

Wind-Tunnel Testing for the Second AIAA Stability and Control Prediction Workshop

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Image credit: NASA

AIAA Stability and Control Prediction Workshop II (S&CPW2)

- Applied Aerodynamics and Atmospheric Flight Mechanics TCs
- Goal: establish best practices for prediction of S&C derivatives
- Workshop II: static and dynamic stability derivative prediction
- Website: www.sandcpw.com
 - Test cases/geometry/meshes
 - Latest information
- Email: sandcpw@gmail.com



Common Research Model in the NASA Langley 12-Foot Low-Speed Tunnel.



Summary of S&CPW2 Test Cases



Static Test Cases

($M = 0.052$; $Re = 200,000$; $T = 518^\circ R$)

- **Case 1a:** α -sweep with sting
- **Case 1b:** β -sweep with sting ($\alpha = 0^\circ$)
- **Case 1c:** β -sweep with sting ($\alpha = 4^\circ$)
- **Case 1d:** α -sweep with sting and no tail
- **Case 4:** repeat Case 1 without sting

Participants report/submit:

- Data for each test case
- Static/dynamic stability derivatives

Dynamic Test Cases

$$f_r = \omega l / 2V$$

($\alpha_o = 3^\circ$; $M = 0.036$; $Re = 140,000$)

- **Case 2a:** pitch oscillation with $f_r = [0.04, 0.06, 0.08, 0.10]$
- **Case 2b:** roll oscillation with $f_r = [0.2, 0.4, 0.6, 0.8]$
- **Case 2c:** yaw oscillation with $f_r = [0.2, 0.4, 0.6, 0.8]$
- **Case 3:** use alternative methods to determine static/dynamic derivatives
- **Case 5:** repeat Case 2 without sting

Red text = required case



- Common Research Model
- 12-Foot Low-Speed Tunnel
- Data Processing
- Test Results
 - Static Results
 - Forced Oscillation Results
- Questions/Discussion



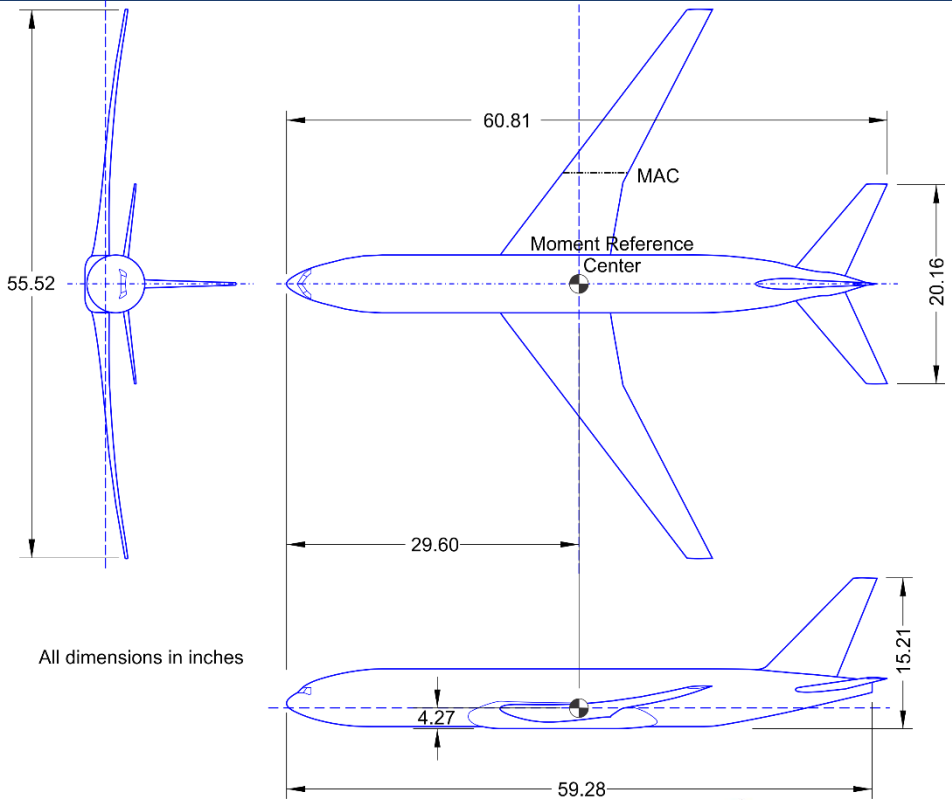
Image credit: NASA

Common Research Model (CRM)



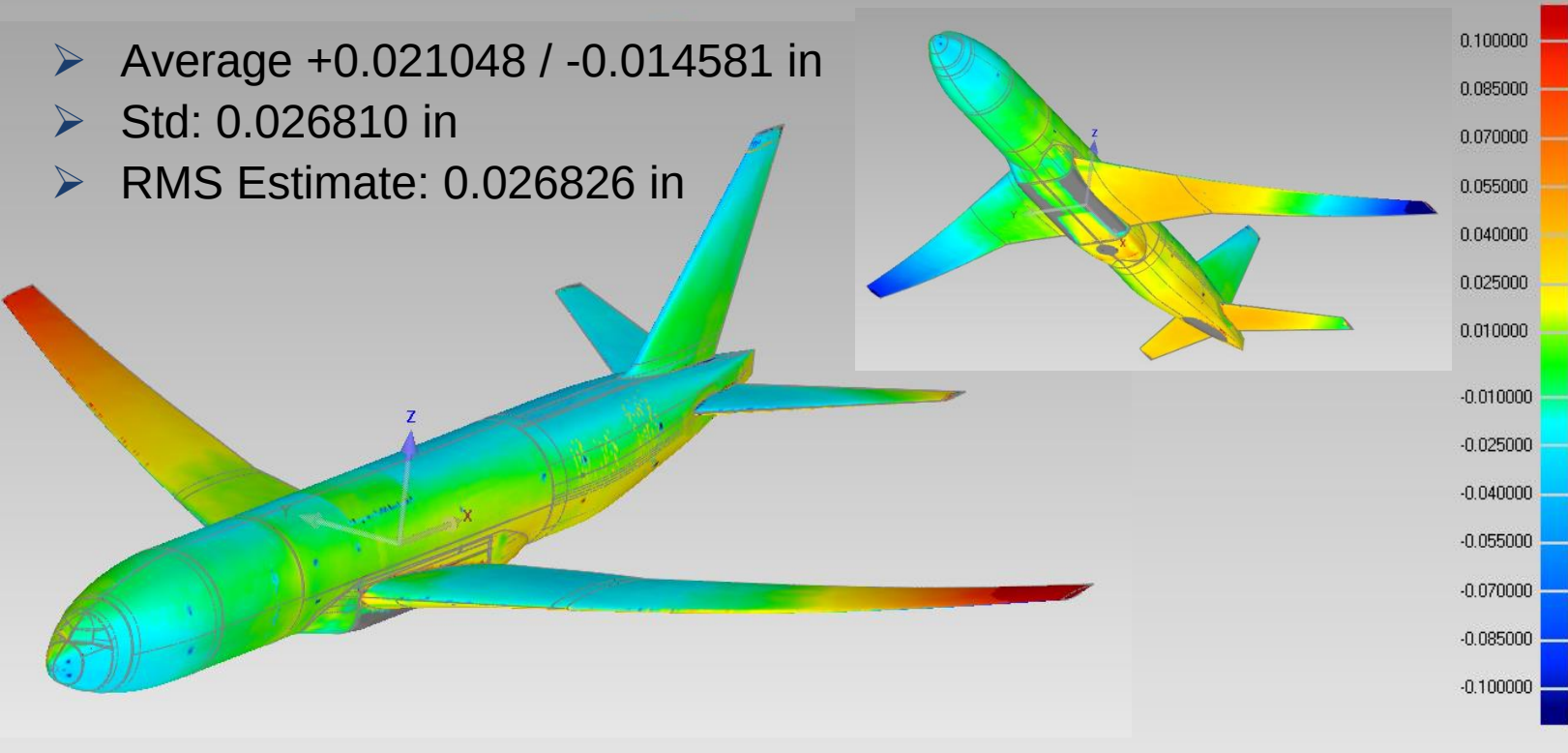
Image credit: NASA

$S_{ref} = 2.379 \text{ ft}^2$
 $b = 4.627 \text{ ft}$
 $c_{mac} = 0.552 \text{ ft}$
Weight = 15.85 lbs



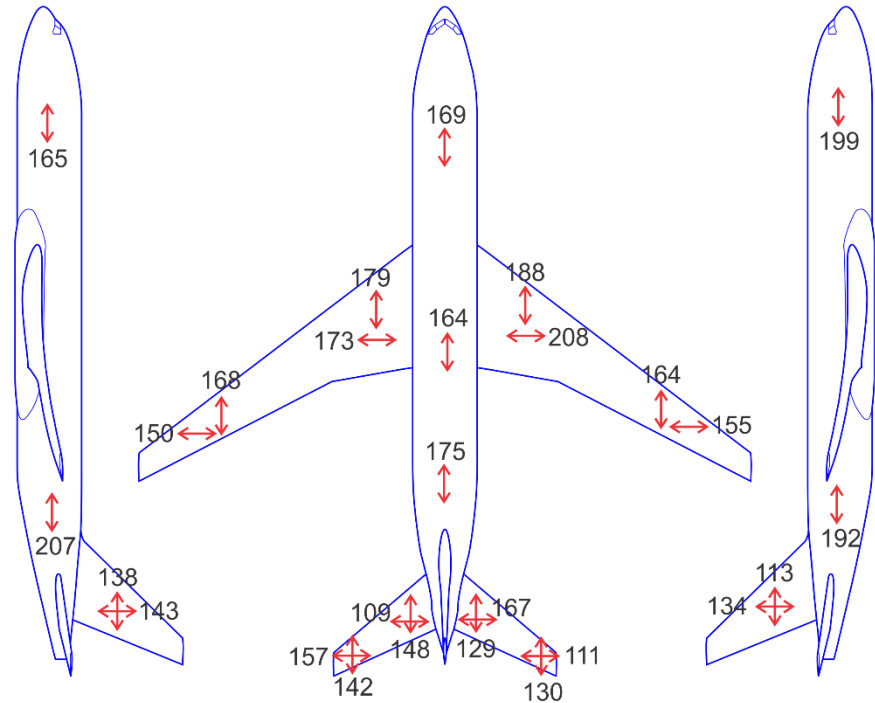
CRM As-Built Geometry Comparison

- Average +0.021048 / -0.014581 in
- Std: 0.026810 in
- RMS Estimate: 0.026826 in



CRM Surface Roughness

Rq roughness measurements
RMS μ inches



12-Foot Low-Speed Tunnel

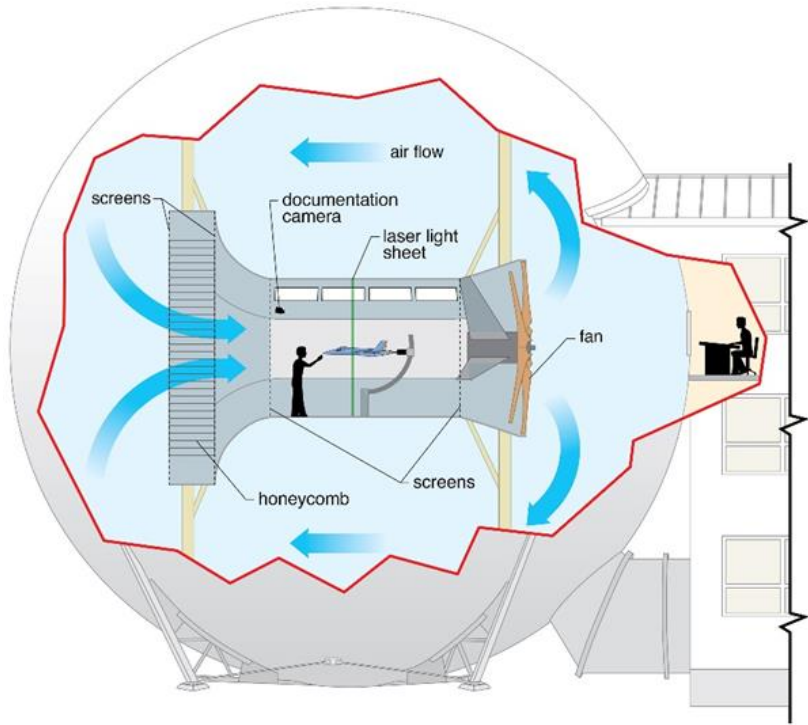


Image credit: NASA

CRM 12-Foot Tunnel Installation





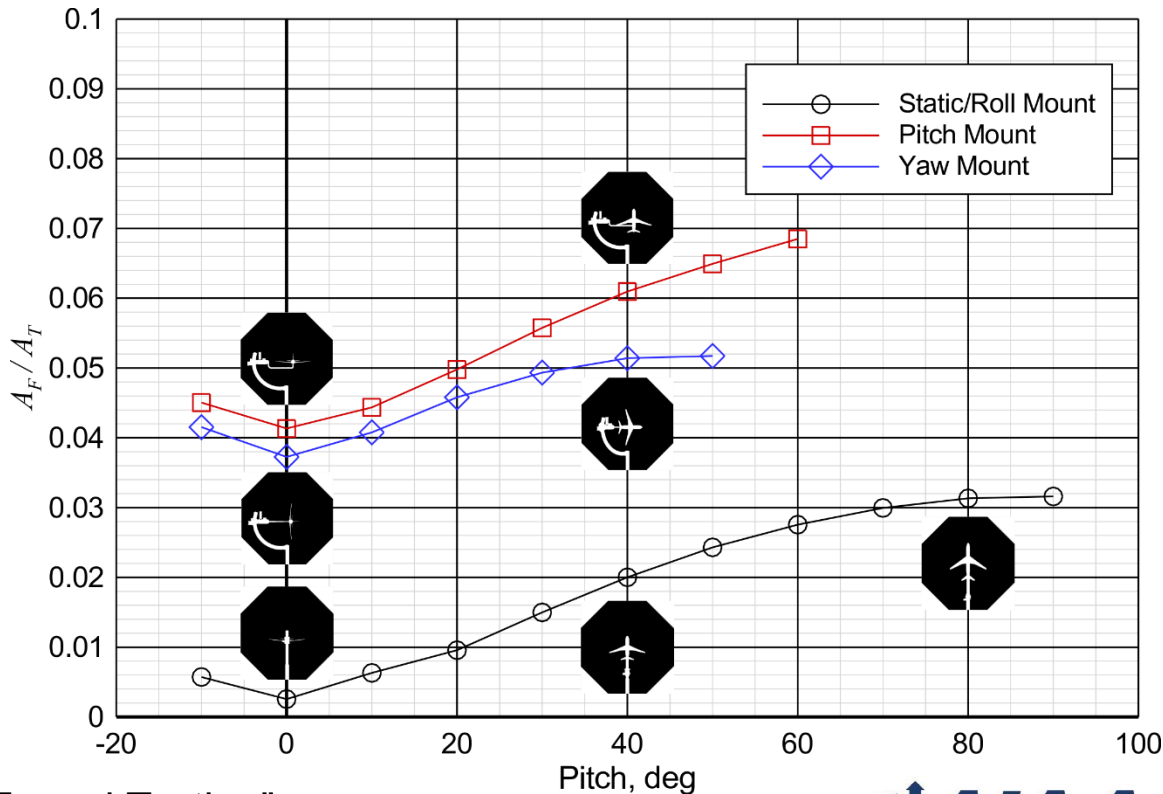
Data Processing



- Tunnel Data Corrections
 - Flow angularity (0.26° upwash correction)
 - Blockage
- Signal Filtering
 - Digital 4 Hz low-pass filter of balance signals (50 Hz sample rate)
- 1-cycle averaged forced oscillation measurement

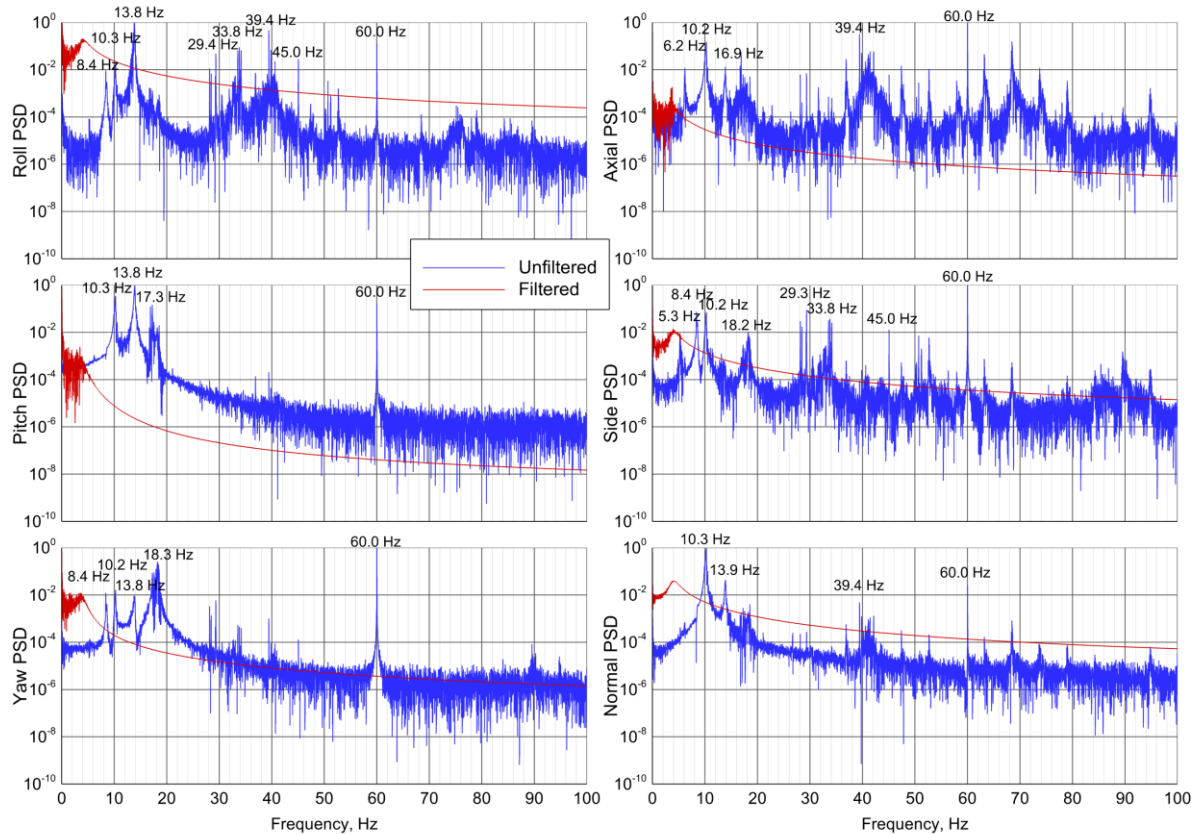
Blockage correction to dynamic pressure

$$q_c = q_u \left(1 + \frac{1}{4} \frac{A_F}{A_T} \right)^2$$

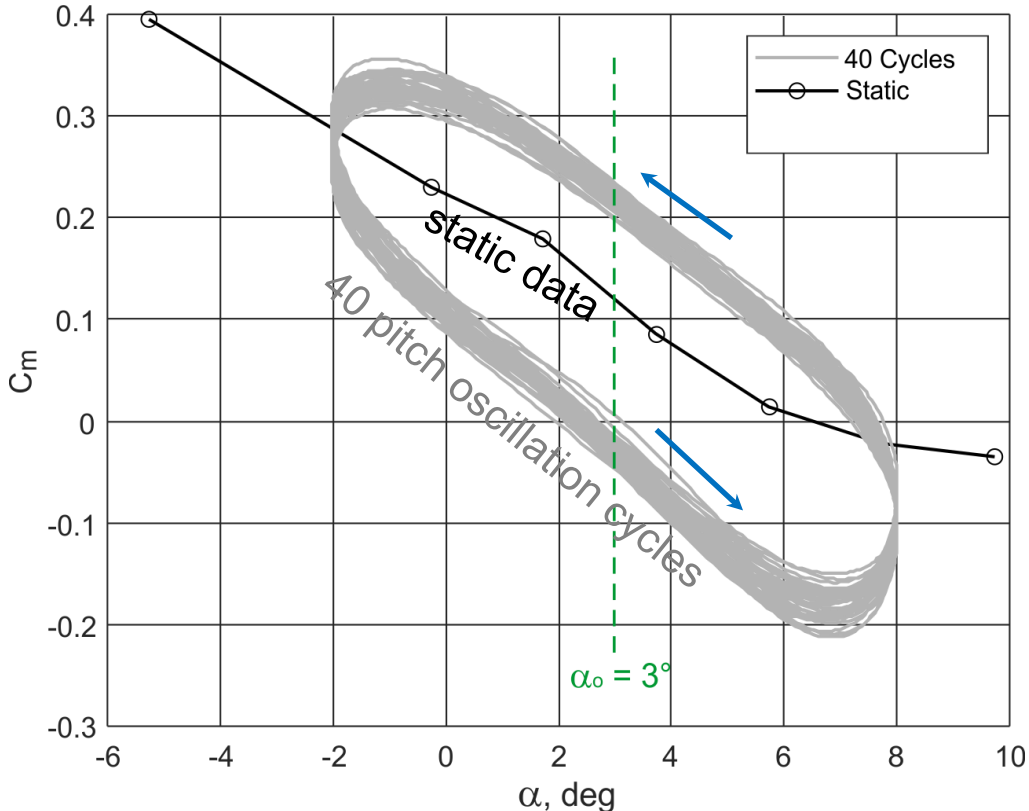




CRM Mount Vibration – Pitch Excitation

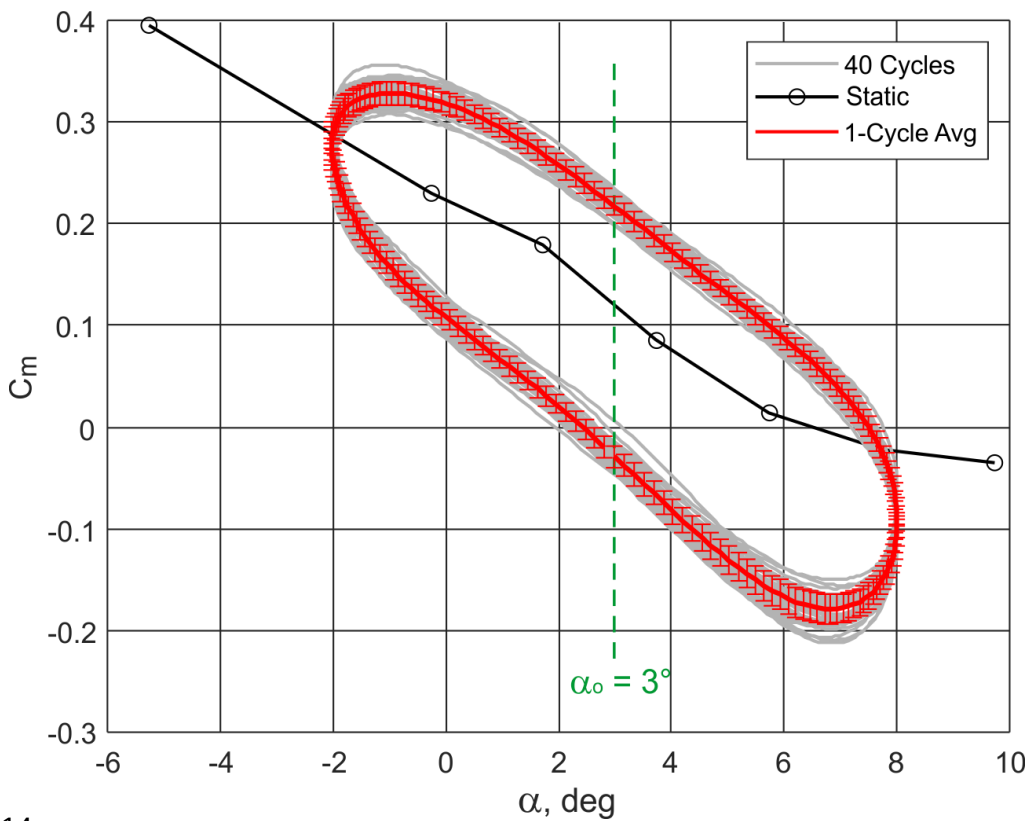


Forced-Oscillation – 40-Cycles of Data

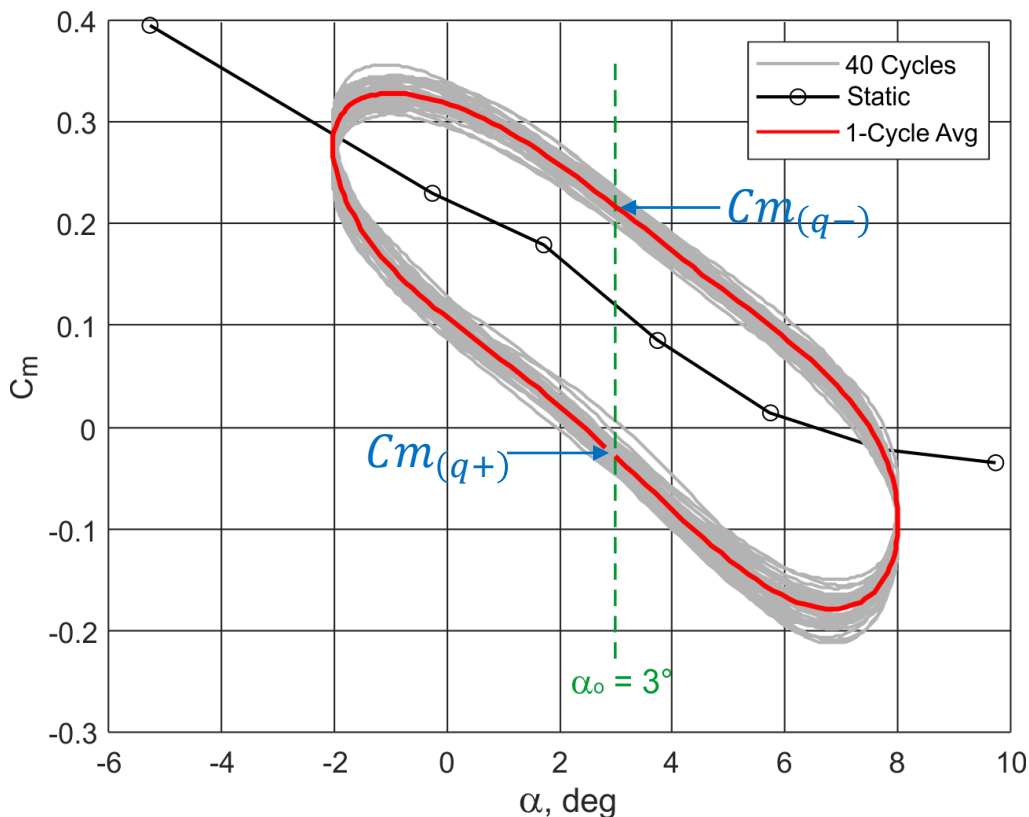


Comparison of static and 5° pitch oscillation about 3° angle of attack.

Forced-Oscillation – 1-Cycle Average



Compute 1-cycle average
with standard deviation

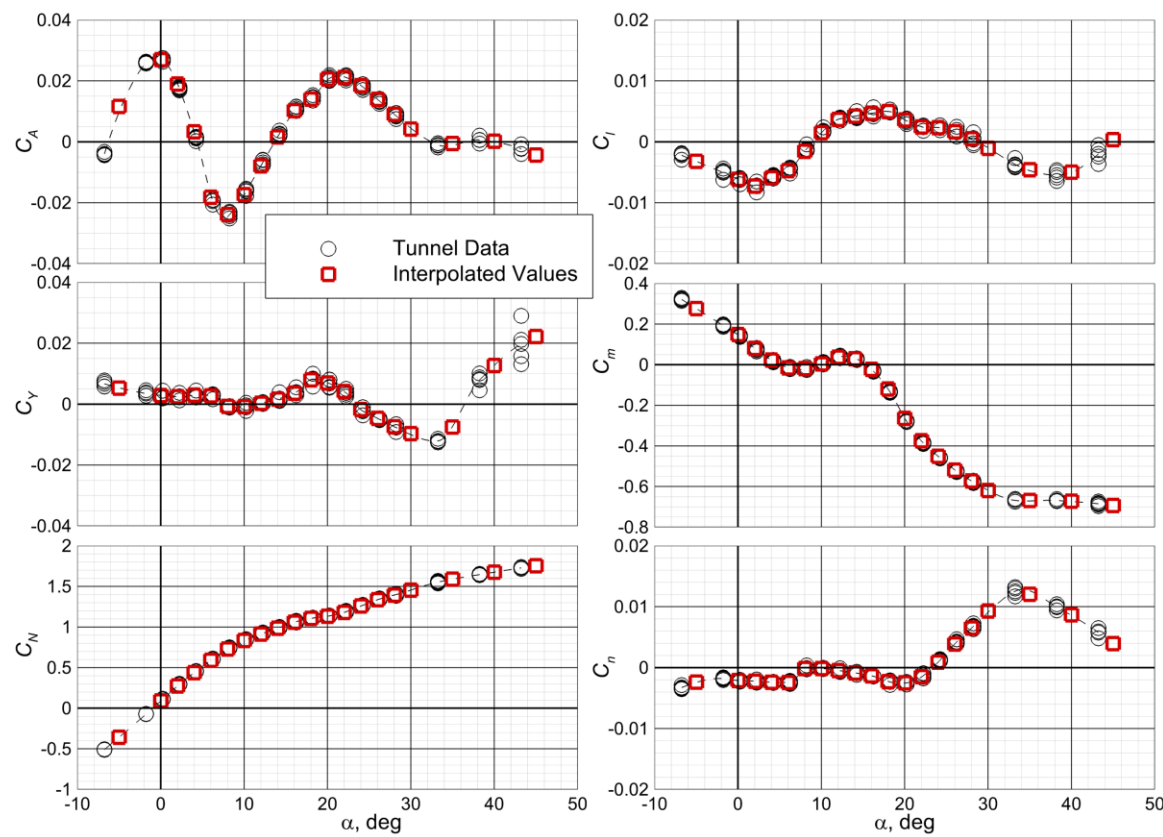


$$Cm_q = \frac{V}{\bar{c}A\omega} [Cm_{(q+)} - Cm_{(q-)}]$$

A oscillation amplitude
 $\bar{c}$ mean aerodynamic chord
 ω oscillation frequency

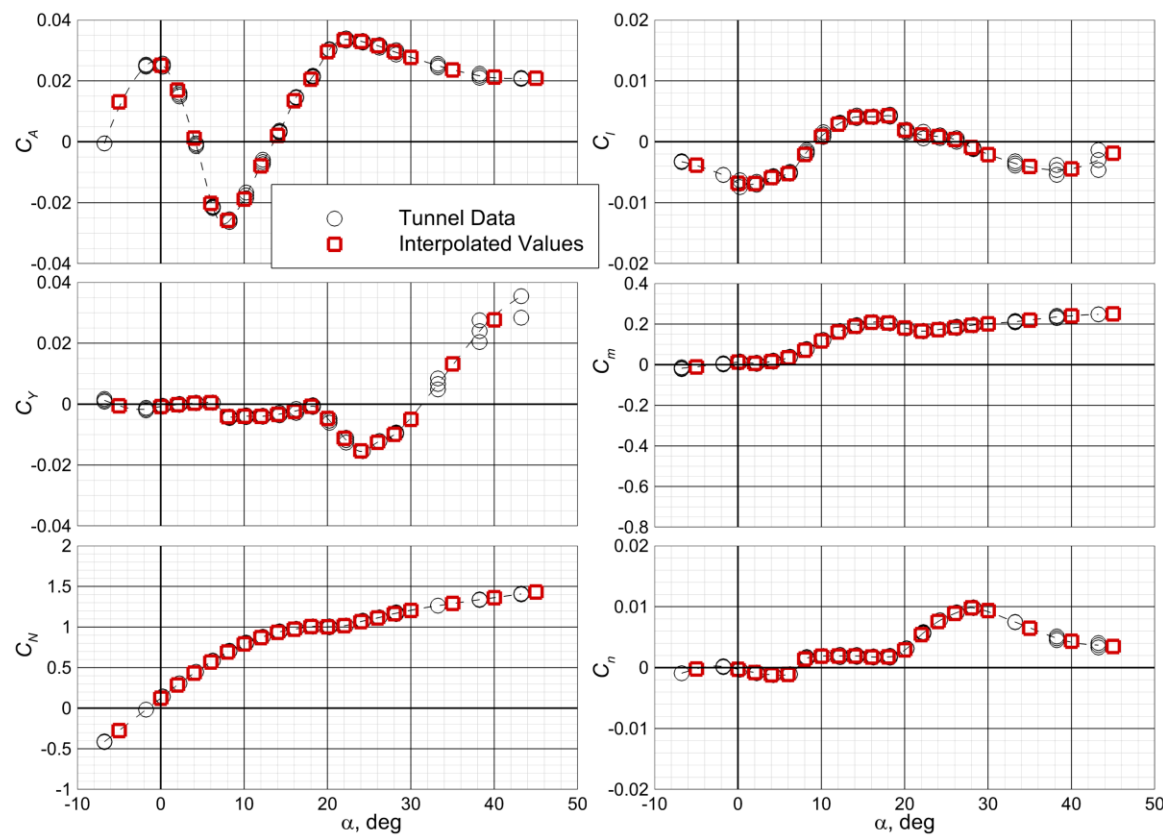
Ref: Vicroy, D. D., "A Guide to Forced Oscillation Data Processing and Analysis," NASA TP-20210023569, June 2023.

Static Results – Case 1a (With Tail)

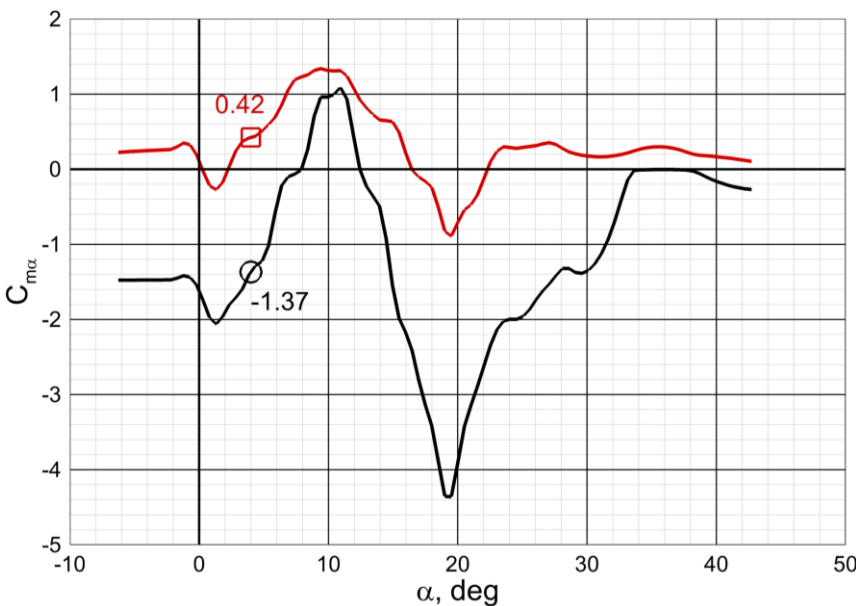
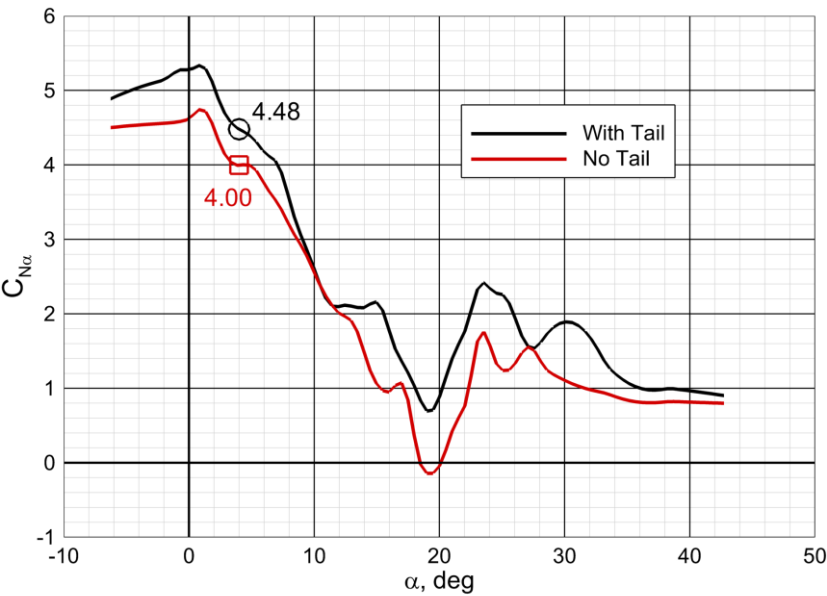




Static Results – Case 1d (No Tail)

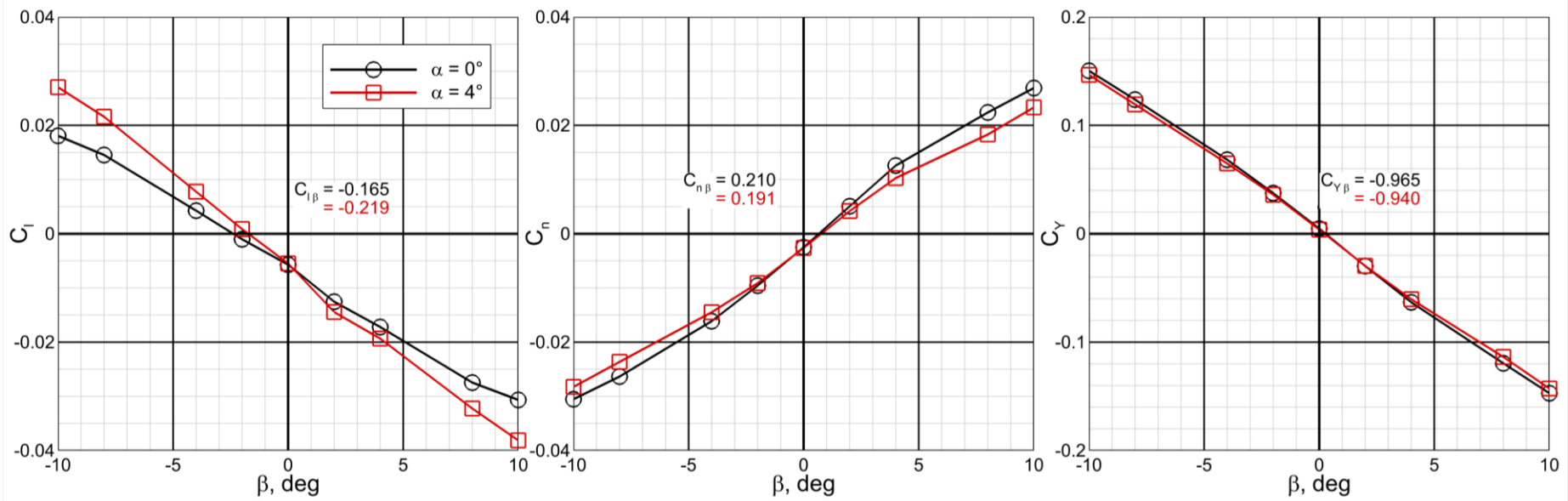


Static Results – α Derivatives



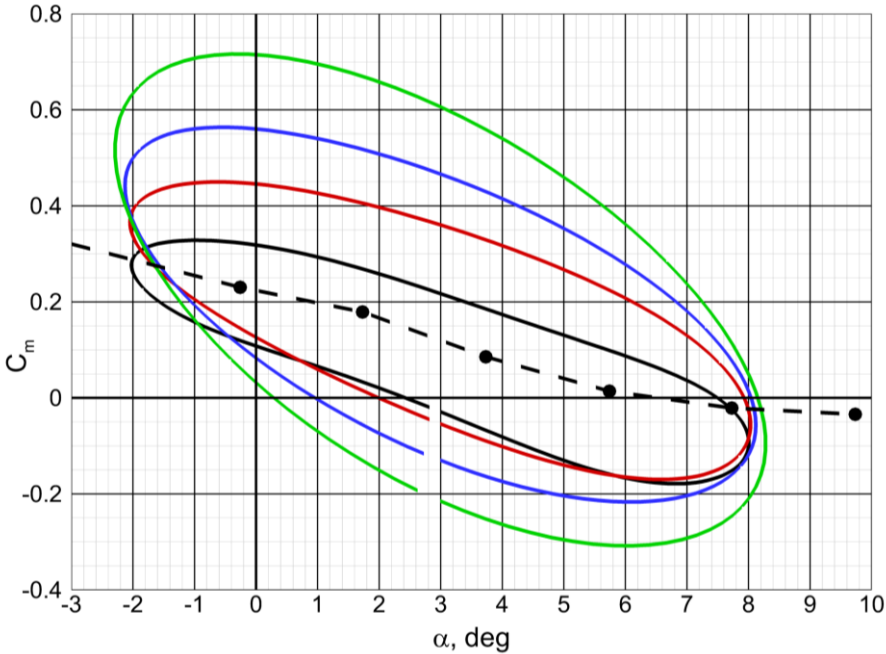
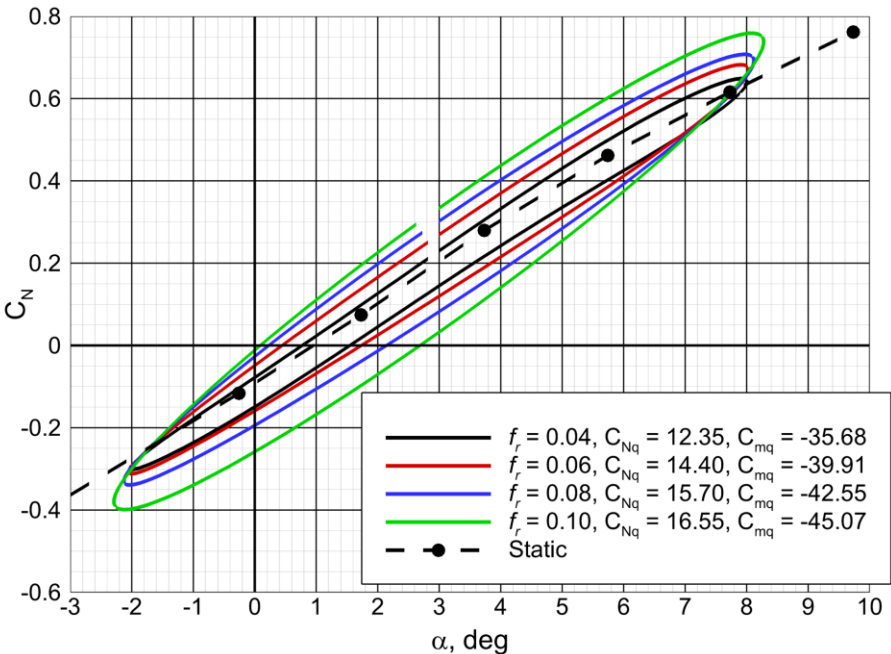


Static Results – Case 1b & 1c (With Tail)



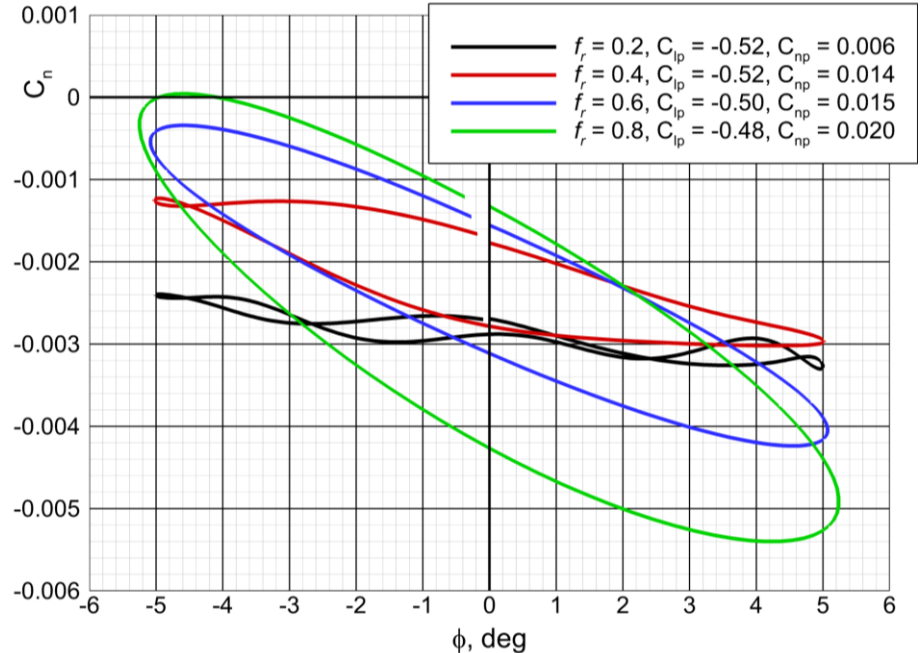
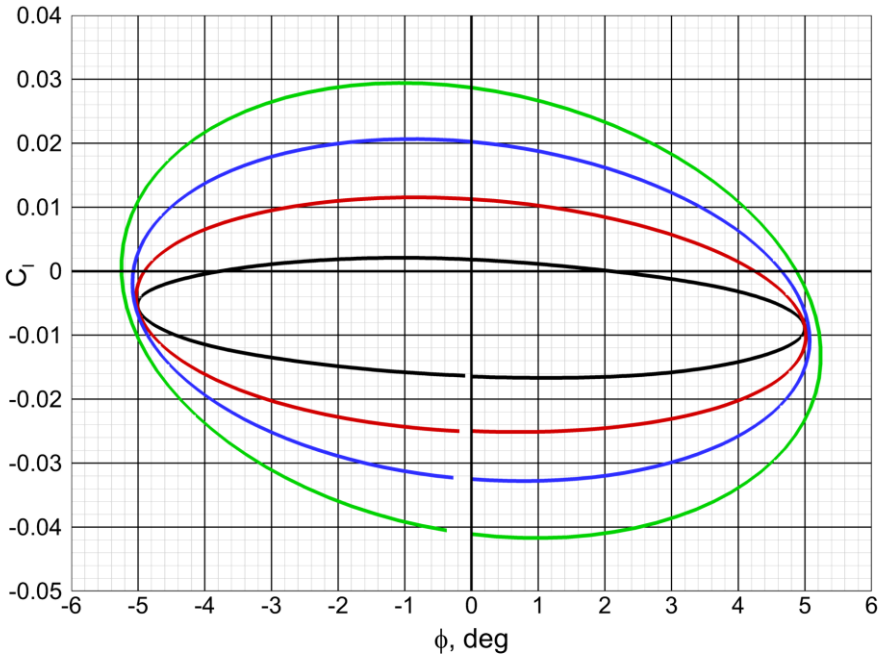


Pitch Oscillation Results – Case 2a



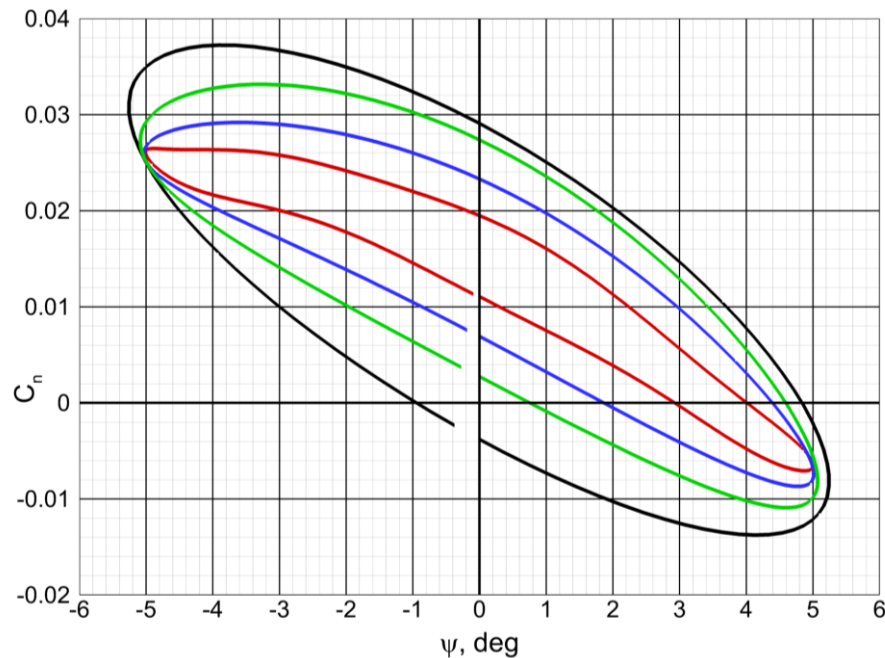
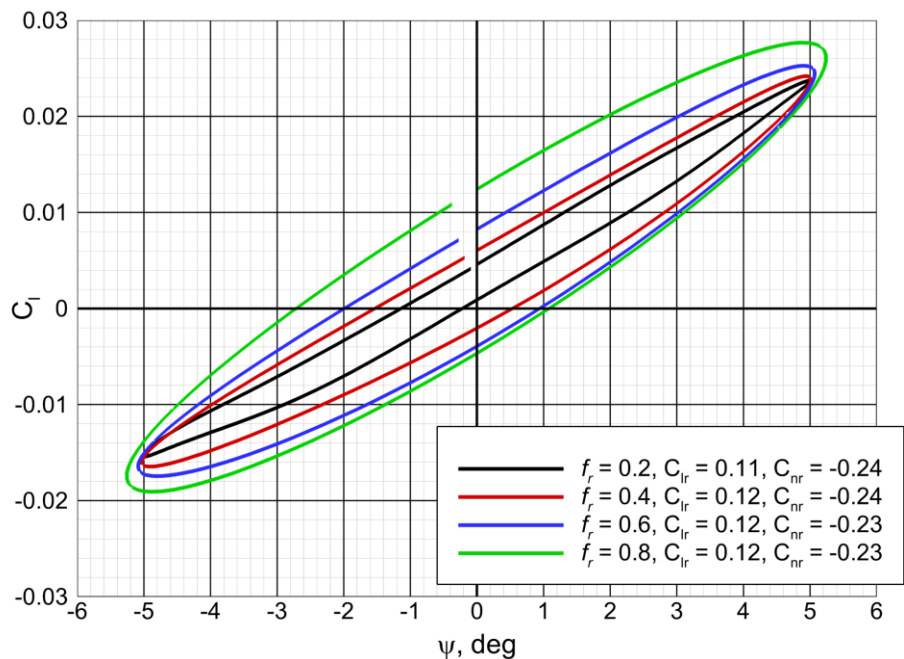


Roll Oscillation Results – Case 2b





Yaw Oscillation Results – Case 2c





Flight Dynamics Research Facility (FDRF)



- New wind tunnel at NASA Langley
- Combining/expanding capabilities of:
 - 12-Foot Low-Speed Tunnel
 - 20-Foot Vertical Spin Tunnel
- Scheduled to open in 2025
- CRM (and SDM) data will be used for check standard tests

Fremaux, C. M., Simmons, B. M., Owens, D. B., Vicroy, D. D., Storch, D. B., “Development and Capabilities of the NASA Flight Dynamics Research Facility,” *AIAA SciTech Forum*, Jan. 2025. **(To be presented in AFM-08)**



FDRF construction progress (Nov. 22, 2024)

Image credit: G. Banziger, NASA



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