Team 25: Taller Wind Turbine for Low Wind Speed Regions

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Outline

- Project overview
- Full scale design
- Prototype design
- Budget
- Challenges faced
- Future work

Project Overview

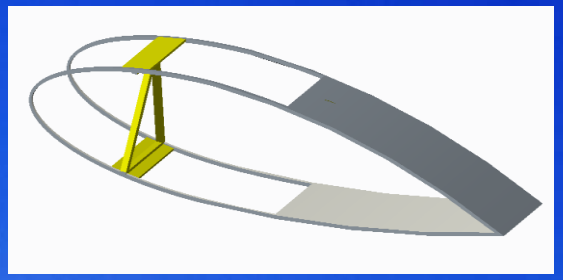
Current 80 meter wind turbines are not cost-effective for use in the Southeastern U.S. due to lower average wind speeds.

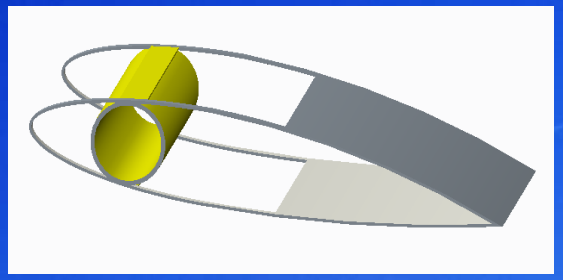
Project Specs:

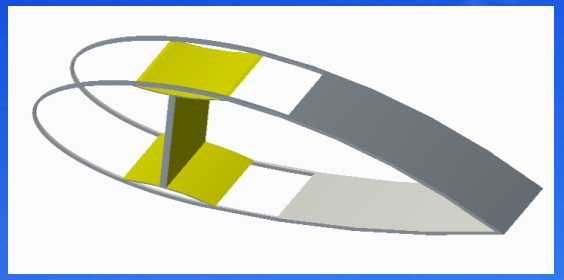
- 5 MW
- Horizontal Axis Wind Turbine
- Taller structure (157.5m)
- Design lighter blades of same size
- Number of blades: 3
- Prototype budget: $2,000

Selecting Final Design

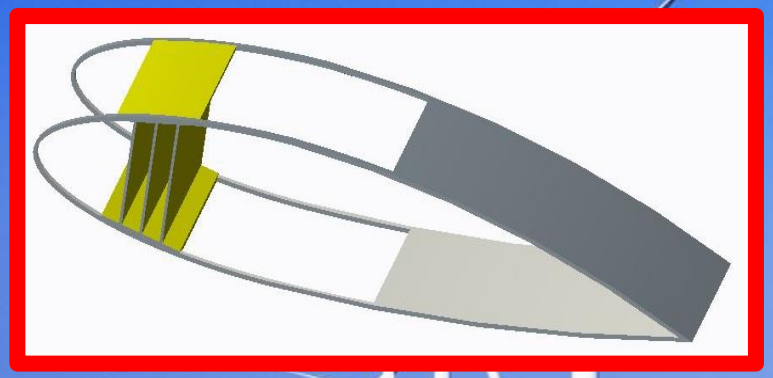
- 4 initial designs for internal spar





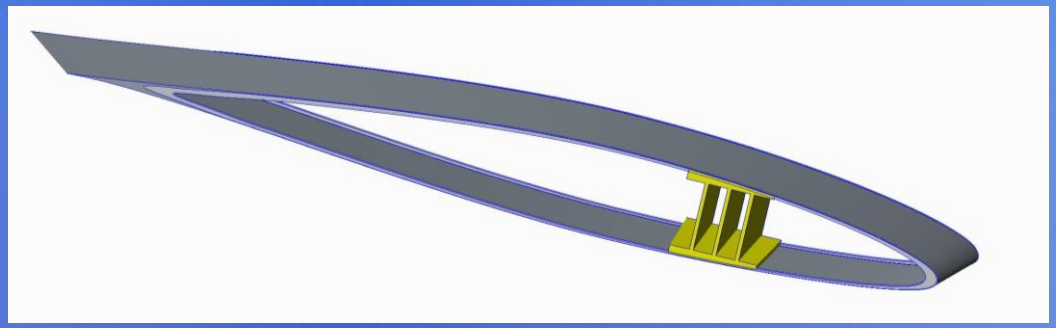


- Compared weight, shape factor, ease of manufacture, risk of failure
- Triple I-Beam selected



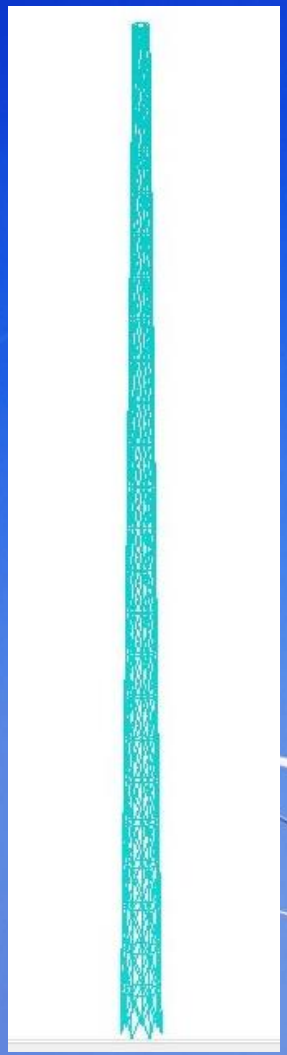
Blade Design

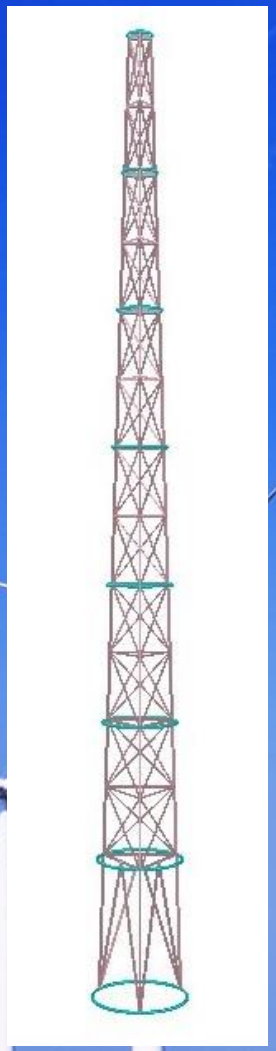
- Blade length: 61.5m
- Cross-sectional shape: NACA-64
- Varying angle of twist
- Shell Material: E-Glass, 12K Carbon Fiber, Epoxy, Styrene Acrylonitrile (SAN) Foam
- Spar: Triple I-Beam
  - Good distribution of load
  - Lightweight
  - AL-6061



Selecting Final Design

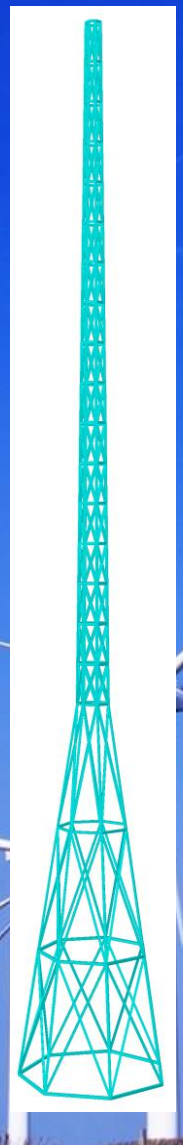
- Initial designs
  - Heptagonal lattice
  - Triangular lattice
- Comparisons
  - Ease of transportation
  - Strength
  - Constructability
  - Weight
- Decision: Combination of two designs



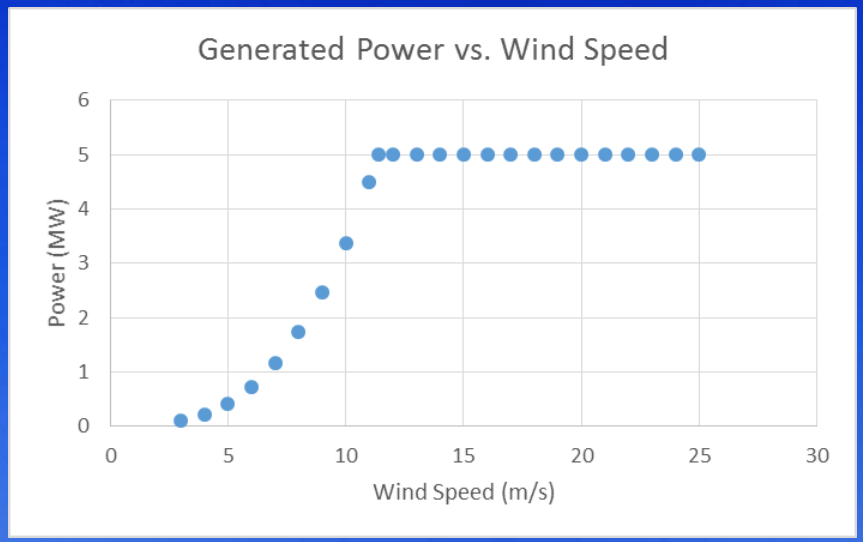


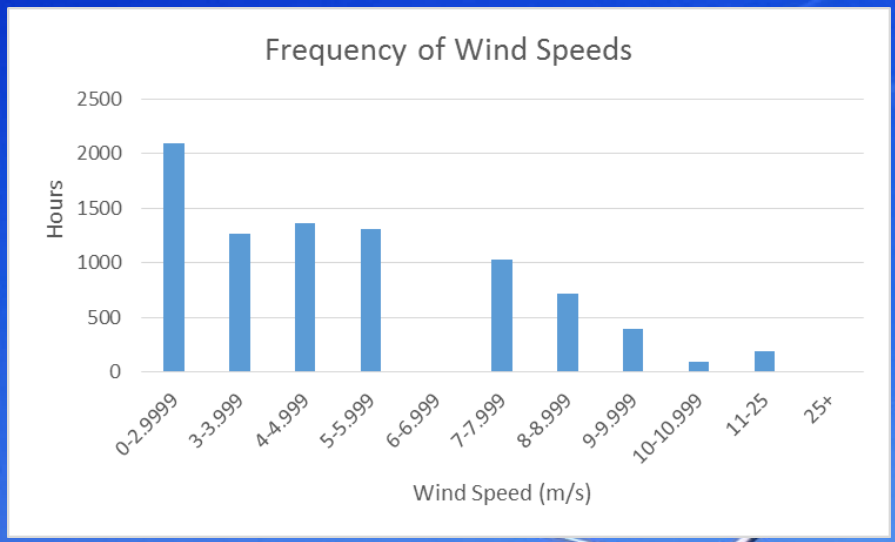
Tower Design

- Hub height: 157.5m
- 7-sided lattice tower
- Materials:
  - Hollow Structural Steel Tubing (HSST) sections
  - Architectural fabric
- Features:
  - Wider base
  - Internal bracing
  - Modular construction



Wind and Power



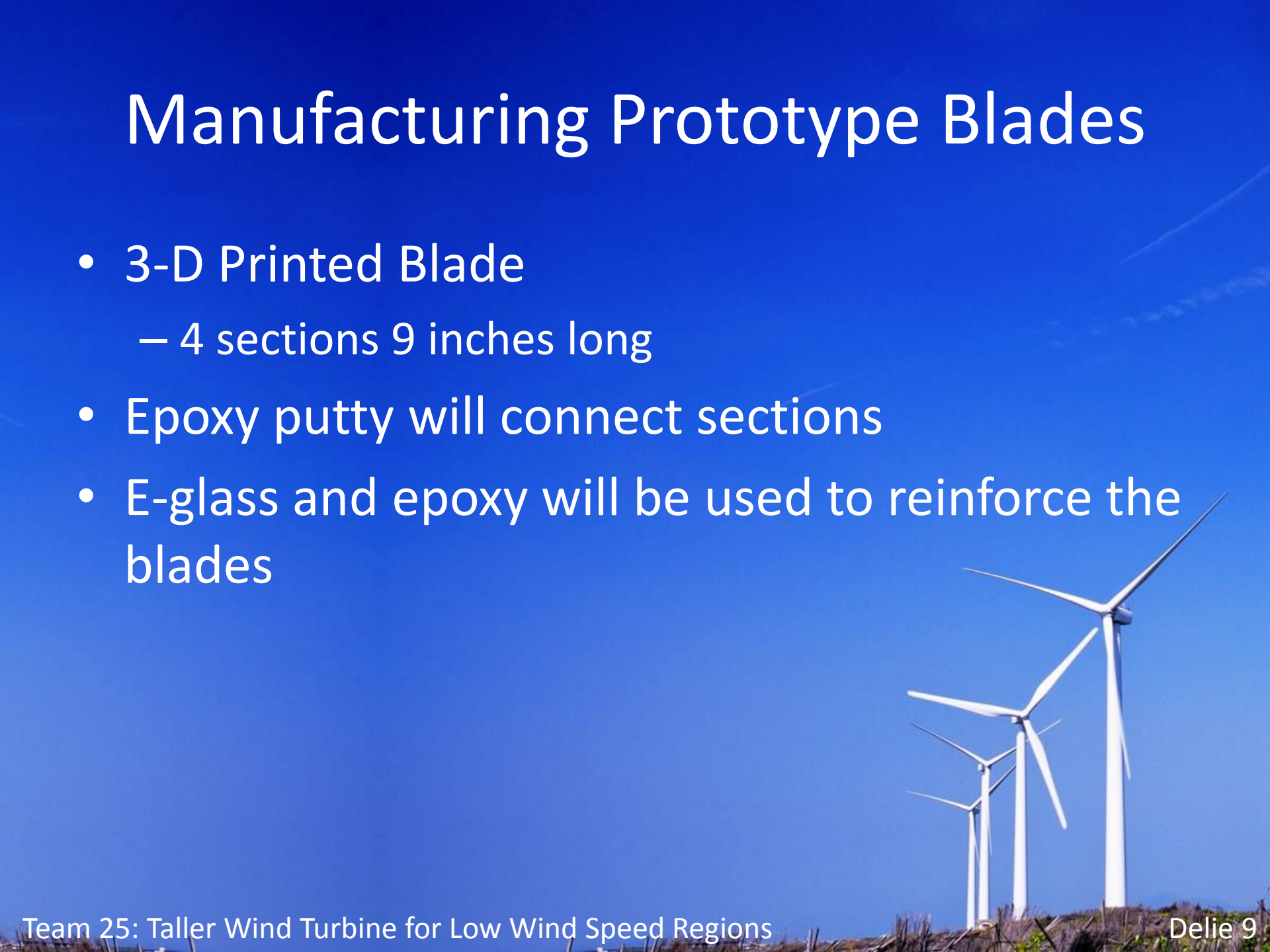


Belle Glade, FL (2014): Power Generated ≈ 137,000 MWh

That's enough electricity to power 12,600 homes.

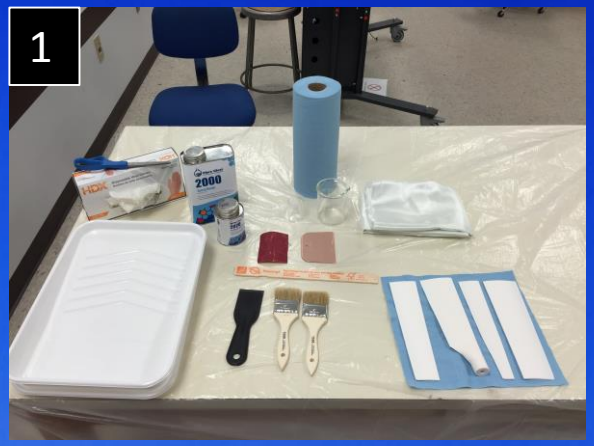
Manufacturing Prototype Blades

- 3-D Printed Blade
  - 4 sections 9 inches long
- Epoxy putty will connect sections
- E-glass and epoxy will be used to reinforce the blades



Blade Assembly

1



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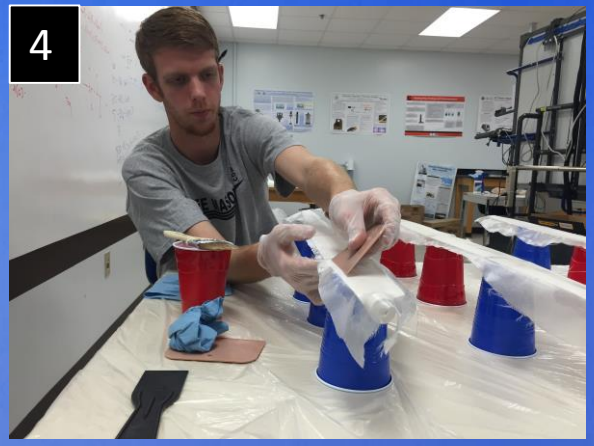

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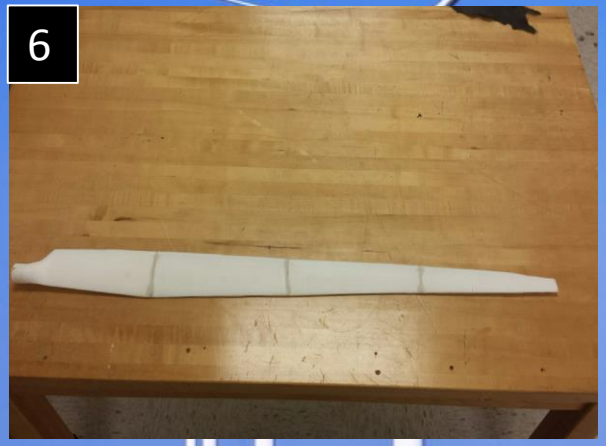
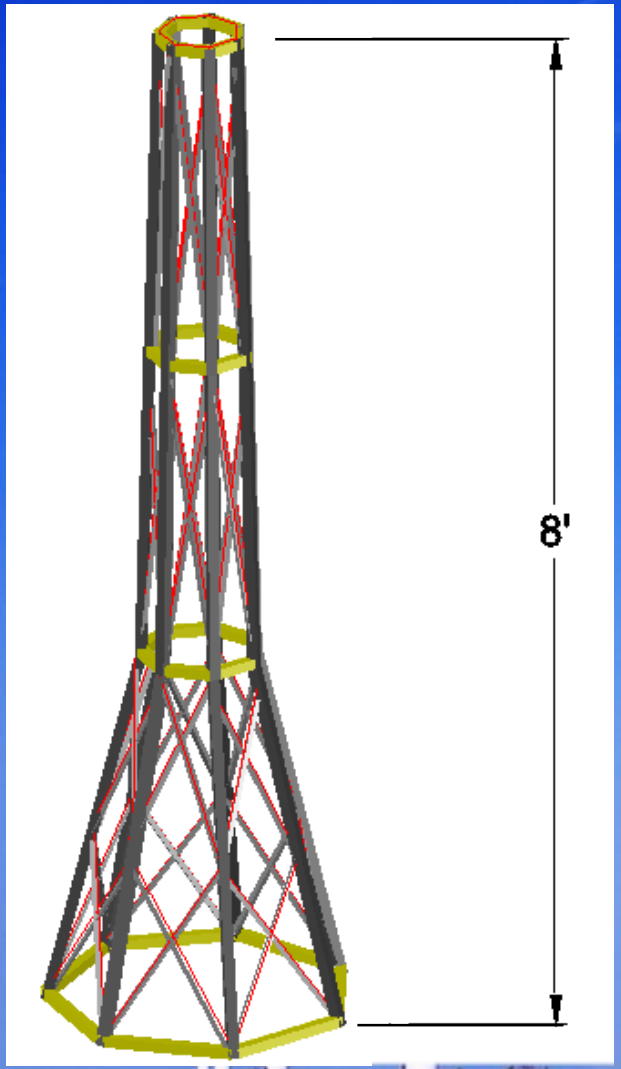


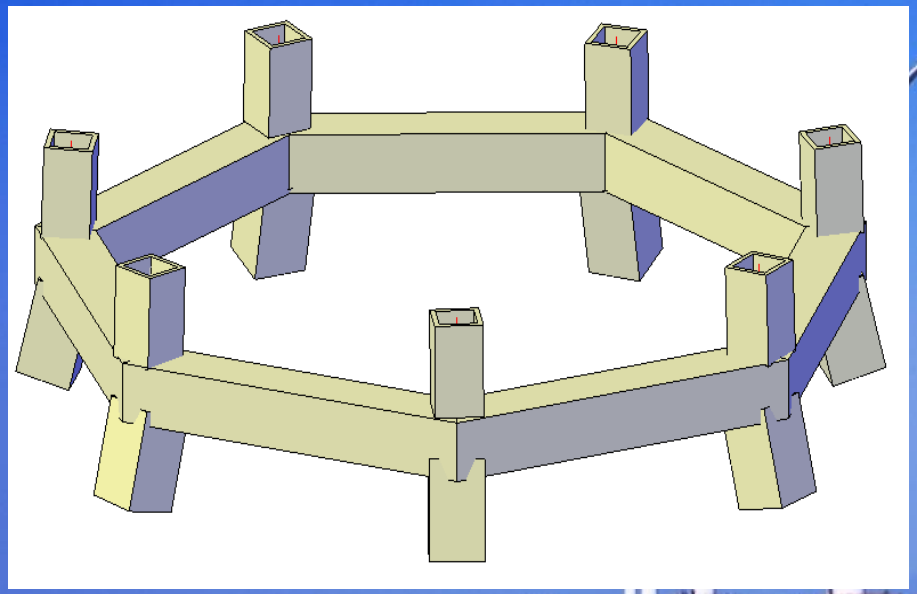
Tower Prototype

- 8-ft Steel Tower
  - 3 typical sections
  - General geometry will be properly scaled
- Connections
  - Custom design
  - Heptagonal rings between sections
- Wrap tower in fabric



Manufacturing Tower Prototype

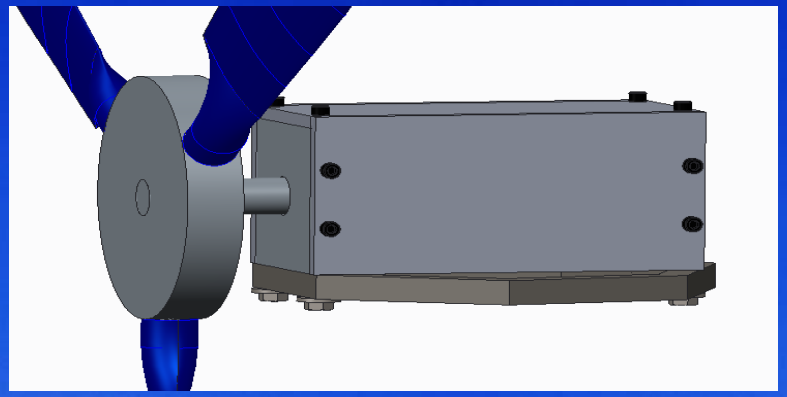
- Steel preparation – cleaning, cutting, grinding
- Fabricate sections in the machine shop
- Connections
  - Heptagonal rings: welded
  - Columns: plugs
  - Bracing: bolts

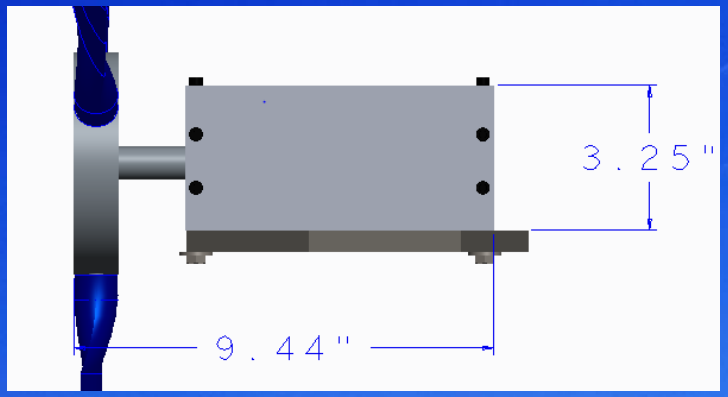


Manufacturing Tower Prototype

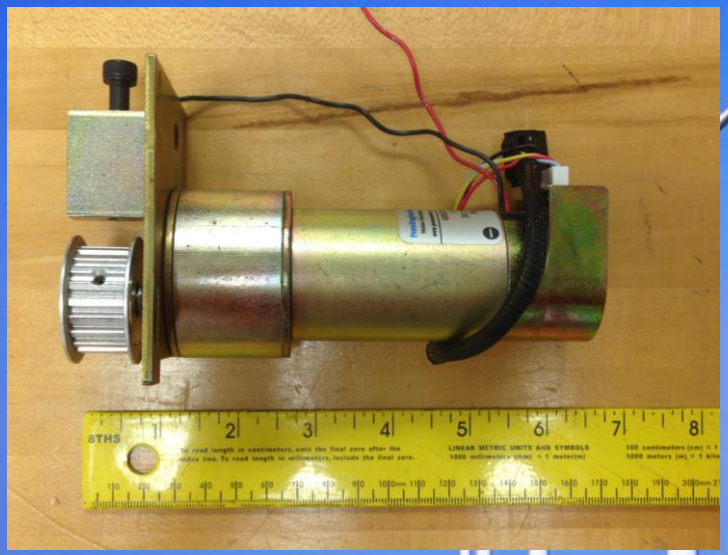
- Heptagonal rings and plugs are ready to be welded
- Next steps:
  - Cut column and bracing members
  - Assemble tower
  - Wrap tower in fabric

Nacelle Prototype

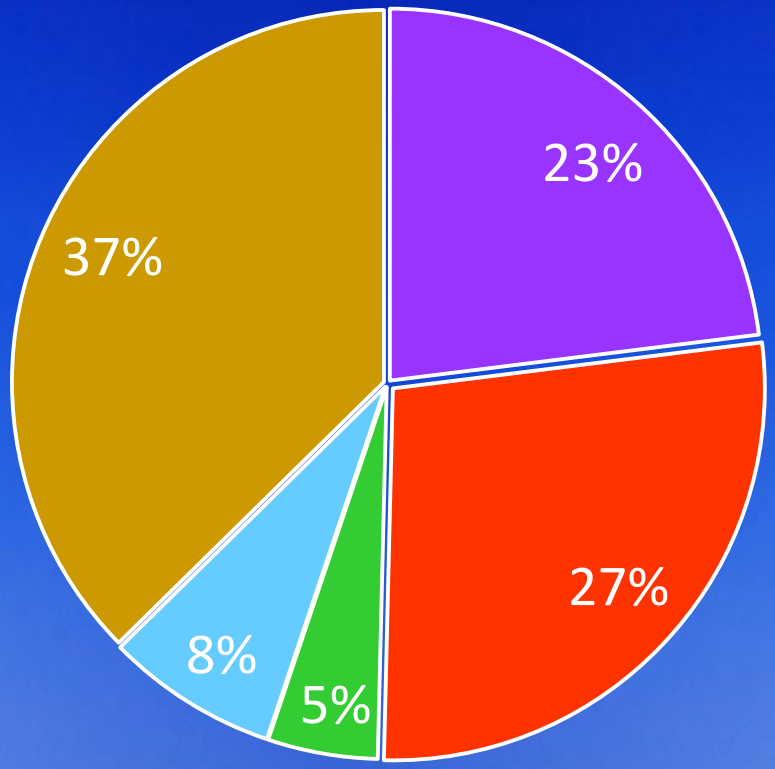




- Nacelle in progress with machine shop
- Plan to couple motor for power generation



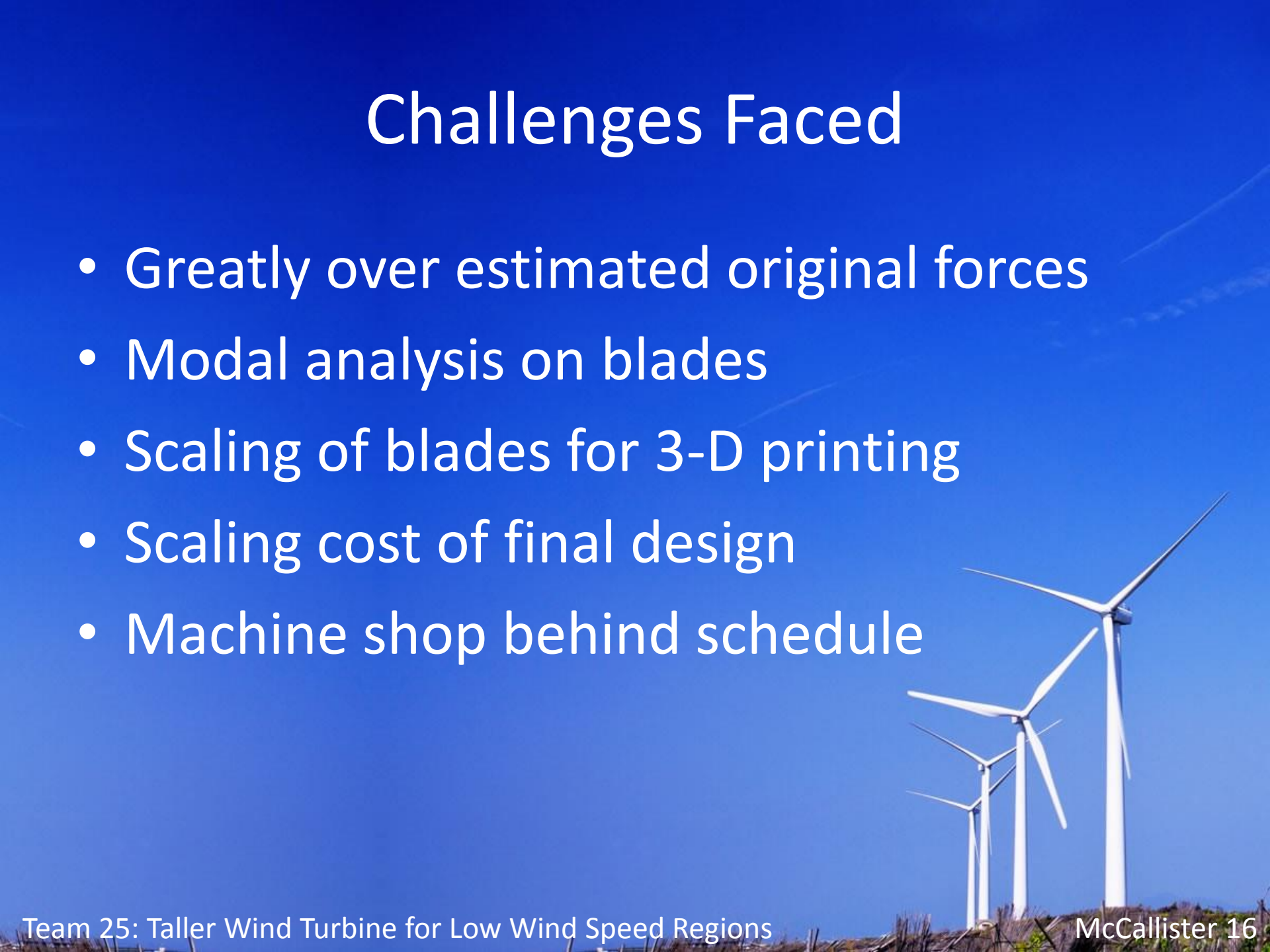
Budget



Material	Cost ($)
Steel	460.49
Blades	547.20
E-glass & Epoxy	95.50
Additional Parts	149.49
Remaining	**747.32**

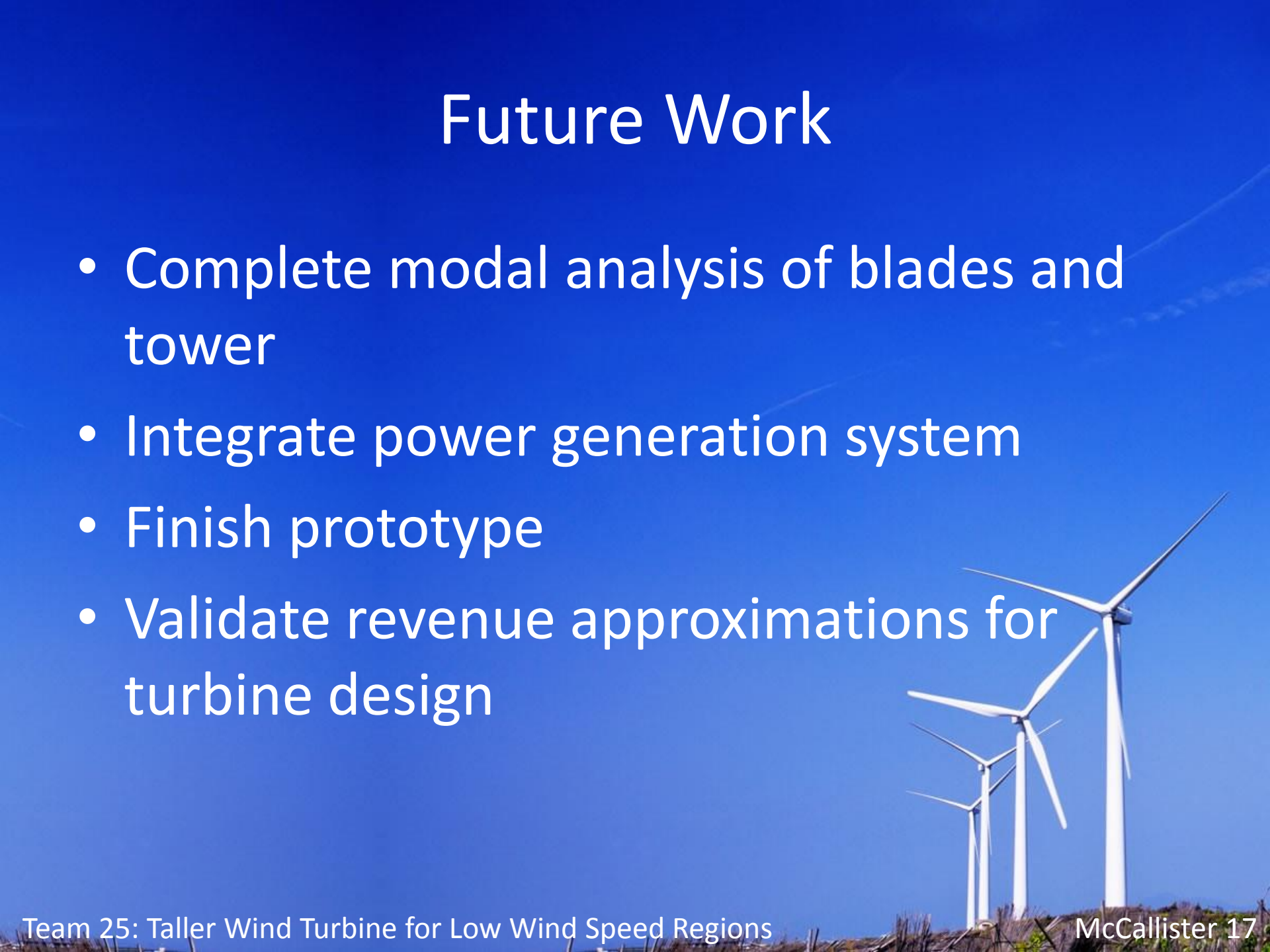
Challenges Faced

- Greatly over estimated original forces
- Modal analysis on blades
- Scaling of blades for 3-D printing
- Scaling cost of final design
- Machine shop behind schedule



Future Work

- Complete modal analysis of blades and tower
- Integrate power generation system
- Finish prototype
- Validate revenue approximations for turbine design



Summary

- Final designs were chosen for tower structure and blade design
- Construction of blades complete, waiting on machine shop
- Next Steps
  - Complete revenue analysis
  - Finish prototype

References

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- http://wind.nrel.gov/public/bjonkman/TestPage/FAST.pdf
- http://www.gettyimages.com/detail/news-photo/aerial-view-of-field-taken-from-goodyear-blimp-above-news-photo/457716040
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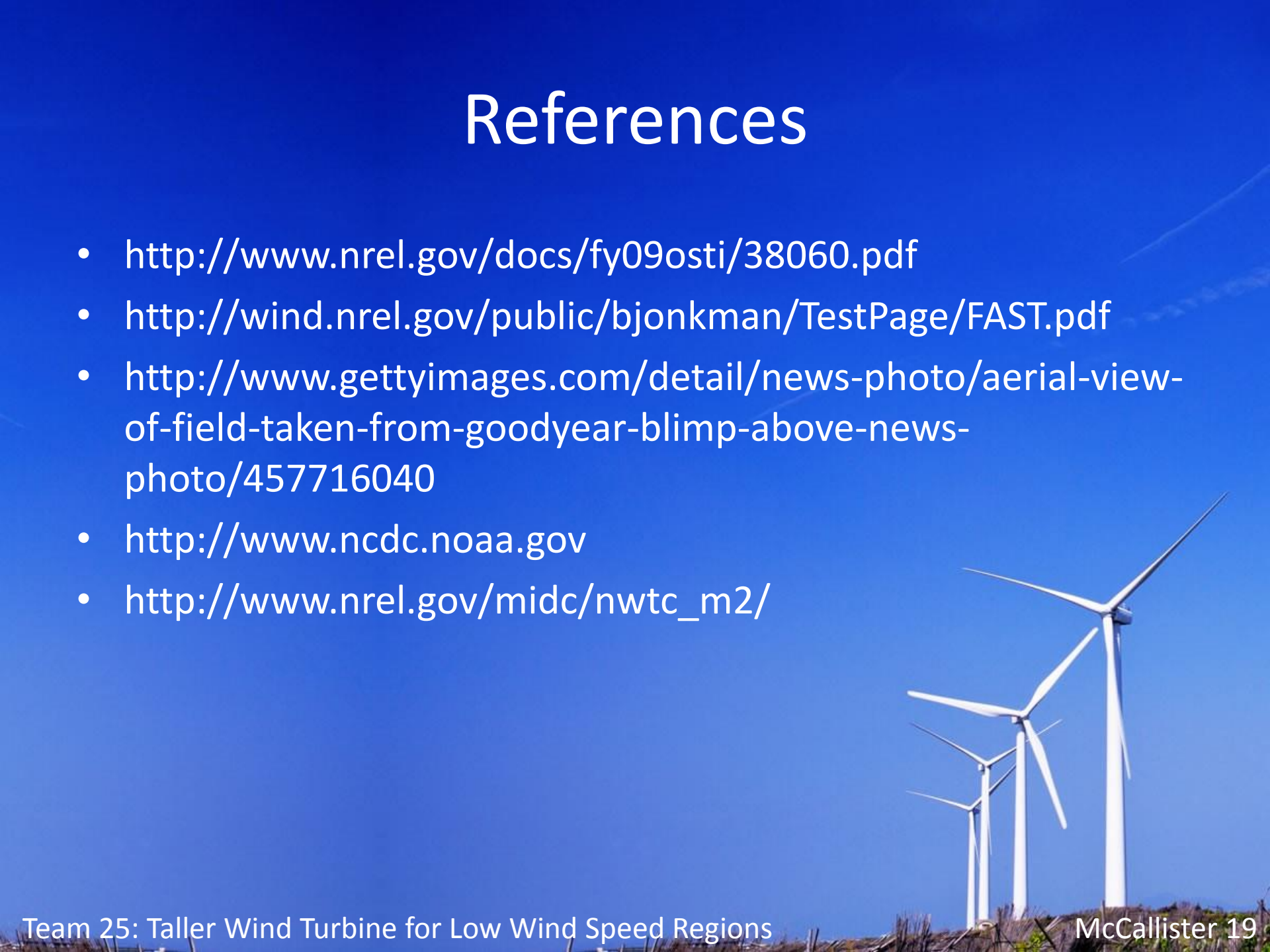

Questions?