Building Your Own Wind Tunnel

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With
Vincent Homer
My background

• BS and MS in aerospace engineering (1960s)
• Transonic wind tunnel work for the Navy (1960s)
• Air Force Flight Dynamics Lab (1970s)
• PhD ME (1970s)
• Emeritus Professor of product design (1980-2005)
  – Life Fellow ASME
• Built two general aviation airplanes
• Electric airplane design (2009- present)
Airplane Design Publications
available at www.davidullman.com/aeronautics

• 2009: “Hear the Hum? An Electric Airplane May Be Coming Soon To An Airport Near You” KITPLANES
• 2015: “Using Vortex Generators to Enhance Pusher Aircraft Cooling” KITPLANES
• 2017: “Comparing Electric Sky Taxi Visions”
  – With contributions from Pat Horgan of CubCrafters, Richard Ouellette of Boeing Commercial and Vincent Homer
• May 2018 “Electric Air Vehicle Performance Prospects: Comparing eVTOL versus USTOL”, Keynote address at the Sustainable Aviation Symposium.
Why Bother with a Wind Tunnel?

• Demonstration
• Visualization
• Measurement
• Confirm theory
• Confirm Computational Fluid Dynamics (CFD) results
We are working on IDEAL: Integrated Distributed Electric-Augmented Lift
Custer Channel Wing (1940s-50s)
Boeing YC-14 STOL Transport (1976)

USB – Upper Surface Blowing
120 mm EDF: 2.3 lbs (1 kg) with controller, 5 hp (4 kw), 15.6 lbs (7 kg) of thrust
What you can do with a Wind Tunnel

• Demonstrate
• See flows
  – Smoke
  – Tufts
• Measure
  – Forces and moments
  – Velocities
  – Pressures

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A Demonstration Tunnel

Very low Reynolds Number
Reynolds Number

Reynolds Number = \(\frac{\text{Inertia force}}{\text{Viscous force}} = \rho \frac{V L}{\mu}\)

\(\rho = 0.002738 \text{ slug/ft}^3 = 1.225 \text{ kg/m}^3\)
\(\mu = 1.79 \times 10^{-5} \text{ Pa} \times \text{sec} = 3.74 \times 10^{-7} \text{ lb} \times \text{sec} / \text{ft}^2\)

For a Jabiru in cruise:
- chord (L) = 39” = 3.3 ft
- \(V = 124 \text{ mph} = 108 \text{ kts} = 181 \text{ ft/sec}\)
So Re = \(3.8 \times 10^6\)

At TO with \(V = 65 \text{ kts}\)  RE = \(2.2 \times 10^6\)
Drag versus Reynolds Number for a Sphere

Sphere Drag Coefficient versus Reynolds Number

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• Axial Fan blades –Multi-Wing
http://www.multi-wing.com/
Micro Load Cell (0-5kg) - CZL635

This load cell measures shear force up to 5kg and connects to a bridge input.

$7.00

Quantity Available: 1000+

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ADD TO CART
Shear Beam Load Cell

Wheatstone Circuit with Compensation
Smoke for Visualization

- Bombs
- Burlap
- Kerosene
- Theater smoke machine: Chauvet DJ Hurricane Pro Fog Smoke Machine Model H700
  - Added extra heating elements and a thermocouple to the evaporation block
  - Added an insulated and headed probe made out of a flex coolant hose intended for a lathe or mill.
  - Swapped out the solenoid pump for a peristaltic pump intended for chemical dosing aquariums. ~$10
Use of pitot rake to get airspeeds
Sensors

  – USB sensing and control
  – Measure pressure, angle, force, rpm
• Accelerometer

• Differential Pressure
Omega hot wire anemometer
$\frac{C_l}{C_d} = .009 + .018 \times C_l^2$
4, 50mm EDFs

Thrust (lbs)

Tunnel Speed

- Experimental
  4 - 50 mm EDFs on 4414
- Theory with efficiency = 40%
90 mm EDF, 1300 watts, 70% eff

- Theory
- Measured
120 mm EDF estimate
4kw, 70% efficient
Send your questions, comments, disagreements or statements of “hogwash” to:

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