REEF Subsonic WT Articulating Robotic Arm

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Outline

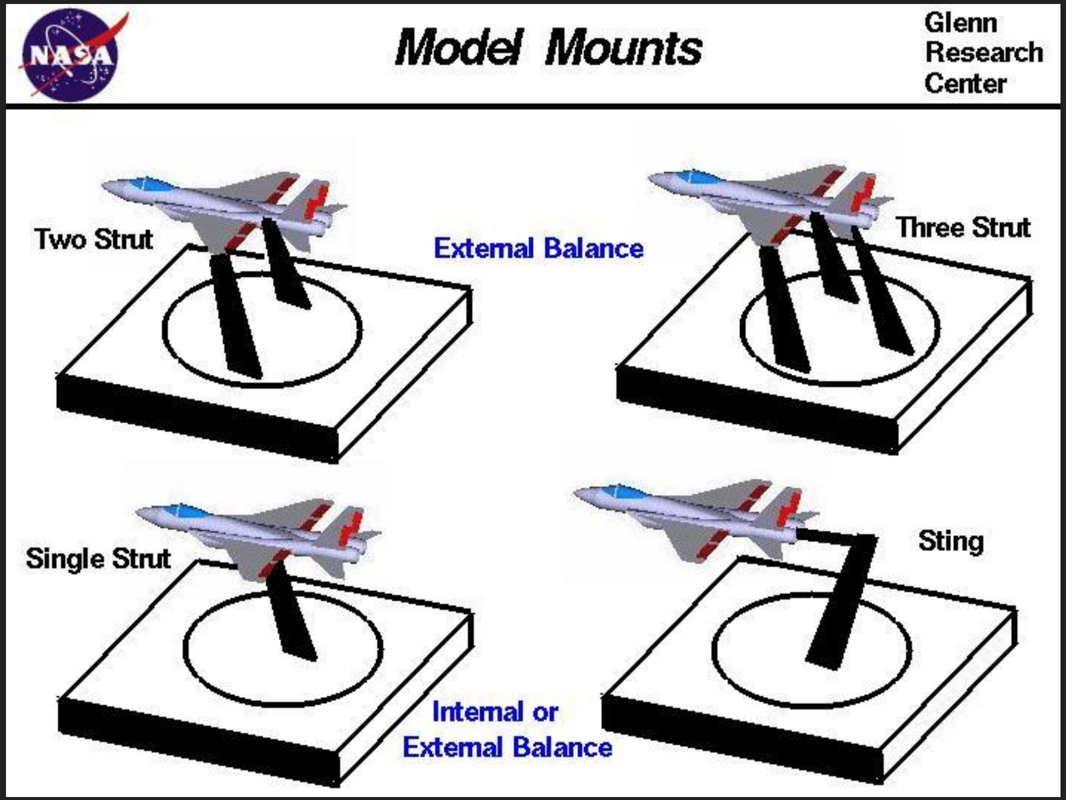
- Project Definition
- Design Choice
- Challenges
- Future Work
- Summary

Problem Statement

- To produce an articulating robot arm for use in a subsonic wind tunnel for the REEF facility

Background (history)

- Wind tunnels are a cost effective means to test an aerodynamic design in a controlled environment
- Through the use of dimensionless quantities scaled models can be used for testing
- Mounts may hold model from underside or back
- Forces and moments may be found by attaching strain gages and measurement devices

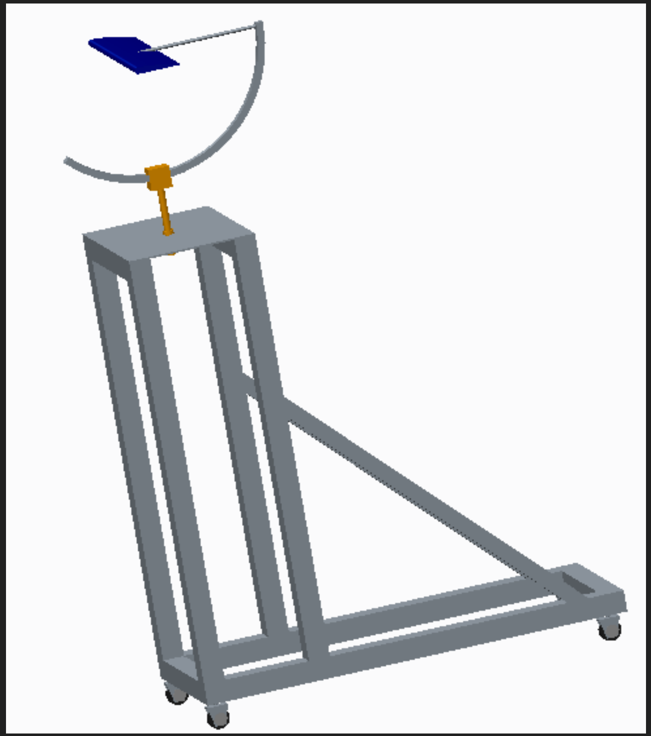


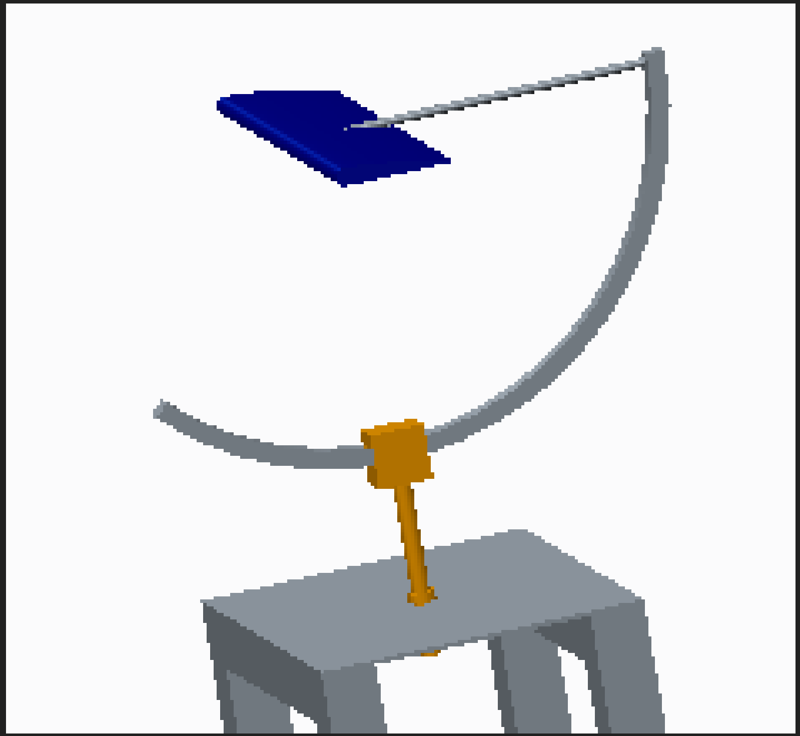
Project Definition

- $42x42\ in^2$ Tunnel Jet
  - Center 82 in off ground
- Model must remain centered during manipulation
- Minimally invasive mounting system
- Range of Motion: ±30° angle of attack and ±20° yaw
- Sponsor requests/suggestions:
  - Structure fabricated with 80/20
  - Stepper motors with encoders
  - Portable
  - Large factor of safety

Design Idea A

- Translates along horizontal arc
- Pivots at base of arc connector
- Wheels for mobility
- Torque reduction gear trains





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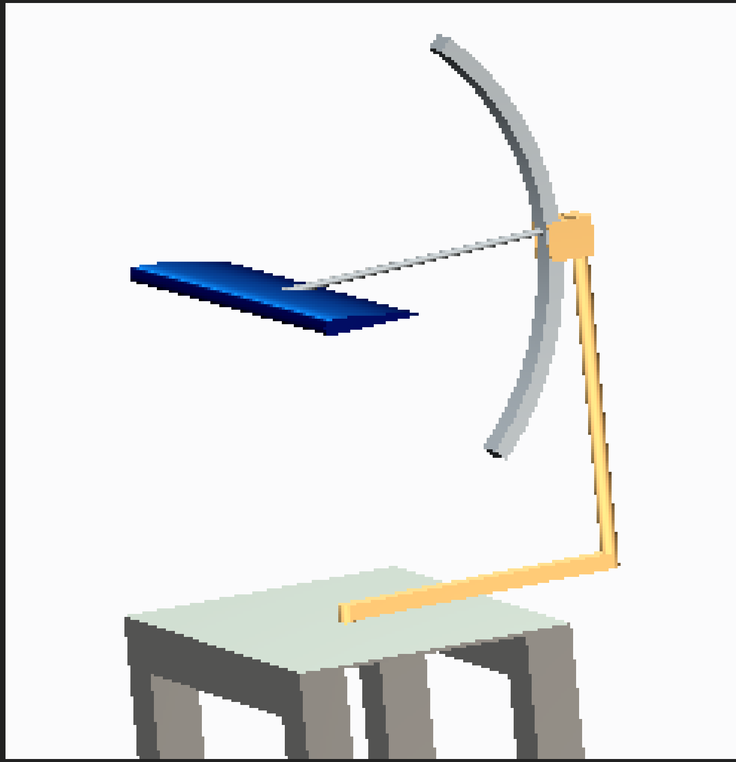
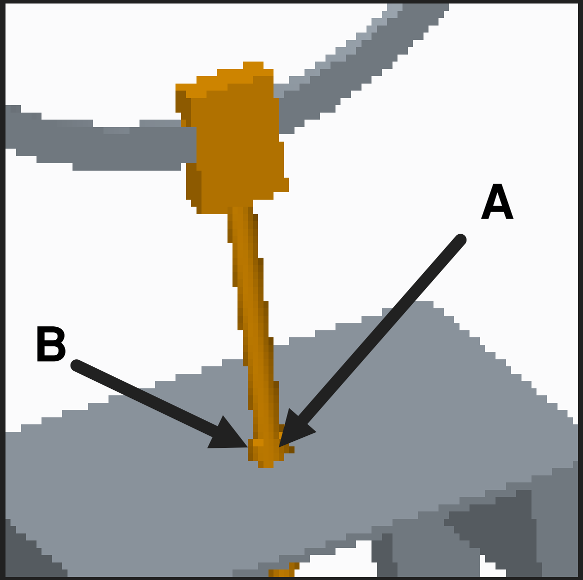
Design Idea B

- Translates along vertical arc
- Pivots at base of arc connector
- Wheels for mobility
- Torque reduction gear trains

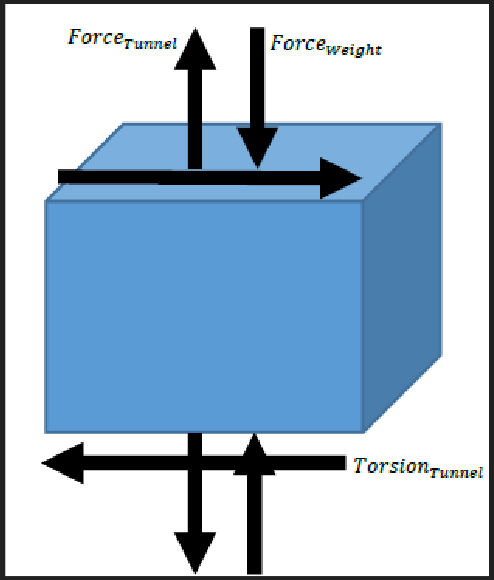


Structural Analysis

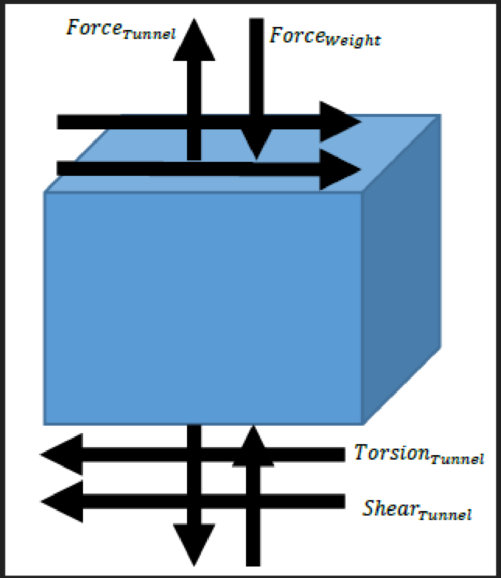
- Calculated lift and drag
  - $F_L = \frac{1}{2}\rho_{air}V_{air}^2 A_{critical} * \sin(\alpha)$
  - $F_D = \frac{1}{2}\rho_{air}V_{air}^2 A_{critical} * \cos(\alpha)$
- Principle Stresses
  - $\sigma_1 = \frac{\sigma_y}{2} + \sqrt{\left(\frac{\sigma_y}{2}\right)^2 + {\tau_{xy}}^2}$
  - $\sigma_2 = \frac{\sigma_y}{2} - \sqrt{\left(\frac{\sigma_y}{2}\right)^2 + {\tau_{xy}}^2}$
  - $\tau_{max} = \sqrt{\left(\frac{\sigma_y}{2}\right)^2 + {\tau_{xy}}^2}$



Stress Location A & B



Stress Location A



Stress Location B

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Decision Matrix

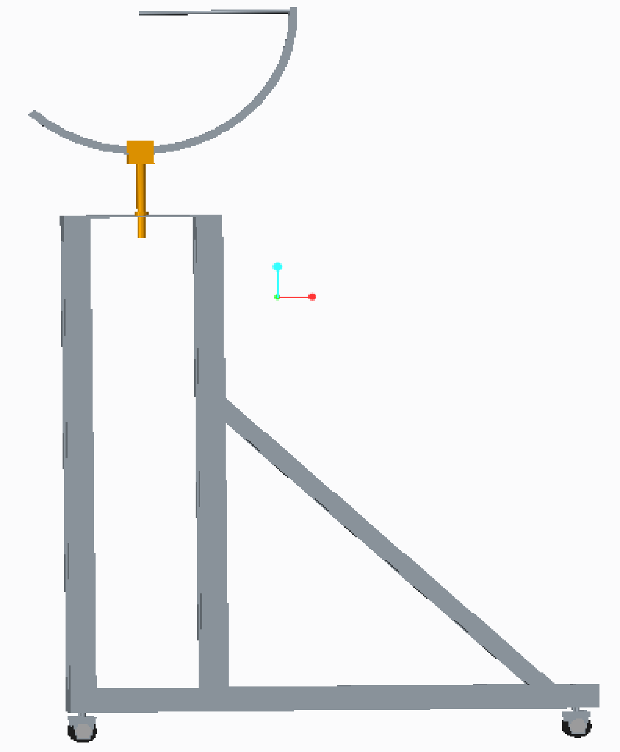
- Mobility
- Strength
- Cost
- Efficiency
- Complexity

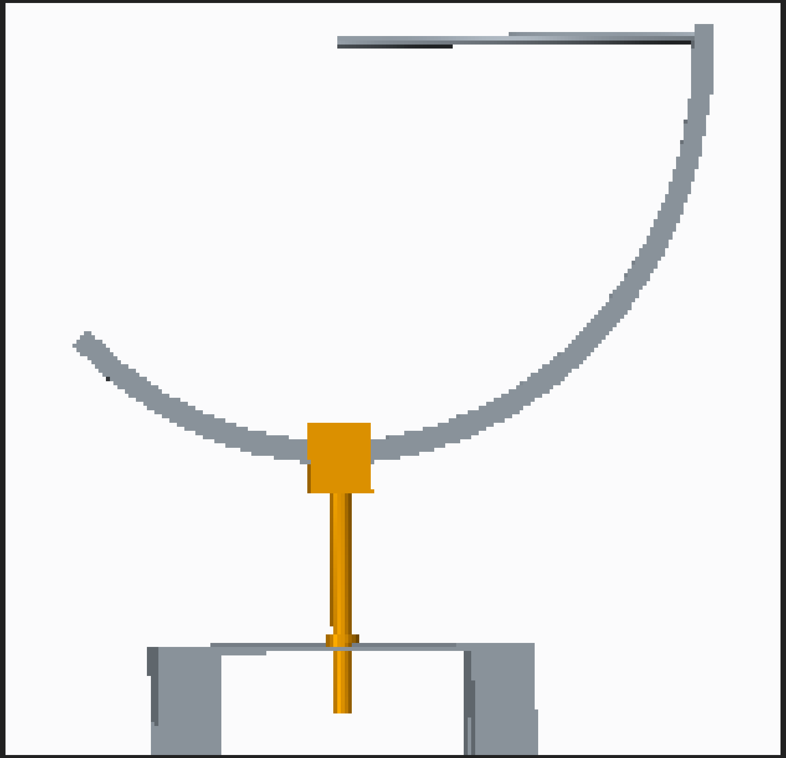
- Design A wins by margin of 16 points

Weight	3	9	6	9	6	33
Designs	Mobility	Strength	Cost	Efficiency	Complexity	Score
Design A	75	80	65	90	75	79
Design B	75	60	50	80	50	63

Final Design Choice

- Design A
  - Stronger structurally
  - Cheaper
  - More efficient
  - Less complex

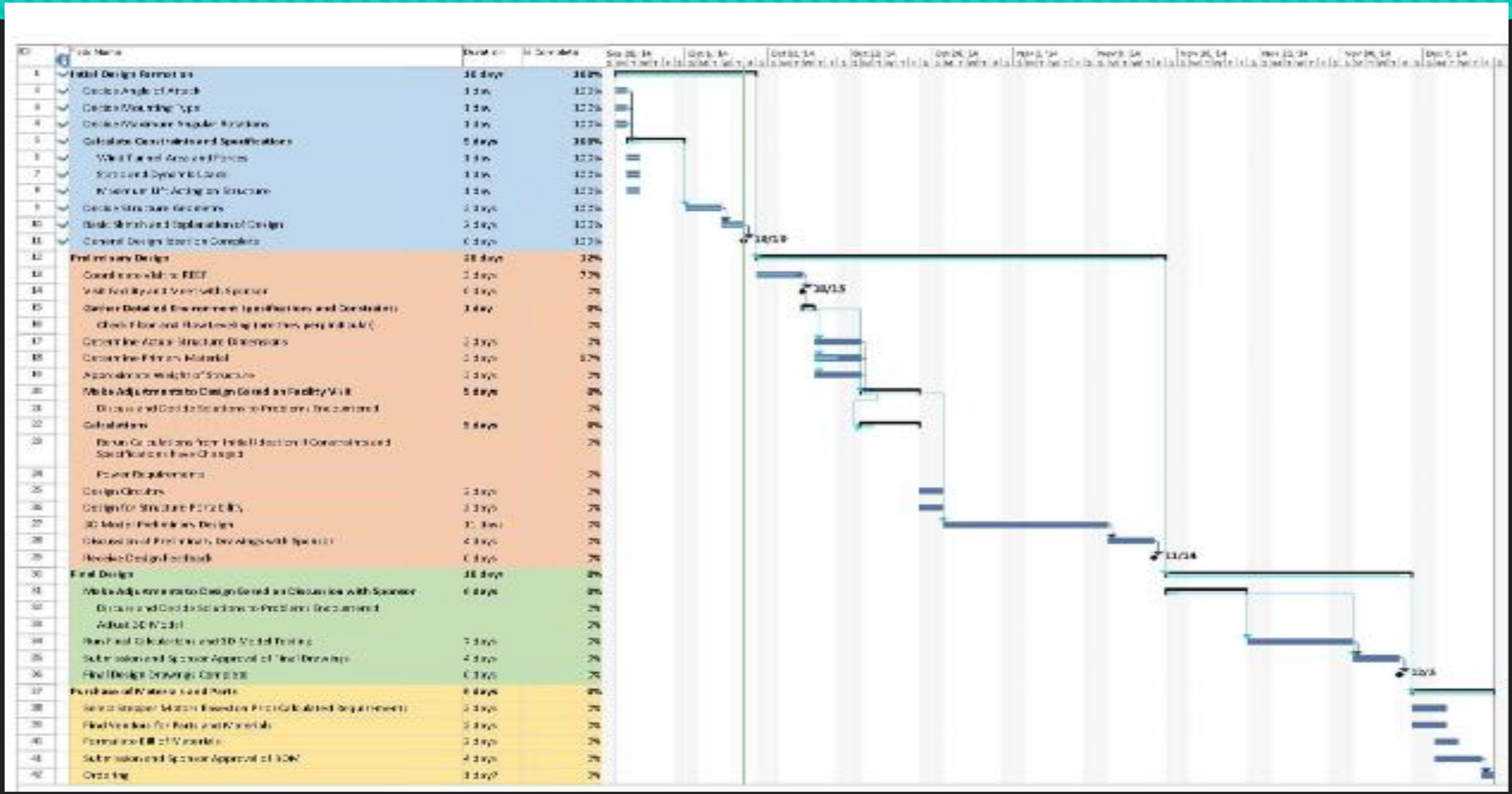




Challenges

- Locking system for both model mount and cart
  - Extended feet
- Leveling system
  - shims
- Translation movement design for arc
  - Chain drive, gear train, friction wheel
- Sponsor communication issues
  - Find quick and efficient way to communicate

Gantt Chart



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Future Work

- Finalize the prototype mounting system/cage design
  - Testing using Pro E/Matlab/MathCAD to confirm bending/stress/loading
- Place orders for stock parts
- Finalize designs for custom parts
- Write code to control pitch and yaw manipulation
- Construct and test (using REEF or local wind tunnels)

Summary

- Objective
  - Create a mounting mechanism for the REEF center that can adjust pitch and yaw during operation
- Stress Analysis
  - Using lift and drag forces, analyzed high stress concentrations for design constraints
- Design Choice
  - Chose horizontal arc in design A
- Future Work
  - Based on estimates $2000 should be adequate for project
  - Have a dimensioned drawings by end of semester

References

- http://blogs.msdn.com/mswanson/archive/2008/07/20/my-decision-matrix.aspx
- "Model Mounts." *Model Mounts*. NASA Glen Research Center, n.d. Web. 15 Oct. 2014
- "My Decision Matrix." - *Mike Swanson's Blog*. N.p., n.d. Web. 15 Oct. 2014.