LA-8 Computational Analysis and Validation Studies Using FlightStream

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Overview

• Introduction

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

• FlightStream
  – Analysis capabilities
  – LA-8 Results

• Conclusions
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


5. Simmons, B. M., and Murphy, P. C., “Wind Tunnel-Based Aerodynamic Model Identification for a Tilt-Wing, Distributed Electric Propulsion Aircraft”
