REEF Subsonic Wind Tunnel Articulating Robotic Arm

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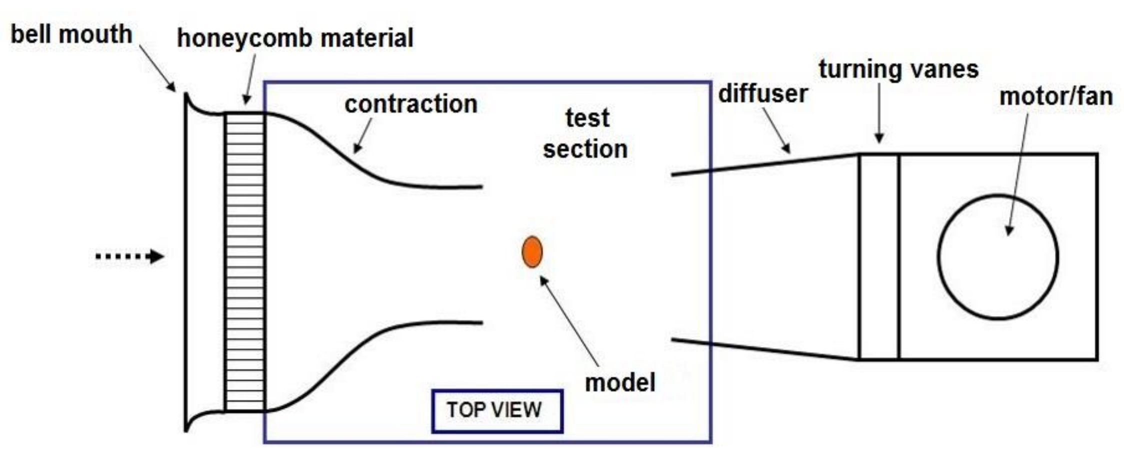
Purpose

The Aerodynamic Characterization Facility (ACF) of the Research and Engineering Education Facility (REEF) requires the design and production of a cost effective mechanism that can maintain and adjust the orientation of a test specimen in a subsonic wind tunnel.

Background

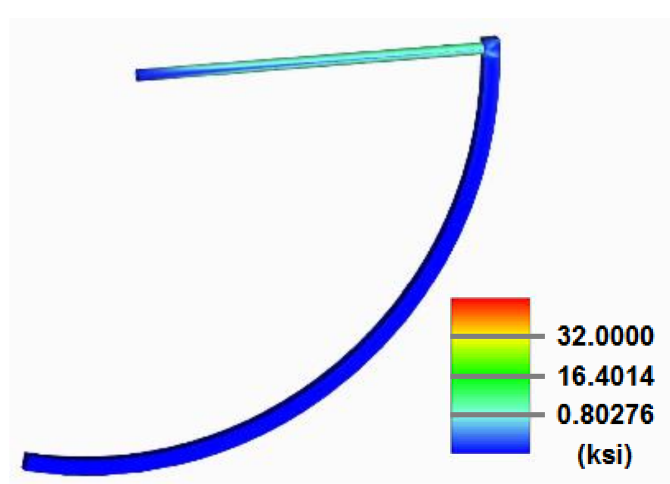
- When a properly scaled model is placed in a wind tunnel, dimensionless numbers can be utilized to generate flows that are dynamically similar to conditions that would be felt by the full-sized design, allowing for cost effective testing
- To achieve ideal results from testing, it is imperative that the model mounting system be minimally invasive. This is especially true for subsonic wind tunnels, as the upstream adjusts to downstream objects and blockages.



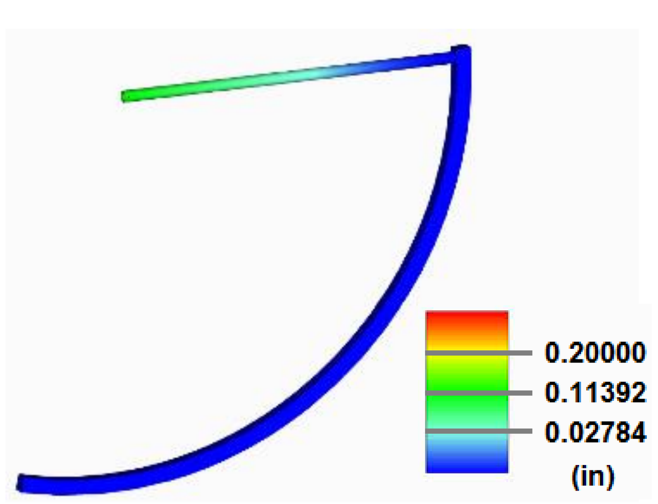
Open Test Section Wind Tunnel Layout

- In an open test section wind tunnel there are no walls bounding the flow immediately after the inlet contraction. This means that as the flow moves away from the inlet, the boundary layer of the flow will expand outward.

Design and Analysis



VonMises Stress Analysis



Displacement Analysis

Objectives:

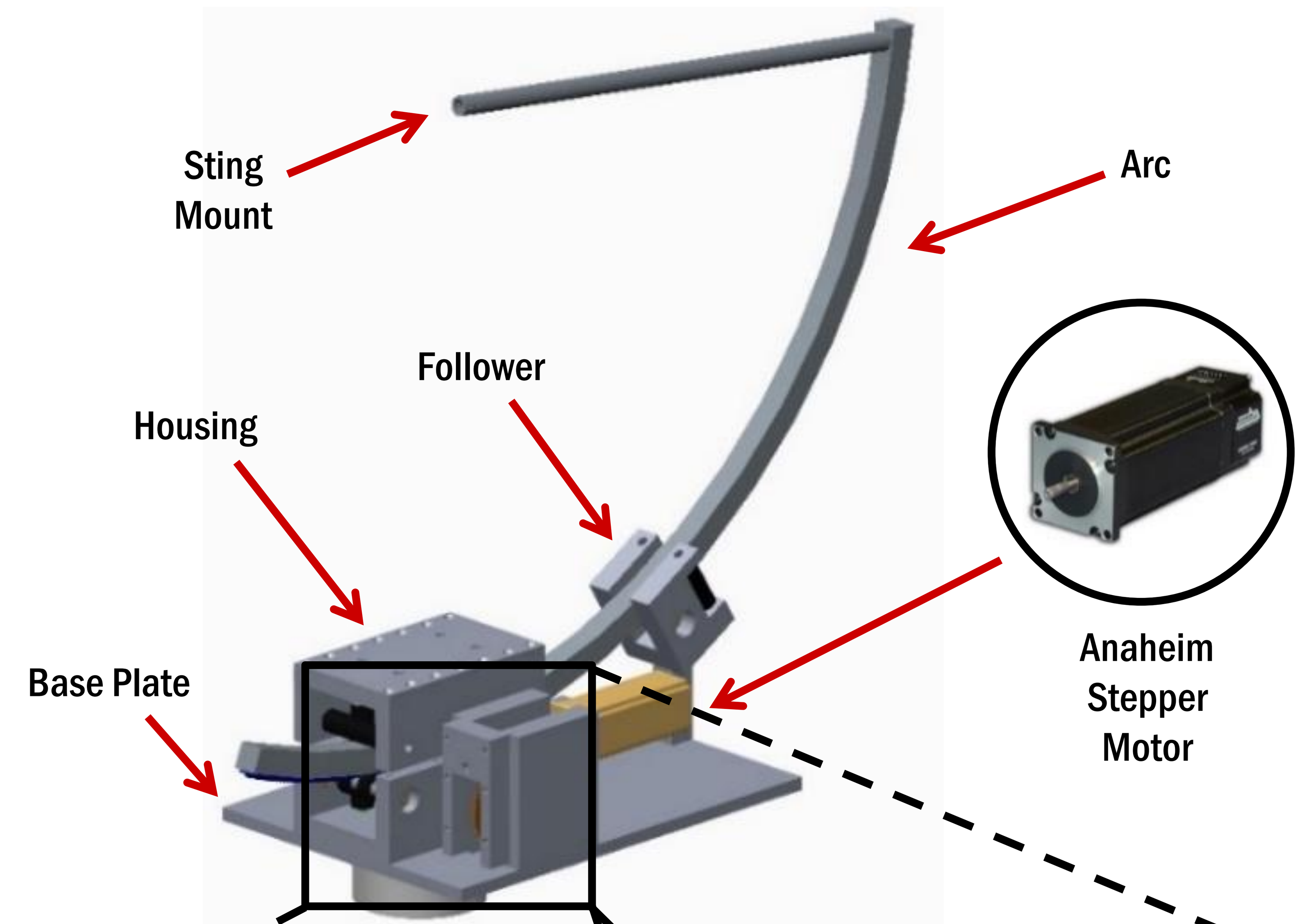
- The structure must be able to withstand the maximum force generated by the wind tunnel which has a maximum velocity of 22 m/s
- The specimen must remain in the center of flow
- The specimen must have an adjustable angle range of -5° to +20° for pitch and ±10° for yaw

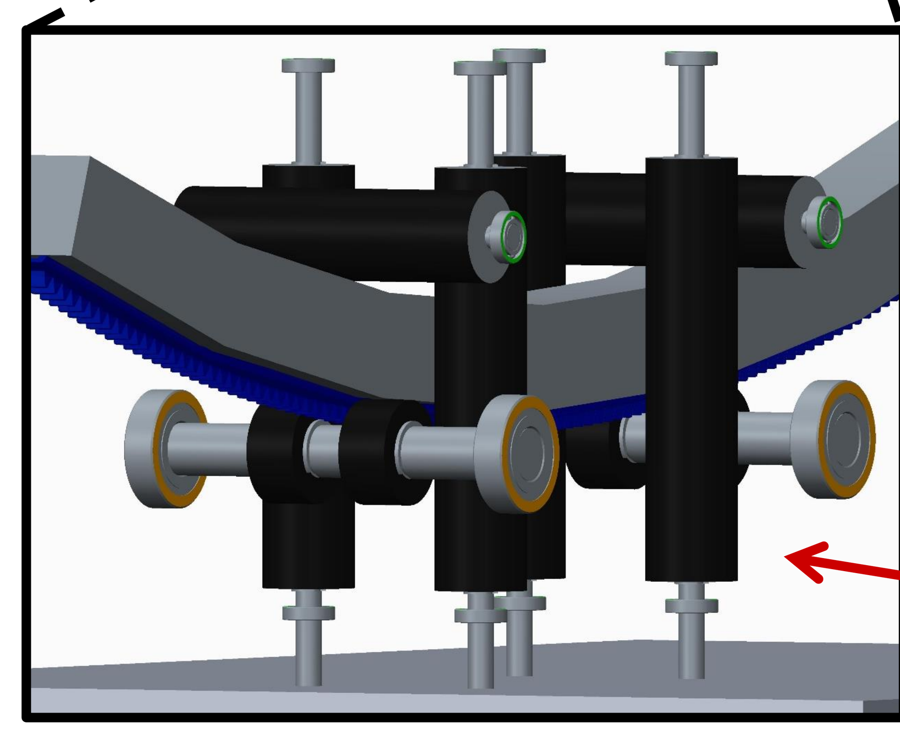
Testing Assumptions:

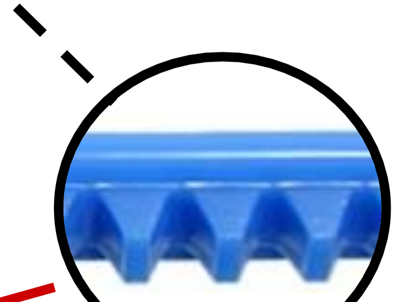
- Maximum coefficient of drag and lift on arc are CD=1 and CL=2
- Maximum allowable flow blockage is 10%*Tunnel Area
- A multiplier of 1.5 is applied forces to account for unsteady loading
- Testing loads were applied to the end of the sting mount

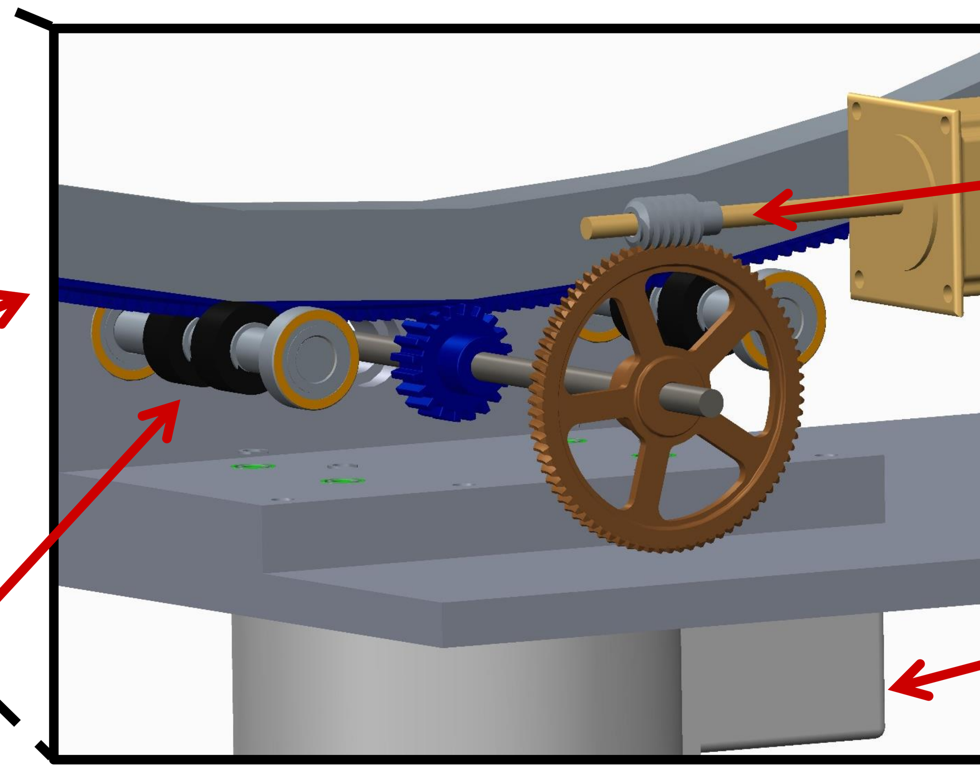
Design Specifications:

- The arc has a radius of 25in. and is 105°
- All components excluding gears, rollers, shafts, bolts, and screws are machined from aluminum 6061




Support roller structure with gear track of arc





Power train set up with gear track of arc

Software

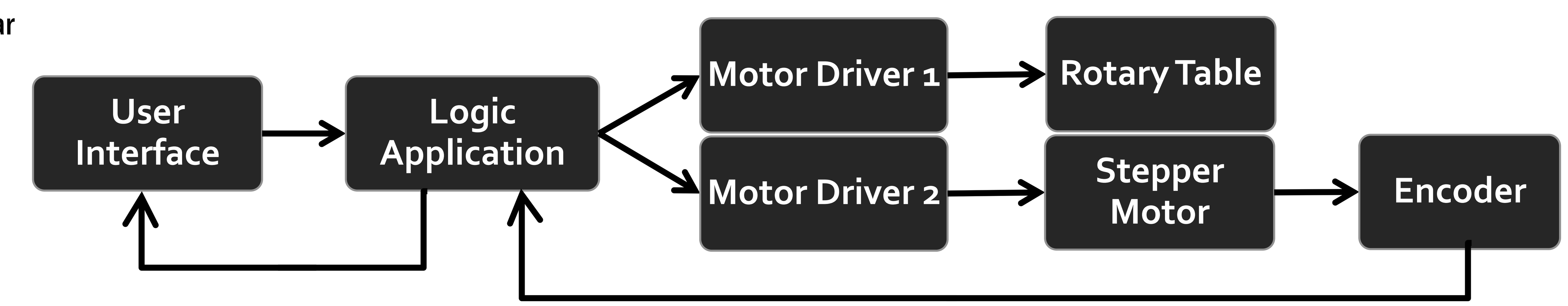
- LabVIEW for user interface
- DMC (Digital Motion Controller) code for motor initialization and commands
- Controller programs written in GalilTools
- Shared library enables software communication

LabVIEW

GalilTools

Hardware

- Velmex stepper motor rotary table with magnetic reed homing switch
- Anaheim Nema-23 stepper motor with encoder
- Galil DMC-4040 Motion Controller



System Operational Flow

Future Improvements

- Redesign the base plate with a shaft to fit in the rotary table and add an absolute encoder to the shaft base
- Add a gyroscope (or similar sensor) to the sting for more accurate feedback of actual specimen position
- Incorporate other sensors for testing needs in the system and user interface