5% CHEETA UAV

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Mentor: Sam Hince
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Aerospace Engineering

Overview

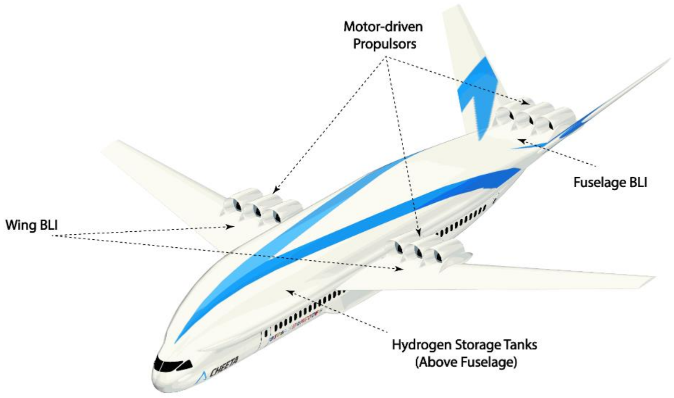
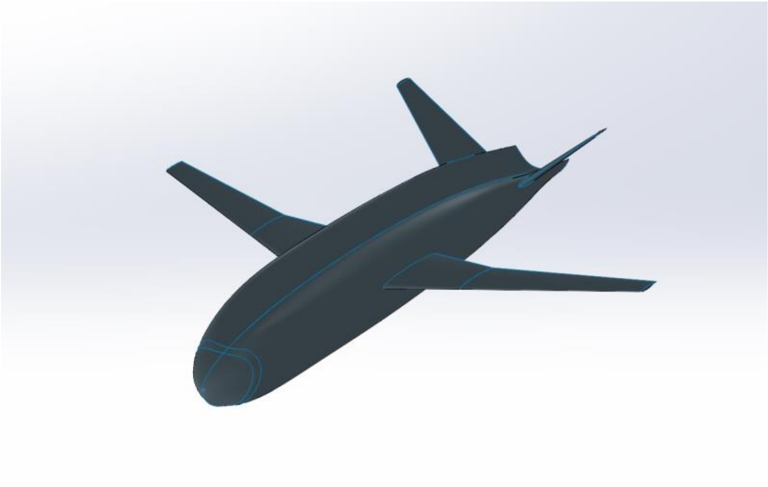
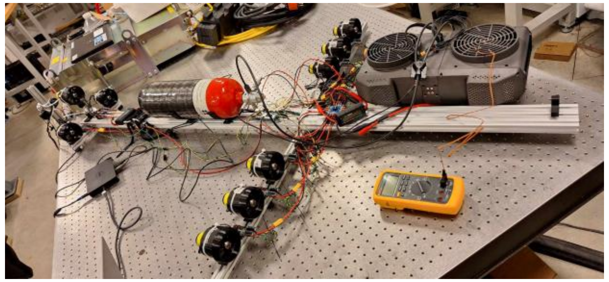


Fig. 1 Isometric view of the CHEETA aircraft concept

CHEETA concept



Reduce geometry to 5% scale



Design an aircraft and evaluate

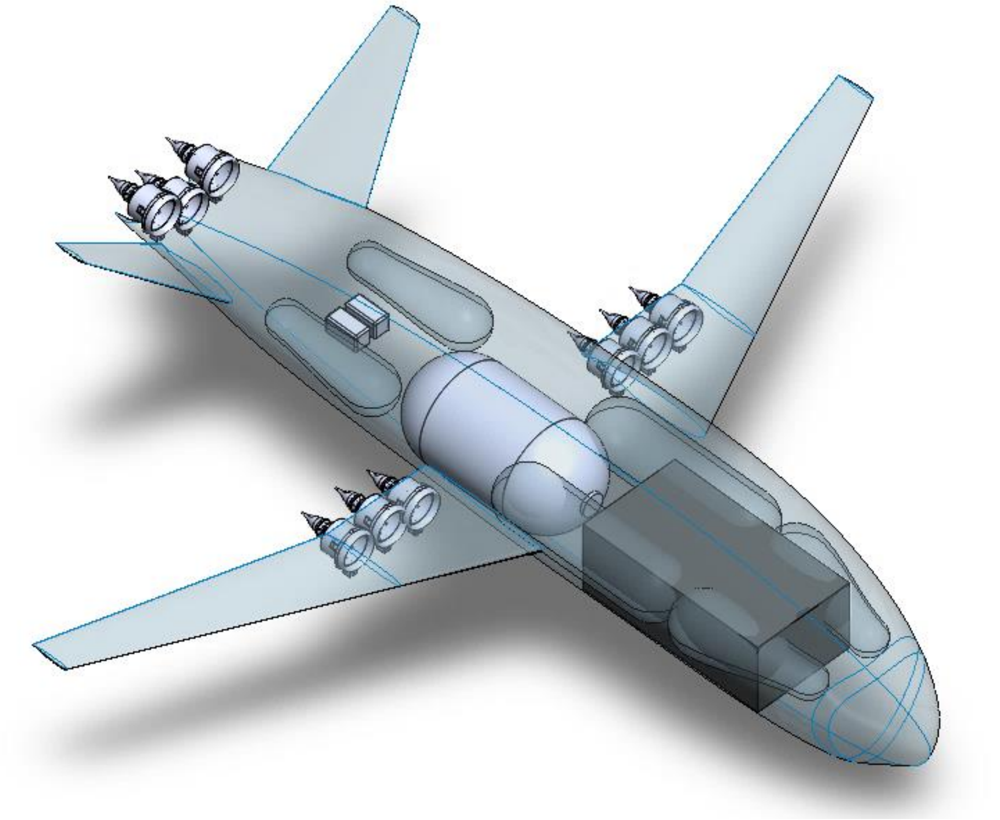
- Full flight duration ground test
- Wind tunnel tests

White, A. S., Waddington, E., Merret, J. M., Greitzer, E. M., Ansell, P. J., and Hall, D. K., "Trade-Space Assessment of Liquid Hydrogen Propulsion Systems for Electrified Aircraft," *AIAA Aviation Forum*, June 2023, AIAA 2023-4345. DOI: 10.2514/6.2023-4345.

Objective: Sub Scale

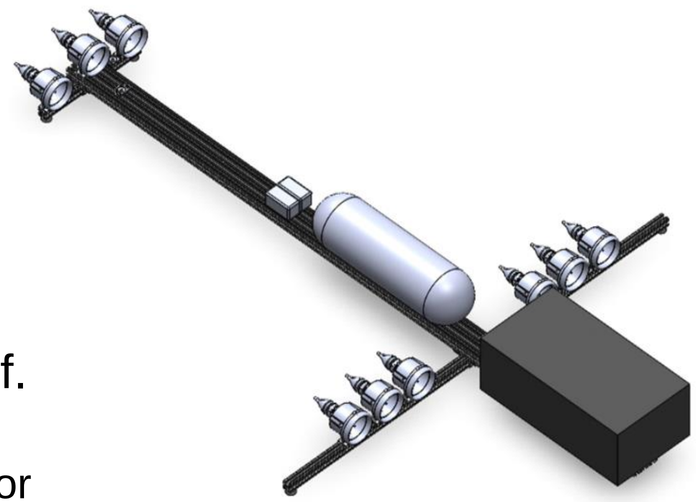
Experimentally verify efficiency of planform, aero-propulsive system

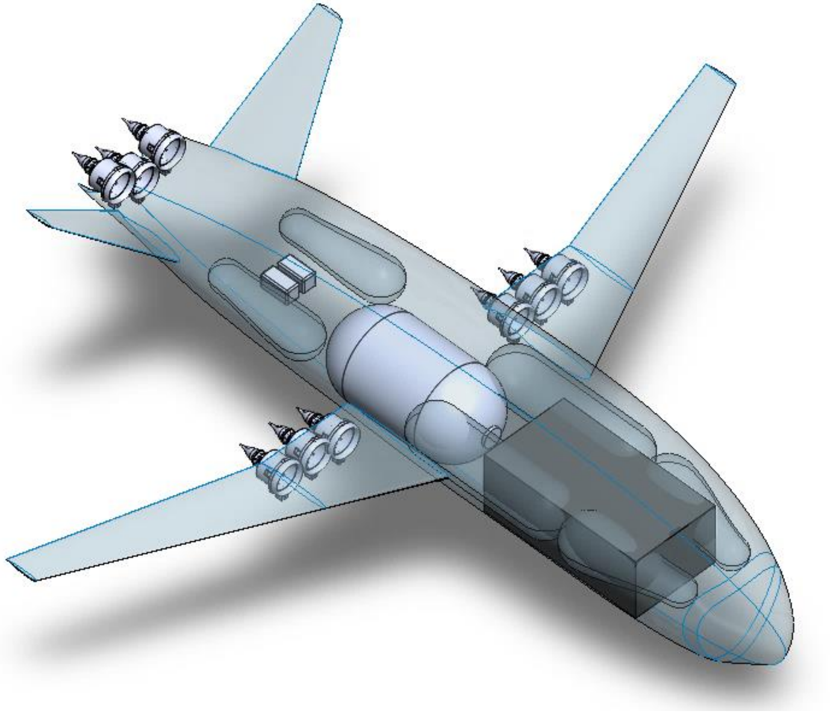
- 5%-scale (6.7 ft span) flight test article to be developed
  - Low-speed aero-optimized planform
  - Balsa/composite construction
  - Integrated GH_2 tank and fuel cell
- Power system
  - Fuel cell: 2.4 kW continuous power
  - Hybrid configuration: 5 kW peak power
- 9x Schubeler DS-30-AXI HDS EDFs
  - 69 mm fan diameter
  - 1.3 kW max power (4.5 lb_f thrust)



Iron Bird

- Complete integrated powertrain test
- Understanding of GH2 power system
- Integration exercise

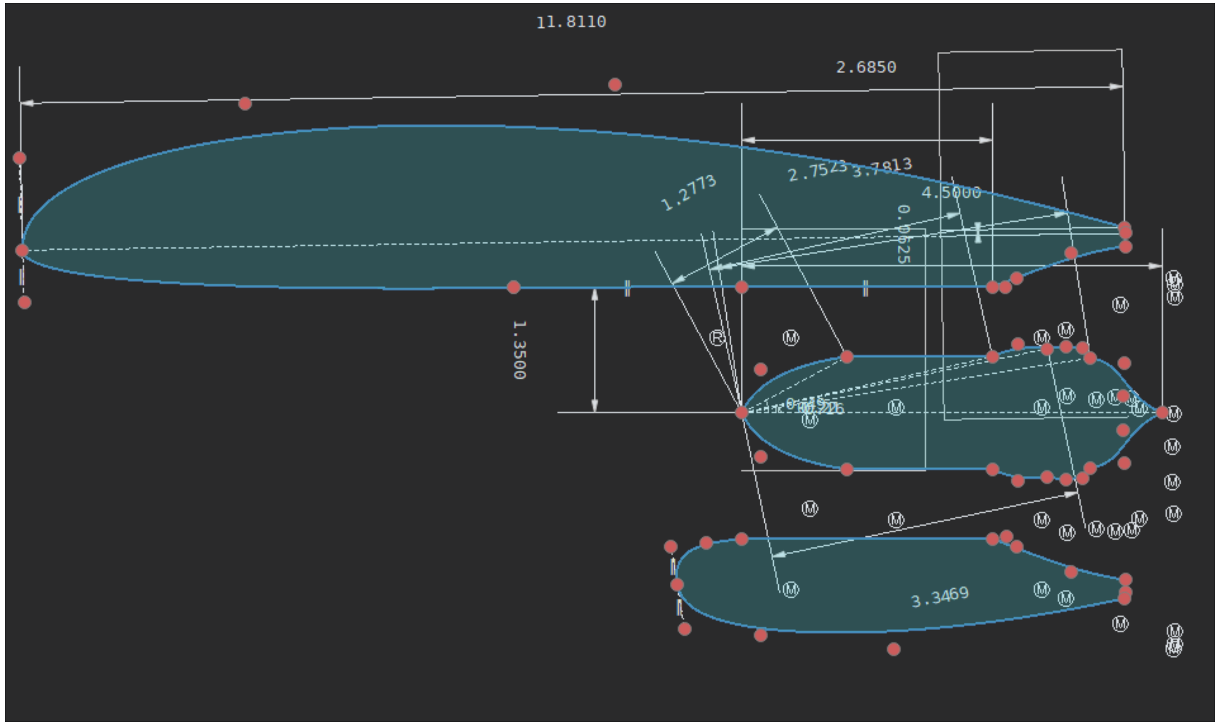




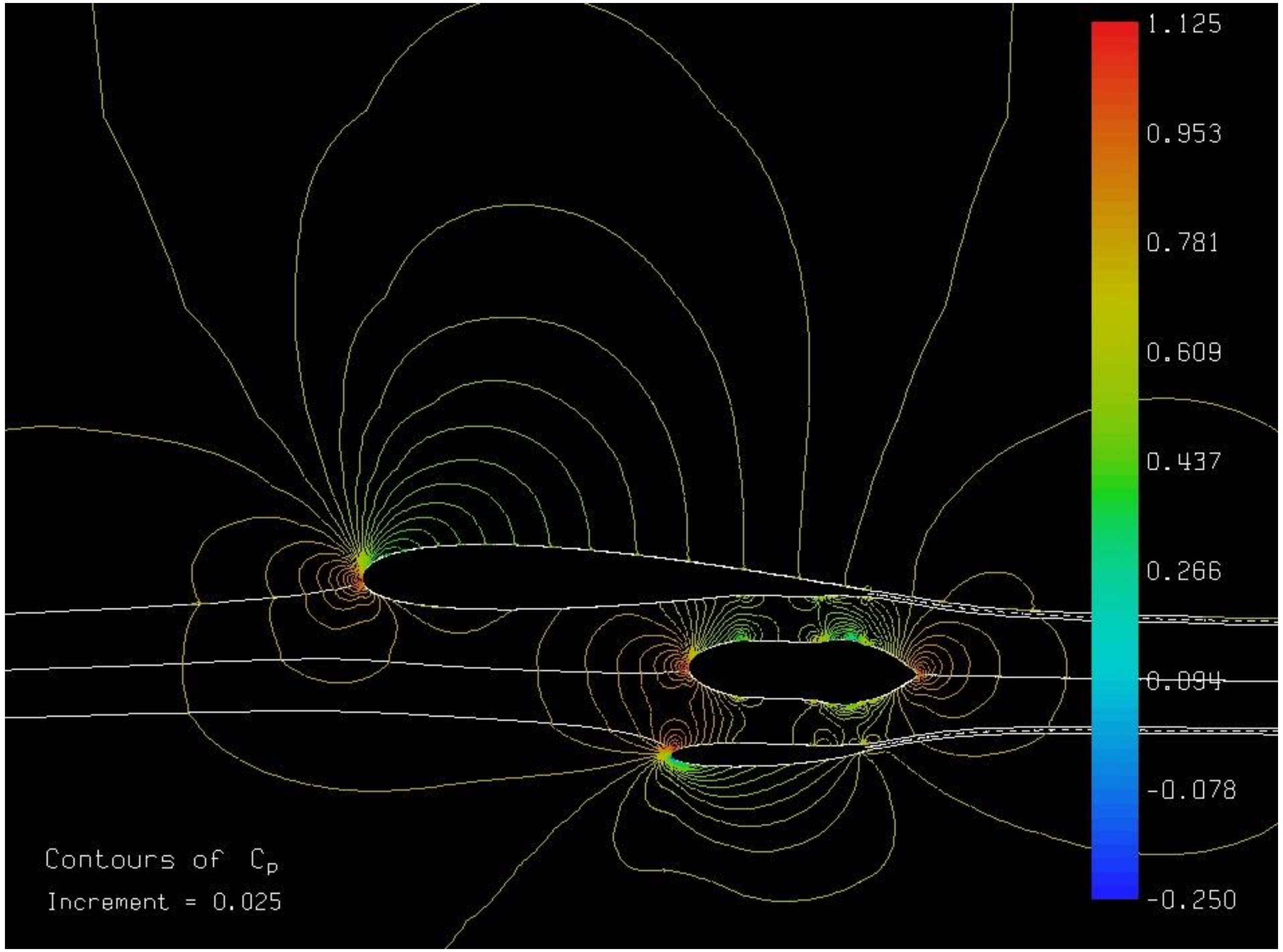
Requirements for the powertrain system:

1. Total continuous thrust of at least 10 lbf.
2. Fault tolerant
    - Maintain cruise thrust with one propulsor bank inoperative.
3. Total mass of less than 30 lbm.
    - 55 lbm (14 CFR Part 107).

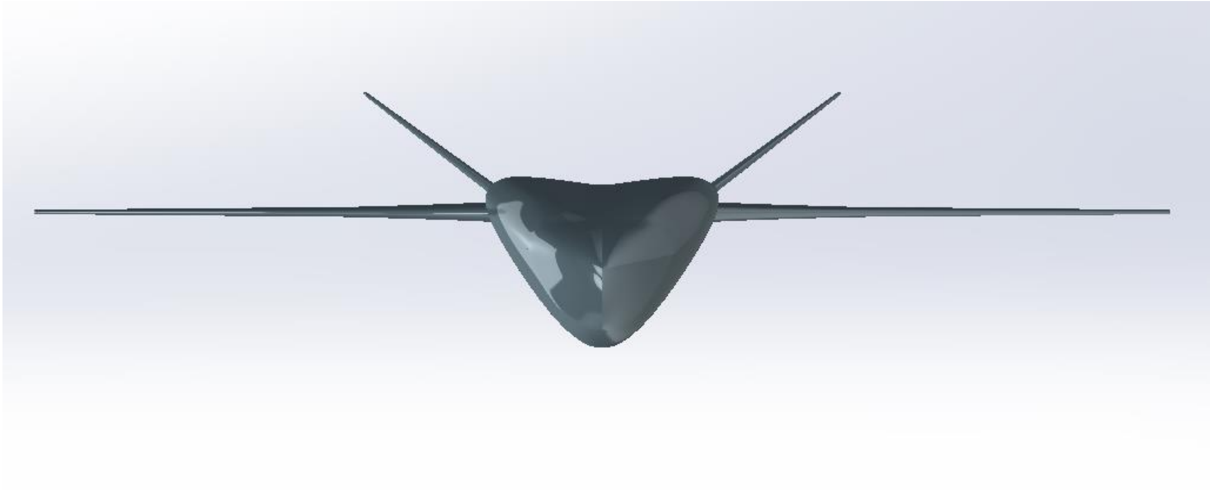
Aero optimization



PyMEAD

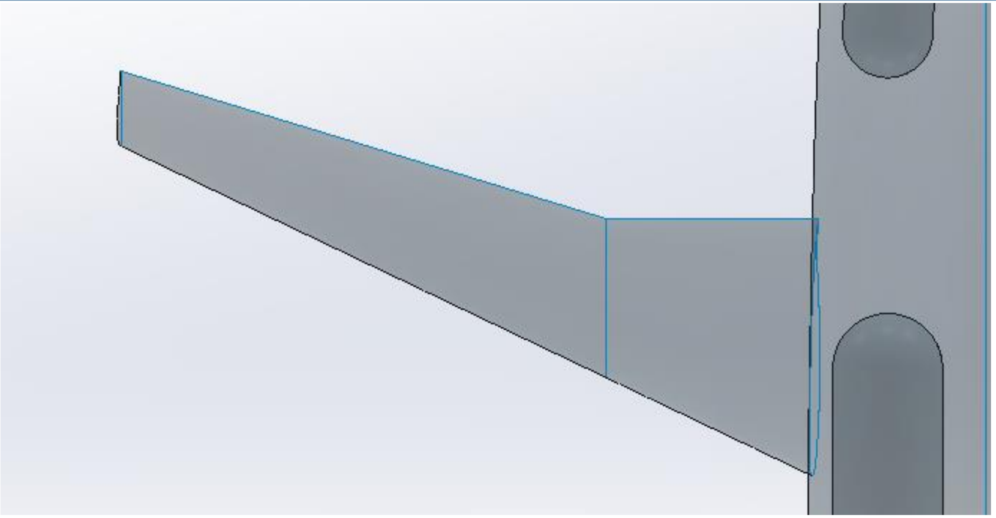


Design Challenges



- Large fuselage frontal area
- High wings w/ thin airfoil
- 40 lbs. flight weight

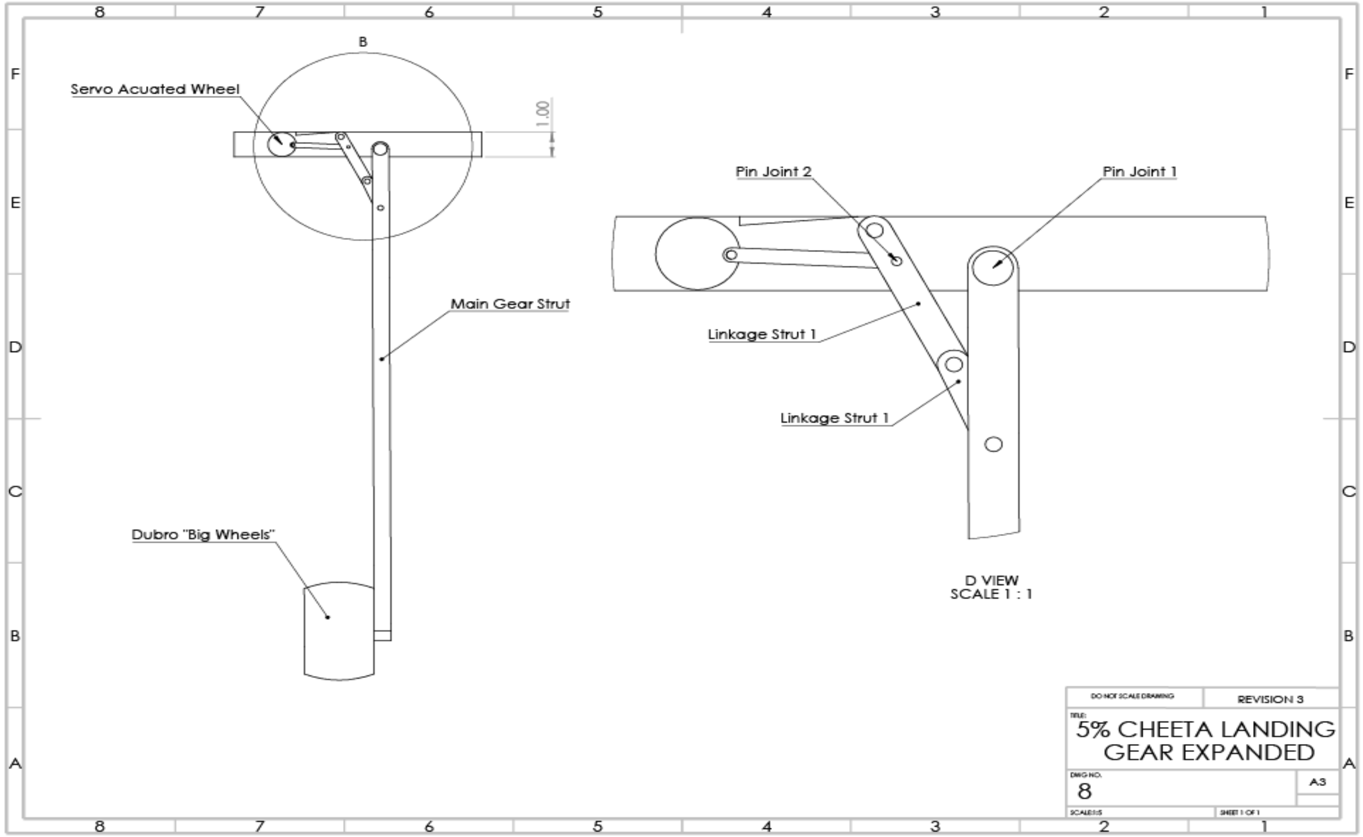
→ Need compact landing gear with long impact resistant struts



- Swept wing with kink
- Thin section supporting ~20 lbs.
- Non-constant airfoil and twist

→ Need well-informed material and structure choices

Mechanical Design



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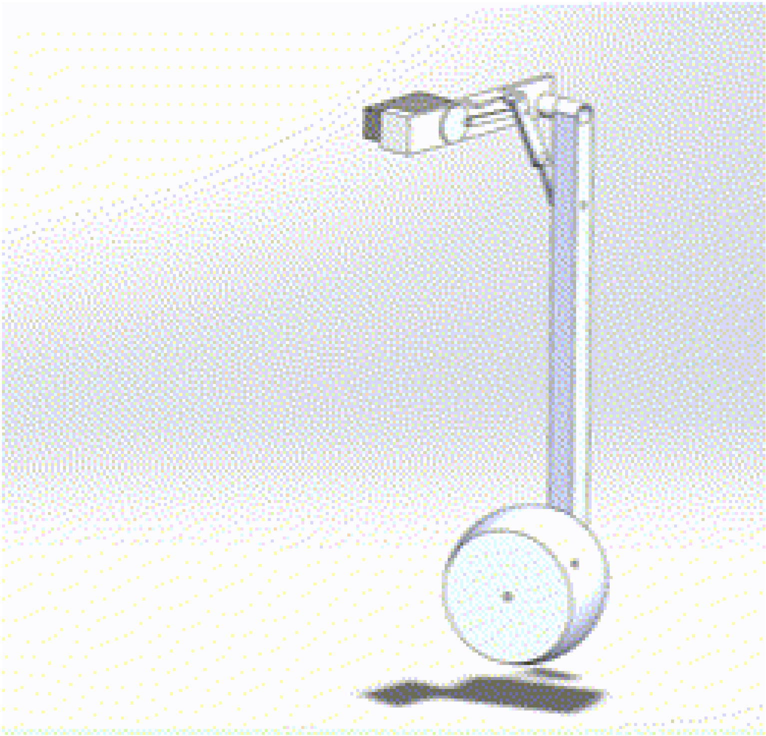
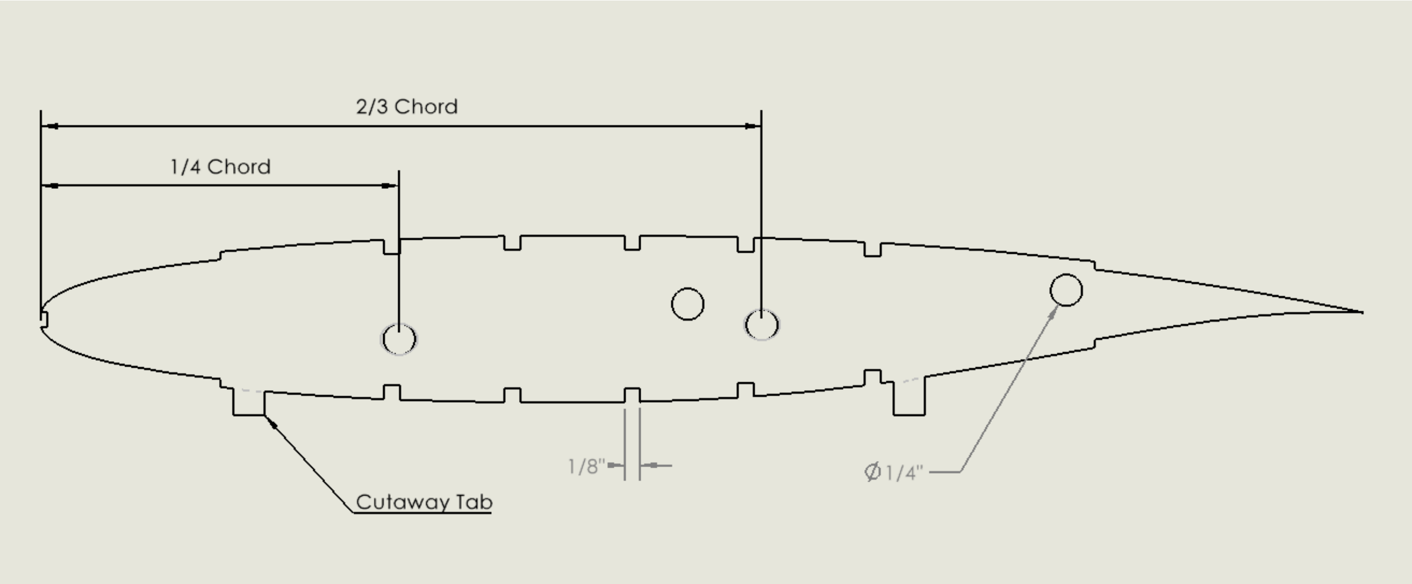
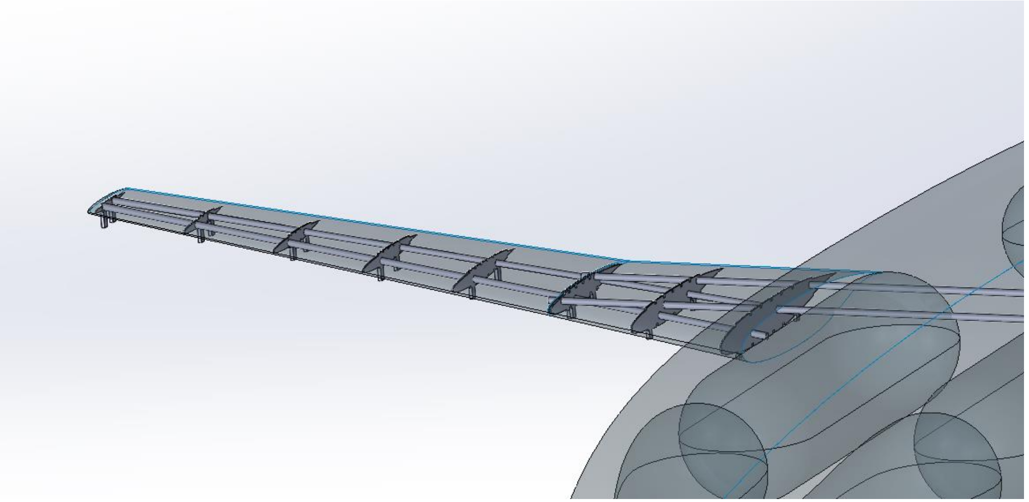
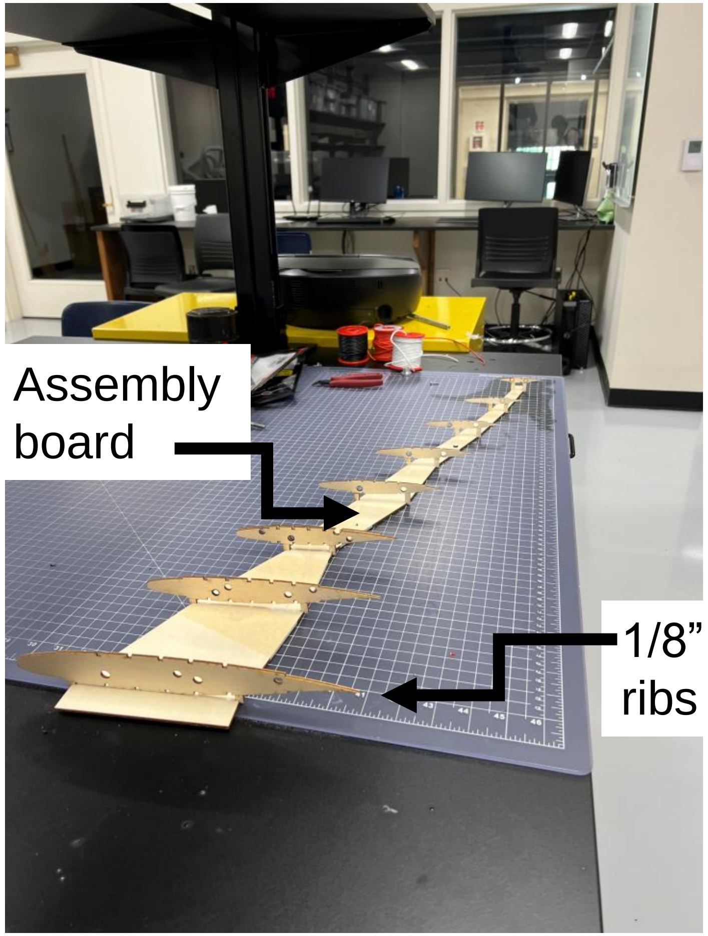


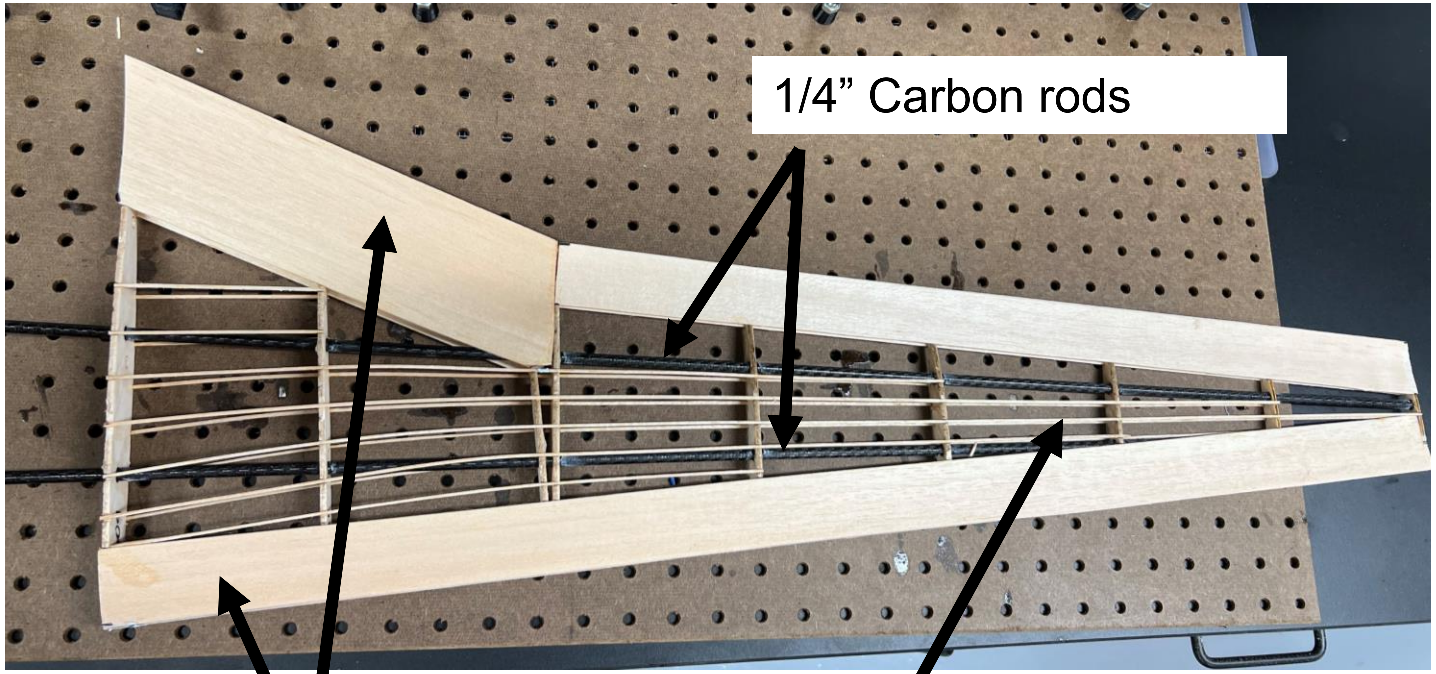
Structural Design



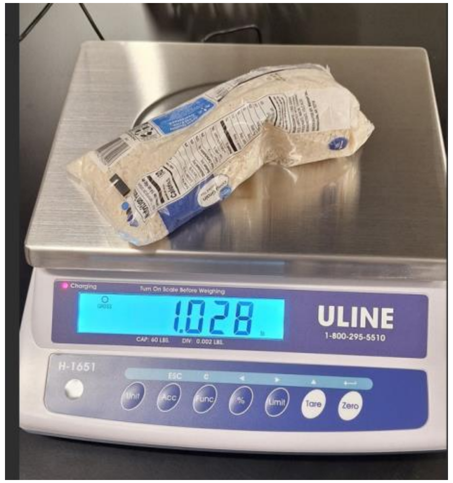


Materials


Assembly board
1/8” Lite Ply ribs


1/4” Carbon rods
1/8” Balsa
1/16” Balsa stringers

Wing Strength Testing



Wing Strength Testing cont.

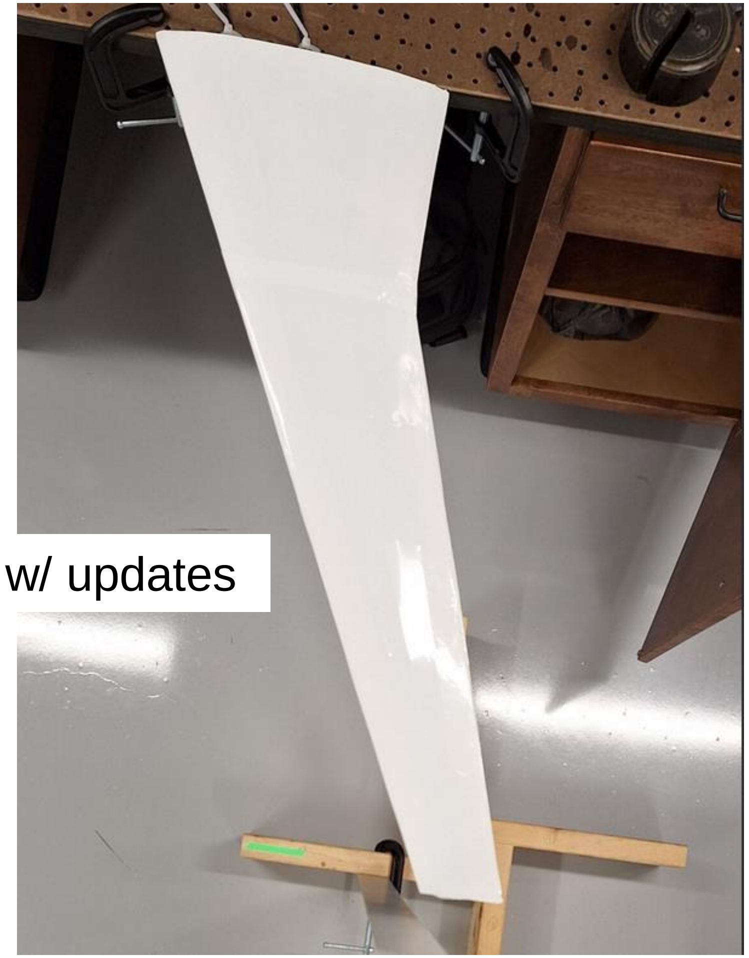
Wing Strength Testing cont.

Results of First Test Wing

- 23 lbs. distributed elliptically causes failure
- Abrupt failure condition at root
- 1% twist maintained until failure

- ~40% wing tip deflection before failure

- Updates on material choices
  - 1/8” Lite Ply for ribs
  - 1/8” Balsa for stringers



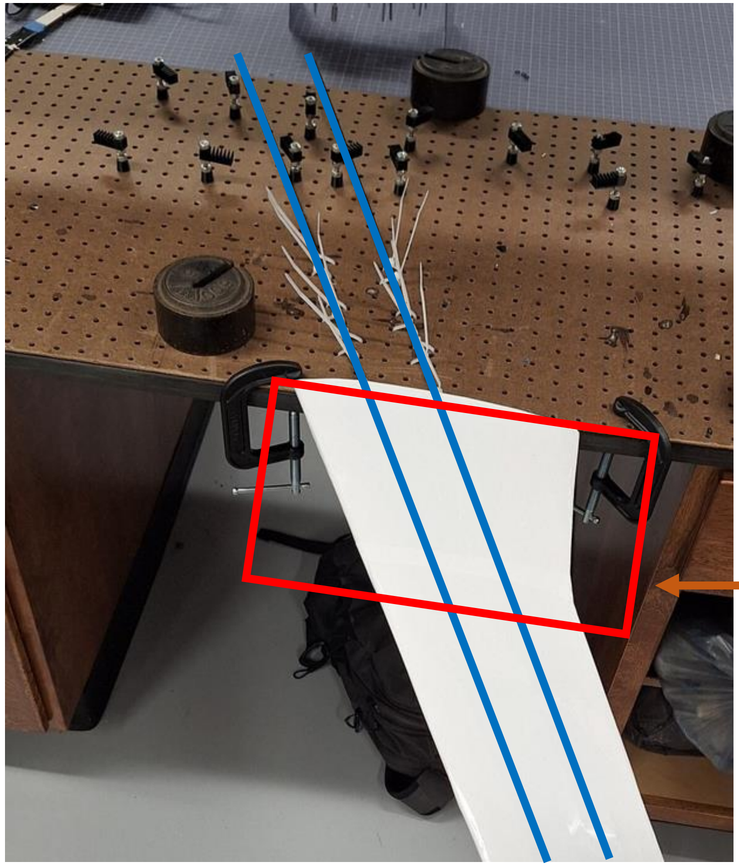
New wing w/ updates

Results of Second Test Wing

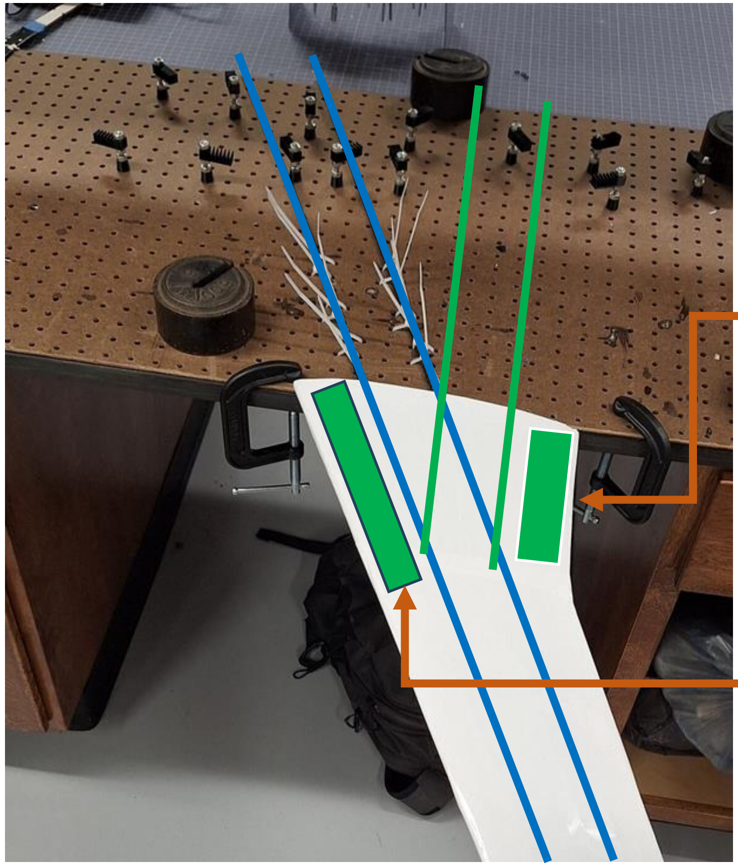
- From 23 lbs. to upward of 26 lbs. at failure
- Failure occurred within carbon spars
- ~7% improvement in deflection at flight load
- ~3% improvement in deflection at failure

- Still not achieving 30% tip deflection at maximum

Deflection Mitigation



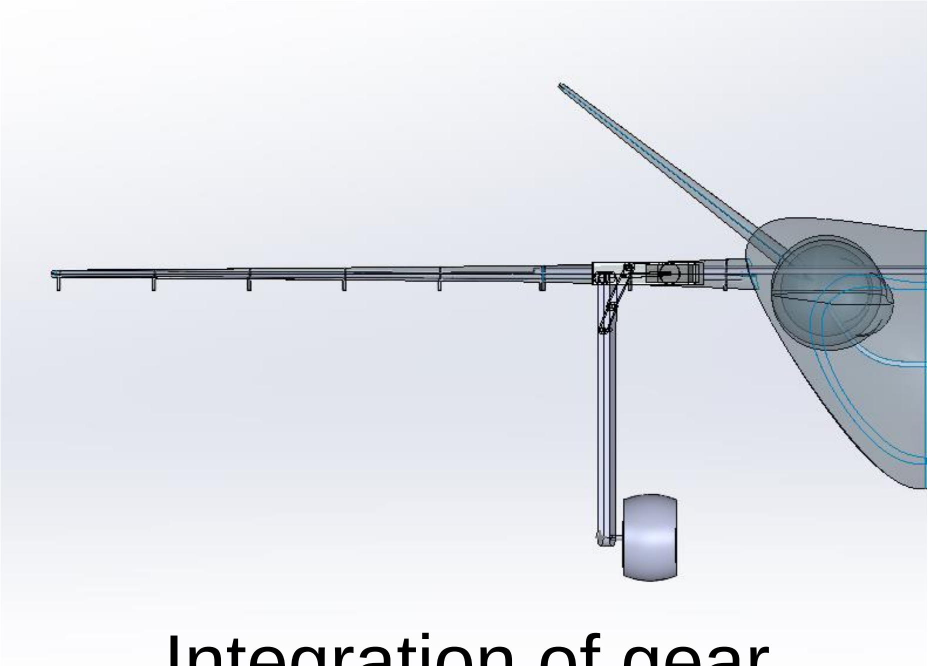
Location of maximum bending



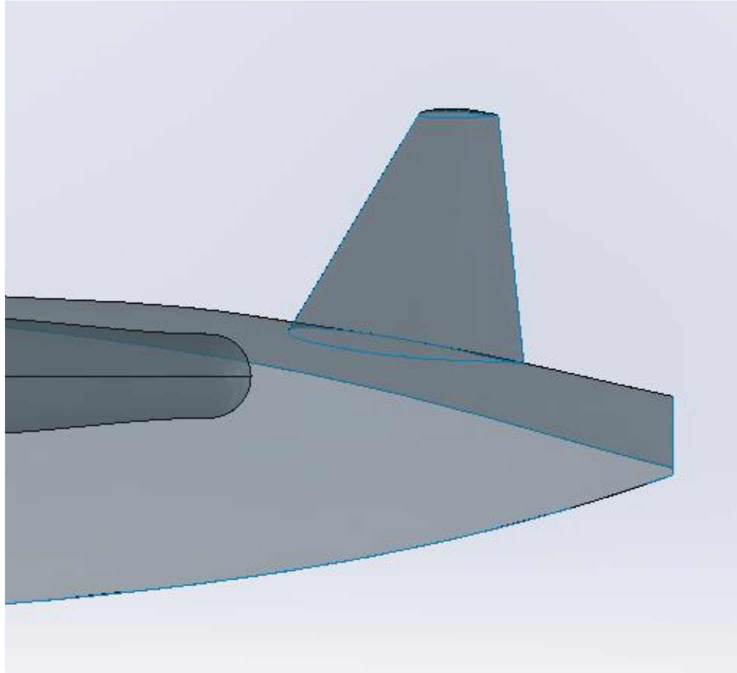
Propulsors

Landing gear

Future Work



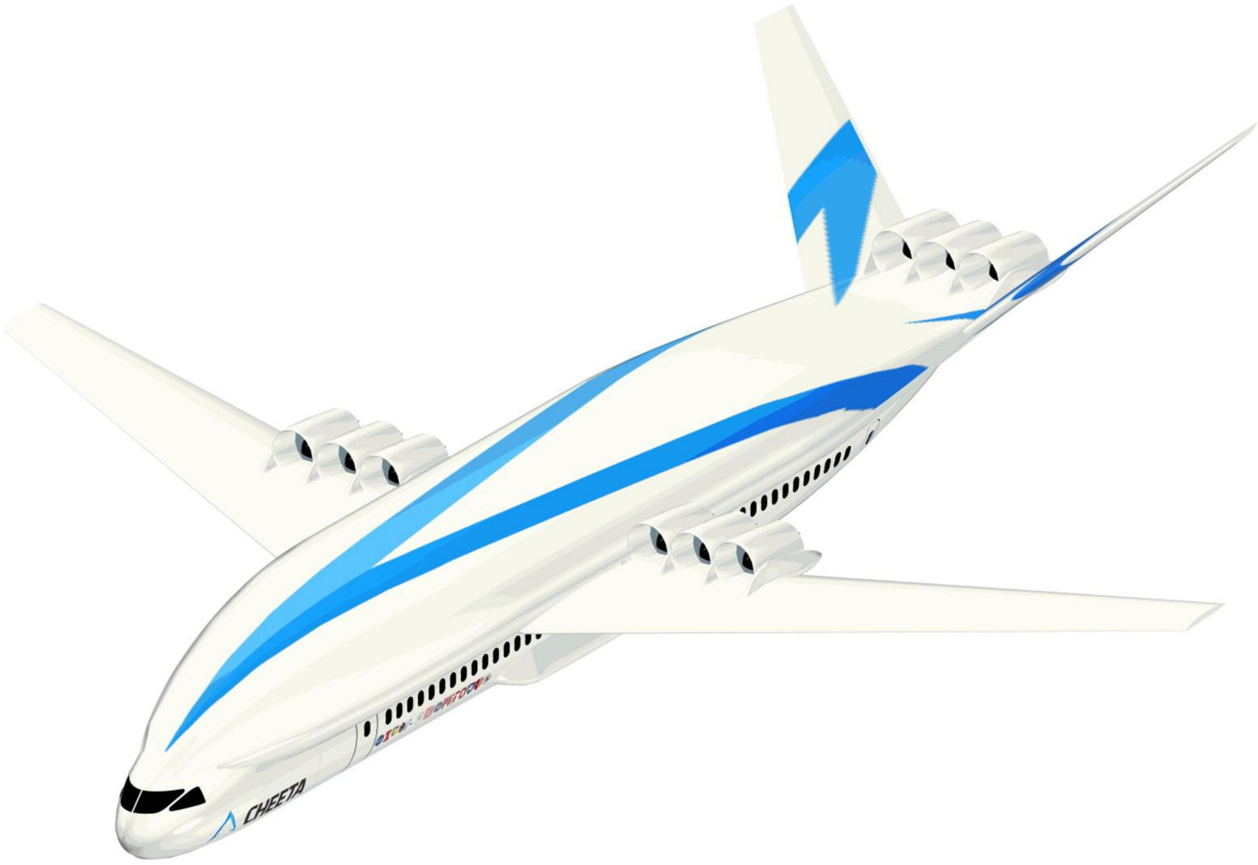
Integration of gear and propulsors



Empennage trade study

Objective: Full Scale

The mission of our team is to **develop**, **mature**, and design **disruptive technologies** for **electric aviation**. Research themes include **distributed electric propulsion**, **electrical components**, **energy storage**, and **systems integration**.



Acknowledgements

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CHEETA

Center for High-Efficiency Electrical Technologies for Aircraft