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)
  - Text "*The Mechanical Design Process*" 6th edition
  - Life Fellow ASME
- Built two general aviation airplanes
- Electric airplane design (2009- present)

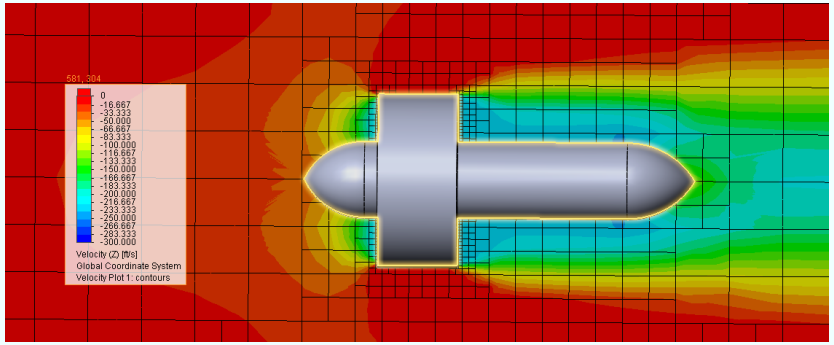
Airplane Design Publications

available at www.davidullman.com/aeronautics

- 2009: "*Hear the Hum? An Electric Airplane May Be Coming Soon To An Airport Near You*" KITPLANES
- 2010: "*The Electric Powered Aircraft: Technical Challenges*" EAA Experimenter.
- 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

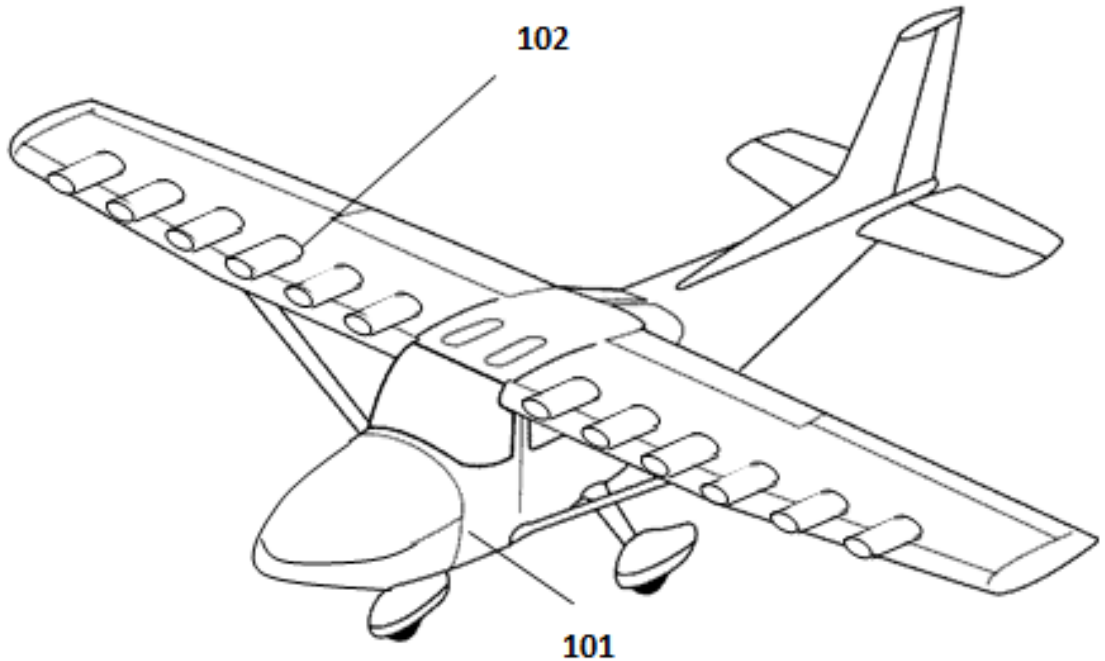
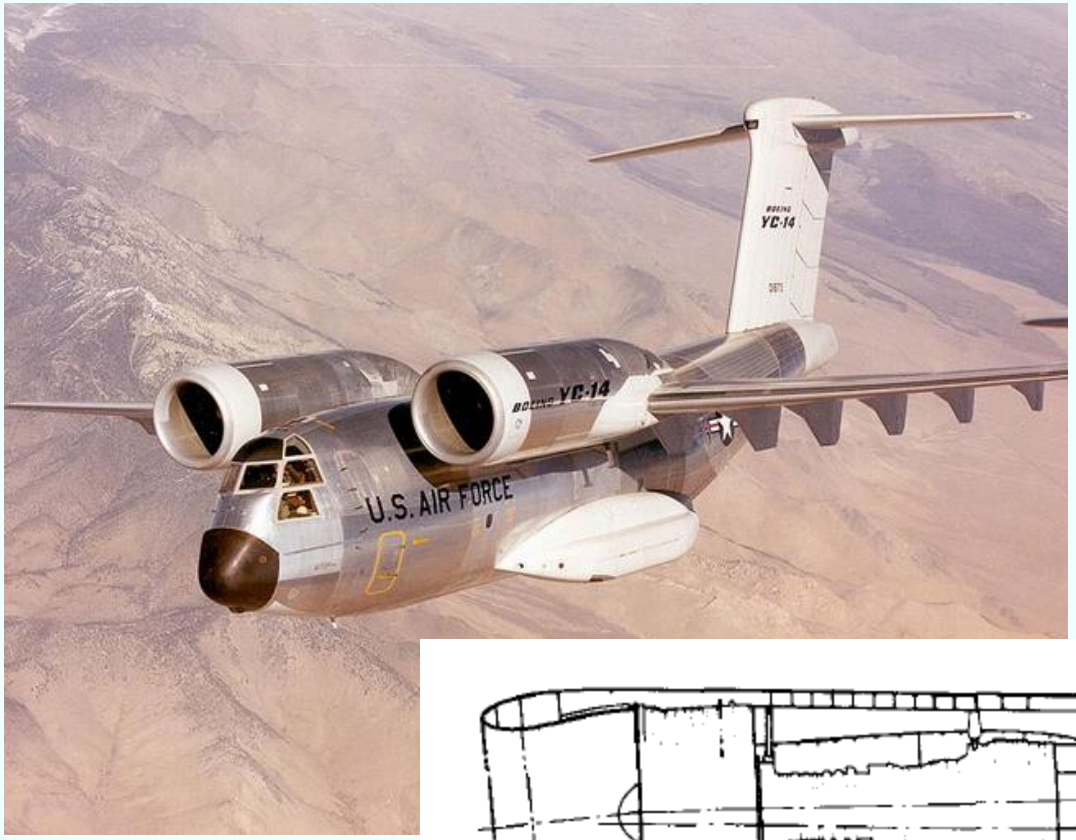


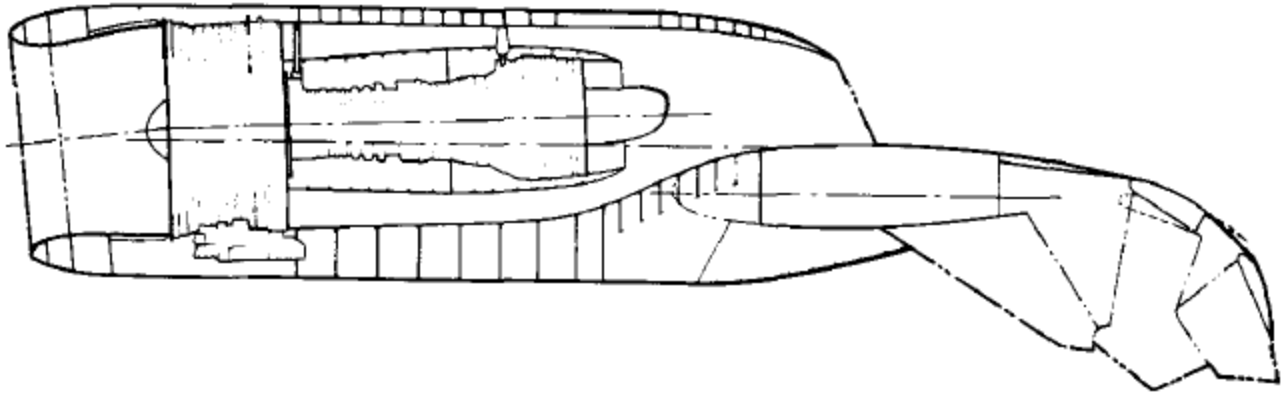
Figure 1

Custer Channel Wing (1940s-50s)

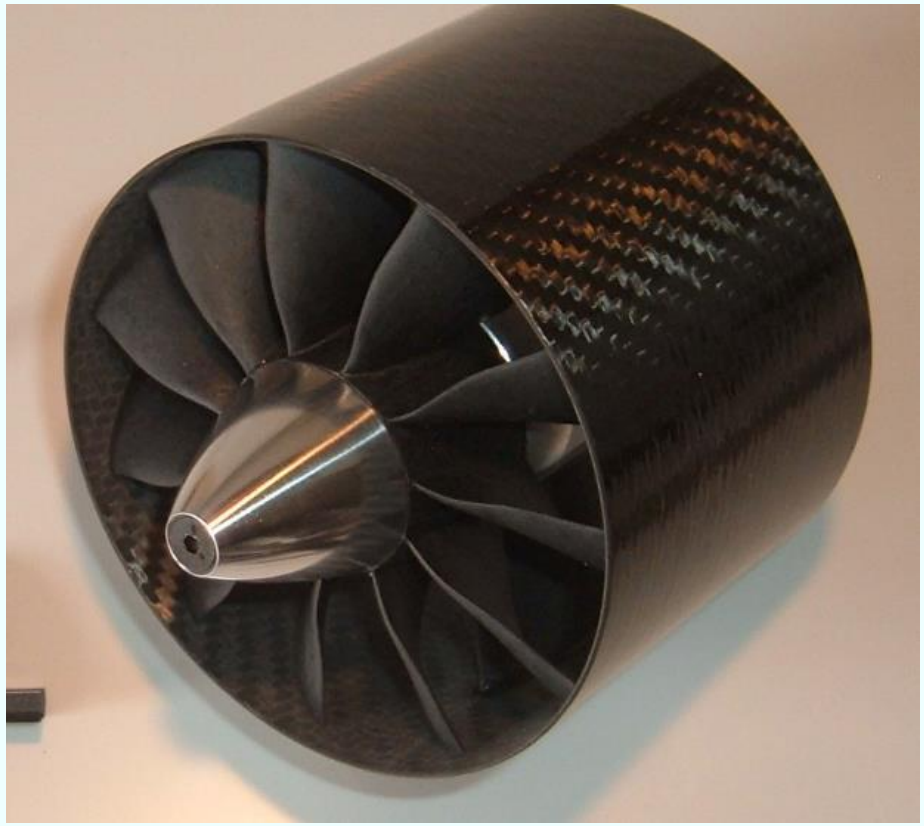
Boeing YC-14 STOL Transport (1976)

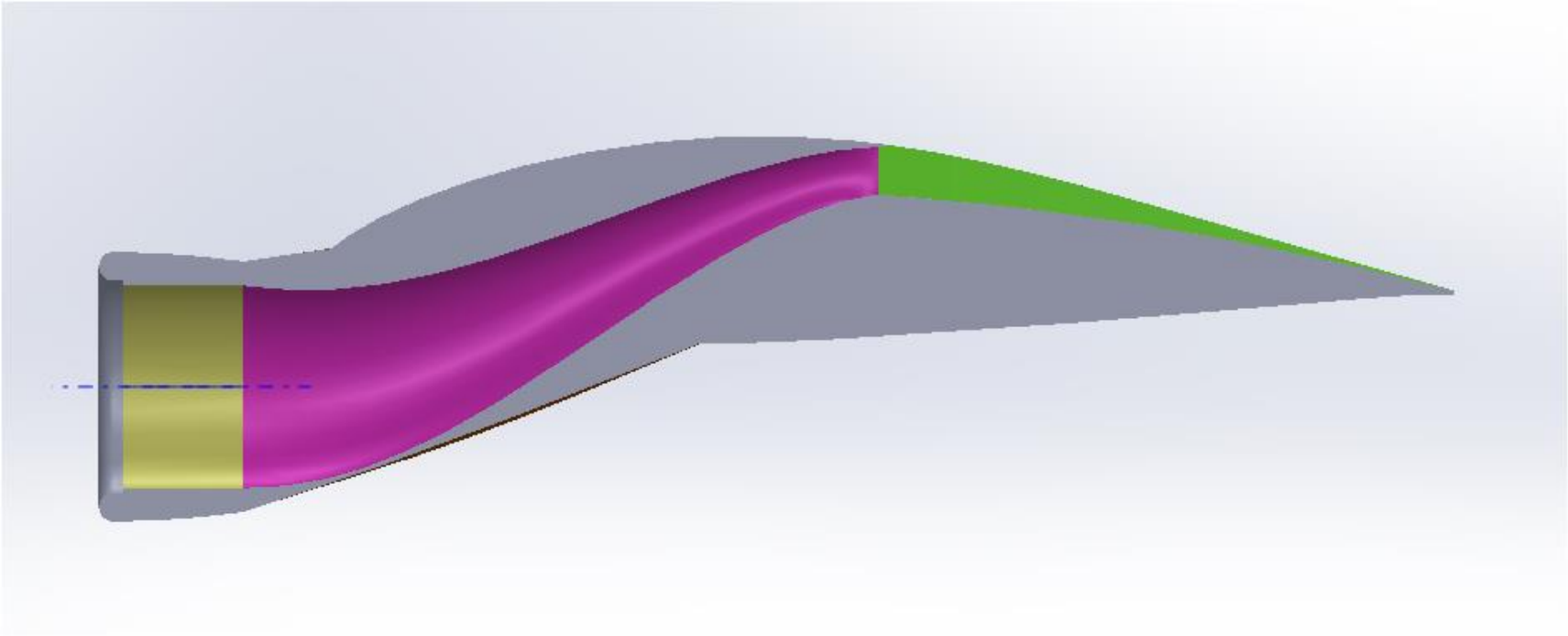


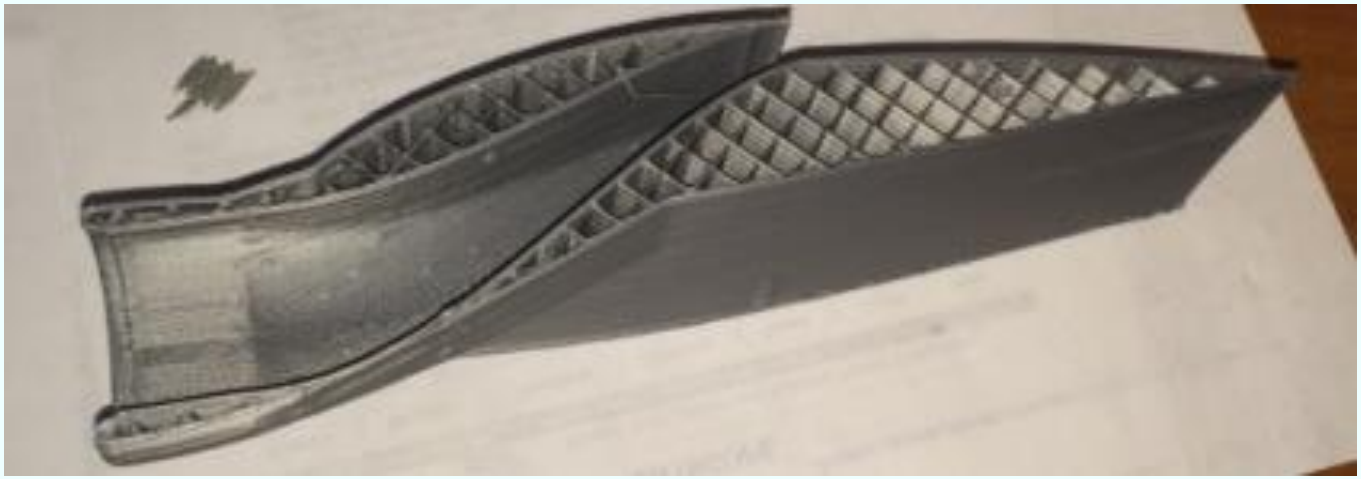
USB – Upper Surface Blowing

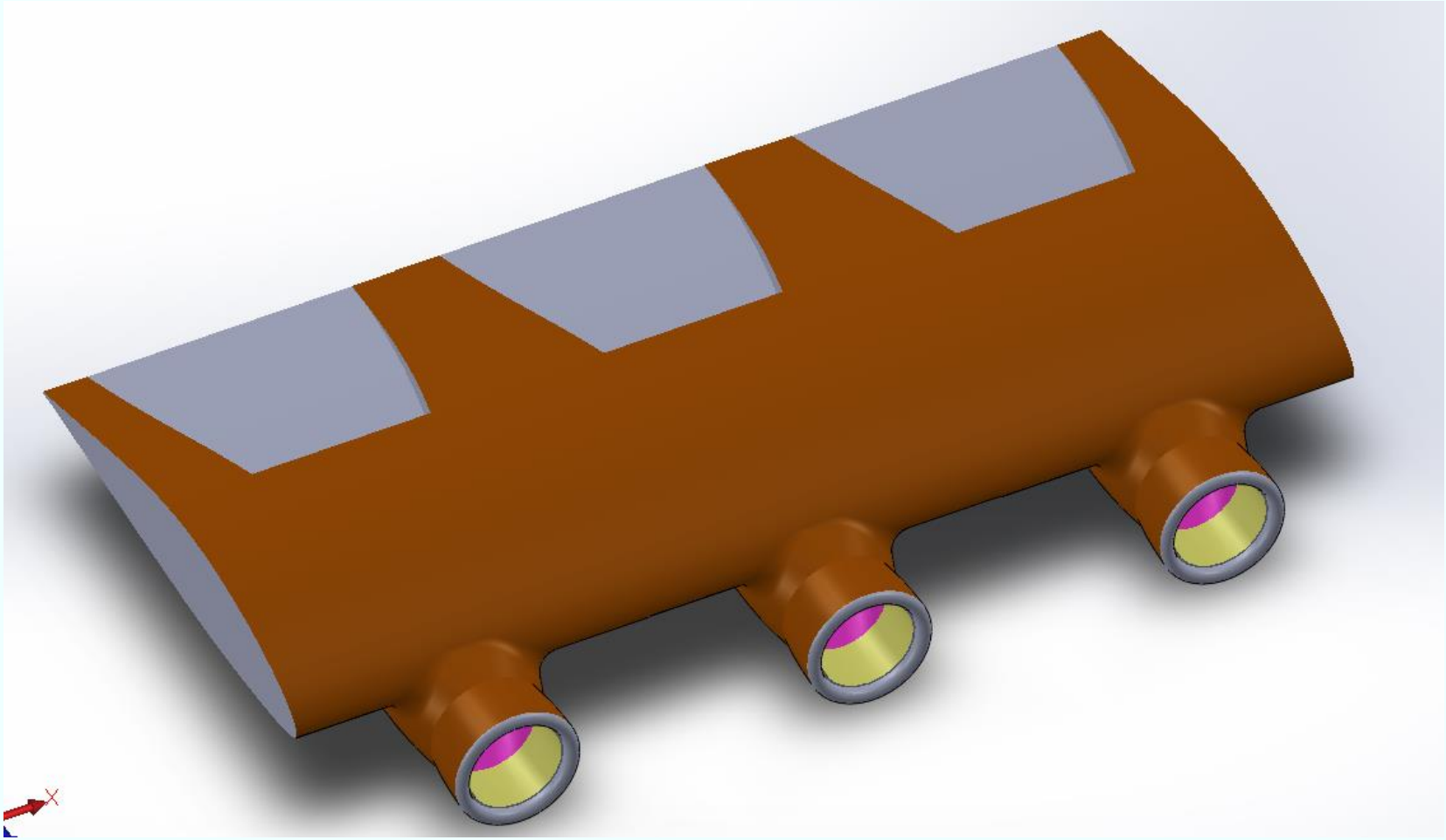


120 mm EDF: 2.3 lbs (1 kg) with controller, 5 hp (4kw), 15.6 lbs (7 kg) of thrust



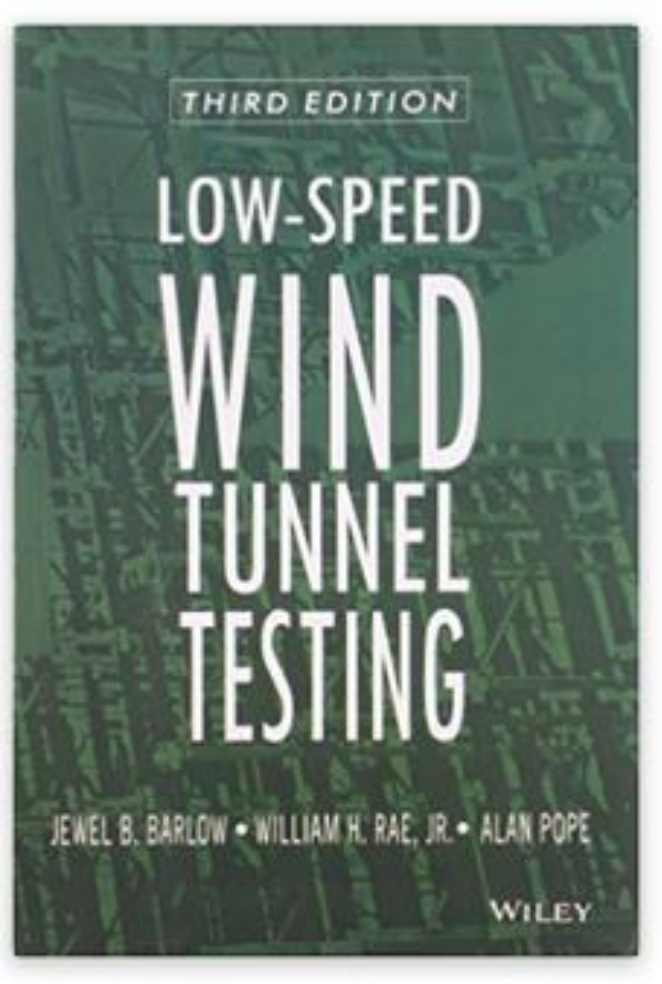






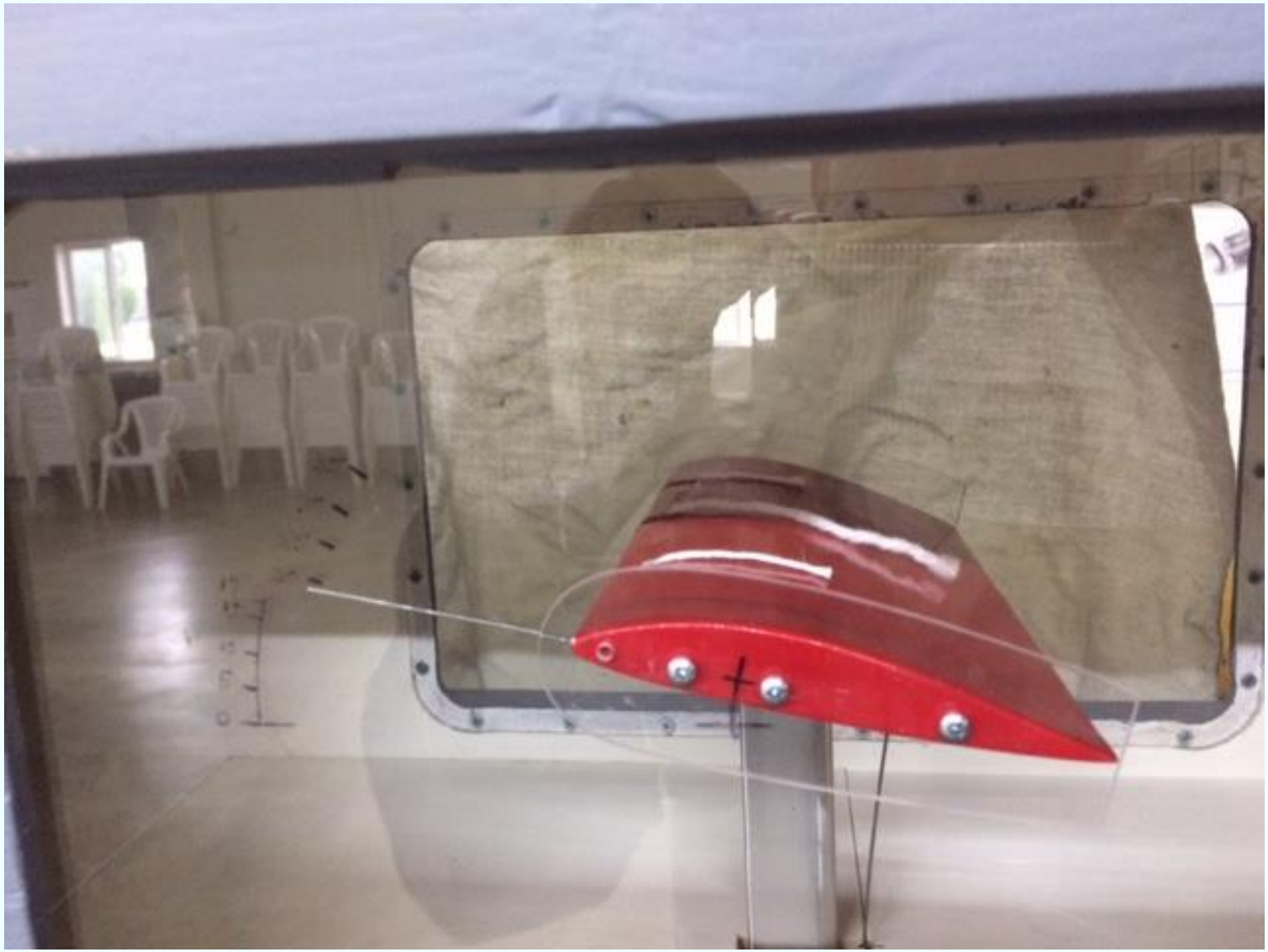
What you can do with a Wind Tunnel

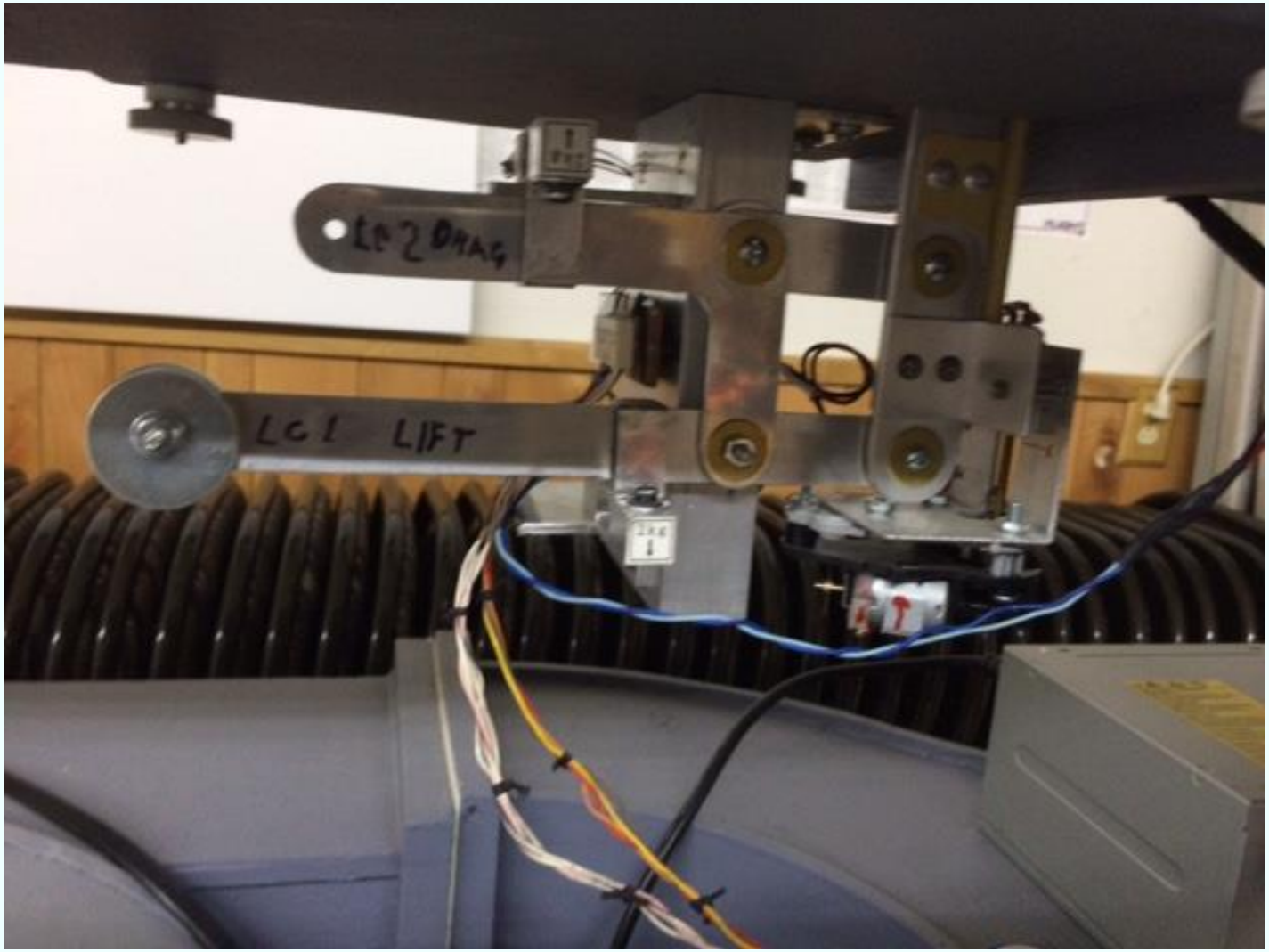
- Demonstrate
- See flows
  - Smoke
  - Tufts
- Measure
  - Forces and moments
  - Velocities
  - Pressures
- Good resource - *Low Speed Wind Tunnel Testing*; Barlow, Rae, and Pope; John Wiley, 2010.

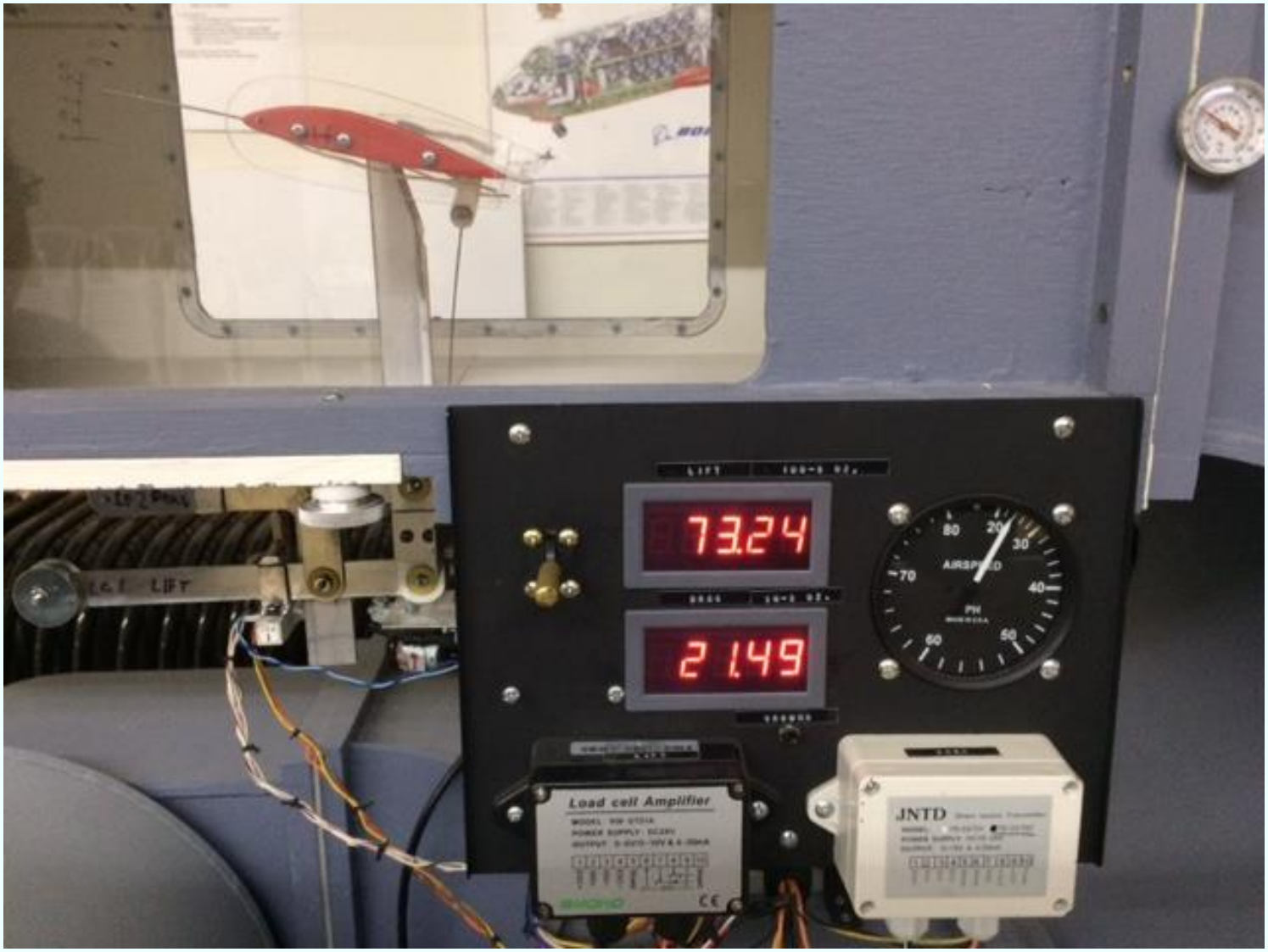


A Demonstration Tunnel

Very low Reynolds Number







Reynolds Number

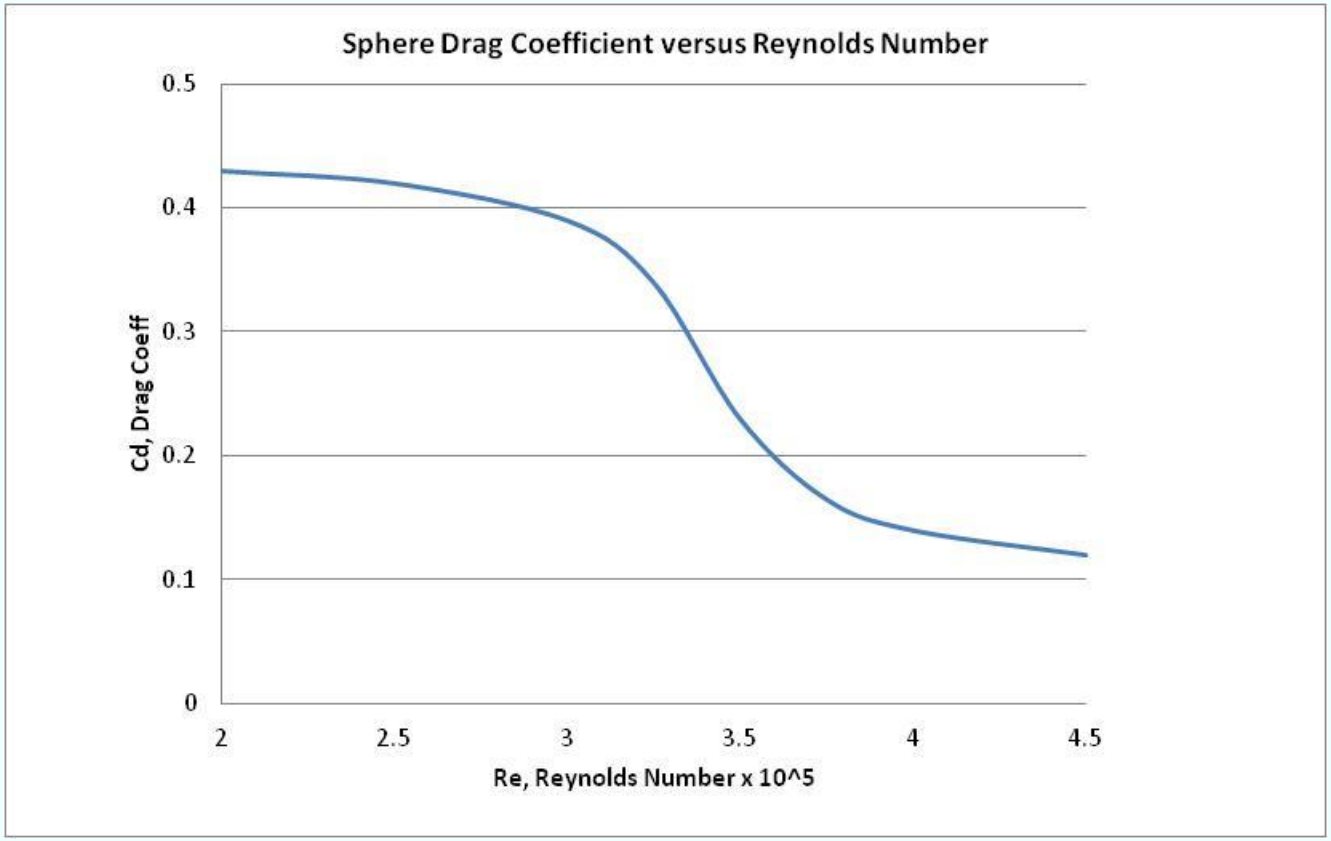
$$\text{Reynolds Number} = \frac{\text{Inertia force}}{\text{Viscous force}} = \rho V L / \mu$$

ρ = .002738 slug/ft^3 = 1.225 kg/m^3
$\mu = 1.79\times10^{-5}$ Pa * sec = 3.74 10^{-7} lb * sec / ft^2

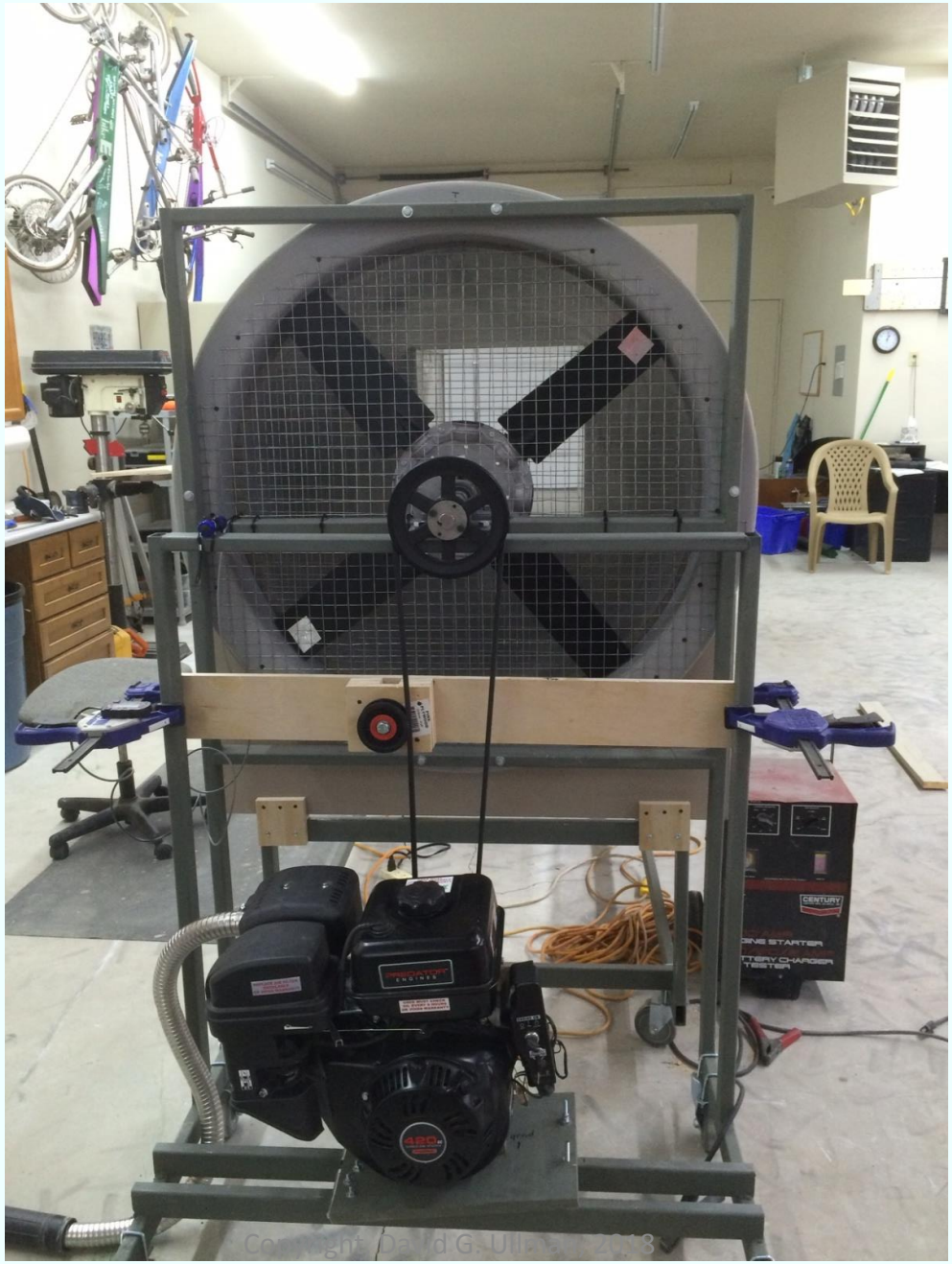
For a Jabiru in cruise:
chord (L) = 39” = 3.3 ft
V = 124 mph = 108 kts = 181 ft/sec
So Re = 3.8 *10^6

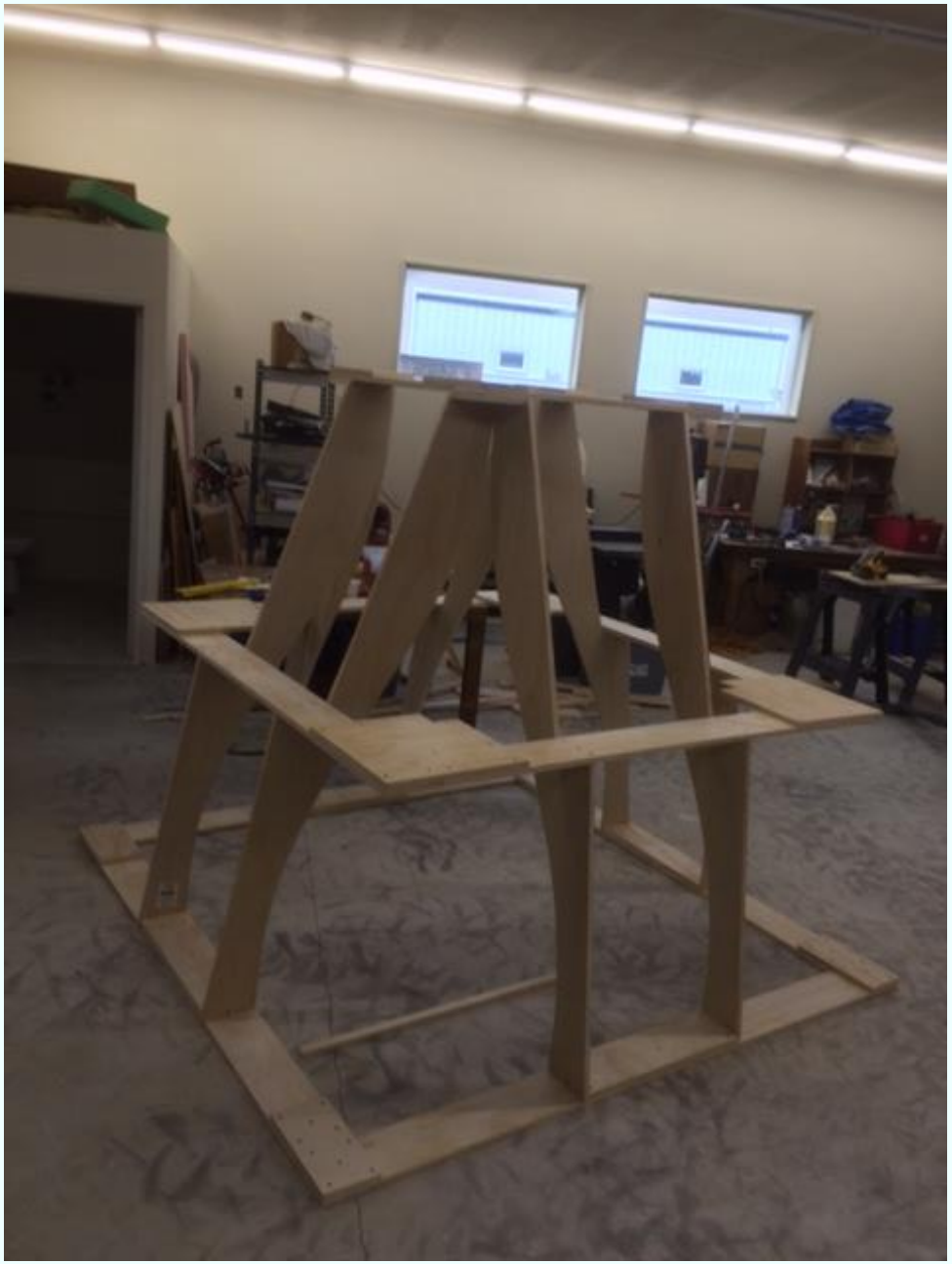
At TO with V = 65 kts RE = 2.2 * 10^6

Drag versus Reynolds Number for a Sphere

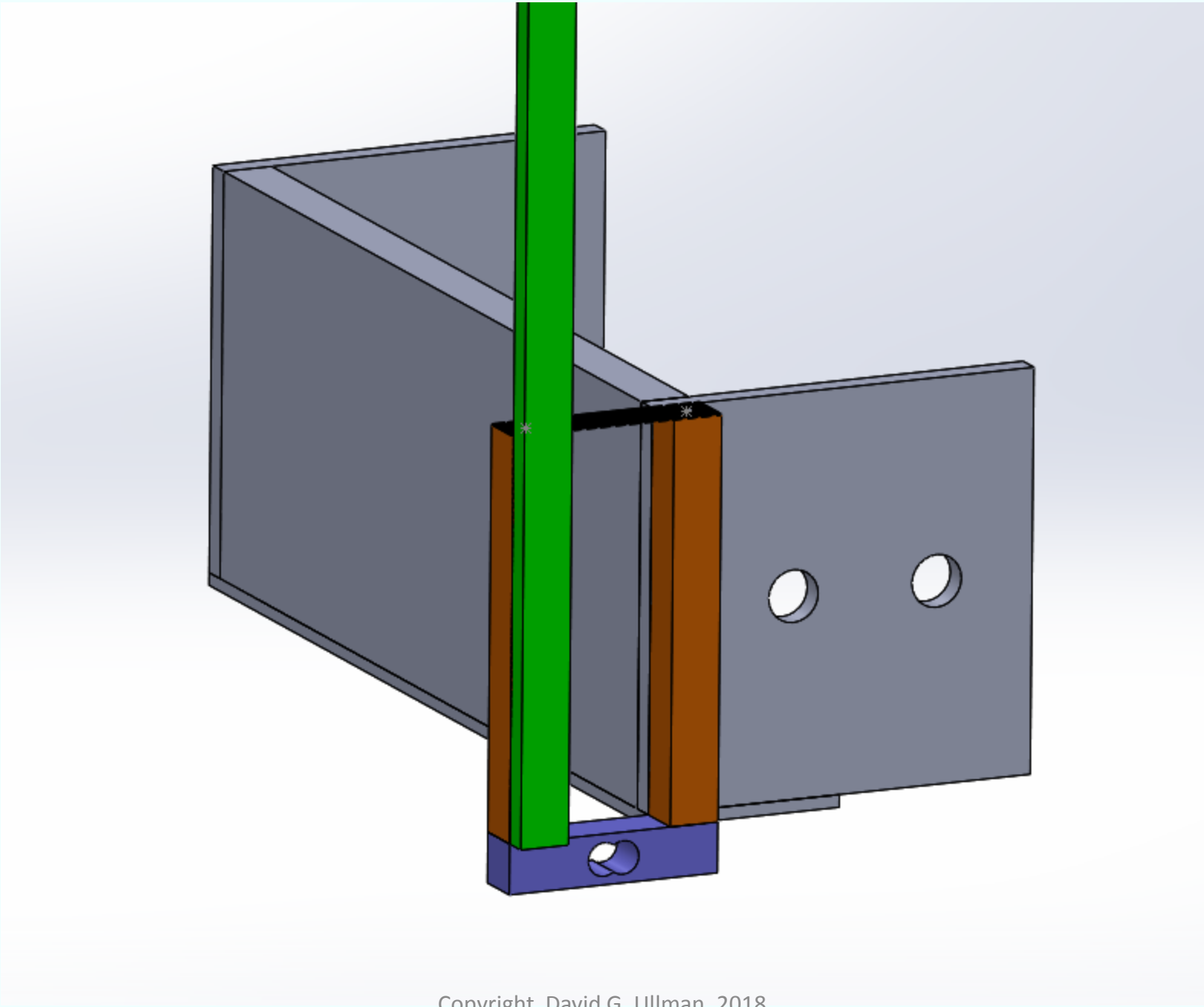


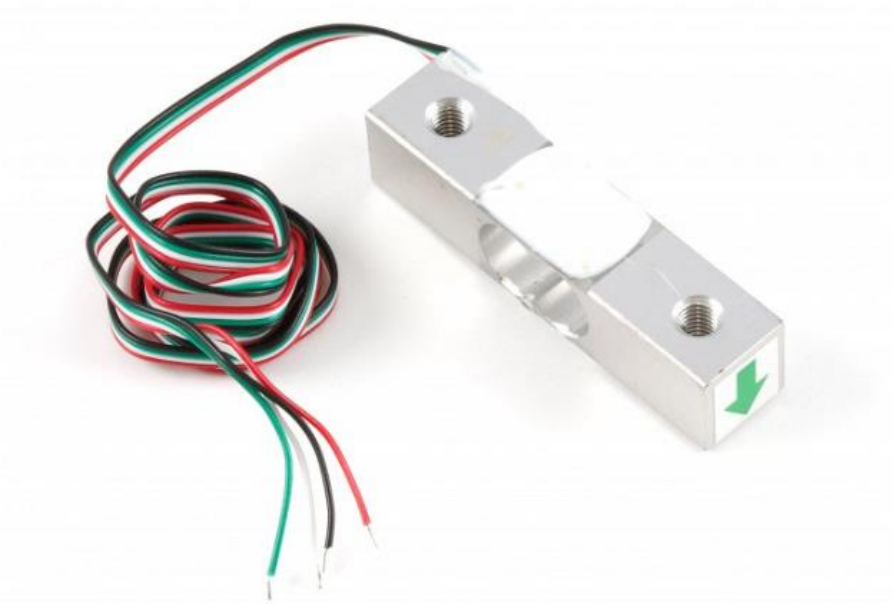

AIRPLANE RIDES
5.00
EVERY SUNDAY





- Axial Fan blades –Multi-Wing http://www.multi-wing.com/





Micro Load Cell (0-5kg) - CZL635

ID: 3133_0

RoHS COMPLIANT

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

$7.00

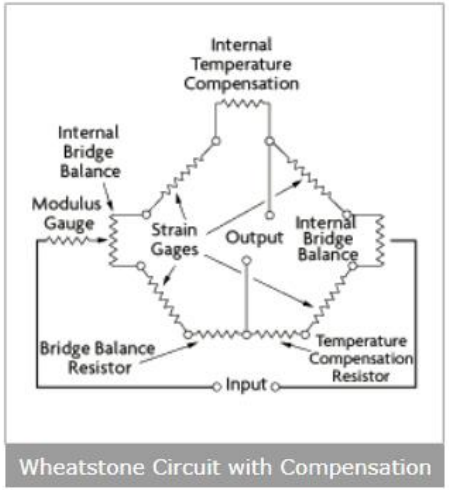
Quantity Available: 1000+

Qty	Price
5	$6.65
10	$6.30
25	$5.60
50+	...

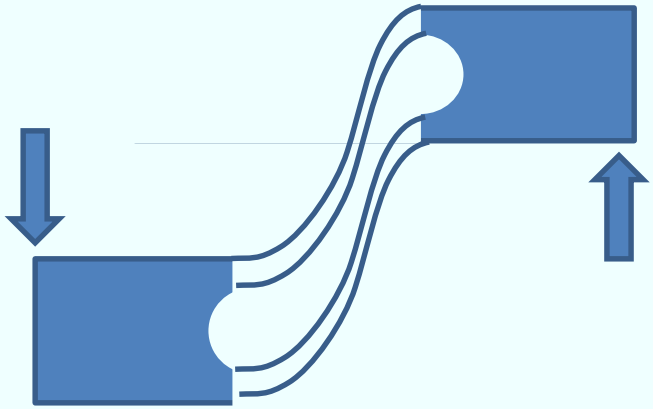
− 1 +

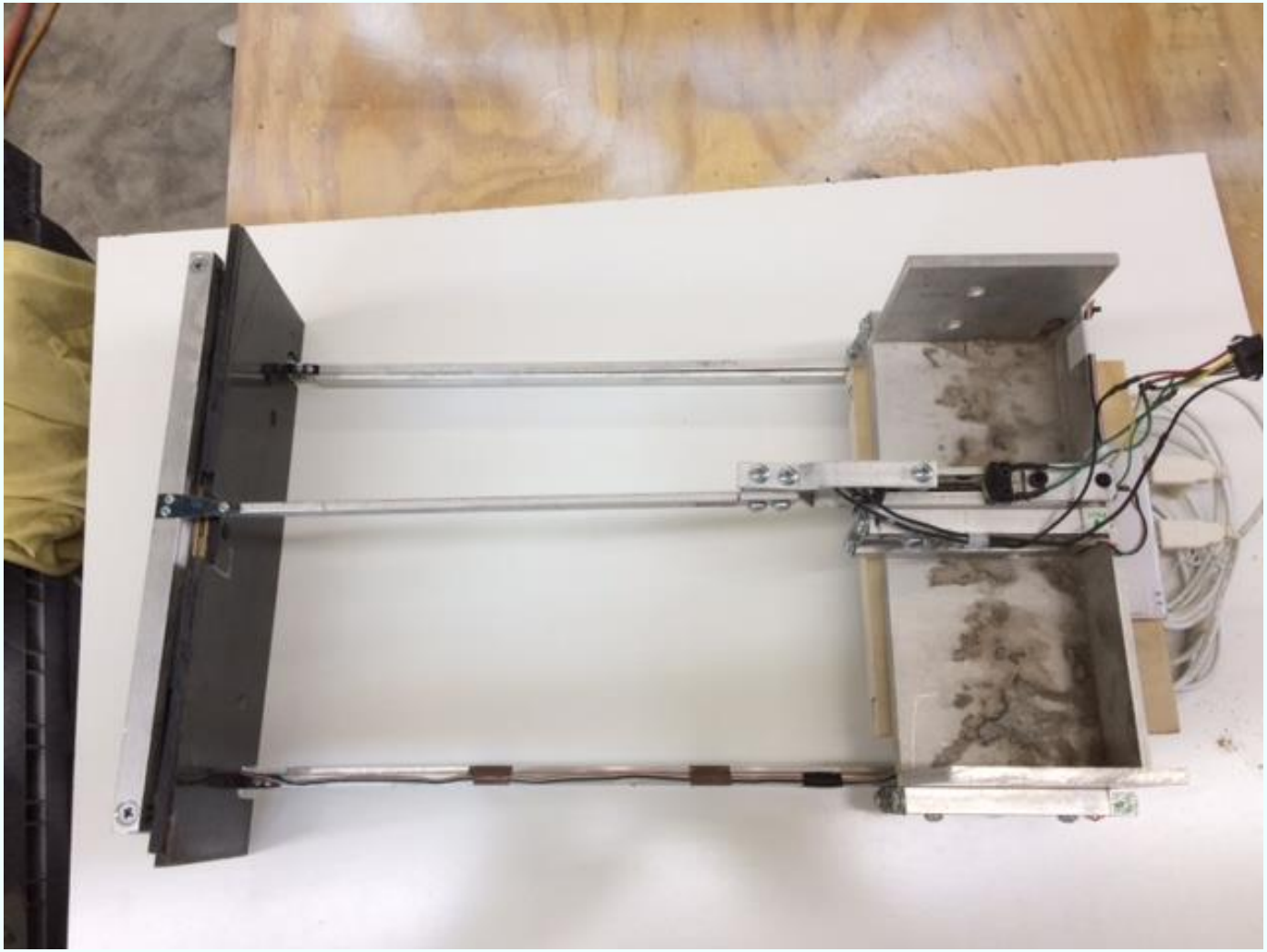
ADD TO CART

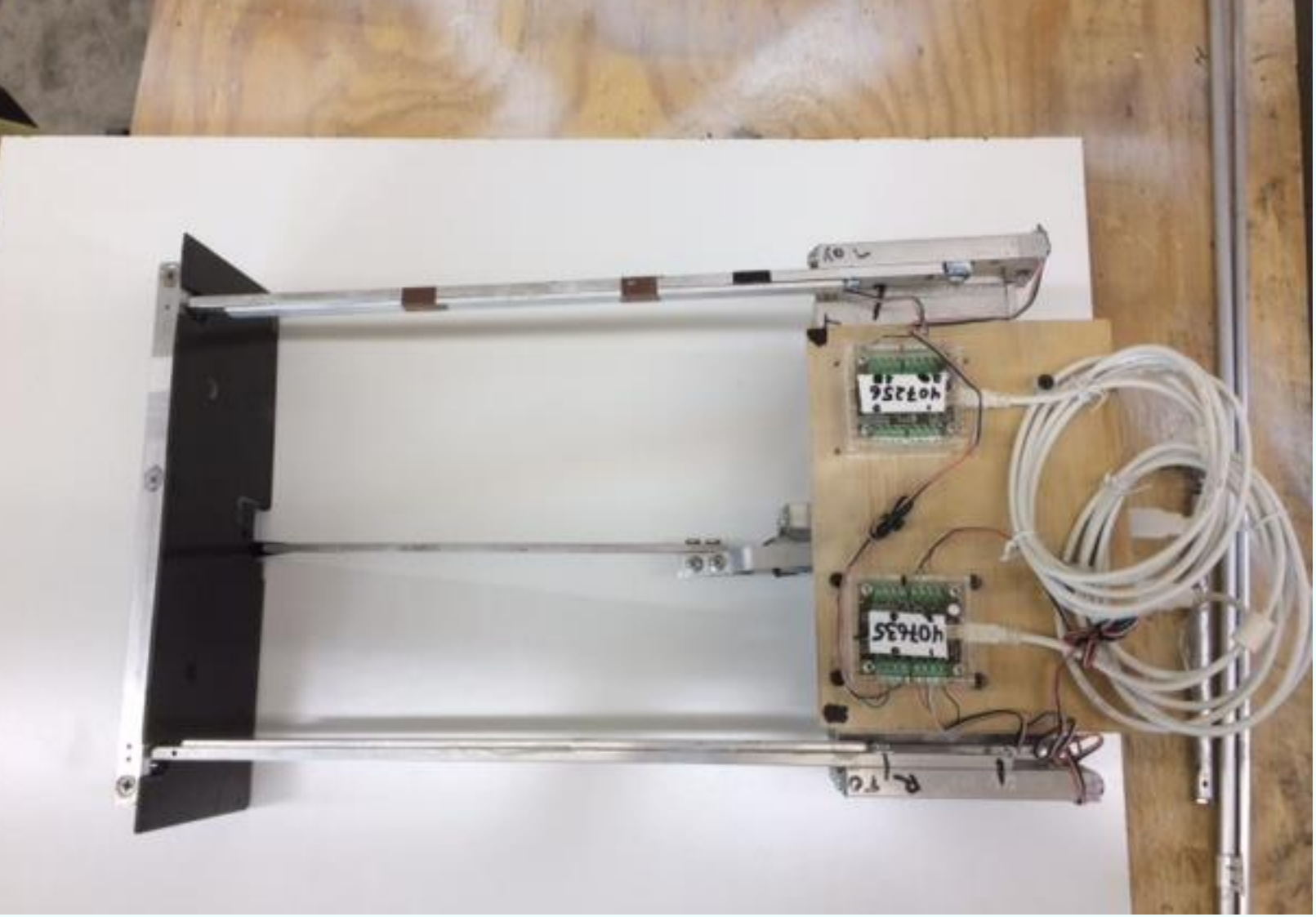
Shear Beam Load Cell



Wheatstone Circuit with Compensation



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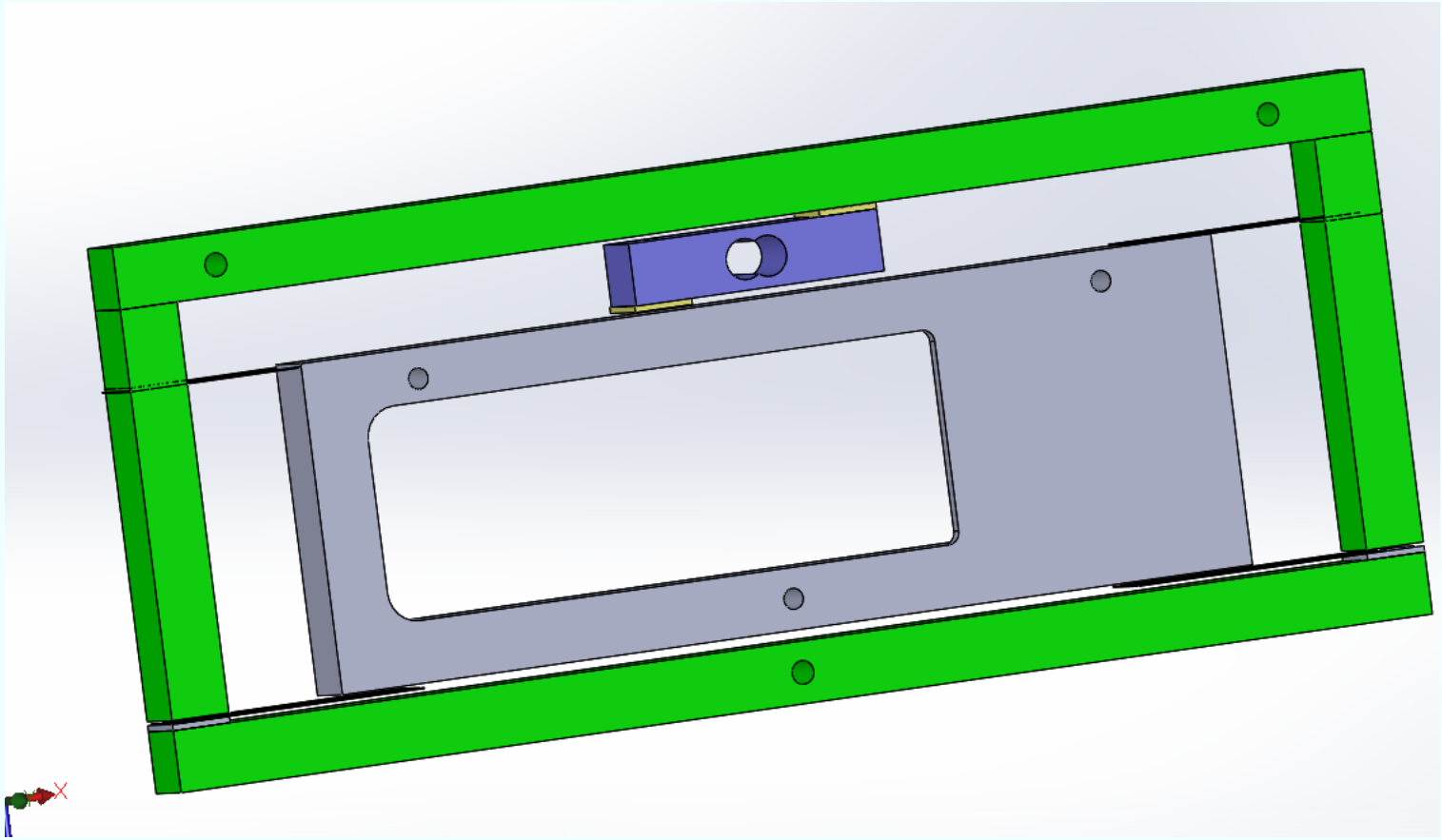
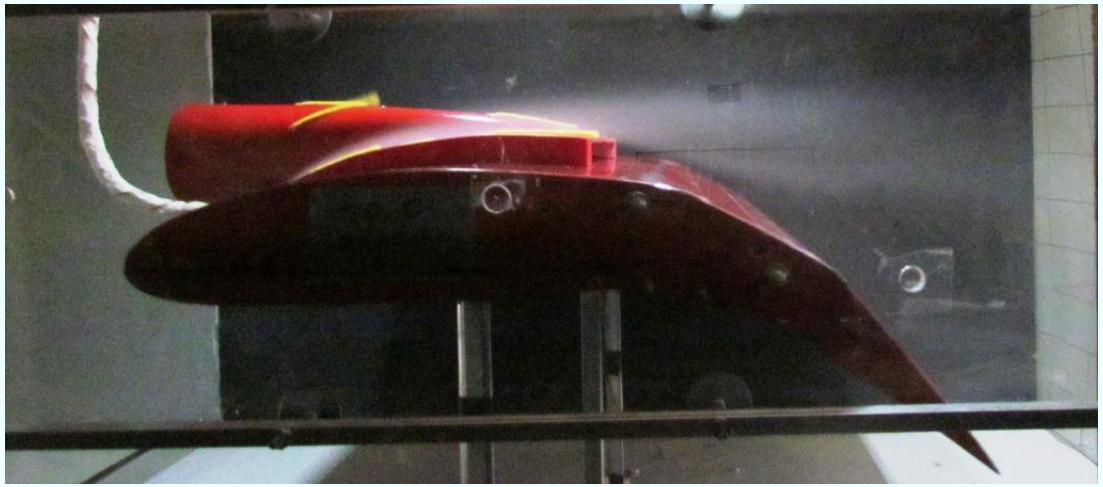
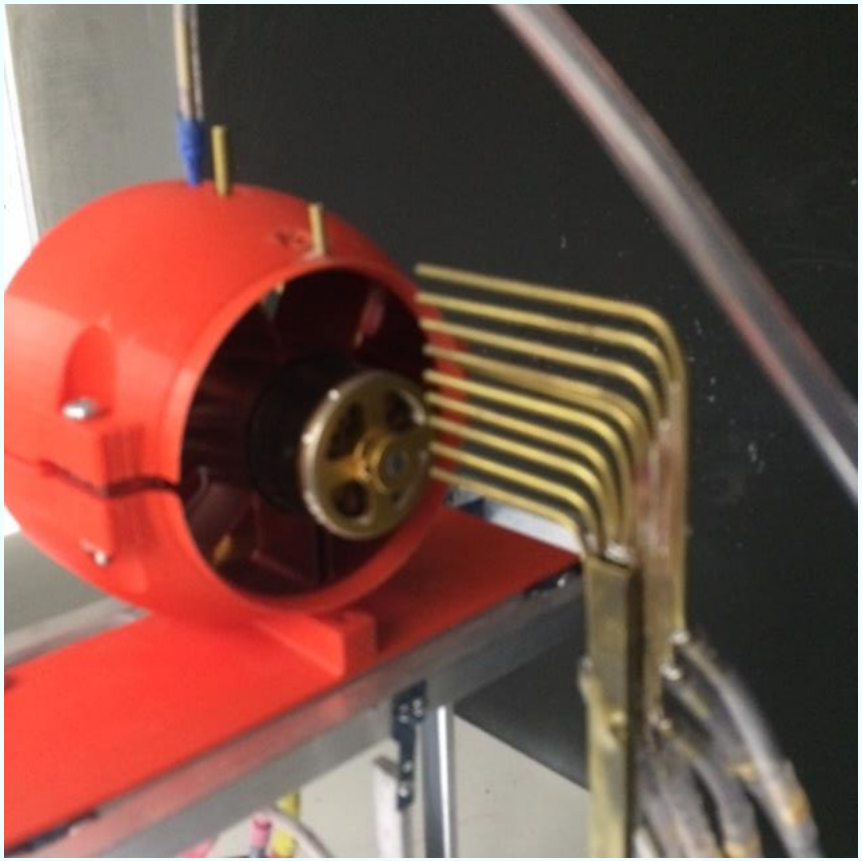


Smoke for Visualization

- 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

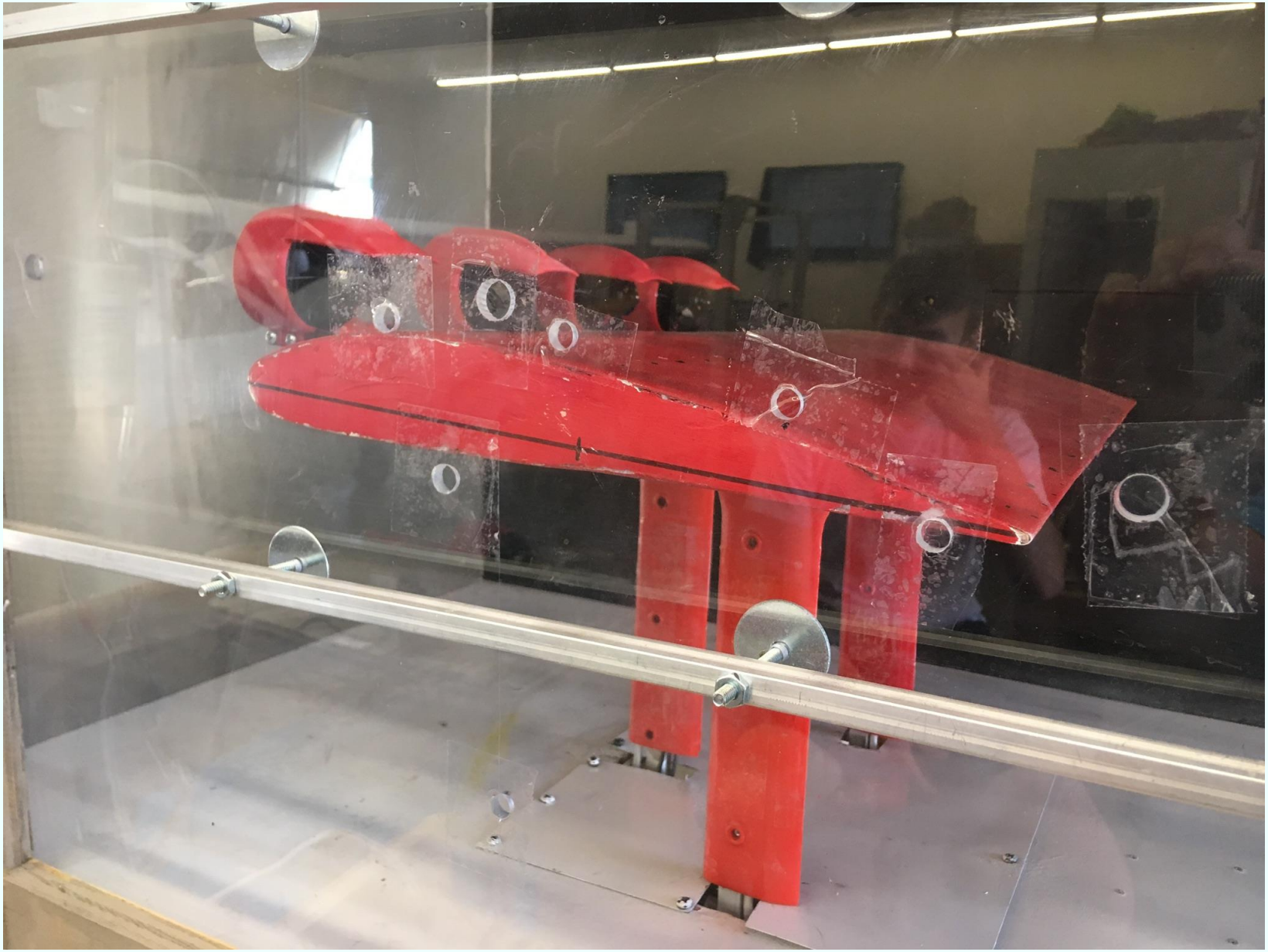


Sensors

- Phidget: http://www.phidgets.com/
  - USB sensing and control
  - Measure pressure, angle, force, rpm

- Accelerometer

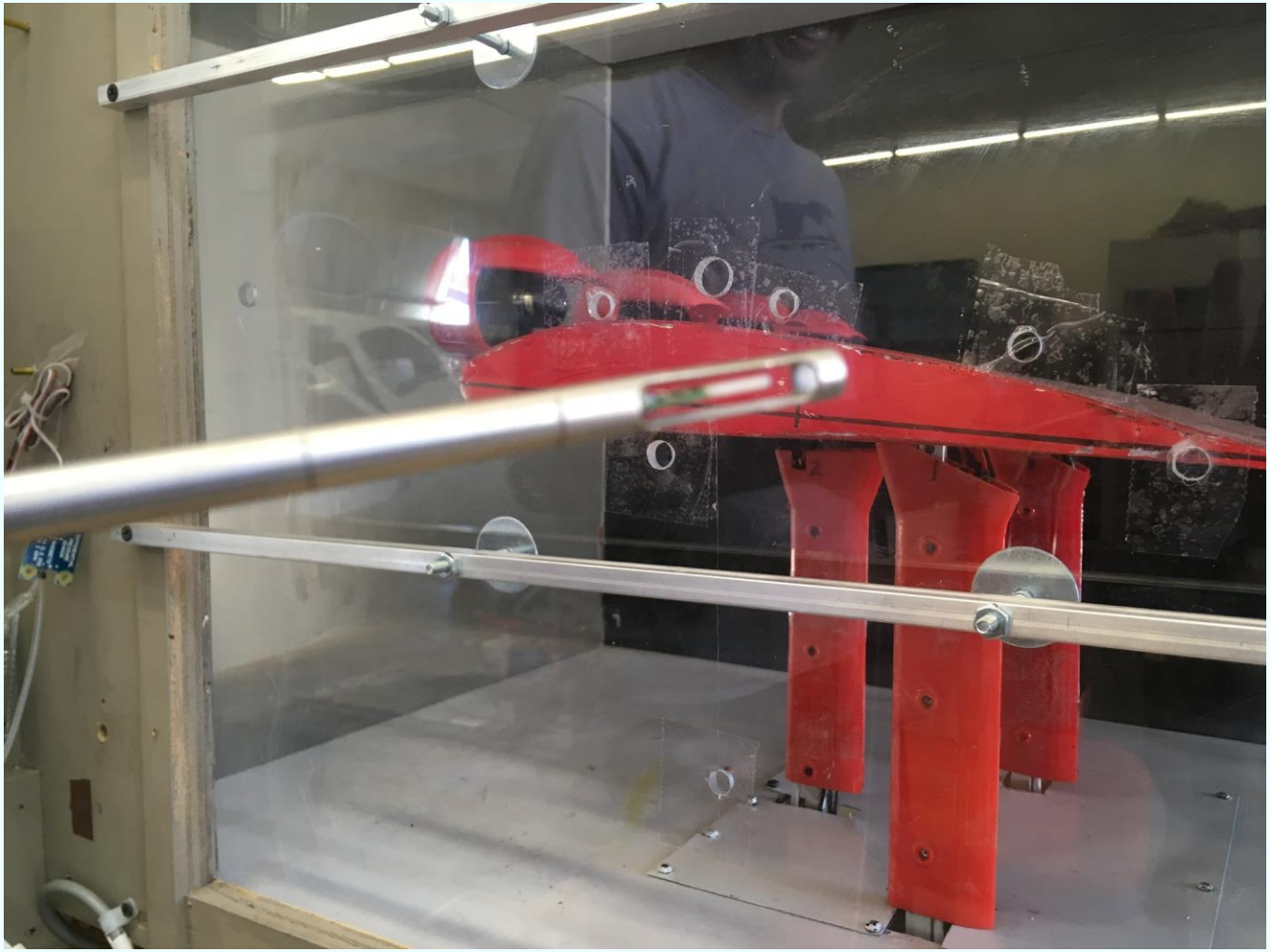
- Differential Pressure

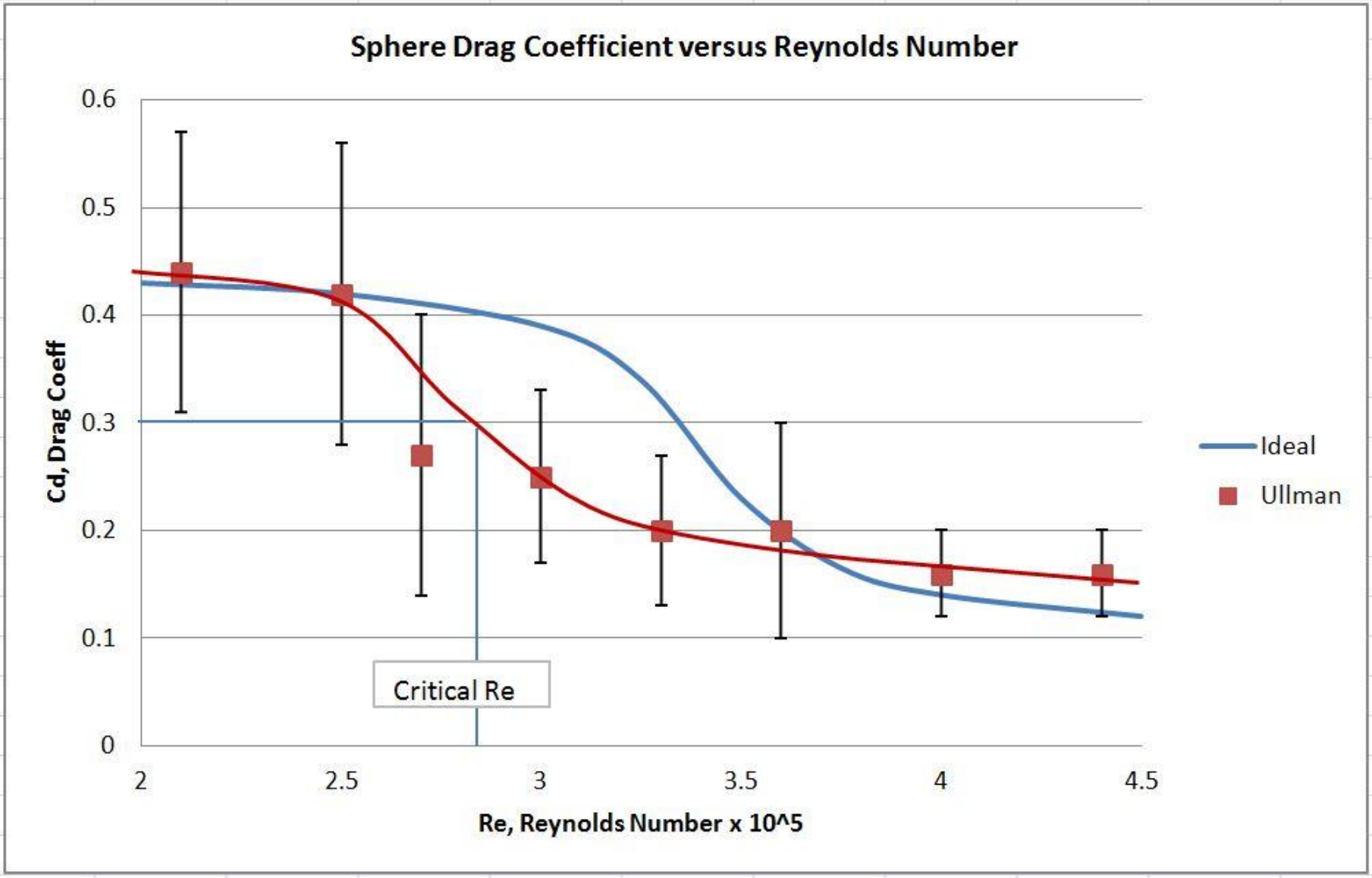


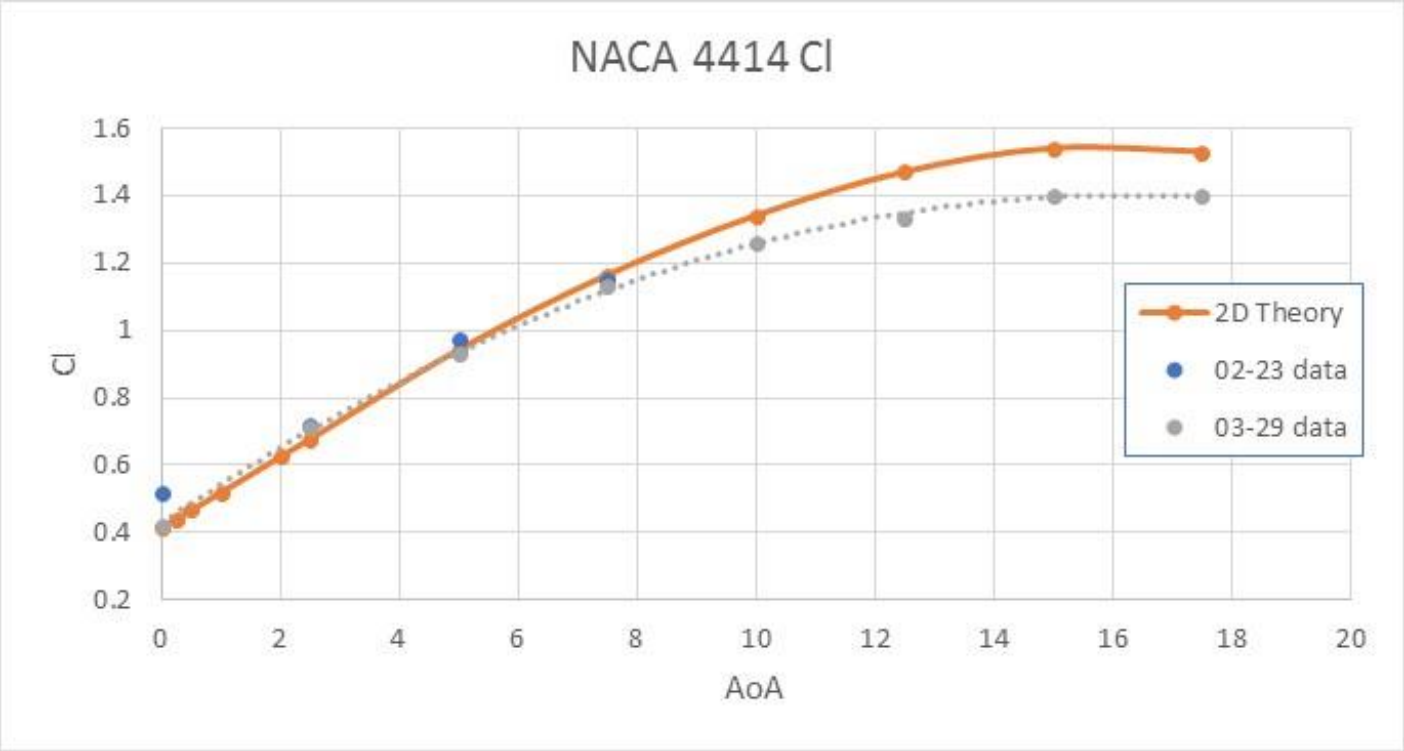
Omega hot wire anemometer

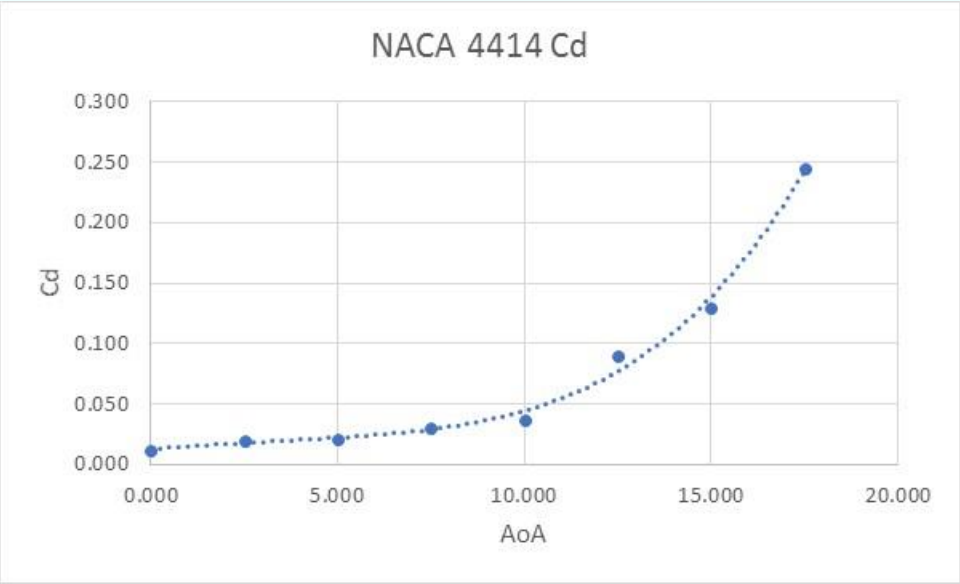
HHF-SD1

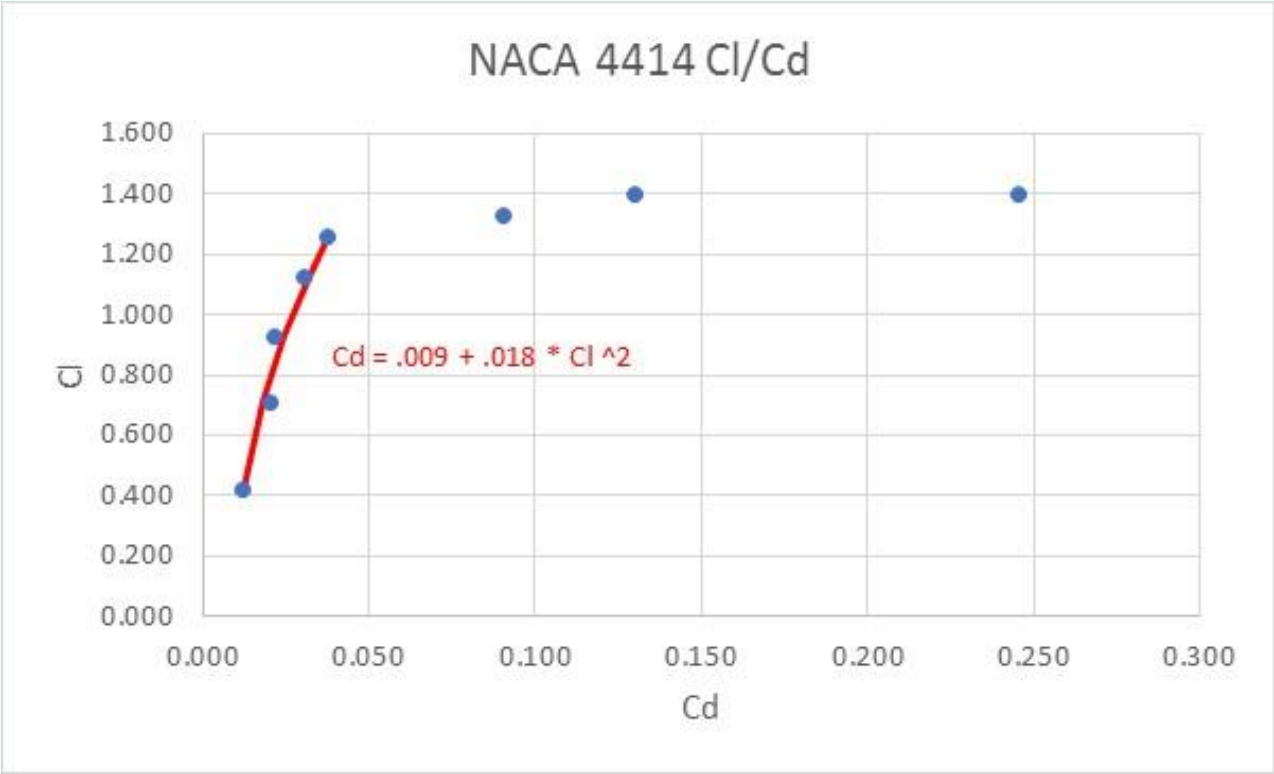
Hot Wire Anemometer with Real Time Data Logger

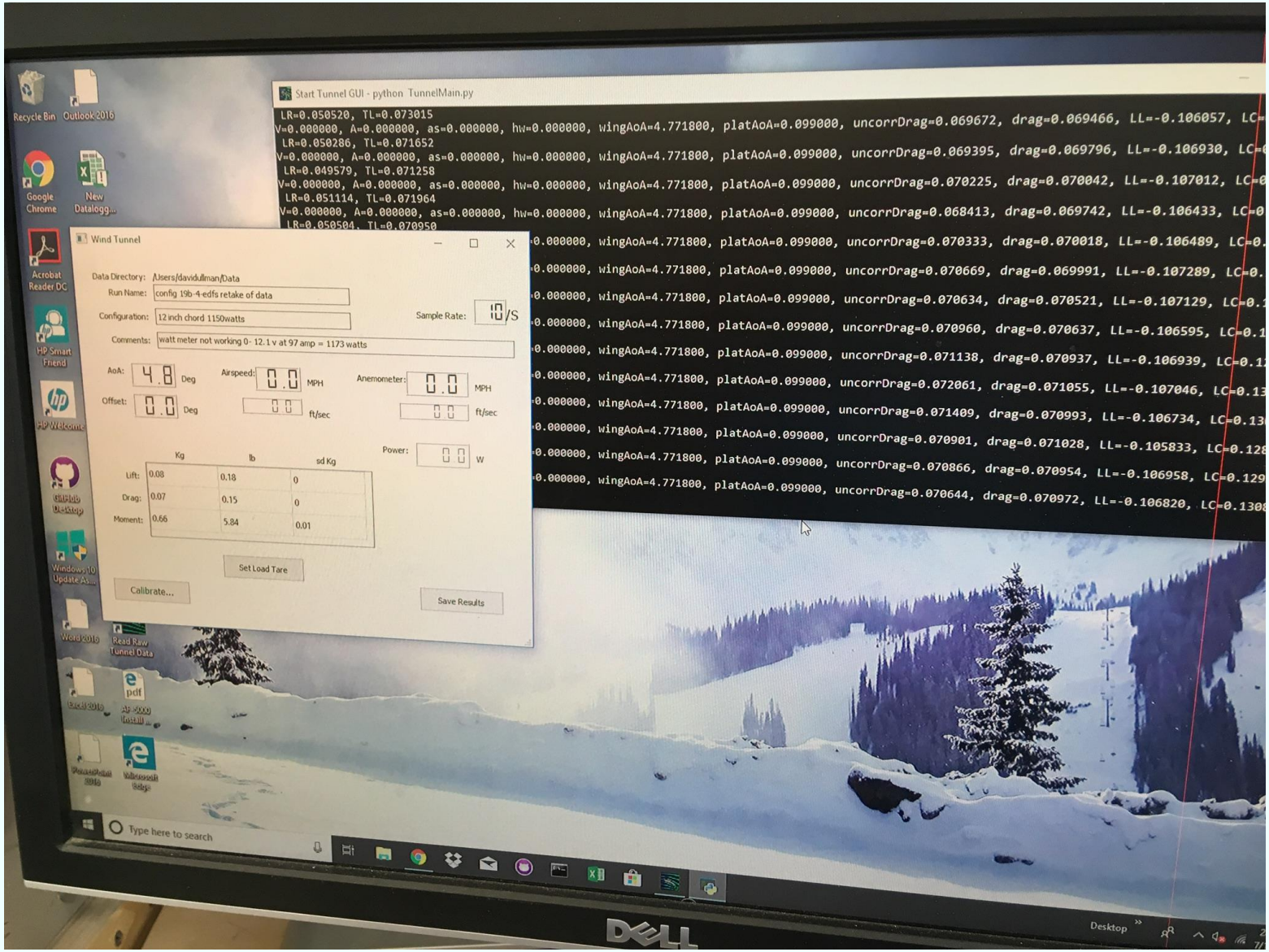










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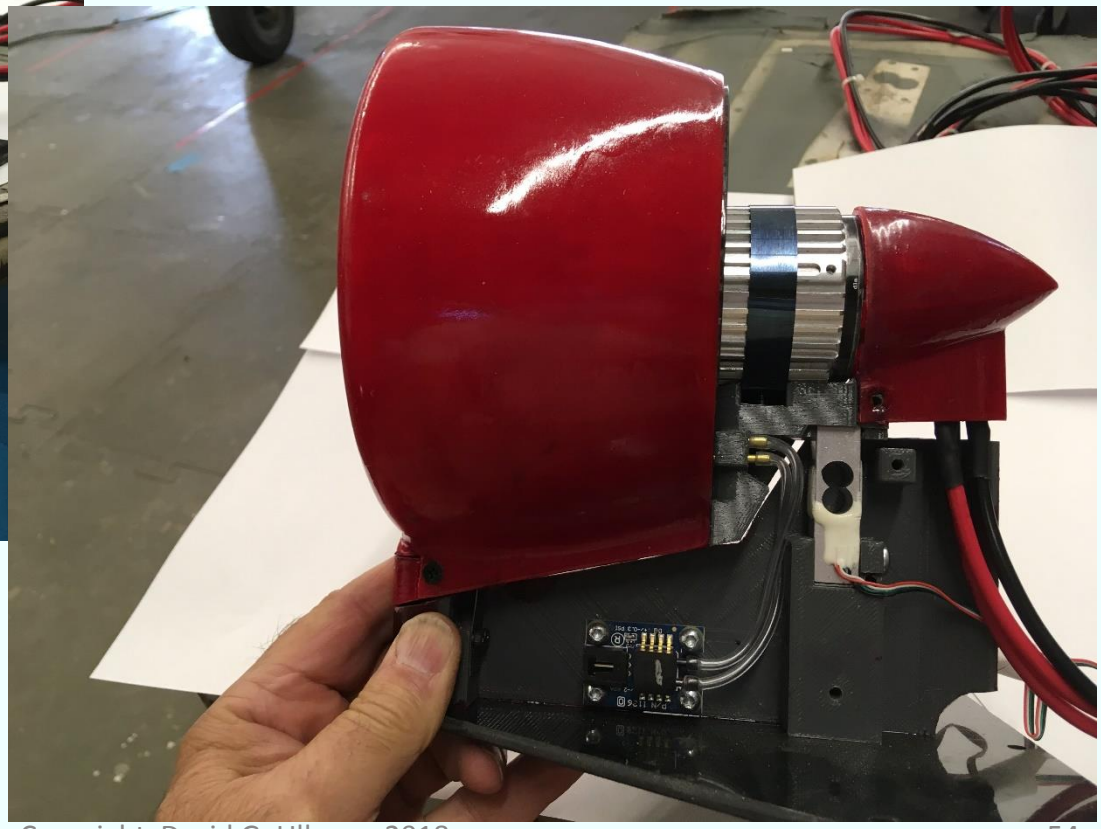

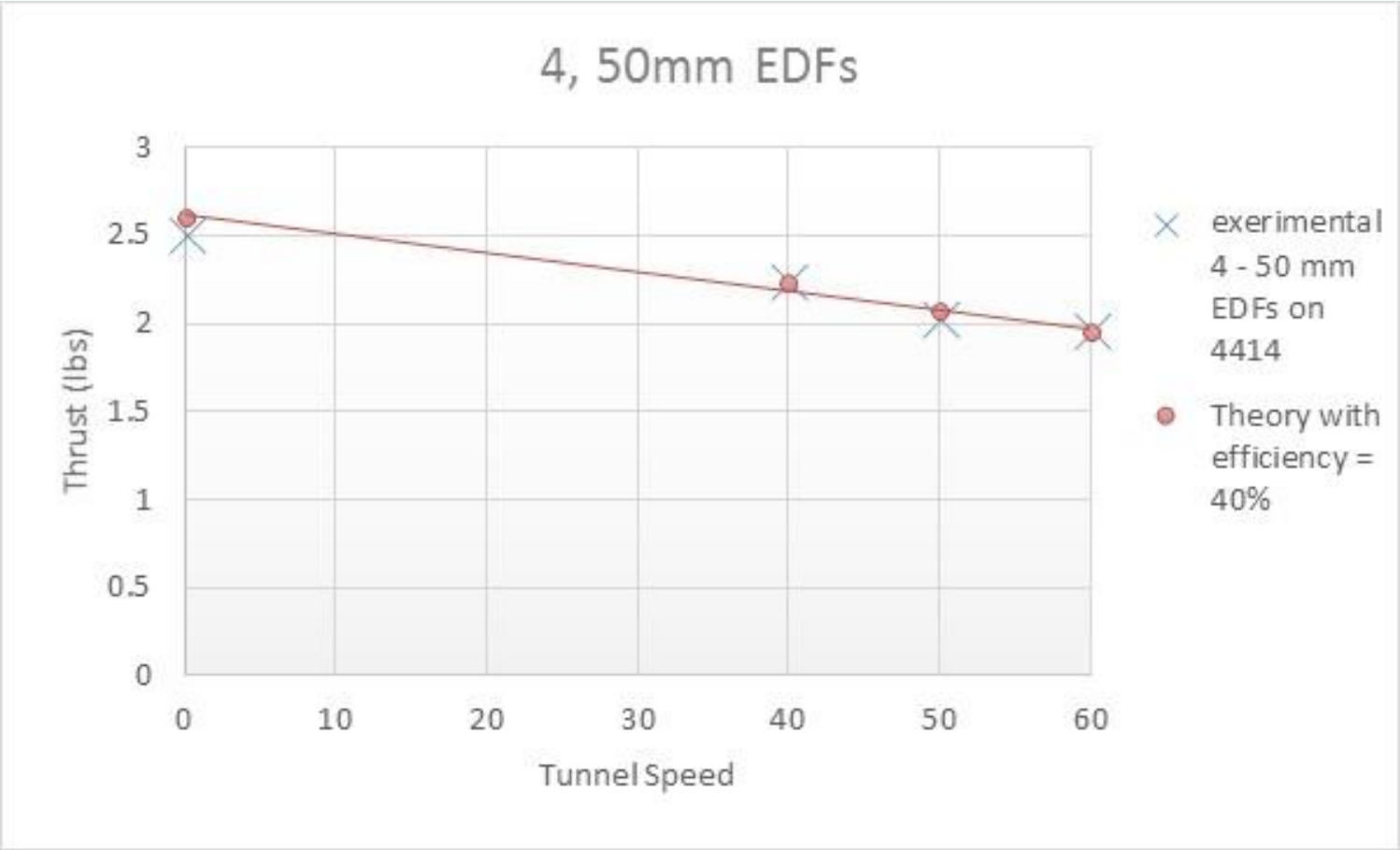

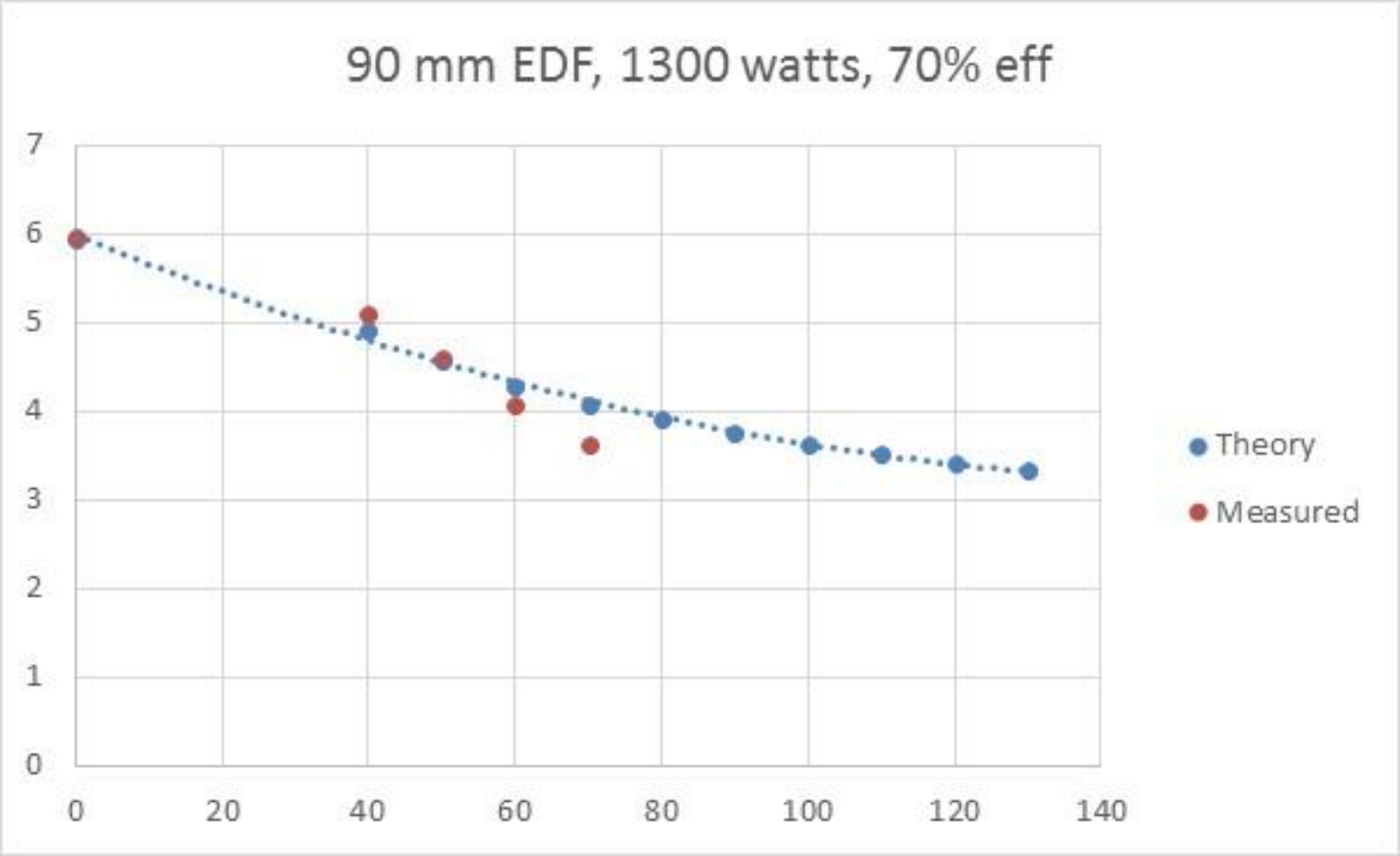

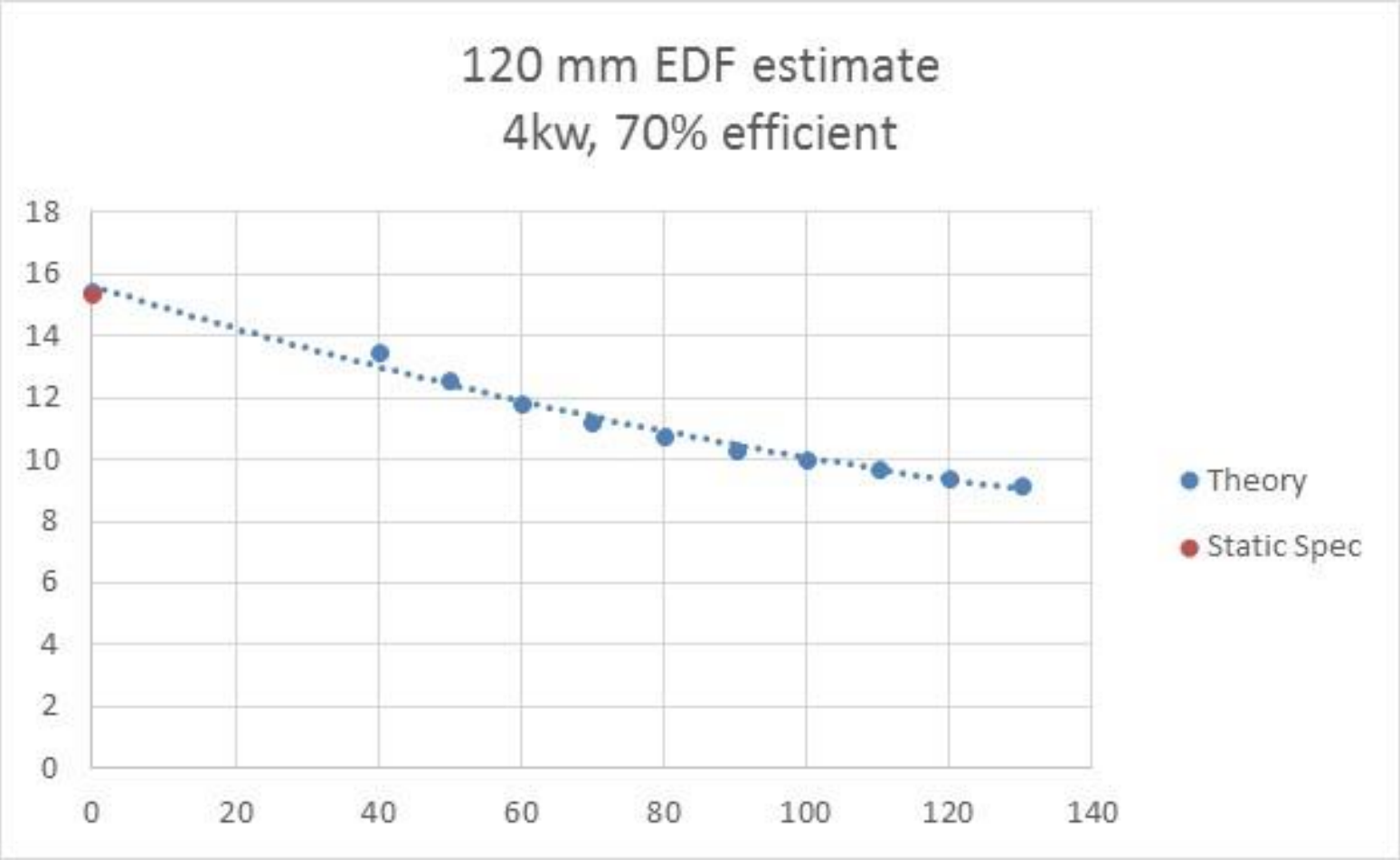

Send your questions, comments, disagreements or statements of “hogwash” to:

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541-760-2338