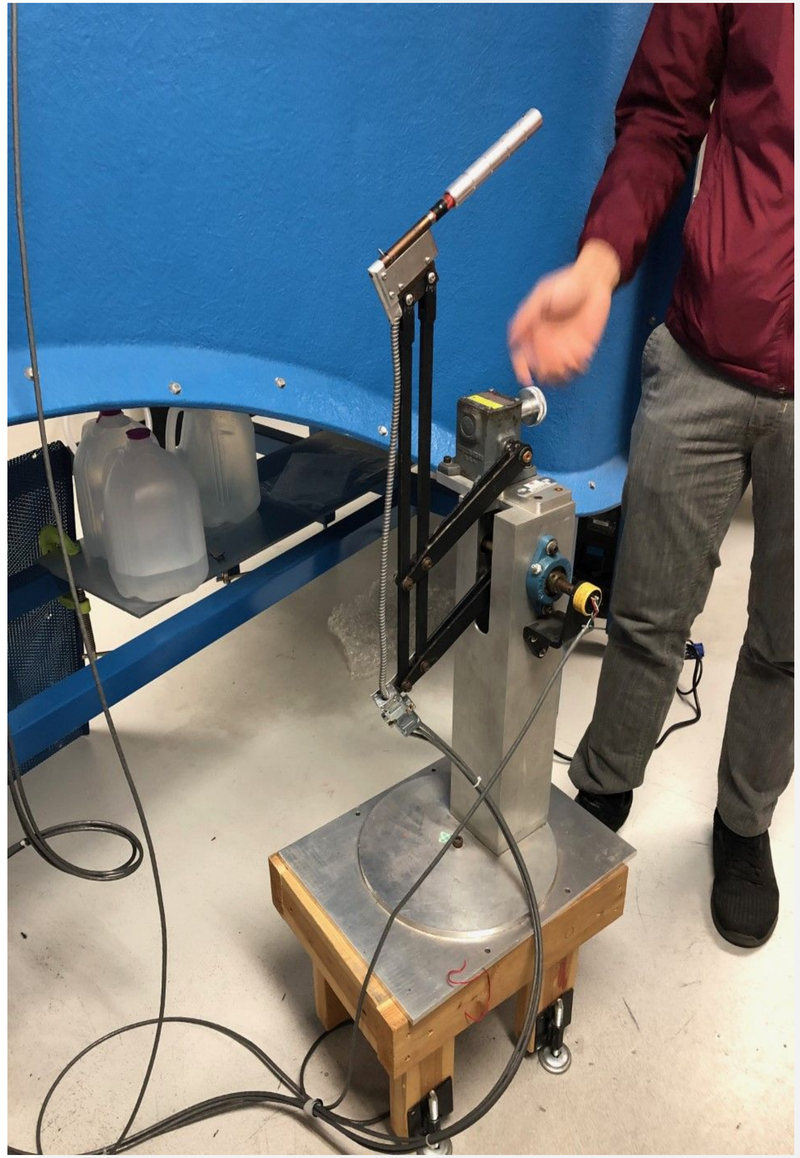
Airfoil Testing Facility

University of Idaho
College of Engineering

James Angele, Bryce Graveline,
Ryan Kirby, Bryan Williams



Current Stand and Load Cell

Current Data Acquisition

Value Proposition

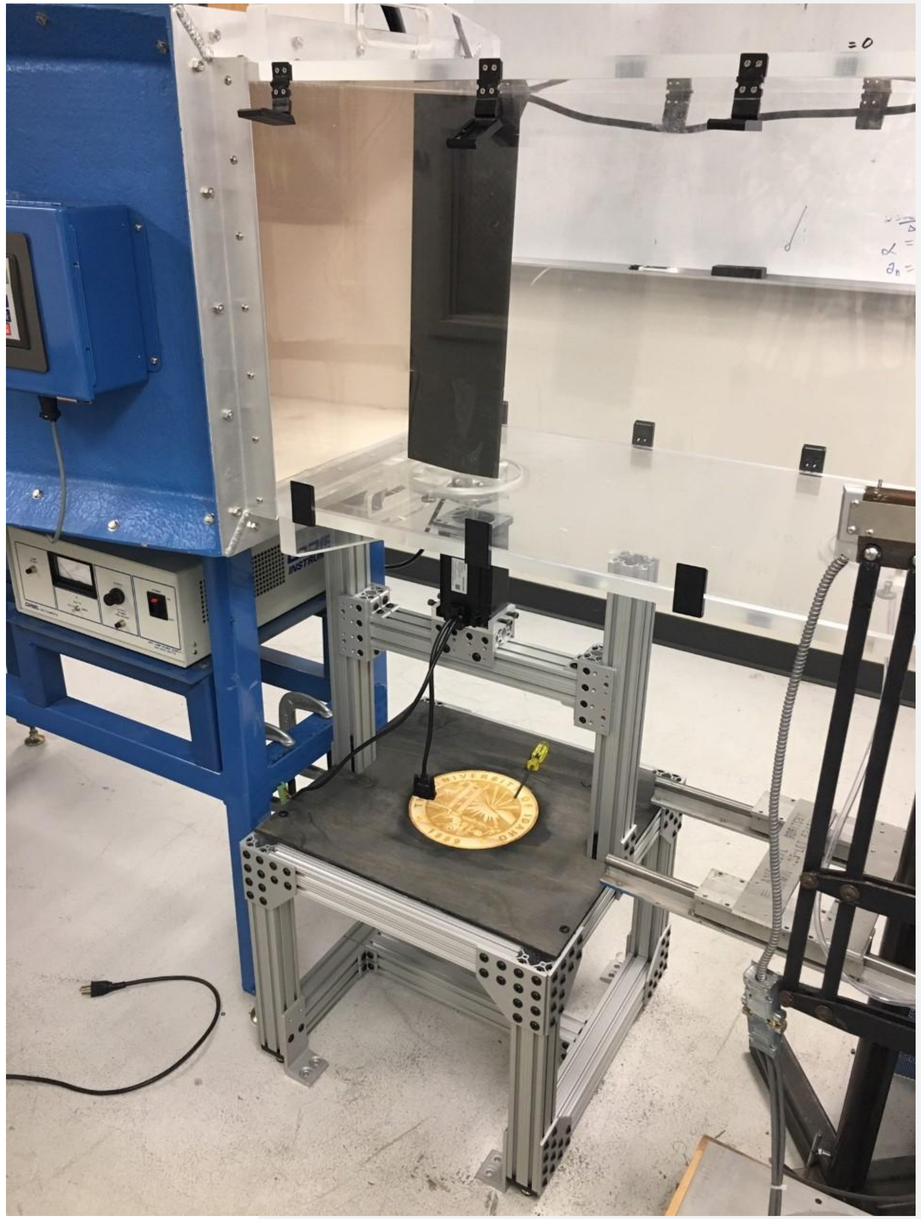
- Minimize need for operator intervention
- Expeditious data acquisition with intuitive user interface
- New system will change angle of attack and acquire aerodynamic data autonomously.
- Wider range of demonstrations for campus visitors.

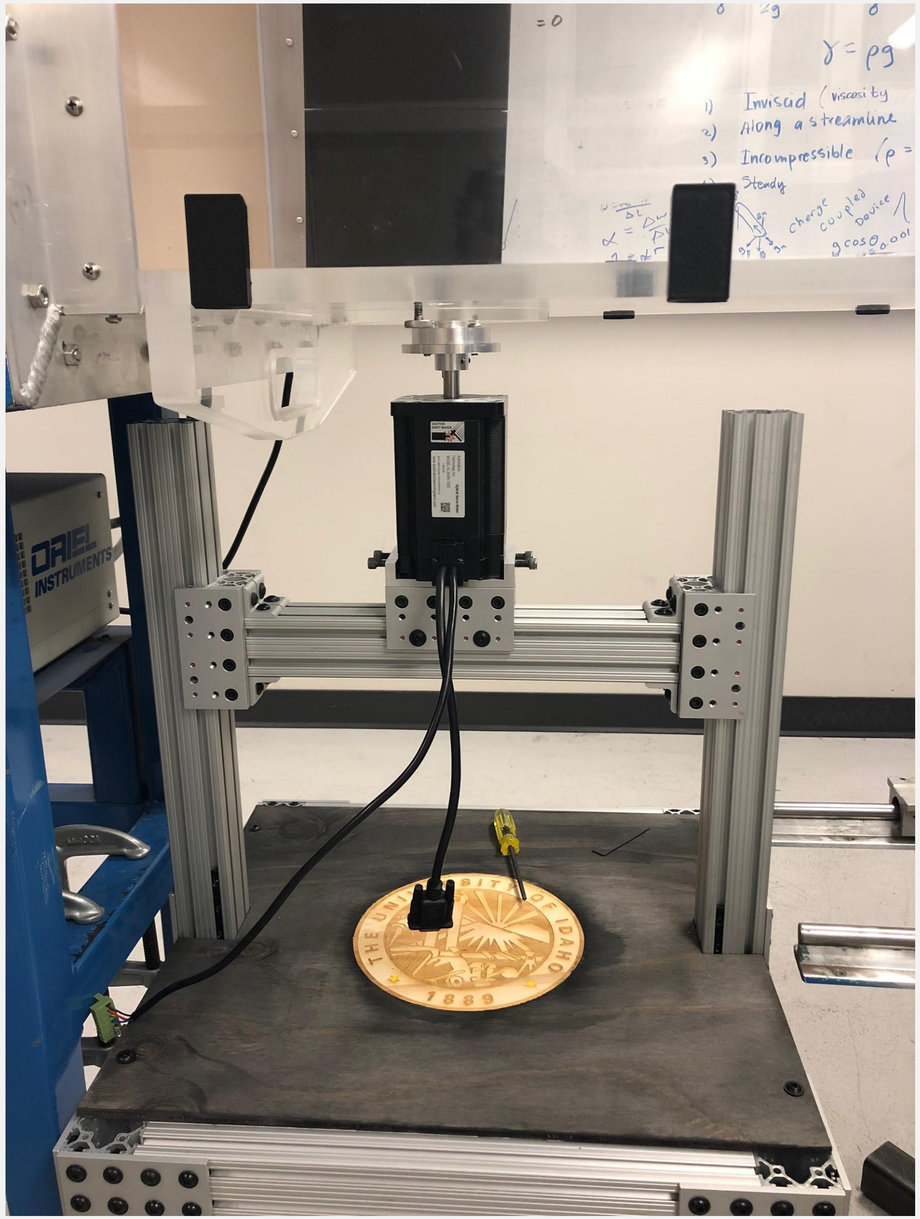
Primary Objectives

- Operate a stepper motor at 0.1° increments.
- Design and manufacture airfoil.
- Design and manufacture a modular stand with load cell placement as a primary consideration.

Secondary Objectives

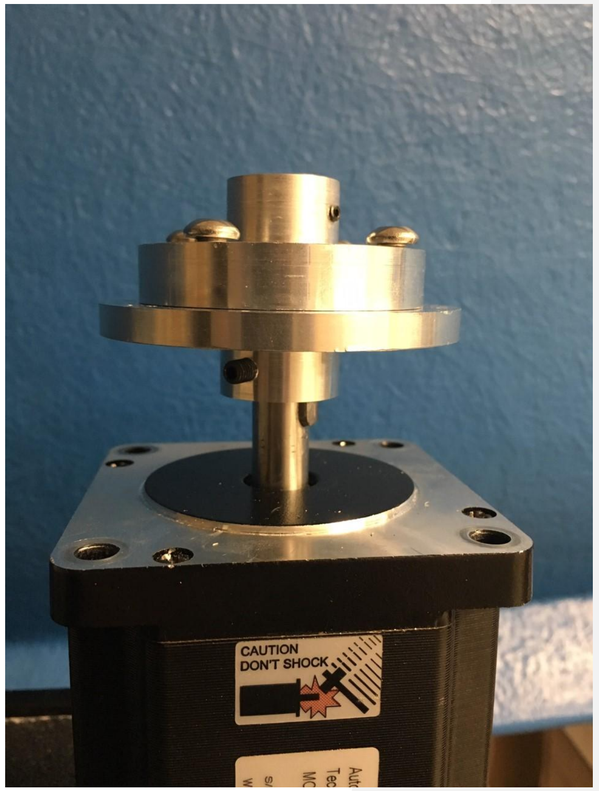
- Physically integrate load cell into the system.
- Create a stand assembly process diagram for users.
- Use load cell to achieve lift, drag, and zero angle of attack measurements.

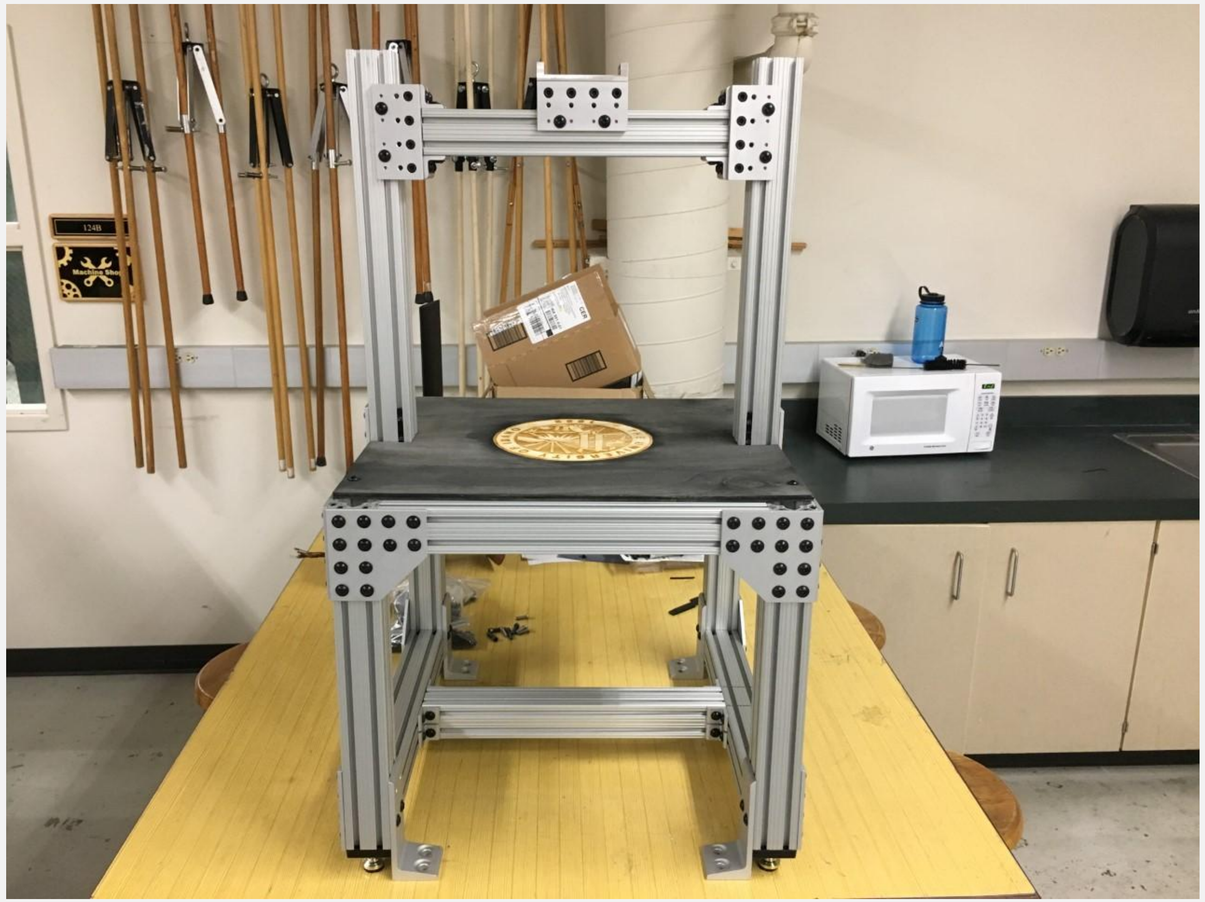




Full System in Windtunnel

Important Design Points - Machined Parts





- Connector plates can be utilized with or without load cell integrated
- Robust stand can be adjusted according to specific needs

Airfoil NACA-0009

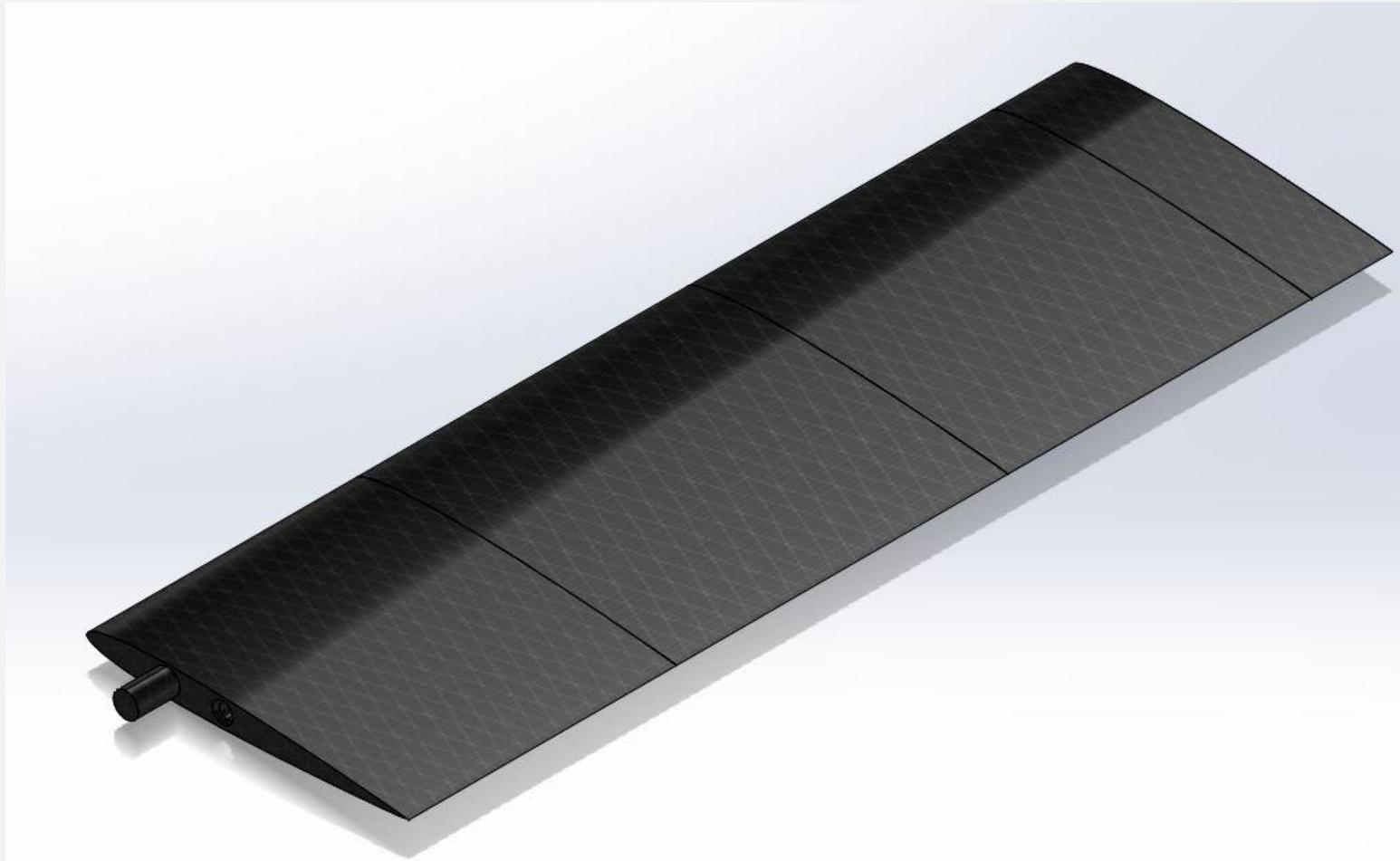
- **Wind tunnel test section is 18 in by 18 in (324 in^2)**
- **Projected Airfoil area can not take up more than 10% of the testing area at any given time**

- **Airfoil Height = 17.8125”**
- **Chord Length = 5.825”**
- **Max AoA = 18°**

$5.825\sin(18^\circ) = 1.8$”

Projected area of airfoil in test section at Max AoA:

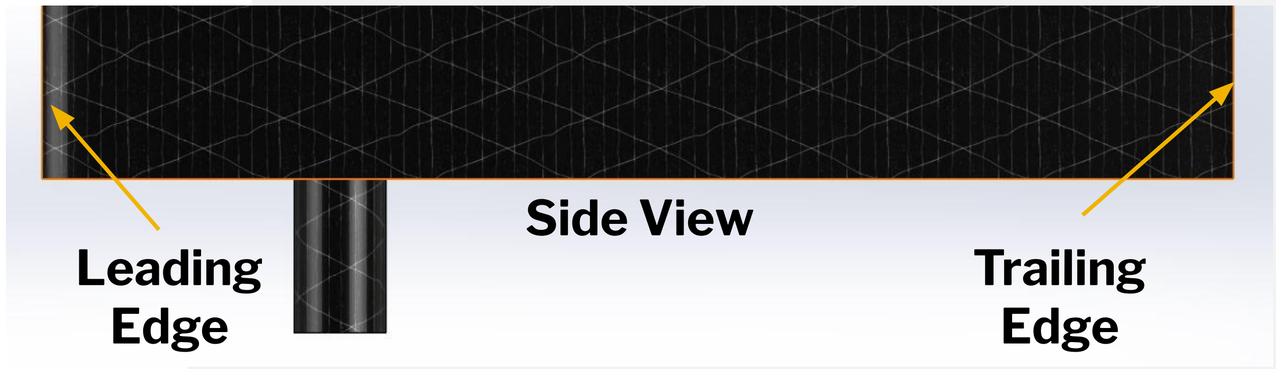
1.8” x 17.8125” = 32.06 in^2



Airfoil Manufacturing

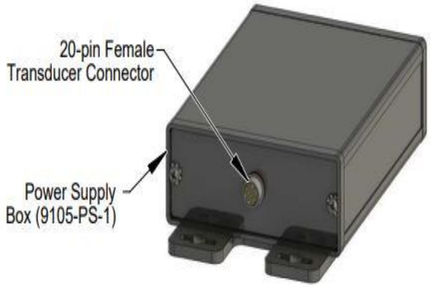
- **Printer Used - Markforged Mark Two**
- **Machining - Not an option for in house**
- **Machining - Very expensive out of house (>$4000)**
- **Our Airfoil - Good for project validation**
- **Not perfect by any means - trailing edge, surface finish, profile may not be 100% NACA 0009**

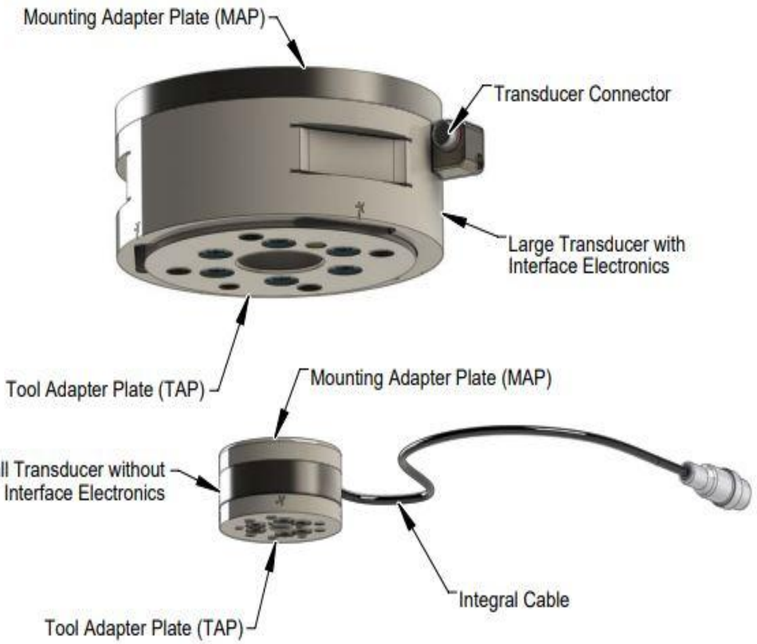
Airfoil NACA-0009



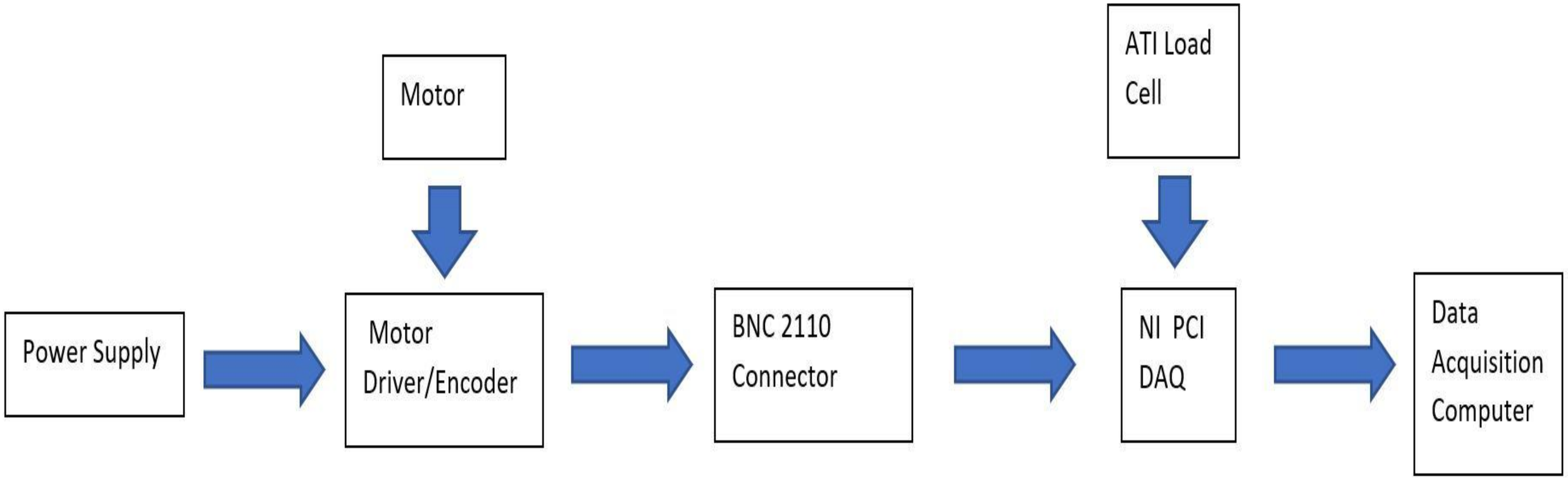
- 3D Print was done in four parts due to height constraints on printer.
- Part fit together as shown to self align.
- Made out of Onyx filament (Tensile strength 36 MPa)
- Machined aluminum rod clamps parts together and offers higher rigidity.

Data Acquisition Hardware

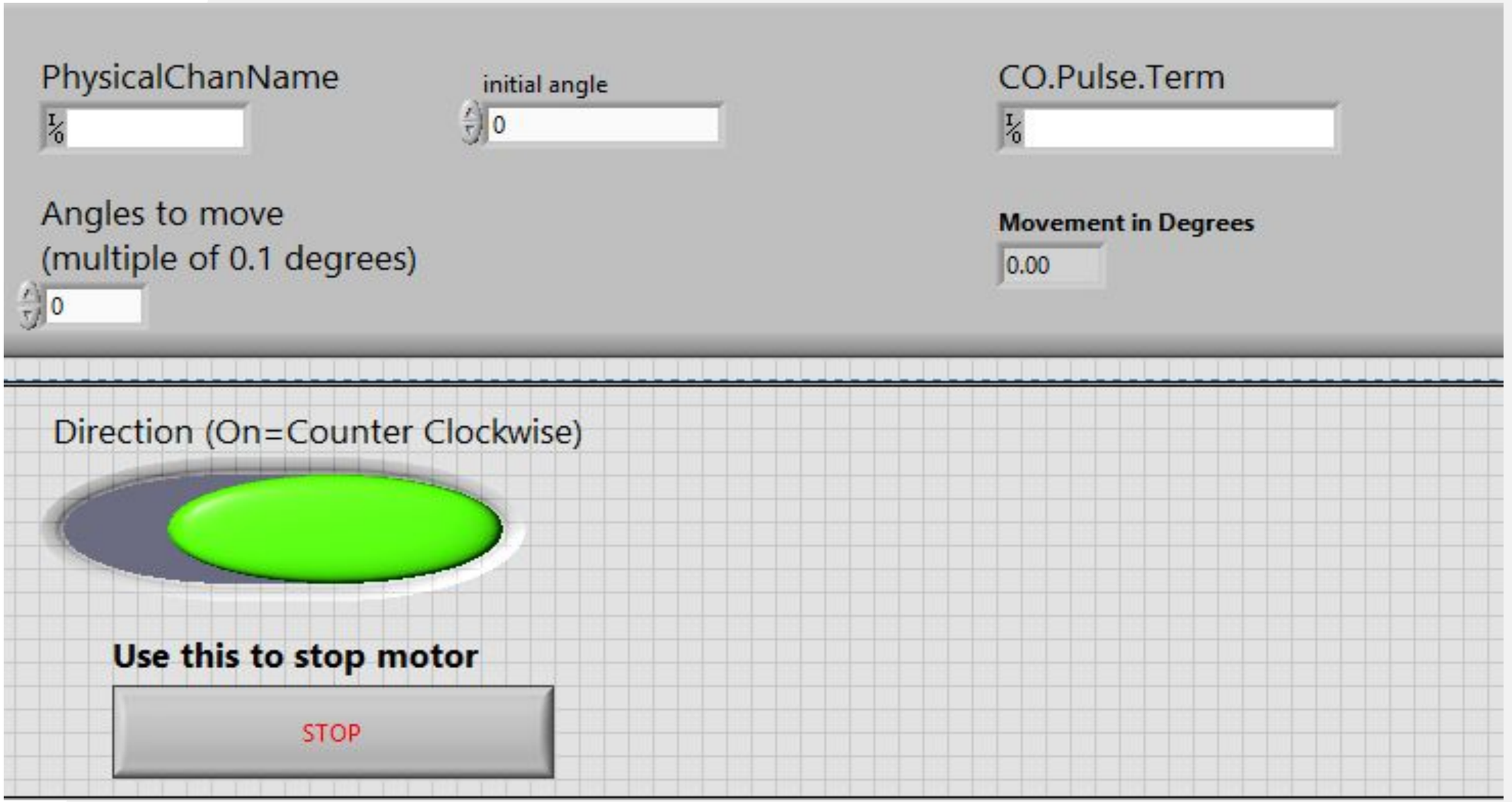




System Diagram



Labview Interface



Load Cell Calibration and Validation

Fx	-0.18408	0.00240	-0.42564	-32.64984	-0.82713	33.11492
Fy	-0.90809	37.5948	-0.31255	-18.93101	0.64524	-19.20865
Fz	18.49972	-0.67777	18.46290	-0.43781	18.27523	-0.50139
Tx	-0.09304	-1.00392	-32.12175	1.25064	31.74744	-0.16168
Ty	37.09921	-1.30072	-18.40886	-0.35263	-18.29474	1.26489
Tz	0.38197	-18.13236	-0.27698	-18.45858	0.61459	-18.59703

Design Validation Plan

Requirement	Test	Test Subject	Target Date	Result	Recommendation
Airfoil needs to have a chord length such that no more than 10% of the test section area will be taken up at maximum the angle of attack	Do mathematical calculations and figure out what that chord length needs to be	Airfoil Model	7/18/19	Chord length needs to be 5.825 inches with a max angle of attack of 18°. Test Passed (7/2/19)	Re-design the airfoil in SolidWorks and make the chord length the proper dimmension.
Airfoil needs to follow the profile of the NACA 0009 model	Research where NACA airfoil coordinates can be found and how to create a SolidWorks model	SolidWorks Model	9/21/19	Test Passed (7/10/19)	
Airfoil needs to fit together with smooth edges from 3D printer	Place the pieces together and ensure proper connection.	Airfoil Prototype parts	11/22/19	Test Passed 11/22/2019	The airfoil fits together as expected but needs to be glued together with an epoxy to give smoother edges.
Airfoil needs to have a surface finish with a K value of 4 or less.	Use a test guage, if available and measure the surface finish of 3-D printed airfoil.	airfoil	12/4/19		
Airfoil needs to fit into the wind tunnel test section but be as close to the top and bottom as possible to maintain infinte airfoil application. (Within 1/8 in)	Measure wind-tunnel and design airfoil to be proper height to accomplish the infinte airfoil need.	Airfoil, wind tunnel test section	12/3/19	Test Failed (12/3/2019)	The connector on the bottom of the airfoil needs to be longer. We did not take into account the size of the screw heads that connect the load cell to the connector plate so there was not enough clearance for the airfoil to fit.

Major Milestones

- Vertical airfoil design lock - 06/17/2019
- 3-D print airfoil design lock - 07/23/2019
- Final stand design lock - 10/3/19
- Full stand assembly - 11/1/19
- Motor moving at 0.1° accuracy through Labview - 11/12/19
- Obtaining Load Cell reading through Labview - 11/19/19
- Setting stand and electronics in wind tunnel - 12/3/19

Future Work

- Continue developing Labview code to acquire lift, drag, and zero angle of attack
- Choose new Data Acquisition system that allows motor control and data collection through one LabView interface
- Outsource airfoil to respectable machining company