LA-8 Computational Analysis and Validation Studies Using FlightStream

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Overview

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- Langley Aerodrome No. 8 (LA-8) Background
  - Vehicle configuration
  - Wind tunnel tests
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Introduction

- Urban Air Mobility bring to fruition new, novel, complex vehicle configuration to satisfy on-demand operations

- Many challenges are associated with the new aircraft designs
  - Complex interactions between the propellers and airframe
  - Distributed electric propulsion across aerodynamic surfaces
  - Transitioning between two modes of flight
  - Lack of validated tools for design with low computational time

- NASA's LA-8 provides a means to investigate a subset of the complex vehicle components with wind tunnel data available

LA-8 Background

Vehicle Configuration

- Tandem tilt-wing UAS
- Single slotted Fowler flaps
- Hinged elevons and ruddervators
- Distributed electric propulsion
- 3D printed wind tunnel and flight model

Langley Aerodrome No. 8 in the Langley 12-Foot Low-Speed Wind Tunnel.

LA-8 Background

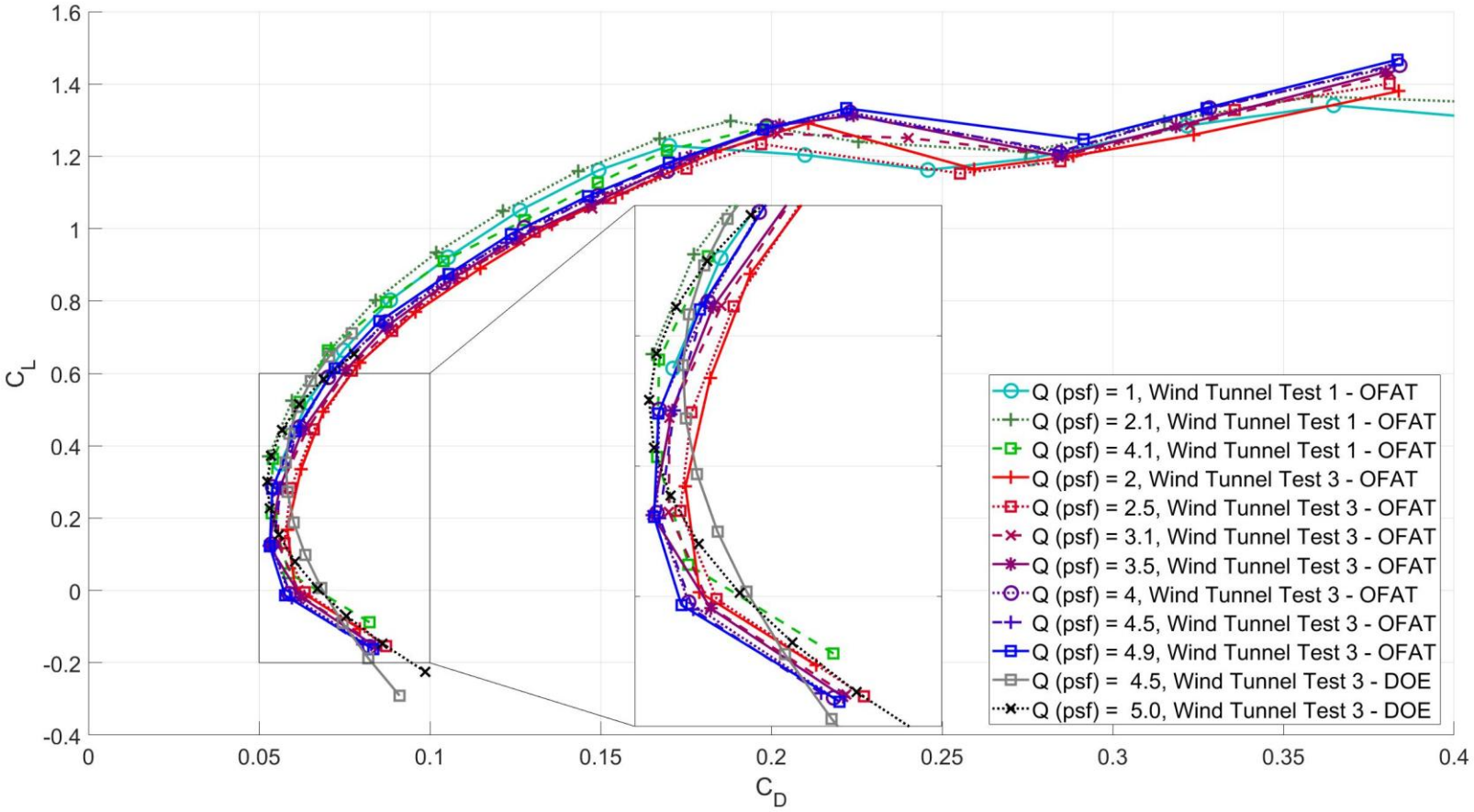
Wind Tunnel Tests

- Wind Tunnel Test 1: One-factor-at-a-time (OFAT)
  - Examined both propellers-on* and propellers-off
- Wind Tunnel Test 2: Design of experiments (DOE)
  - Examined propellers-on
- Wind Tunnel Test 3a: OFAT
  - Examined propellers-off
- Wind Tunnel Test 3b: DOE
  - Examined propellers-off

*This propellers-on data included different propellers than in test 2

LA-8 Background

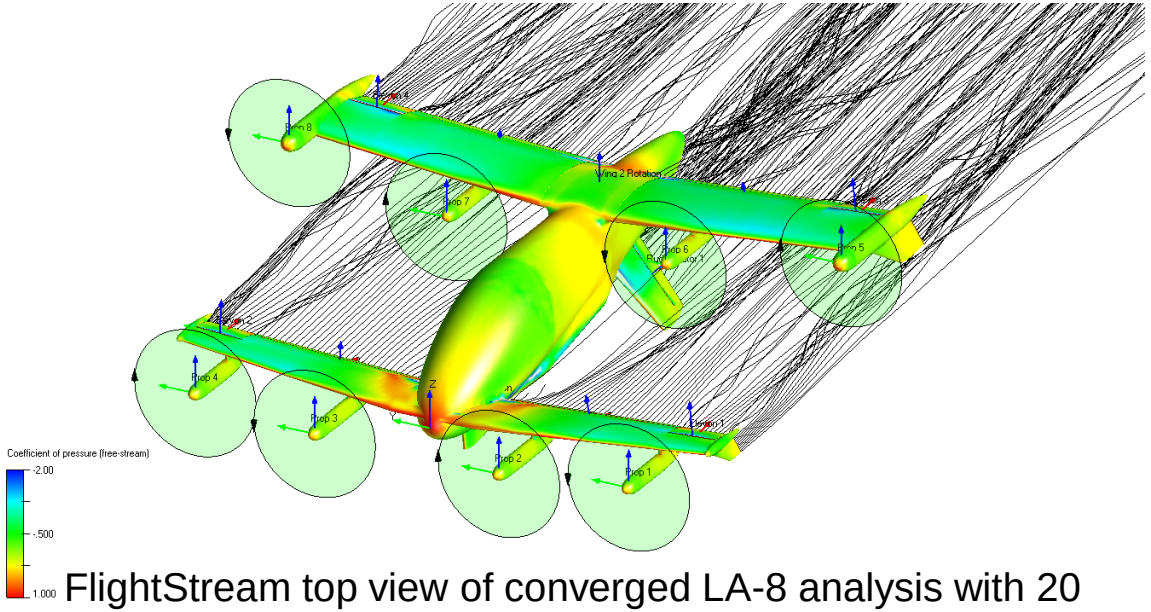
Wind Tunnel Tests



LA-8 wind tunnel results with no propellers, no control surface deflection, and wings at zero degrees, C_L vs C_D.

FlightStream
Analysis Capabilities

- Surface vorticity flow solver
- Pressure solution and vorticity solution
- Previous research on multi-piece flaps, distributed electric propulsion, and tilt-wing concepts
  - Beta test of surface proximity determination
- Results use version 2020.2 – build 11152020 of FlightStream

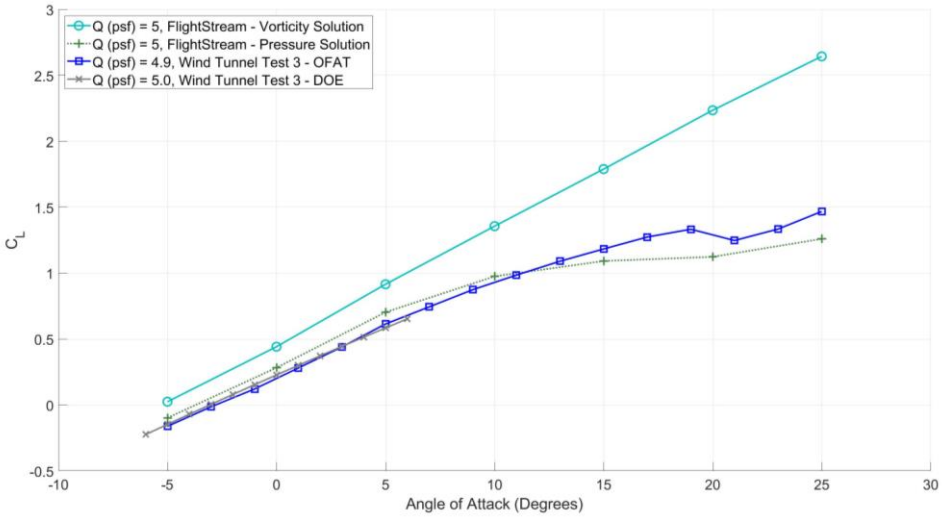


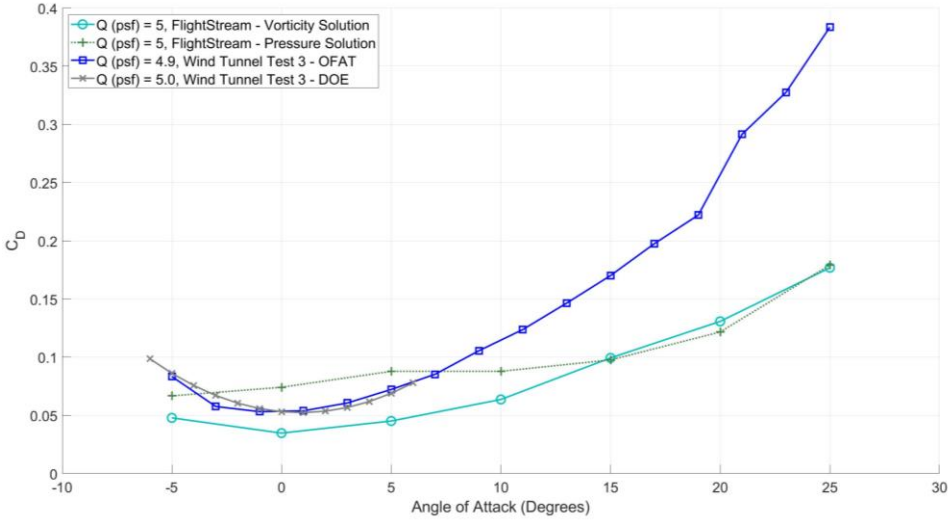
FlightStream top view of converged LA-8 analysis with 20 degree flags and no propellers

FlightStream

LA-8 Results

Propellers off – no flap surfaces deflected



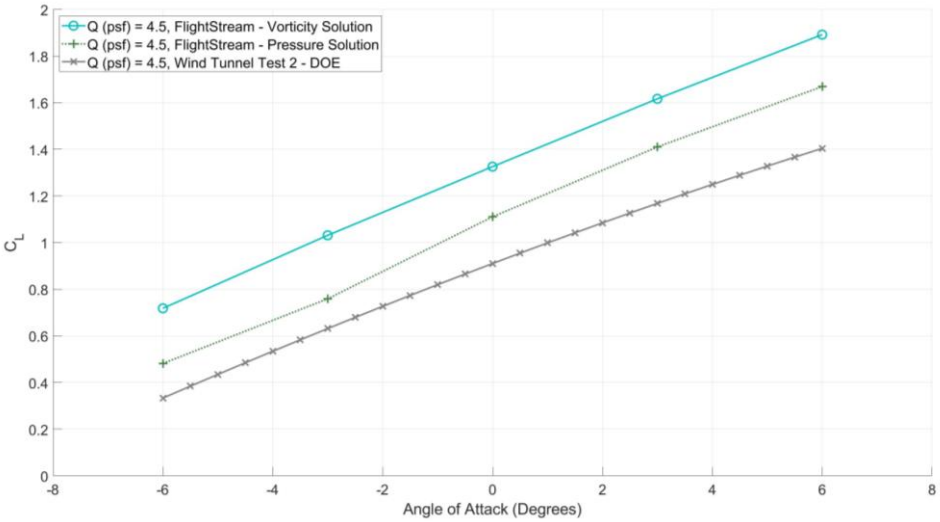


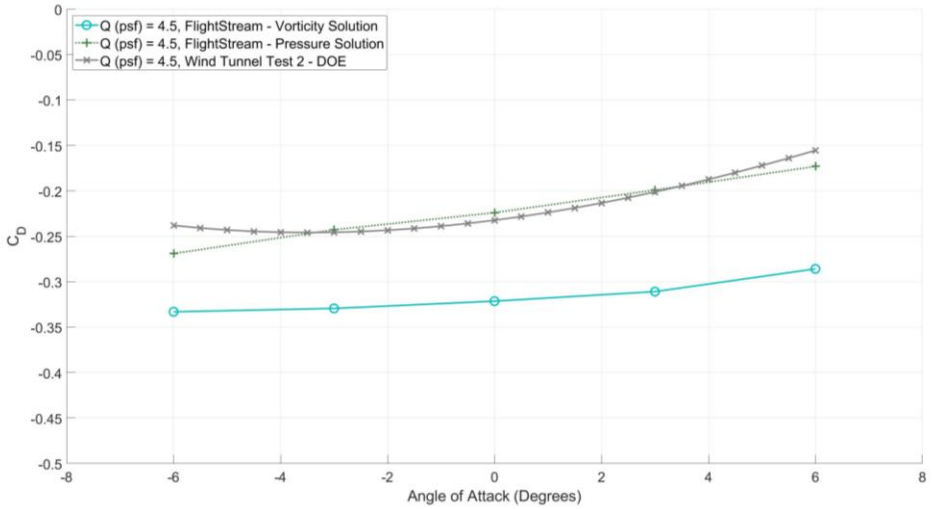
Comparison of FlightStream results and wind tunnel data with zero flaps and propellers off, C_L and C_D vs angle of attack.

FlightStream

LA-8 Results

Propellers on –flap surfaces deflected 20 degrees





Comparison of FlightStream results and wind tunnel data with 20 degree flaps and propellers on, CL and CD vs angle of attack.

Conclusions

- FlightStream can handle a multi-component detailed model that is representative of a UAM vehicle
- The trends produced by FlightStream lift pressure solution are similar to the wind tunnel data for LA-8
- The trends produced by FlightStream drag vorticity solution are similar to the wind tunnel data for LA-8
- The FlightStream pressure solution provided approximate magnitudes for both the lift and drag coefficients for all test cases

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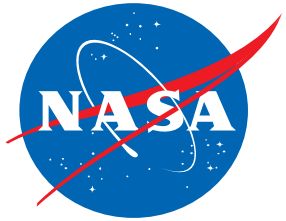
Questions?

Design, Testing, and Modeling for the LA-8 Tilt-Wing VTOL Aircraft I & II References

1. North, D. D., Howland, G., and Busan, R. C., “Design and Fabrication of the LA-8 Distributed Electric Propulsion VTOL Testbed”
2. Busan, R. C., Murphy, P. C., Hatke, D. B., and Simmons, B. M., “Wind Tunnel Testing Techniques for a Tandem Tilt-Wing, Distributed Electric Propulsion VTOL Aircraft”
3. Simmons, B. M., “System Identification for Propellers at High Incidence Angles”
4. **Geuther, S. C., and Fei, X., “LA-8 Computational Analysis and Validation Studies Using FlightStream”**
5. Simmons, B. M., and Murphy, P. C., “Wind Tunnel-Based Aerodynamic Model Identification for a Tilt-Wing, Distributed Electric Propulsion Aircraft”
6. North, D. D., “Flight Testing of a Scale Urban Air Mobility Technology Testbed” (Presentation Only)



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