REEF Subsonic Wind Tunnel Articulating Robotic Arm

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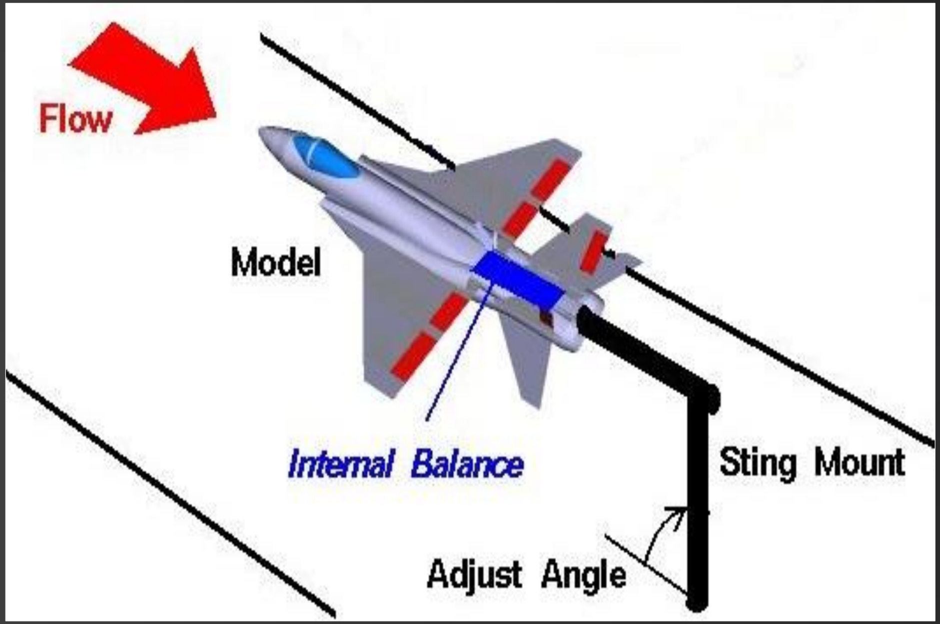
Problem Statement

- The design and production of a cost effective mechanism that would hold and adjust the orientation of a specimen being tested in a subsonic wind tunnel
- The current arm and mount are being removed, therefore a new system is needed in order for testing to continue
  - Quotes from companies that will design/build systems exceed $100,000
  - Working budget of $2,000

Wind Tunnels

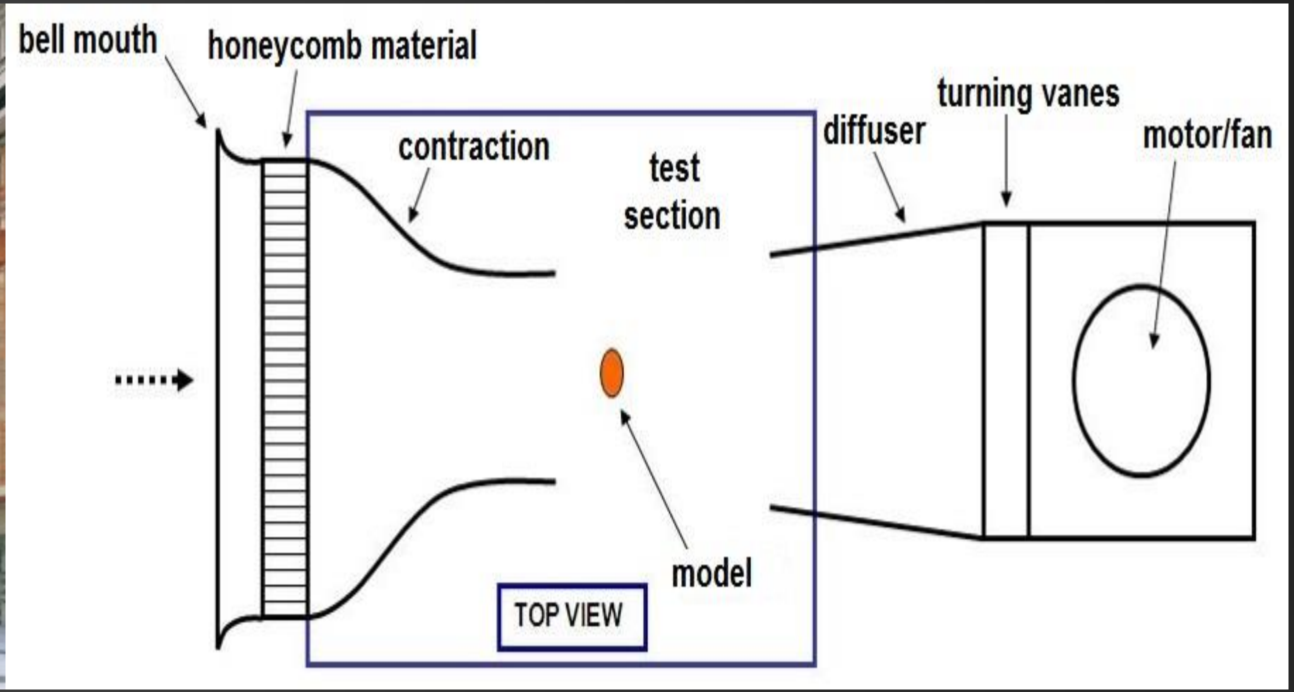
- Research tool to recreate flight conditions
- Cost effective, controlled environment
- Models scalable through the use of dimensionless properties



Sting Mount in Wind Tunnel

The Test Section

Open Test Section



Overhead View of REEF Center Wind Tunnel

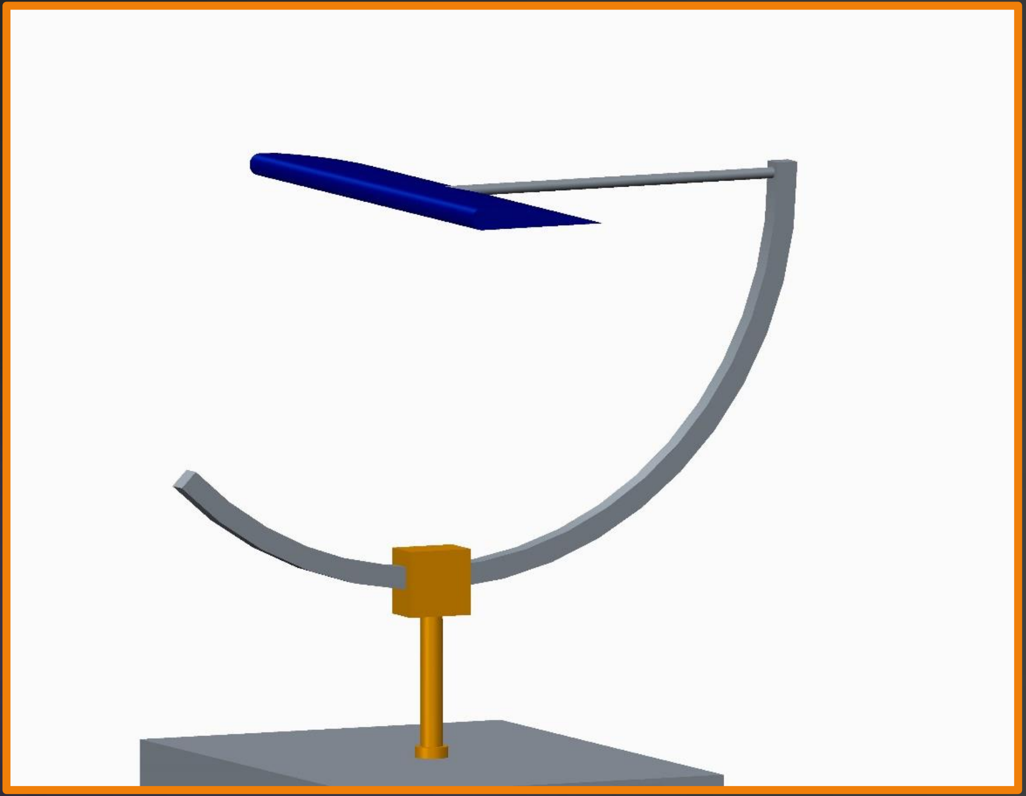
Project Objective

- Arm able to withstand maximum force generated by wind tunnel
  - Maximum Velocity: 22 m/s
- Center of mass of specimen must not change during manipulation
- Adjustable pitch range: -5° to +20°
- Adjustable yaw range: ±10°
- Model must not move when in set position
- User interface to control motion of arc

Design Constraints

- User interface using LabVIEW
- Motion Controller design
- 0.25° orientation accuracy
- Maximum deflection of 0.25 in.
- Factor of safety of 5
- $2,000 budget

Initial Design Concepts

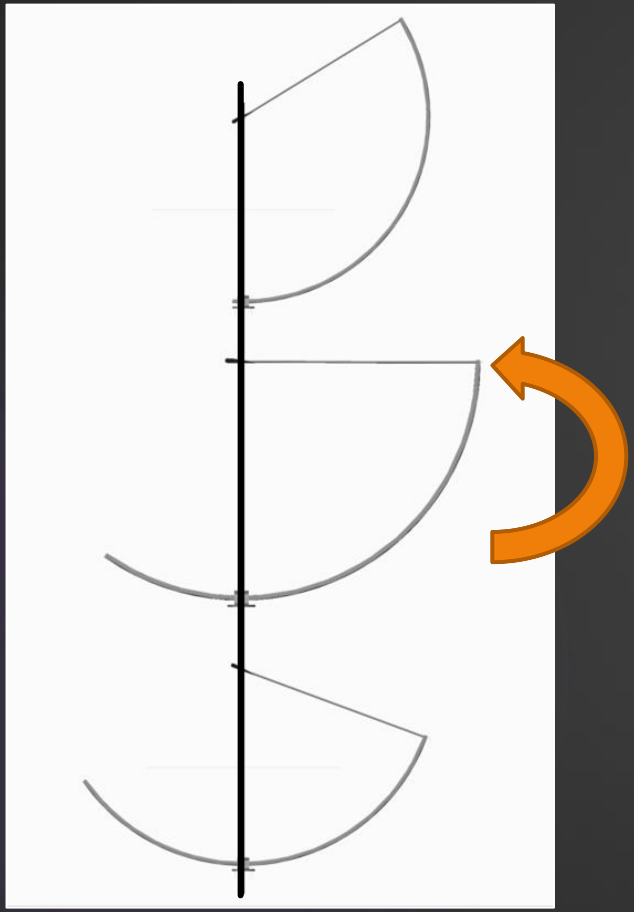


Design 1: Horizontal Translation arc
Low motor location, small turn table moment

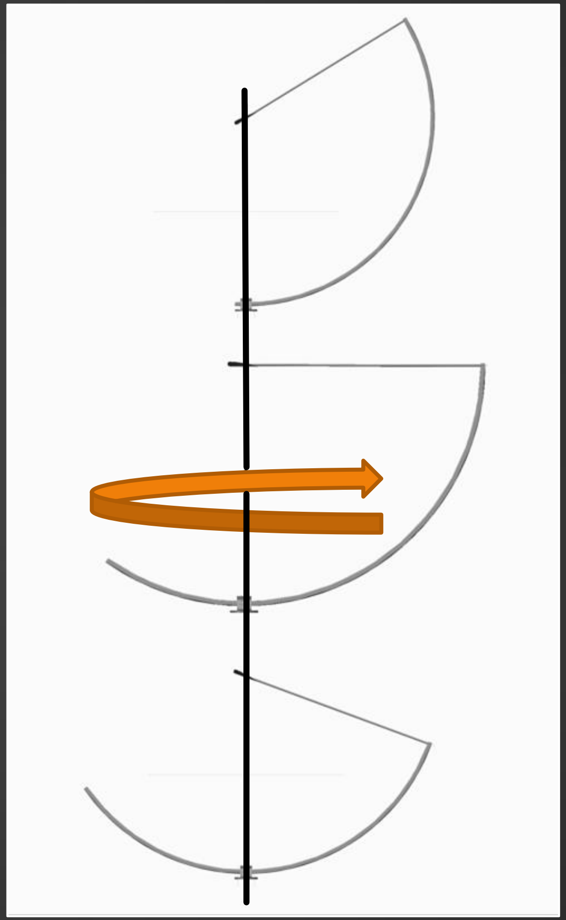
Design 2: Vertical Translation arc
High motor location, large moment

Chosen Design Concept

Pitch Manipulation



Yaw Manipulation

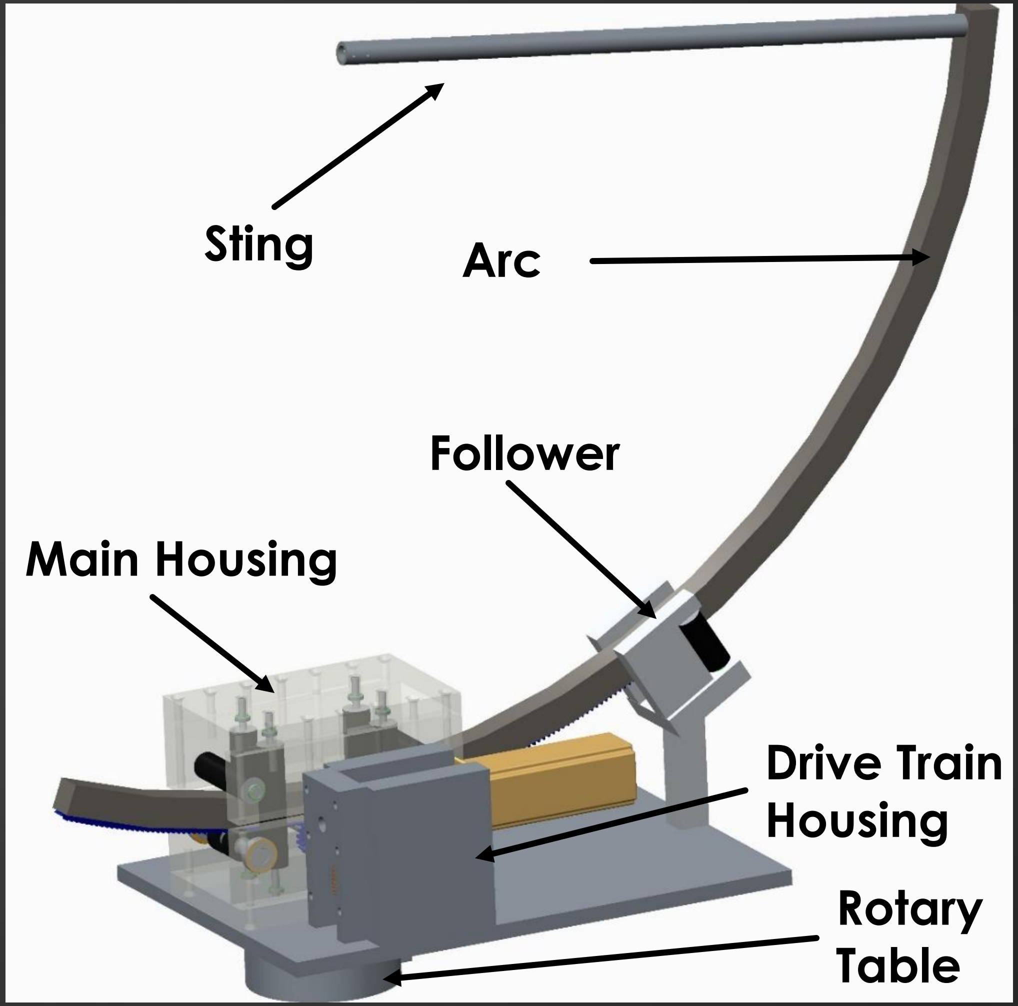


Andrew Baldwin

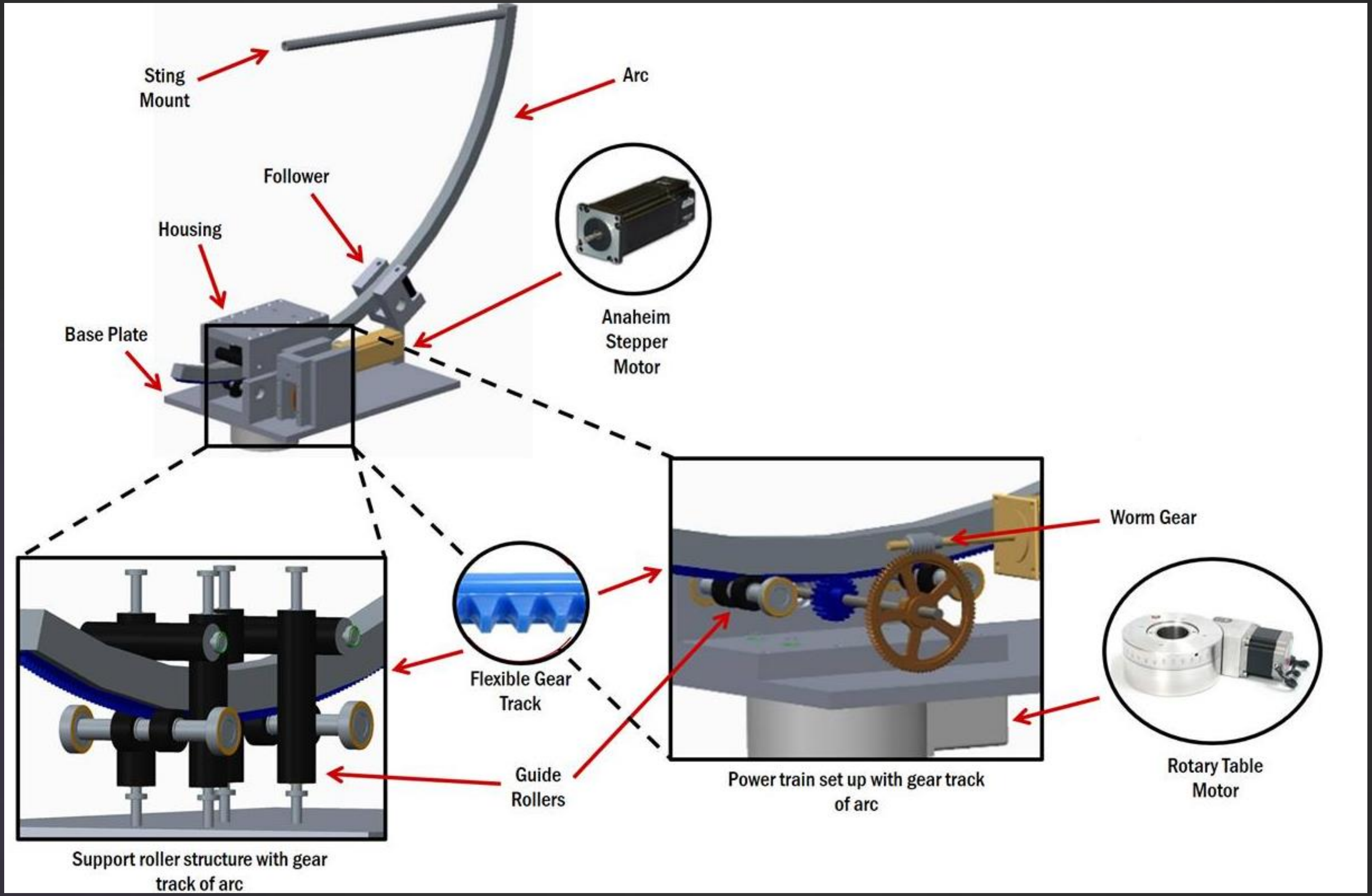
Final Mechanical Design

Main Components:

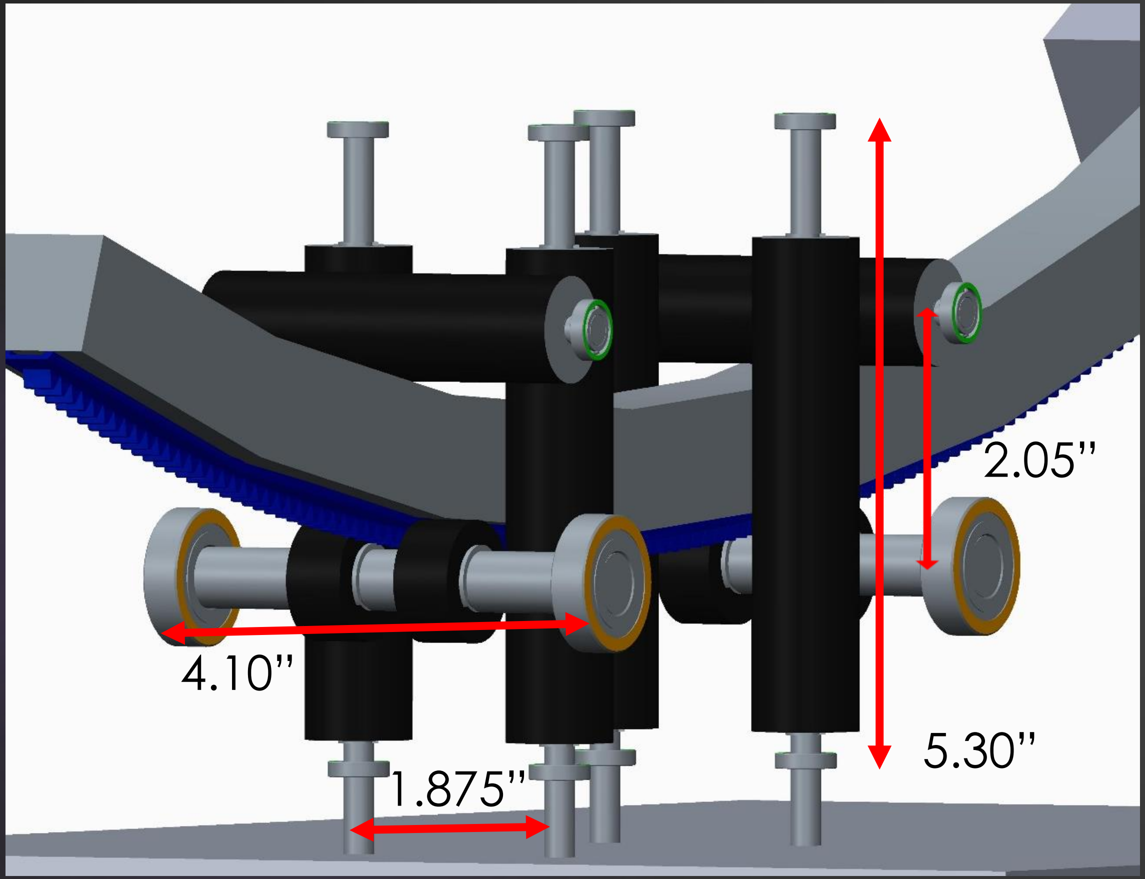
- Sting
- Arc
- Follower
- Main Housing
- Drive Train Housing
- Rotary Table

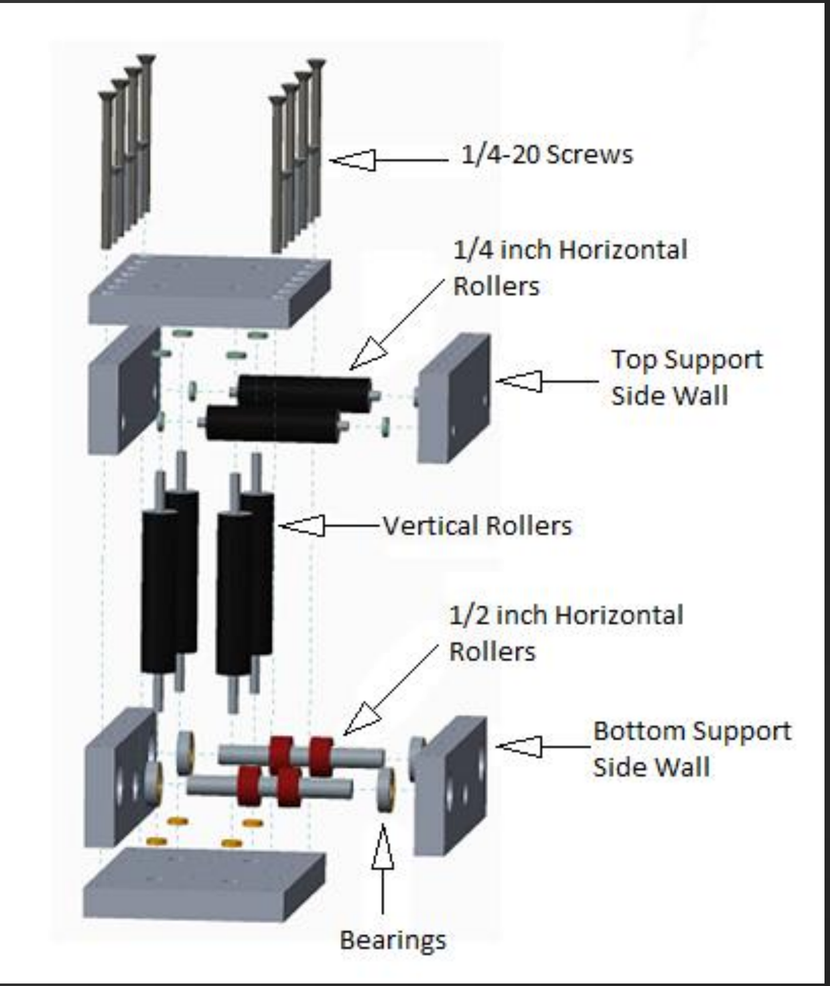


Component Breakdown

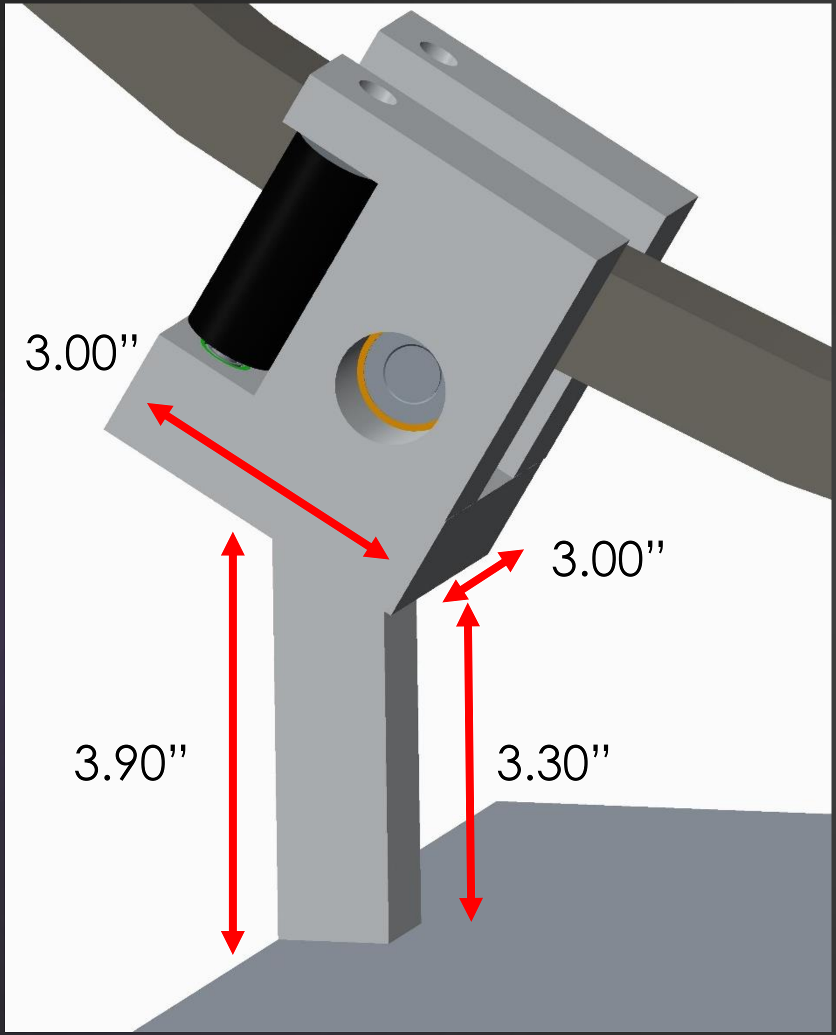


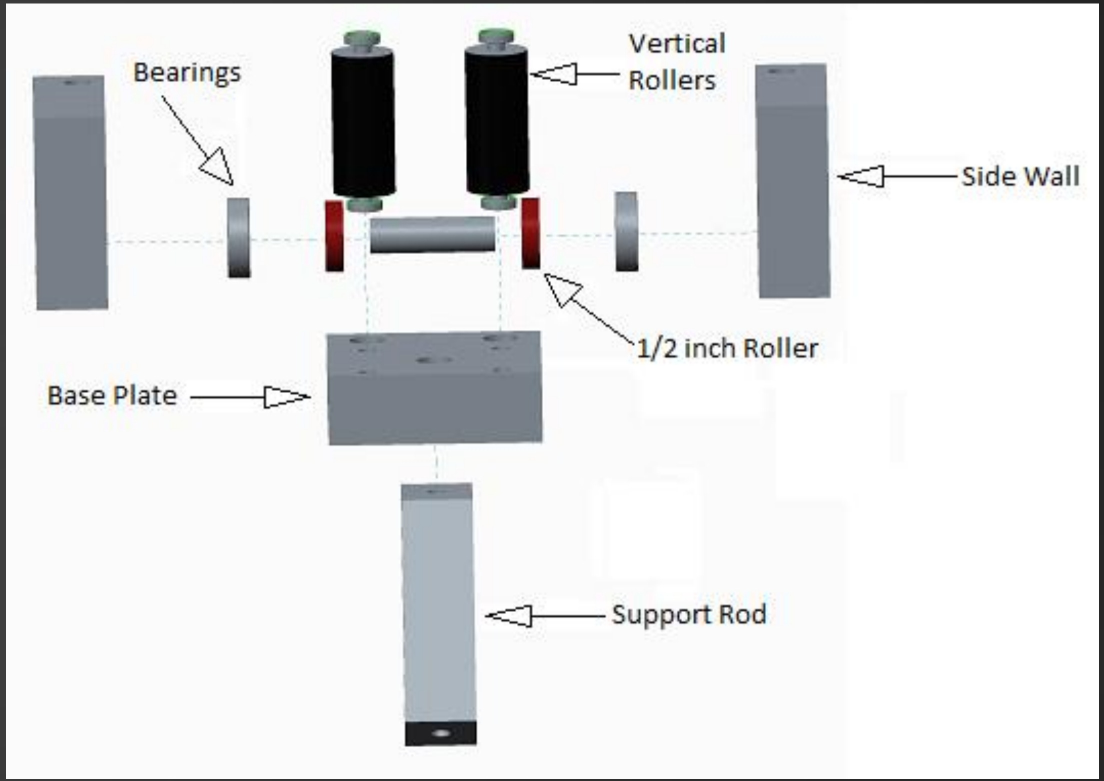
Assembly and Constraints



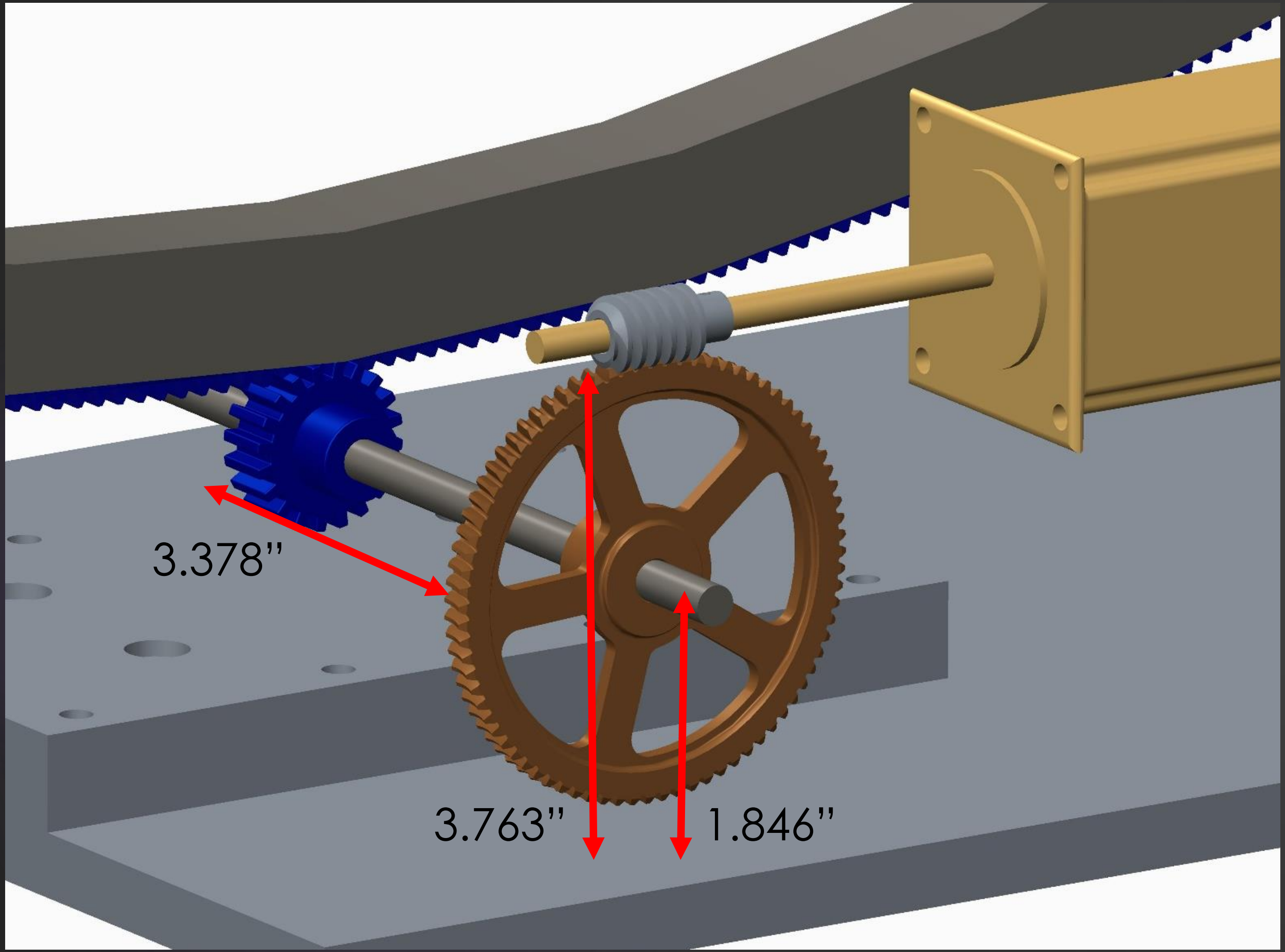


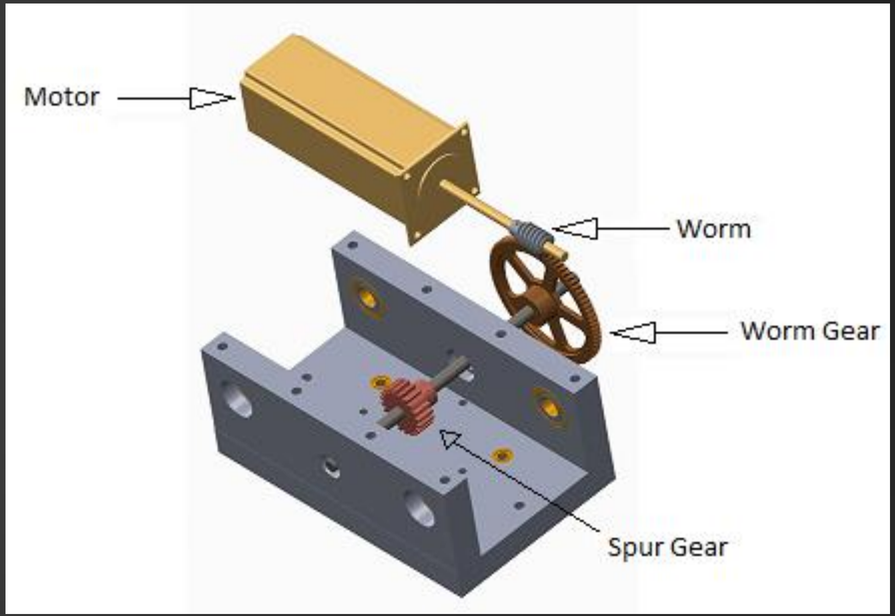
Assembly and Constraints Continued



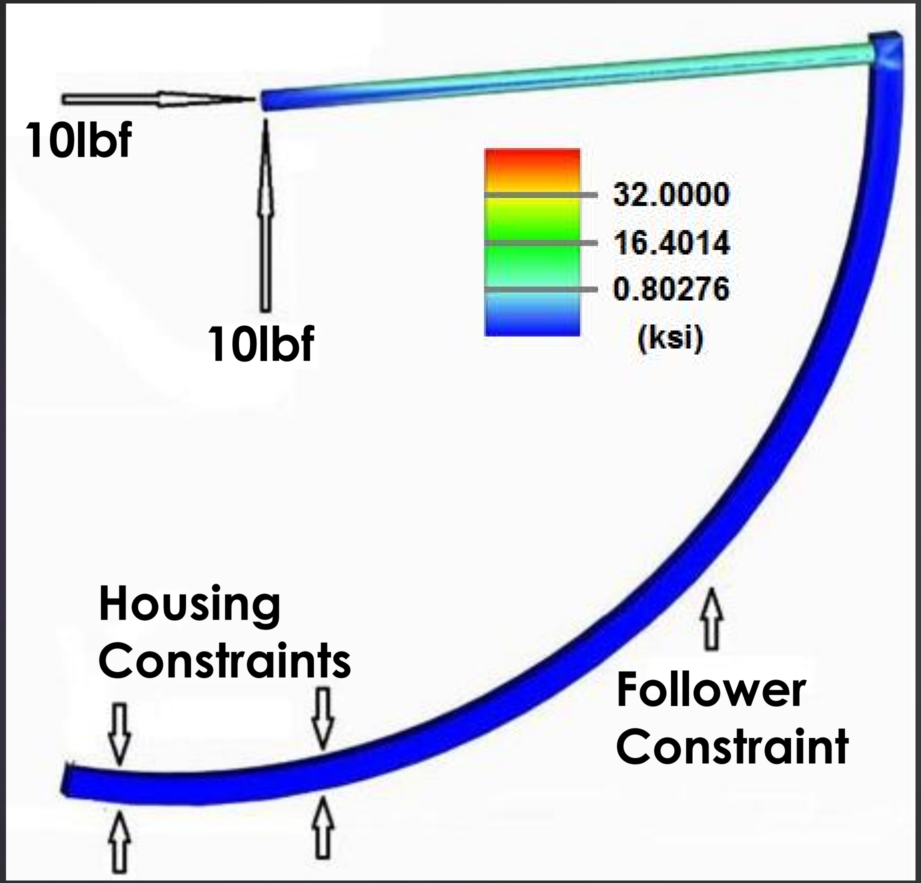


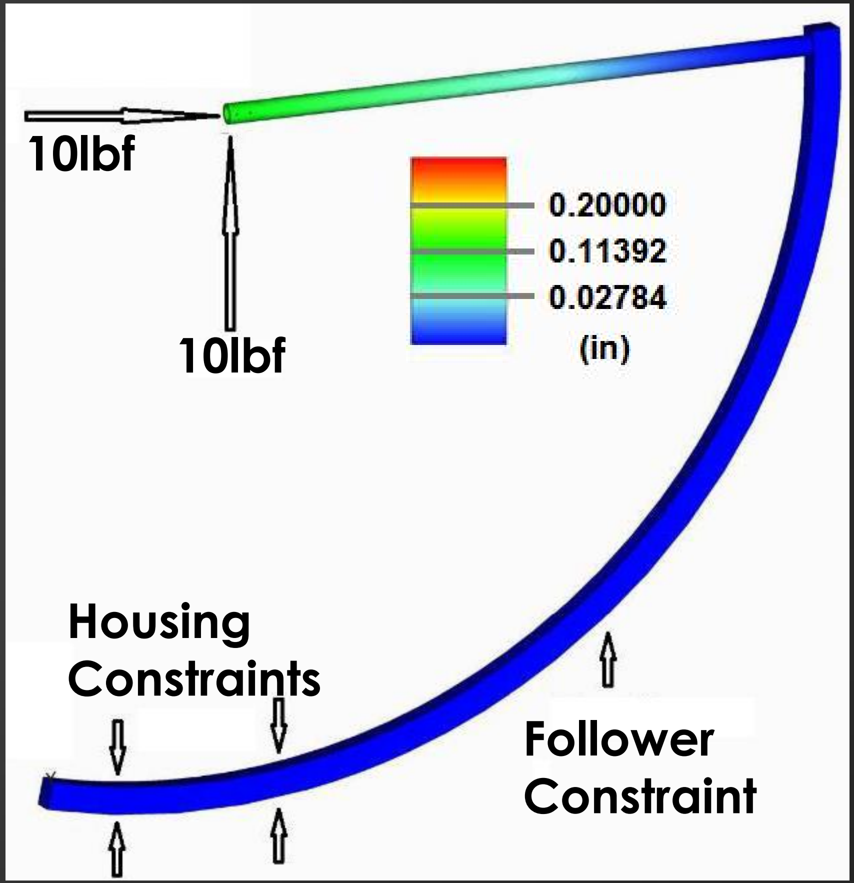
Assembly and Constraints Continued





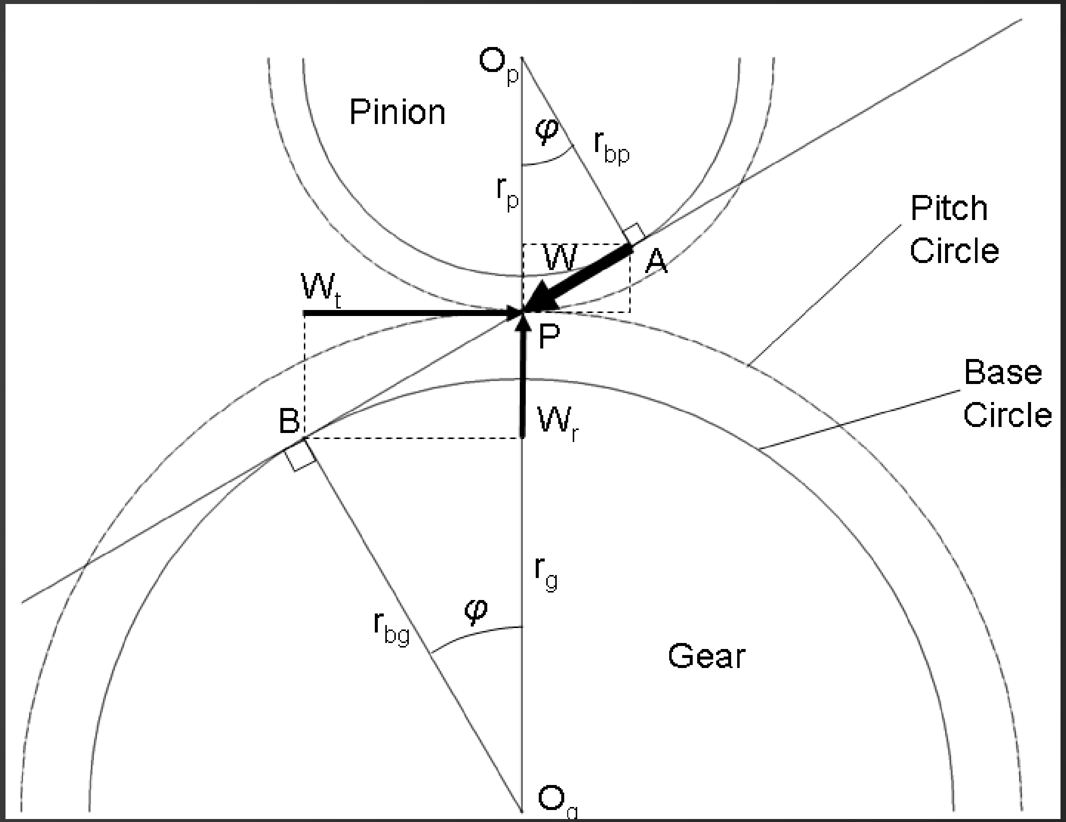
Stress and Deflection Analysis





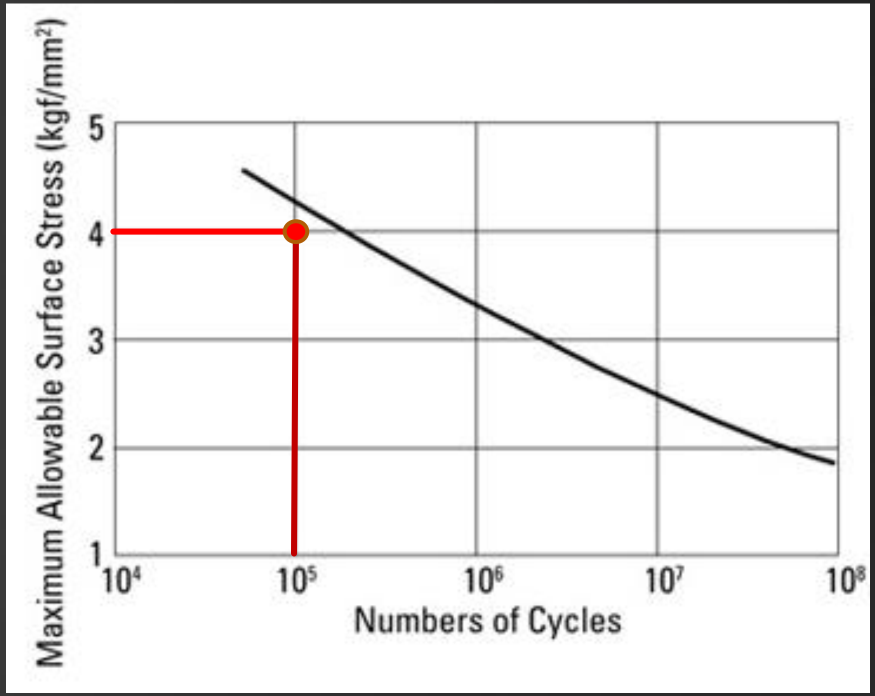
Reliability Analysis

- Place of highest stress → Spur gear teeth
  - Hardened Acetal material (Delrin)
  - Required stress analysis
- Bending stress
  - Stressing factors such as time, temperature, actuation speed, application
  - Max allowable force (Wt) of 23lbf
  - Induced force (Wt) of 10lbf
  - Factor of Safety ≈ 2.3
  - Conservative estimates built in

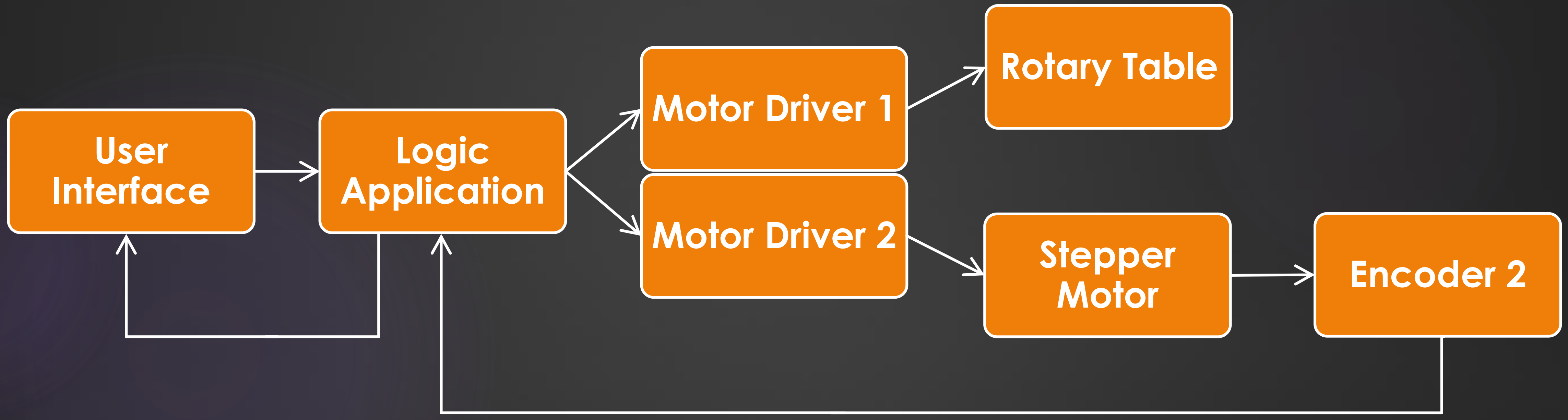


Life-Cycle Analysis (LCA)

- Location of most wear:
  - Location of largest forces, most use, and weakest material
  - Plastic driving spur
- Surface Strength
  - Stressing factors such as bending stress, speed, time, temperature, application
  - Max Surface Strength ≈ $4\frac{kgf}{mm^2}$ (39 MPa) → 105 cycles
  - Cycles/hr ≈ 900 → Life of ≈ 111 hours



Programming and Circuitry



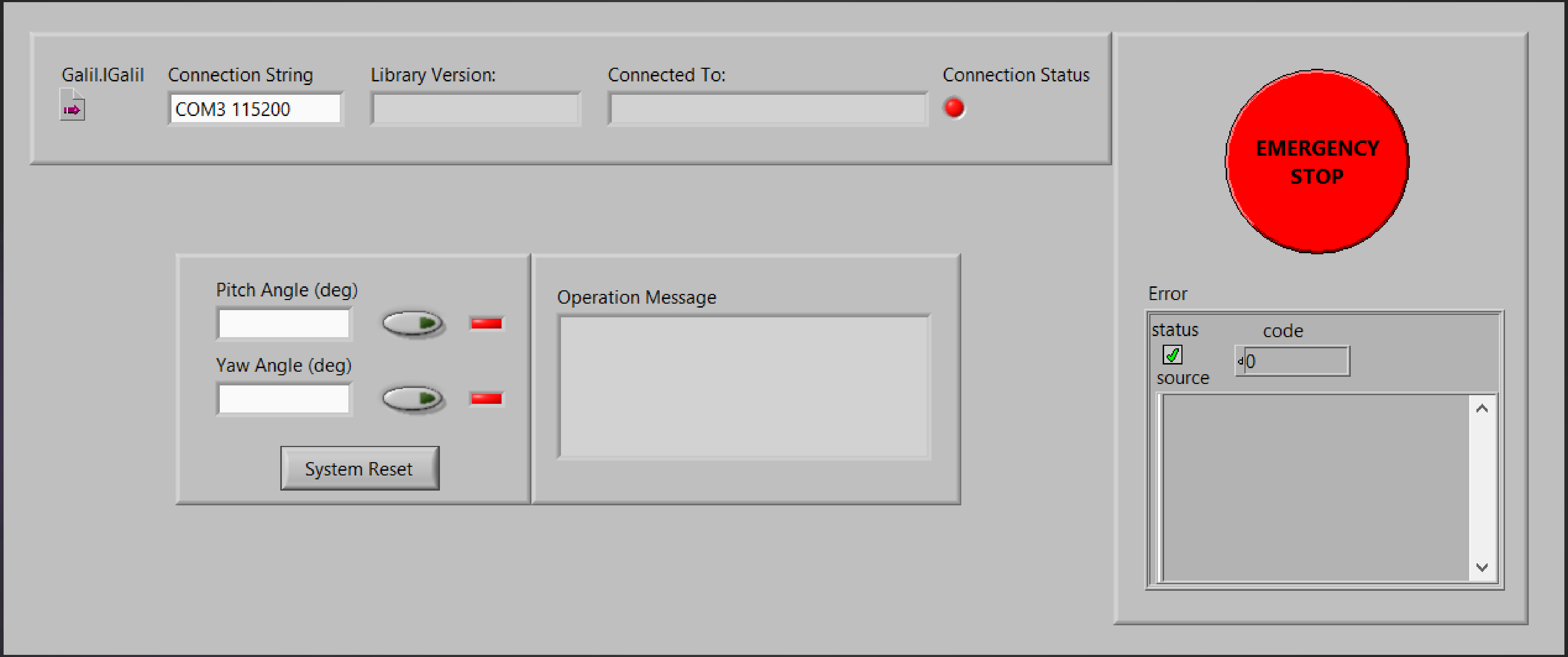
Programming Communication

- Galil motion controller uses DMC (Digital Motion Controller) code
- GalilTools software has an integrated library to use LabVIEW with the Galil controller
- LabVIEW can download programs to the Galil and send commands (as long as they don't contradict the loaded program)

Ideal Logic Configuration

- User input of angles in LabVIEW
  - System will have a “reset”
- Input communication and processing
- Motors actuate the arc to the specified angles
  - New angles will not be able to be entered while the arc is in motion
- Encoders feedback to controller
- Return to LabVIEW interface that actuation is completed
- User can enter new angles or reset the system
- Emergency stop

Final LabVIEW Interface



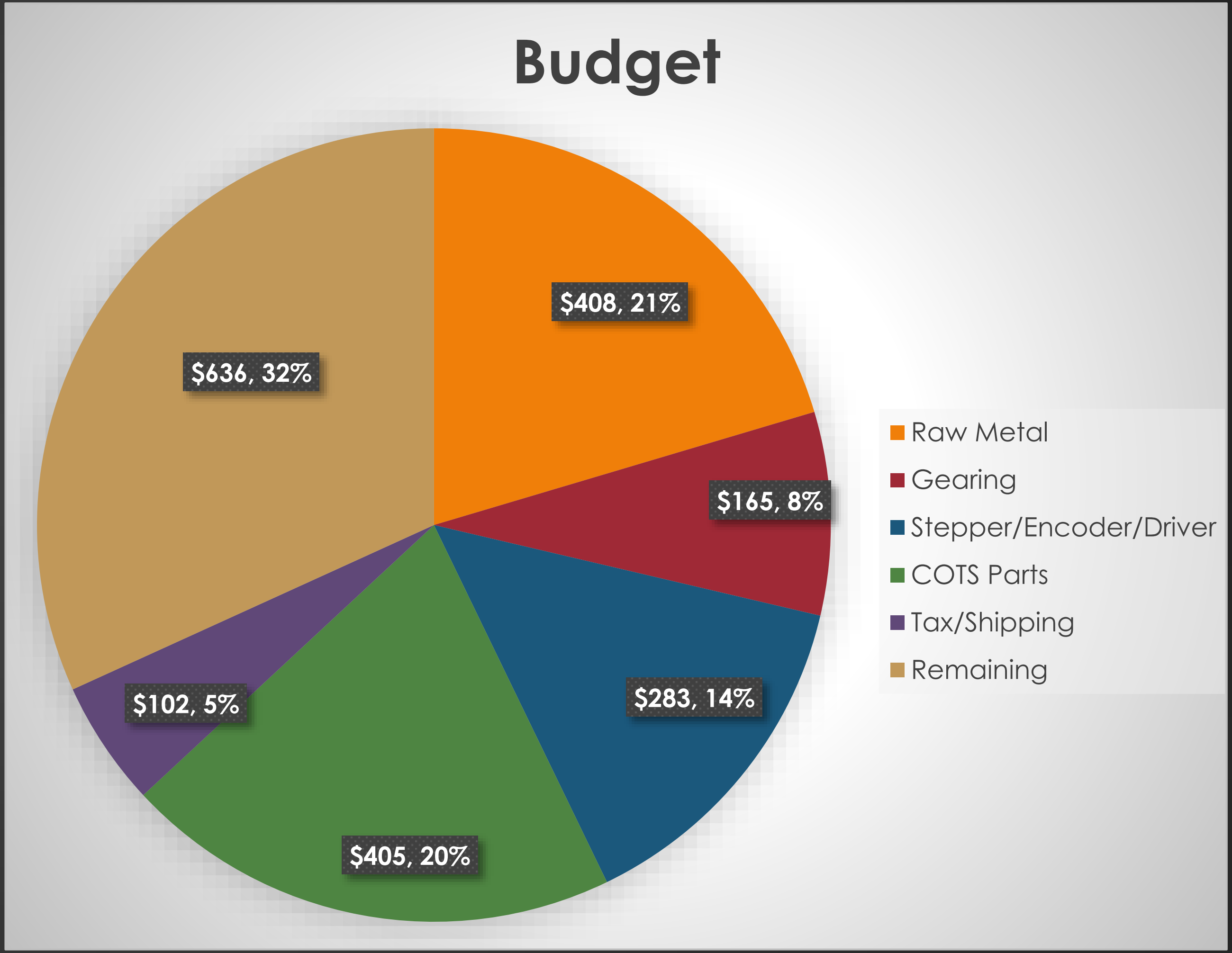
Prototype Demonstration

- https://www.youtube.com/watch?v=yovCVmcjyGs

Design Economics

Costs Reduction Techniques:

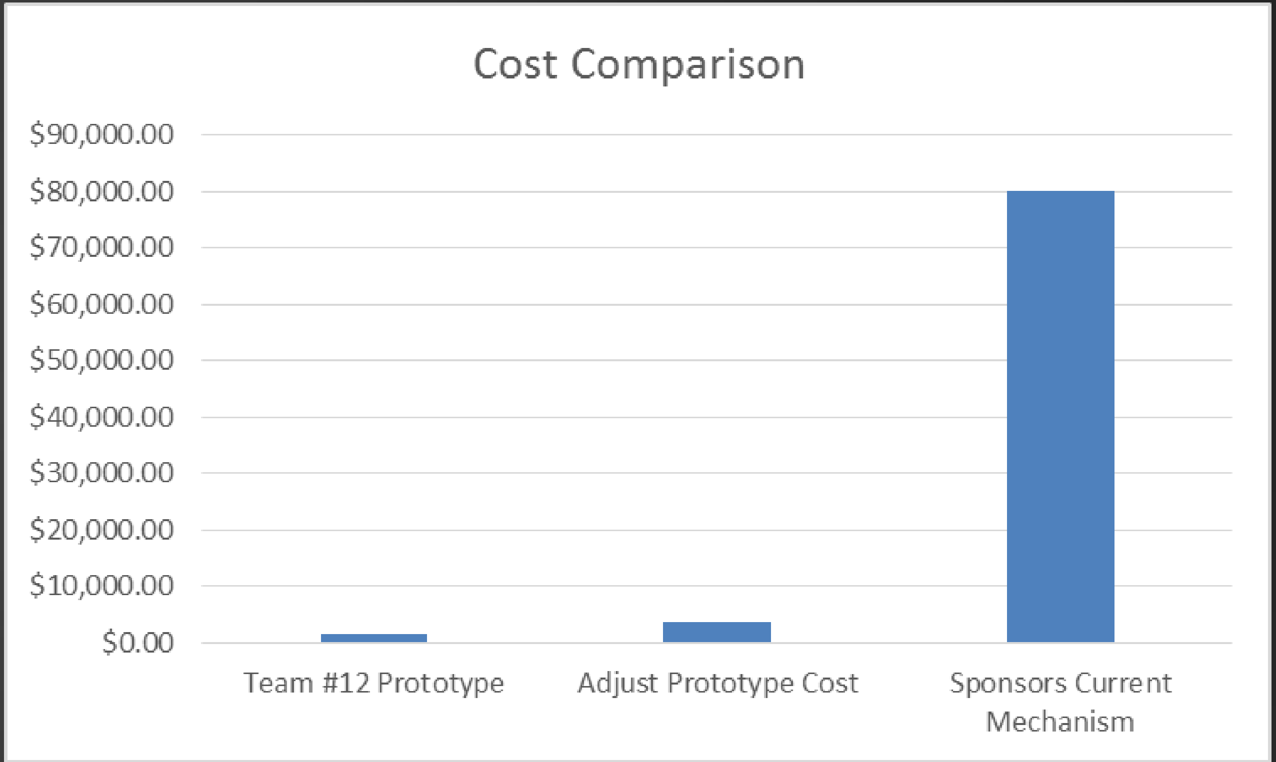
- Consumer Off the Shelf Parts
- Machining Completed at FSU/ CoE Facilities
- Sponsor Provided Controller and Rotary Table
- Price Shopping For Raw Metal



Design Economics Cont...

- Team #12 Prototype - $1,364
- Adjusted Prototype - $3,659
- Accounts for sponsor donated materials
- Sponsors Current Mechanism - $80,000

- The produced prototype is the most cost effective of the current options



Expectations vs. Results

Achieved Goals

- Pitch range: -5° to +20°
- Yaw range: ±10°
- Constant center of mass location
- Model remains still when arc inactive
- Arc controlled by user interface
- Successful actuation under load

Goals in Progress

- Withstand maximum forces generated by wind tunnel
  - Can only be tested upon delivery to sponsor

Project Management

- Management
  - Communication
    - E-mail
    - Text
    - Facebook
  - Delegation
    - Mechanical Work
    - CAD Work
    - Programming Work
    - Budgeting
  - Planning
    - Bi-Weekly Meetings
    - Team set deadlines
    - Intermediate Deliverables
    - Impromptu Meetings

Summary

- What we learned:
  - Time management
  - Project Management
  - Team Work
  - Work Delegation
  - Presentation Skills
  - Work in detail
- Future Modifications:
  - Gyroscope
  - Turn-table encoder
  - GUI improvements

Are there any questions?

Would you like to follow our project?
Check out our website!
http://eng.fsu.edu/me/senior_design/2015/team12/