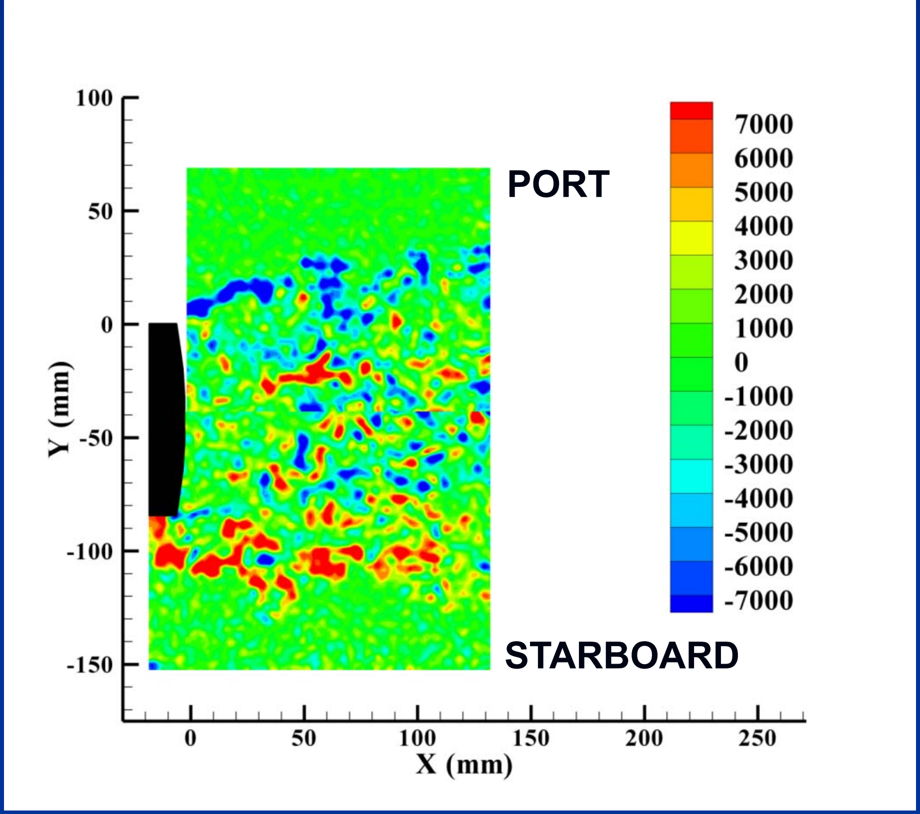


Plane 2 (behind door) shows the flow of out-of-plane vorticity around edges trailing downstream

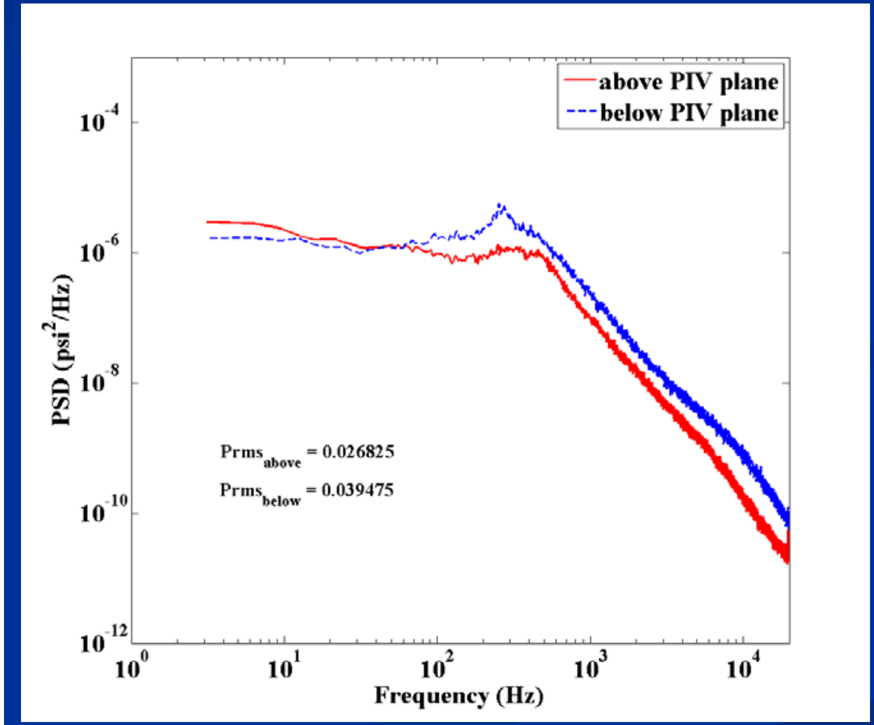




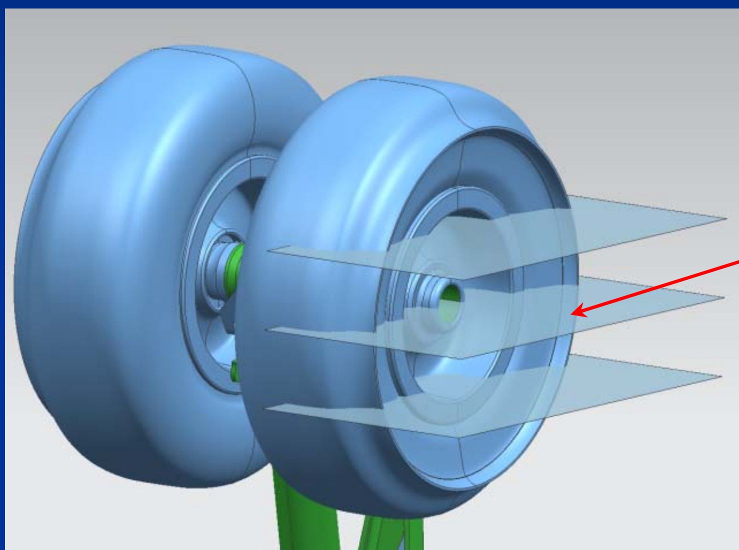
The instantaneous vorticity and PSD give no evidence of persistent, coherent structure shed downstream of door

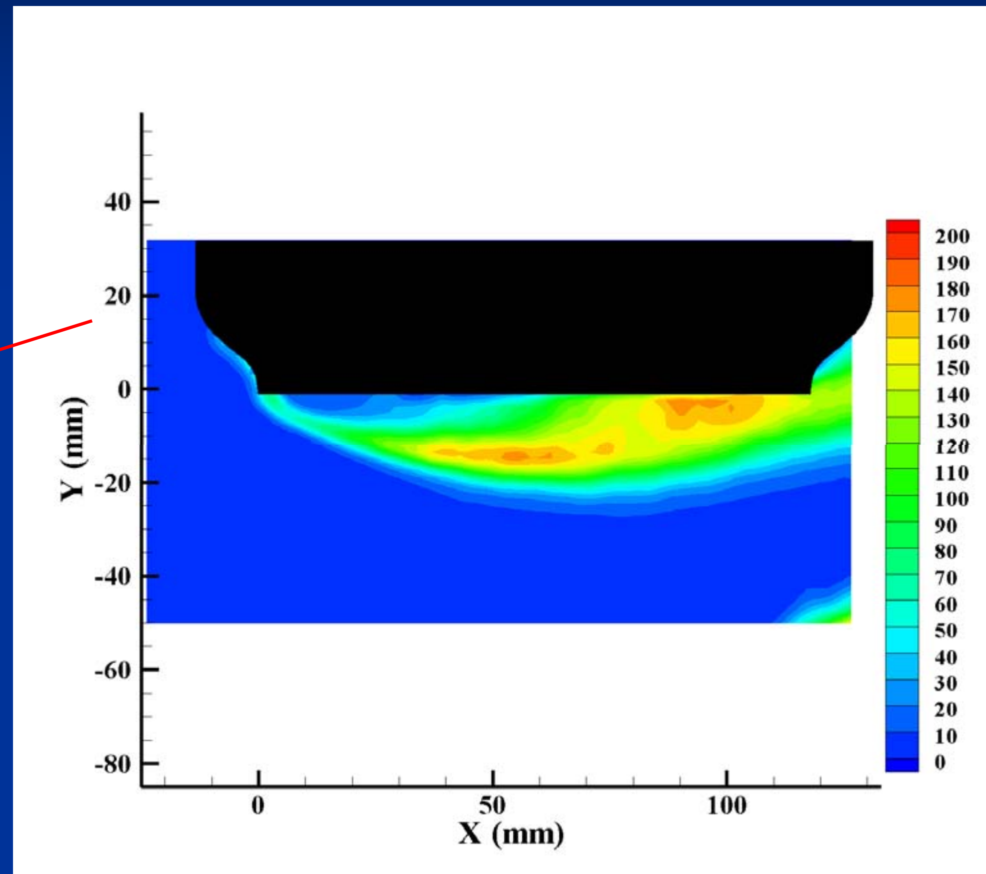


PSD on Starboard Door Edge



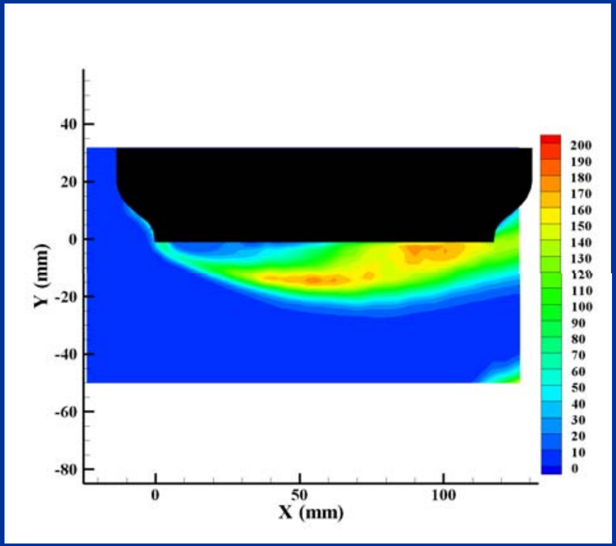
The TKE in X-Y PIV plane (Mid-wheel, Starboard Side) shows concentration of energy in aft wheel hub area

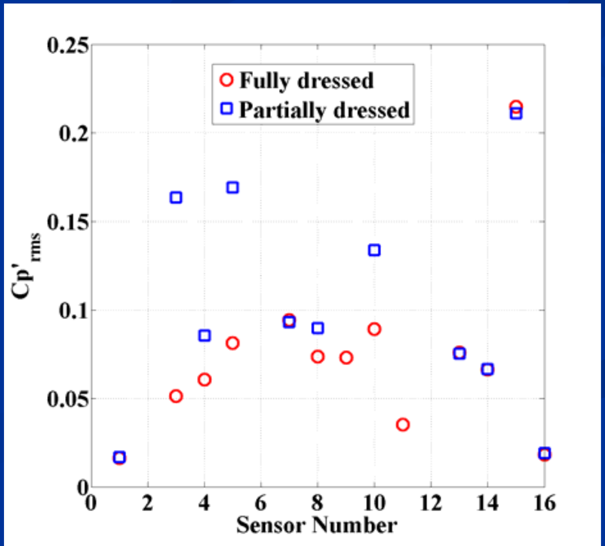




Final Comments – 1 of 2

- Surface pressure spectra were found to be primarily broadband in character and devoid of any local peaks associated with Strouhal shedding
- Removal of select components resulted in stronger pressure fluctuations in certain surface locations
- PIV revealed no large-scale vortical structures shed from gear components corroborating unsteady pressure measurements
- The highest levels of TKE and Cp'_{rms} for the PDCC were measured in the area of the wheel hub, torque arm, door, and the drag brace





Final Comments - concluded

- simplified geometry, complicated physics
- ease/difficulty of performing the tests
  - Instrumentation – in-situ calibration
  - Model changes
    - Clocking wheels
    - Removing components
    - Moving mobile transducer
  - Data acquisition and processing
- what (if anything) would make the dataset better
  - Comments solicited during open discussion

Background material

The details of the data acquisition are…………

- Signal gain incorporated into sensitivity coefficients through in-situ calibration

- <u>AC-coupled data</u>
- Sample rate: 51.2 kHz
- Blocksize: 16384
- Number of blocks acquired: 100
- Anti-alias filter in front of A/D: 20 kHz, elliptic
- AC coupling frequency: 1 Hz
- Range: set as needed for each channel

- <u>DC-coupled data</u>
- Sample rate: 50 Hz
- Number of samples acquired: 1600
- DC coupling frequency: 1 Hz

References

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