

# Low Speed Open Circuit Wind Tunnel Design

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# Presentation Outline

- Overview of tunnel and project objectives
- Components of main tunnel and their design/construction
- Axial fan
- Instrumentation design
- Budget/FMEA
- Conclusion



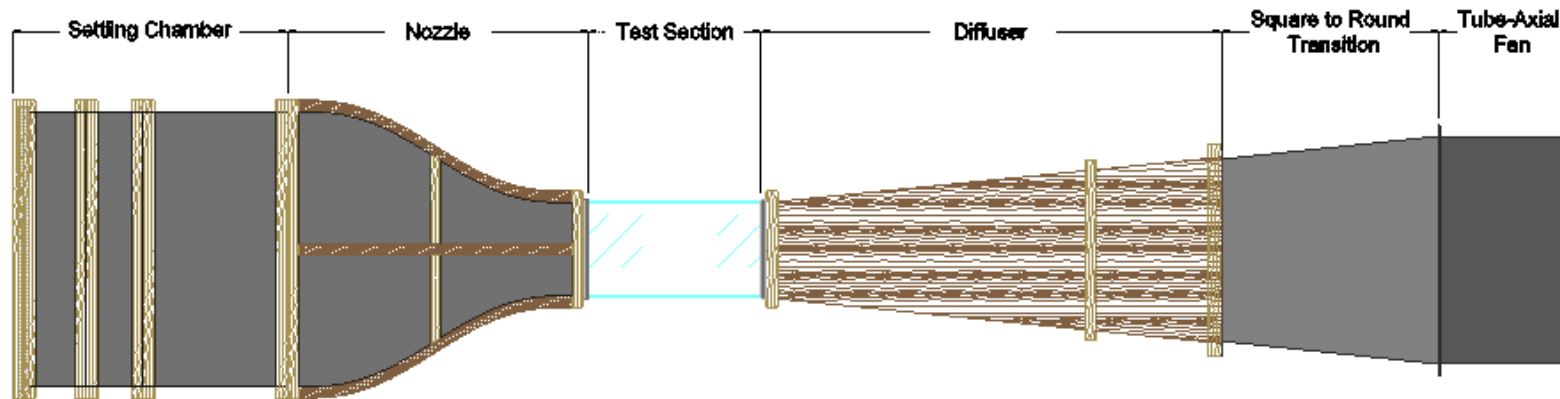
# Tunnel and Project Overview



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# Overview

- Tier One funds were designated for design of a new teaching laboratory wind tunnel
- Open circuit over closed circuit
- Four primary segments



# Project Goals and Objectives Overview

- Maximum air speed of 60 mph
  - Ability to have variable speeds up to maximum desired speed
- Air flow quality
  - Minimal turbulence and experiments easily repeated
- Ability to be disassembled and stored
- Operation is easy and enjoyable for user
- Remain under set budget of \$20,000



# Meeting Goals and Objectives Overview

- Flow Quality and Pressure Losses
  - Utilize screens and a honeycomb to create laminar flow
  - Use favorable geometry in order to avoid flow separation and losses
  - Weather stripping to create seal between parts
- Disassembly
  - Disassembled into four parts
    - Settling chamber and nozzle, test section, diffuser, and fan
  - Test section sets into aluminum frame of nozzle and diffuser
- Support Stand
  - Stand to stabilize wind tunnel during operation
- Instrumentation
  - Test section and model mount design
  - Tunnel control software and instrumentation



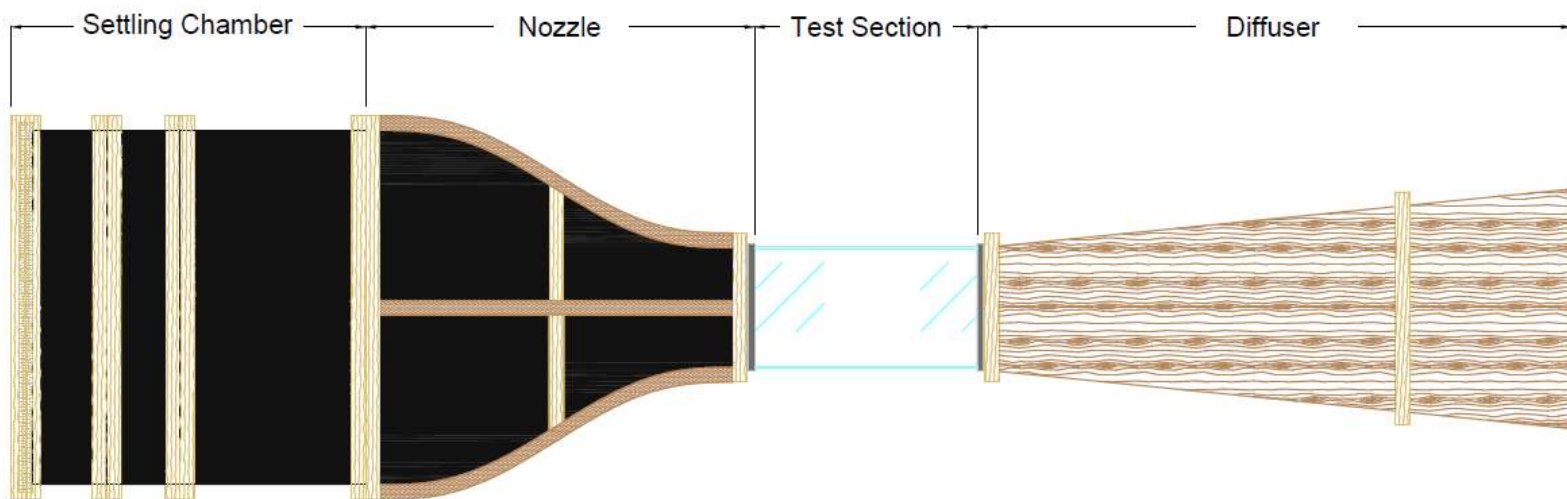
# Main Tunnel Components



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# Wind Tunnel Construction

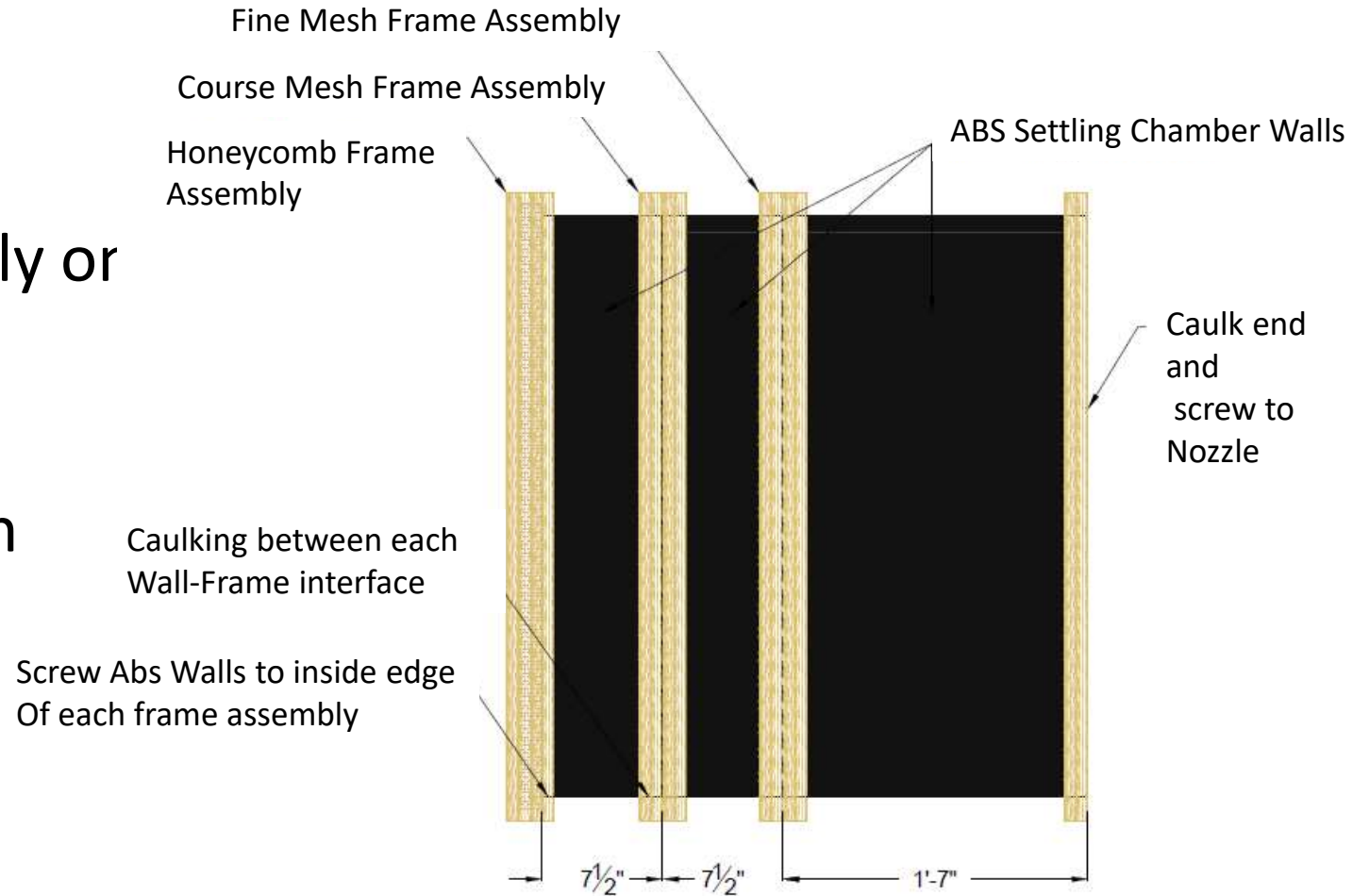
- Arcon Inc.
  - Producing tunnel for a bid of not to exceed \$9,000
- 3 Separate, Connectable Parts
  - Total Length 13'-1"





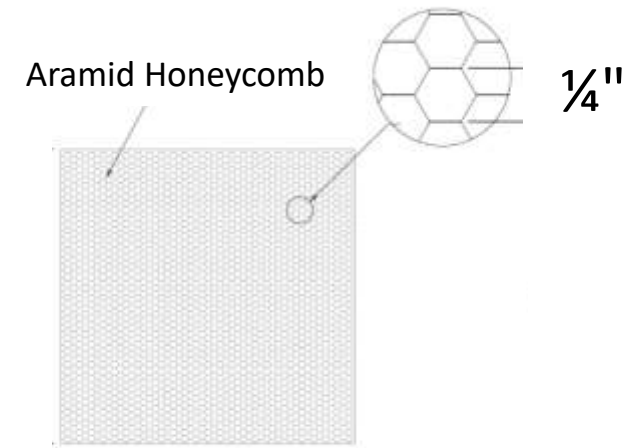
# Settling Chamber

- Housing for screen inlays
  - Honeycomb Frame assembly or end
  - Increasingly fine mesh as heading toward test section
- 3'x3' cross sectional area
- 2'-10" overall length

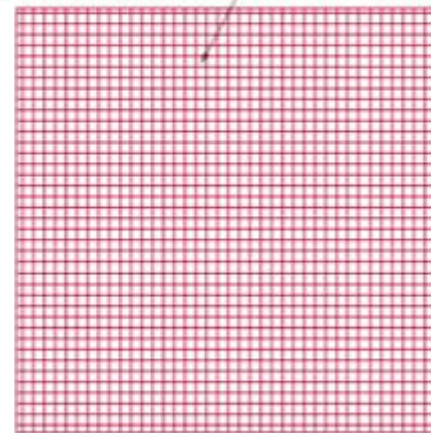


# Mesh Screens

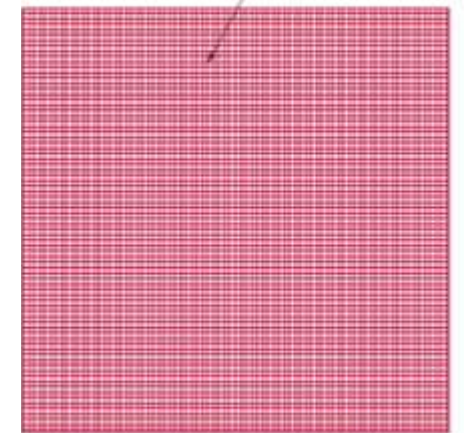
- Screens assembled according to porosity
  - Outermost is Honeycomb
    - 22,500 cells for  $\frac{1}{4}$ " cell diameter
  - 2<sup>nd</sup> screen is a 4 mesh screen
    - 0.0470 inches spacing for porosity of 0.59
  - Final screen is an 8 mesh screen
    - 0.0170 inches for porosity of 0.71



Course Mesh 0.2030" x 0.2030"



Fine Mesh 0.1080" x 0.1080"



# Nozzle

- Nozzle utilizes a fifth-order polynomial profile to increase velocity without introducing turbulent conditions
- 9:1 Area ratio between inlet and outlet
- Nozzle frame out of wood inlayed with ABS plastic

$$\xi = \frac{X}{L} \quad (1)$$

$$h = \left[ -10(\xi)^3 + 15(\xi)^4 - 6(\xi)^5 \right] (H_i - H_o) + H_i \quad (2)$$



# Test Section

- One main test section
  - Used for lift-drag assembly
  - Mounts securely to diffuser and nozzle
  - Permits entry of model mount for experimentation



# Diffuser

- 4:1 area ratio allows 60 mph incoming air to leave the section at 15mph
- Shallow angle ( $5^\circ$ ) prevents separation of flow
- Section made of half inch plywood with 2"x2" supports to maintain its shape



# Axial Fan



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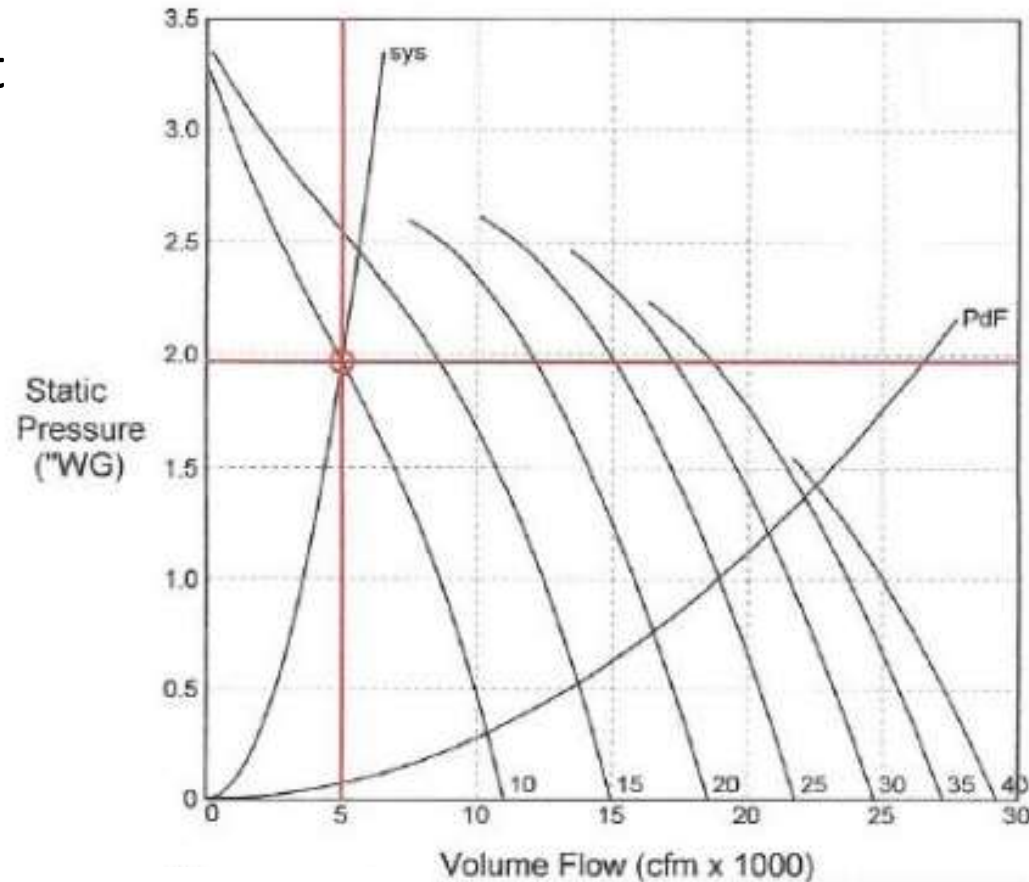
# Square To Round Duct

- Whole duct made from 14 gauge (0.080") sheet metal
- Square cross section of 24" by 24"
- Round cross section of 30" diameter
- Length of 30.5"
- Length made to match angle of diffuser



# Fan

- VirTau 30" Belt Drive Tube Axial Duct Fan
  - Operate at 2.0 inches of water static pressure within test section
- Rated at 5000 CFM at 7200'
  - Operates at 3 HP, 230 V
  - Includes mounting legs and will be mounted to a cart
- Cart rated at 1200 lb load capacity with locking wheels





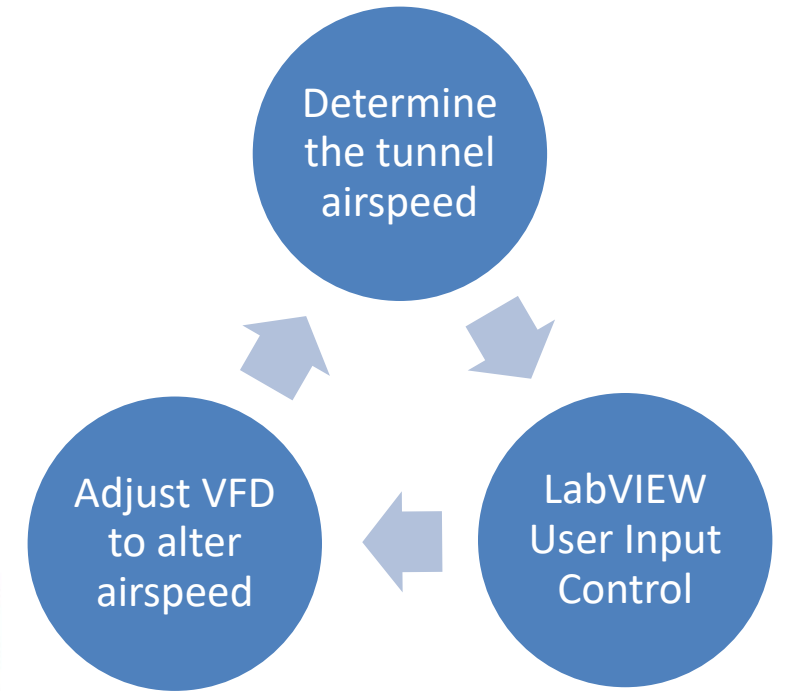
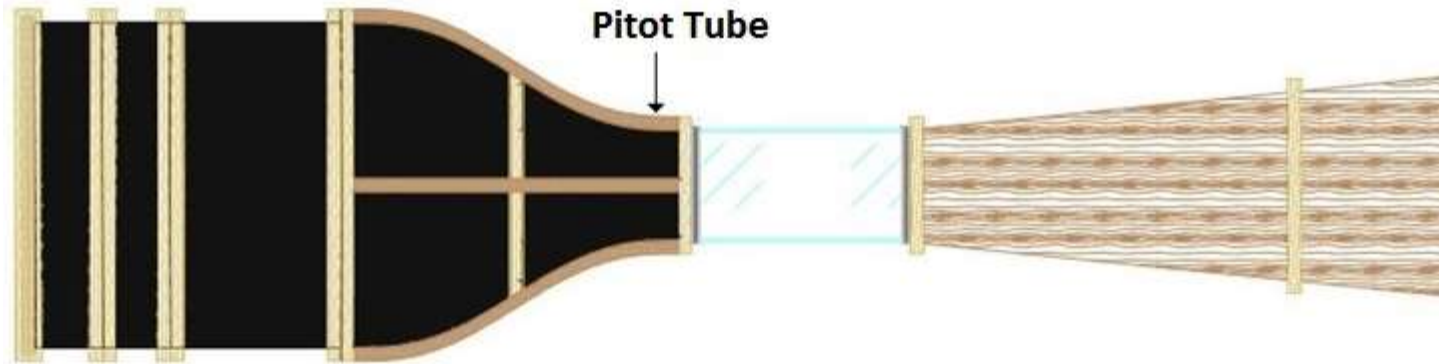
# Instrumentation



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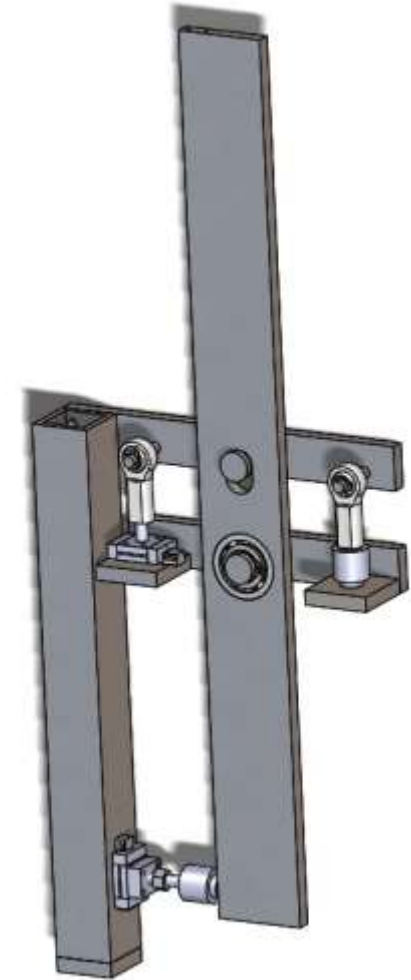
# Tunnel Control Loop

- Main control loop
  - MC DAQ reports wind tunnel airspeed from pressure transducer/Pitot tube to central LabVIEW program
  - The LabVIEW program then adjusts fan speed with a VFD according to the user specified air speed

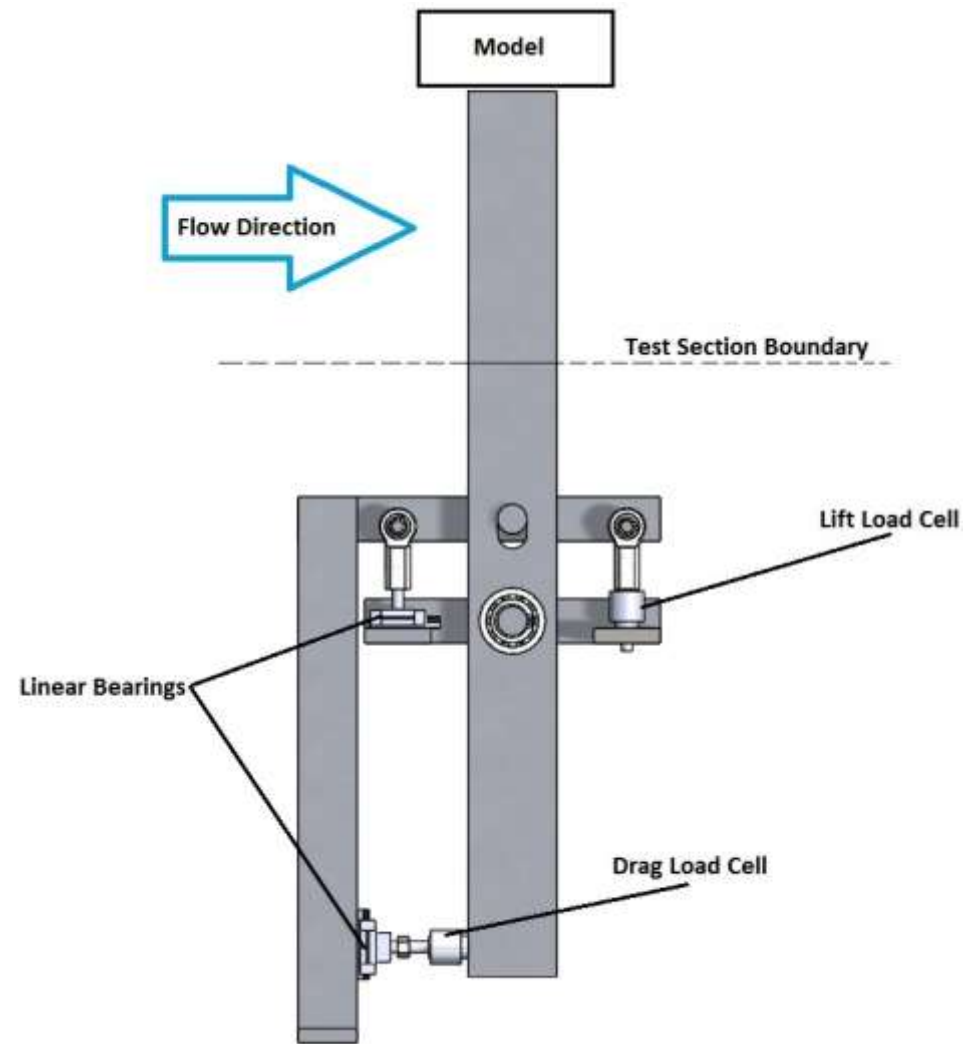


# Lift/Drag Model Mount

- Used to determine aerodynamic characteristics of models
- Capable of determining both lift and drag forces simultaneously
- Load cells were selected based on maximum drag and lift forces expected (25 lb)
- Lift and Drag are recorded and displayed by central LabVIEW program



# Model Mount



# Budget and FMEA



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# Budget Consideration

- Tier One fund of \$20,000
- Budget considerations were a priority
- Itemized list of critical item prices here

Item(s)	Price (\$)
Variable Frequency Drive	655
Data Acquisition Unit	718
Fan	4934
Wind Tunnel Construction	9000
Square to round duct	849
Model mount	491
Total	17924



# FMEA (Failure Mode Effect Analysis)

Process/item	Failure mode	Potential Effect(s)	Severity (1-5)	Potential Cause(s)	Occurrence (1-5)	Current controls	Detection (1-5)	Recommended Action(s)
Assembly								
	Incorrectly mated	Creates turbulence	1	Warped wood	3	Locking joints	3	Channels for connections
	Connections are not completed	Tunnel separates in operation	1	Mounted locking joints move	2		2	Check clamps
Flow straighteners								
	Wire mesh comes loose	Creates turbulence	1	Incorrectly mounted	1		3	
Lift/Drag Measurements								
	Rust/parts come loose	Incorrect measurements	2	Over usage	3		1	Use rust resistant materials
	Load cells fail	Incorrect measurements	1	Over usage	1		1	
Diffuser								
	Flow separates from wall	Lower pressure difference across the fan	2	Incorrect design of the diffuser	1	Low angle for diffuser	1	

- FMEA is a process to identify possible failures of a system
- FMEA preformed on aspects that would affect testing



# Conclusion



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# Thank You

- Dr. Kilty
- Dr. Naughton
  - Marlin Holmes
  - Eric DeMillard
- Dr. Belmont
  
- Questions?

