# Axial Fans for ACCs

*Cooler By Design.*

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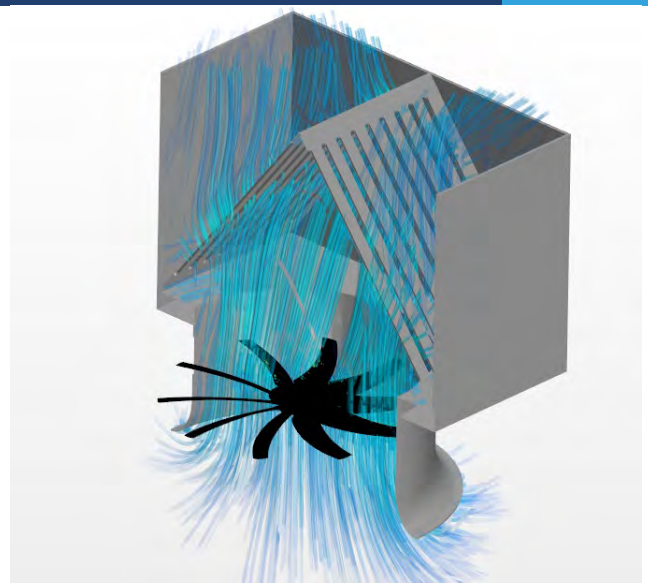
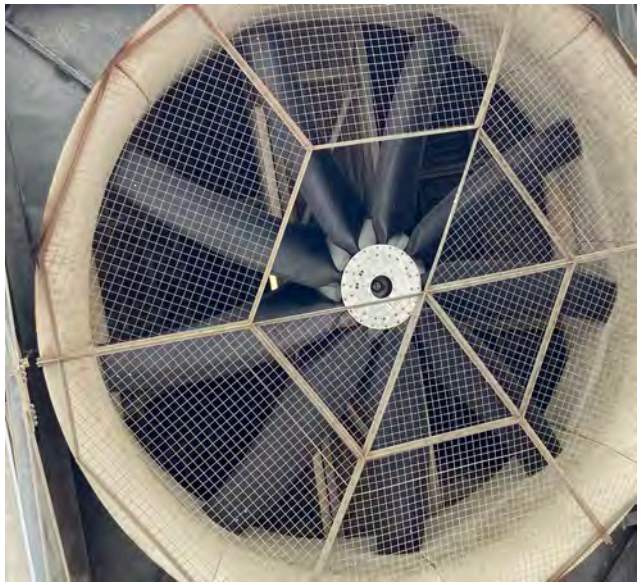
# Industrial Axial Fans

- Also known as Propeller Fans
- Airflow direction parallel to axis of rotation
- Low speed – not exceeding 14,000 ft/min (71 m/s) tip speed
- Low pressure – between 0” and 1” of $H_2O$
- High volume – Moves large volume of air due to lower system resistance & sizable area





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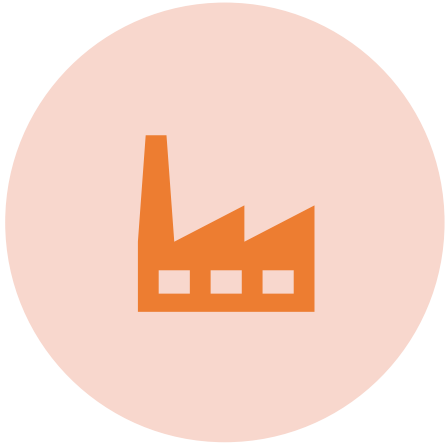
# Design Methodology

AERODYNAMIC DESIGN

STRUCTURAL DESIGN



MANUFACTURING

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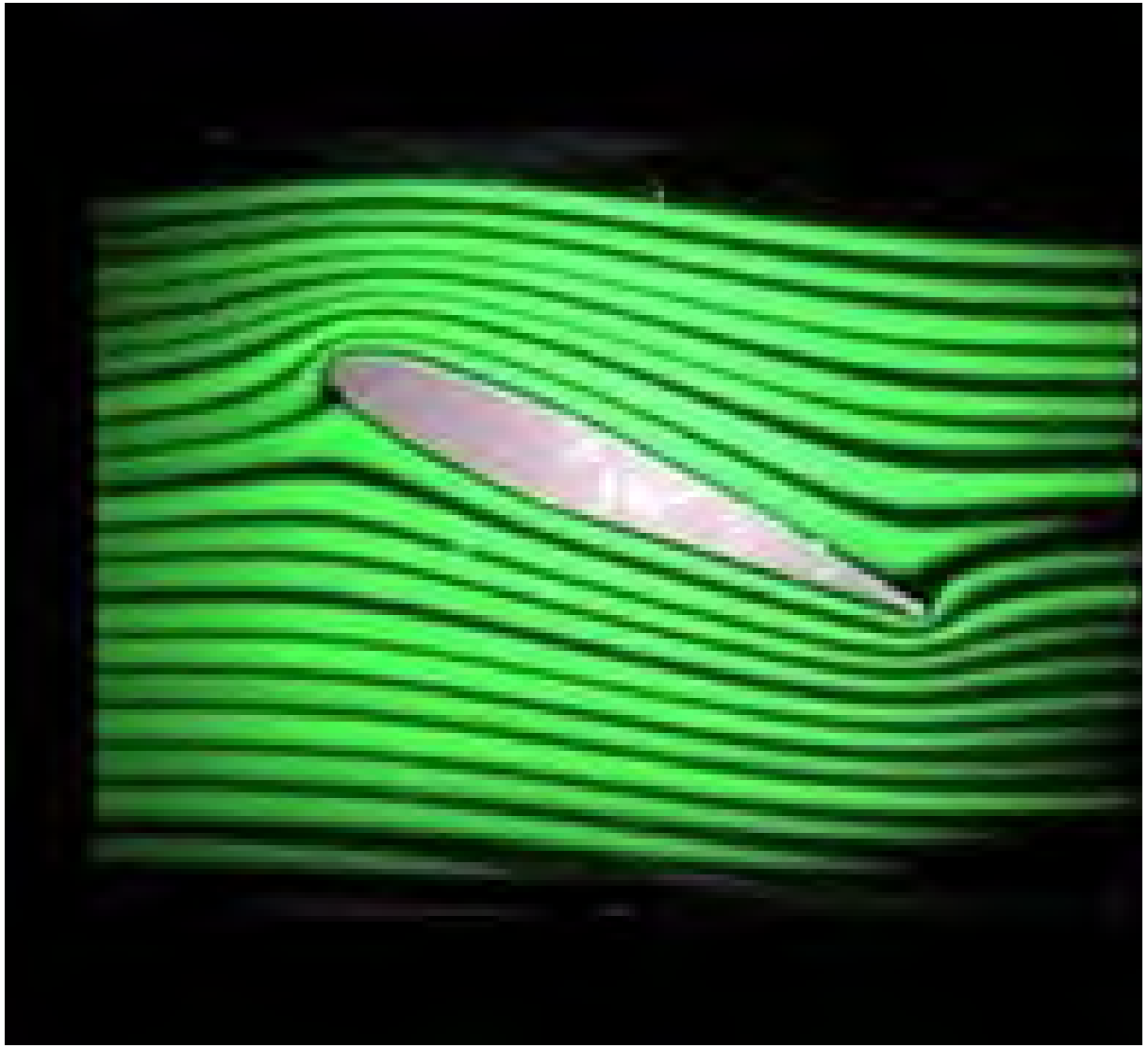
# Aerodynamic R&D



- Purpose - Optimize the physical shape of fan blade. Hubs categorized as non-aerodynamic
- Goal - increase the lift-to-drag ratio of the fan blade, similar to aircraft wing
- 2D cross-section of a blade is an optimized cambered airfoil

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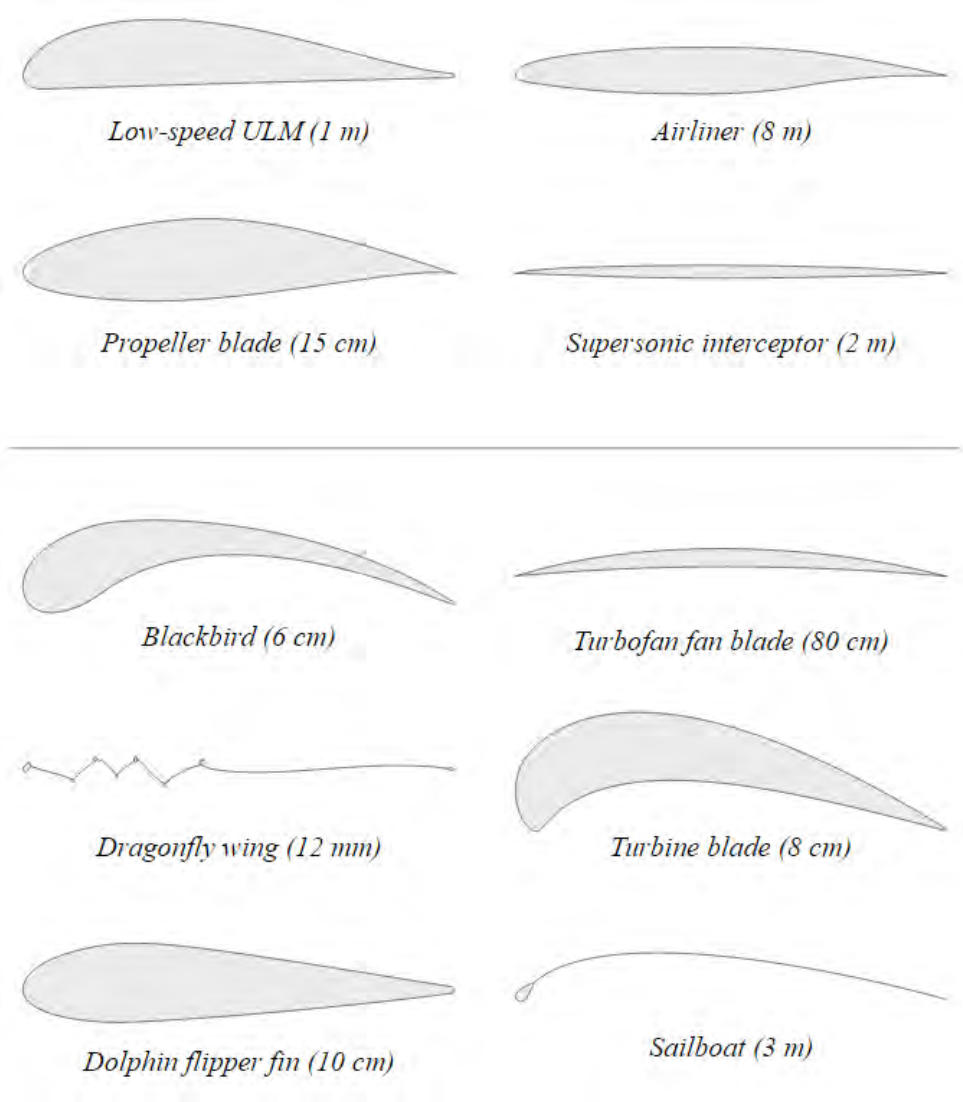
# Airfoil Selection

- The first and the most critical part of the design process
- The National Advisory Committee for Aeronautics (NACA) possesses the largest library for airfoils
- Consider a class of airfoil that would serve the purpose within the operational Reynolds number regime

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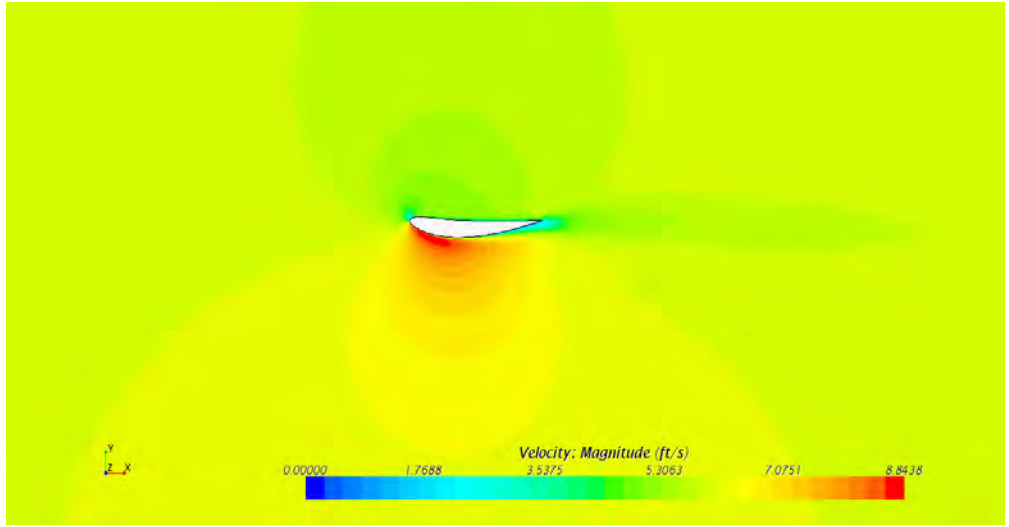
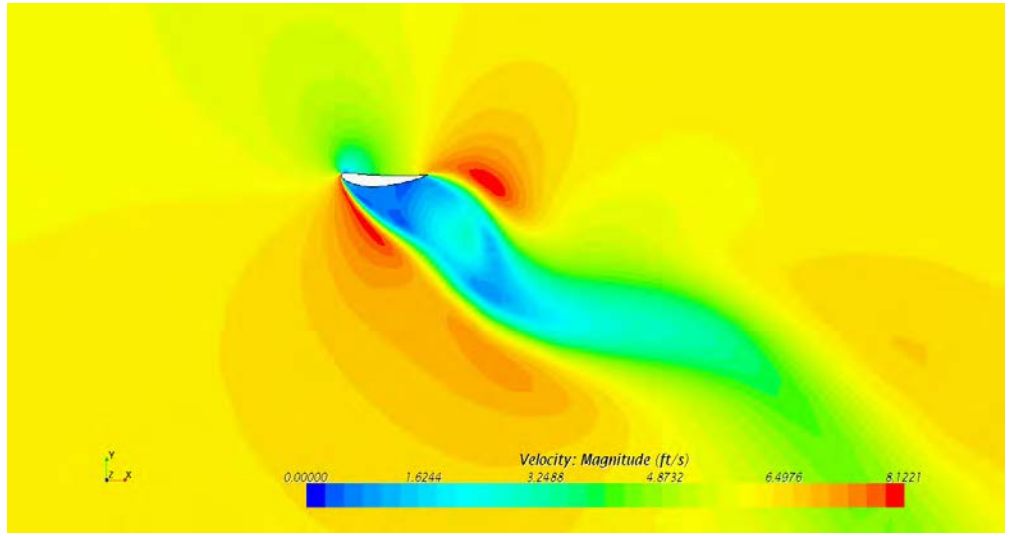
# CFD to Pick Optimum Airfoil

- Excellent tool for analyzing pre-selected group of airfoils at appropriate Reynolds number
- Simple 2-dimensional analysis to determine lift, drag and stall characteristics
- Use of parametric optimization tools

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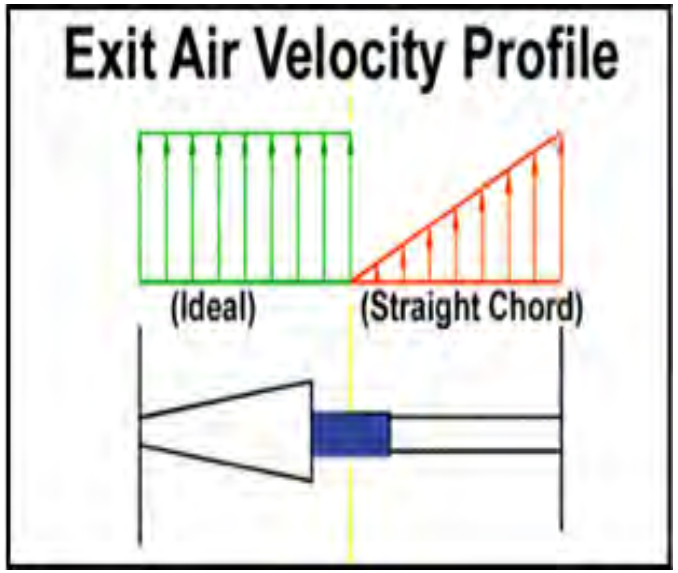
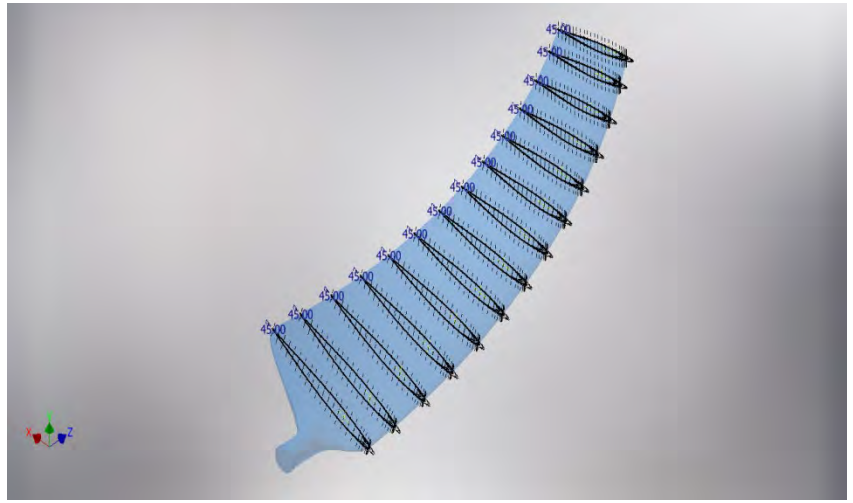
# 3D Modeling of Blade

- Use of different airfoils along the blade span and/or employ twist, taper & sweep to attain uniform pressure distribution

- Model the fan blade using 3D modeling tool with the chosen airfoil(s)

- Using automated optimization makes it easier to design custom airfoils for different span-wise locations



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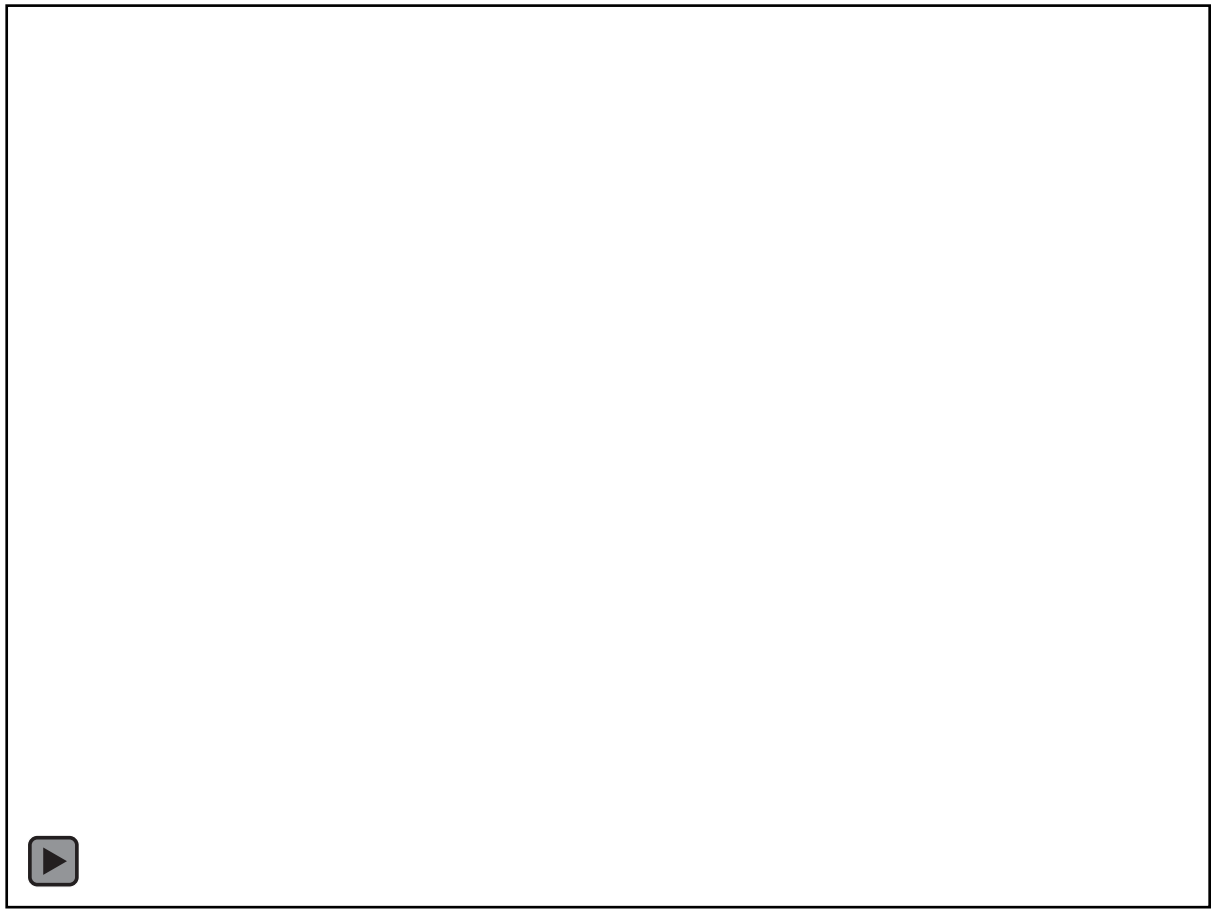
# 3D CFD



- Perform 3D CFD simulation of axial fan with newly designed blades operating at nominal speed with various pitch angles and number of blades
- Optimization will help determine the right chord widths, twist, taper & sweep along the span, and other critical features that serves the application
- As a result of optimization study, the designer will have the best possible fan blade model based on the given criteria
- Predict fan noise using aero-acoustic models available in popular CFD codes & helps optimize further, if noise is the criteria

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# Experimental Validation

- Validation will help demonstrate the accuracy of CFD codes and hence develop greater confidence for future simulations
- Validation testing required to be in a controlled environment using instruments with engineering accuracy
- Usually, size is a limitation in a lab environment and hence scale model testing is done using smaller but geometrically similar model
- Such validation may also be combined with obtaining the performance data for establishing fan curves of the new fan

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# Industry Standards & Need for Certification

- ANSI/AMCA 210 - provides guidelines for aerodynamic performance rating of fans
- ANSI/AMCA 301 - standard for determining sound power levels from laboratory test data
- AMCA 802 - instructions on establishing true size fan performance using smaller laboratory models, i.e., dimensional analysis and scaling laws
- Benchmarking from HVAC industry – certify fan performance by independent body?

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# Manufacturing - RTM

- RTM stands for Resin Transfer Molding – used for fabricating structurally reliable FRP fan blades
- Allows for complex blade shapes and monolithic design
- Primary Equipment:
  - Mold Tool
  - Hydraulic Press
  - Resin Pump
  - Temperature Control Unit

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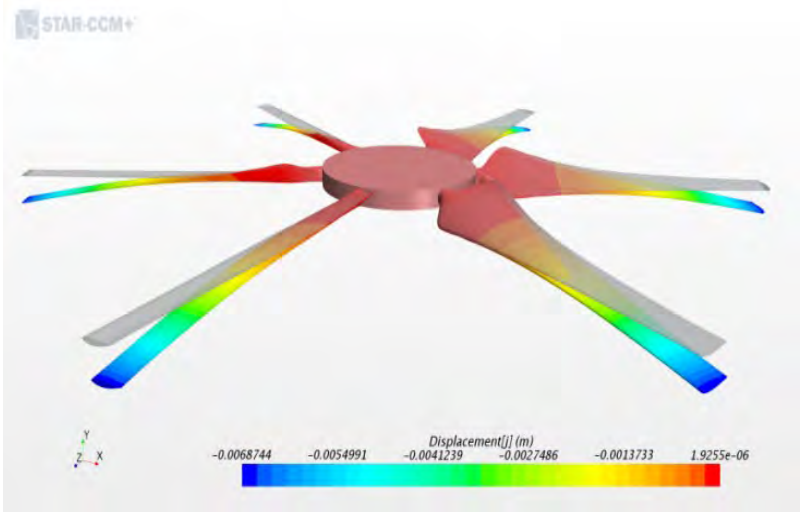
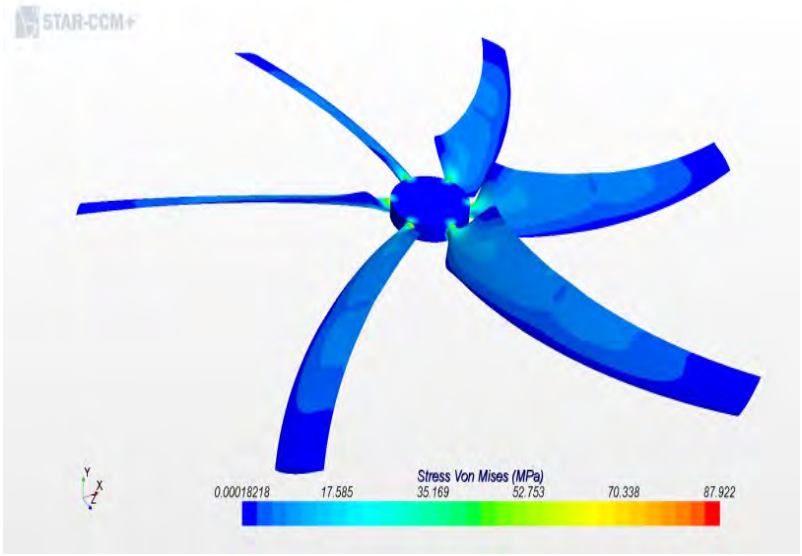
# Structural R&D

- Hudson worked with material vendors to carry out composite FEA
- Utilizing FEA, fiberglass lay-up options will be obtained which will be able to withstand aerodynamic loads obtained from CFD
- Full size prototypes manufactured using such lay-ups
- Fatigue & buckle testing  carried out to validate FEA
- Based on these results, the optimum lay-up will be finalized

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# Structural R&D

Various fiberglass/carbon fiber options and resin options are considered and tested for buckle and fatigue strength.

Buckle tests for static strength

Endurance tests for dynamic strength

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# Thank you

Questions?

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