GALLOGLY COLLEGE OF ENGINEERING
SCHOOL OF AEROSPACE AND MECHANICAL ENGINEERING
The UNIVERSITY of OKLAHOMA

BOEING

Sustainable Regional Aircraft Family for Net-Zero Emissions by 2050

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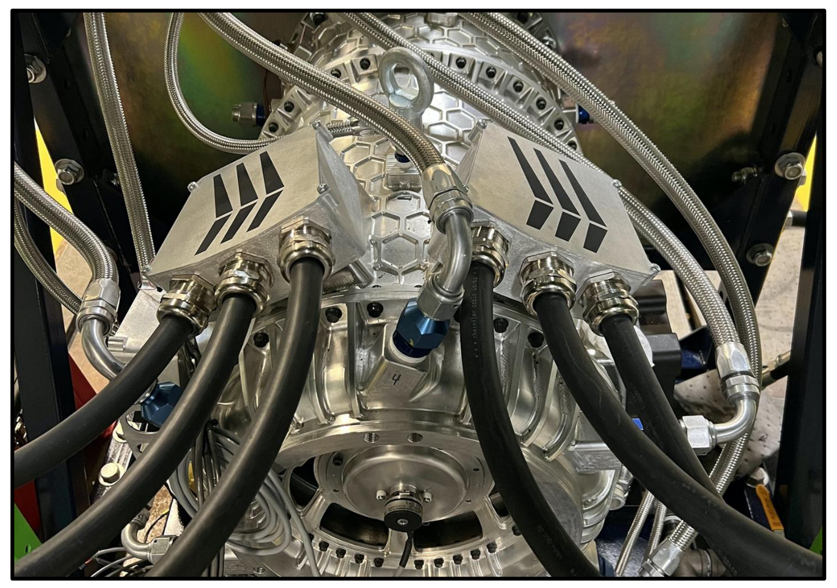
Introduction

Our team created a conceptual design of a net-zero emission family of aircraft to be put into service by 2050. We were tasked with designing a 50 and 75 seat regional aircraft to be used in short to medium distance journeys. We modeled our aircraft after similar aircraft currently used in the industry such as the ATR-42 and Q-700. To achieve net-zero emissions the decision was made for the aircraft to be propelled by two 2MW electrical motors powered by hydrogen fuel cells.



Constraints and Goals

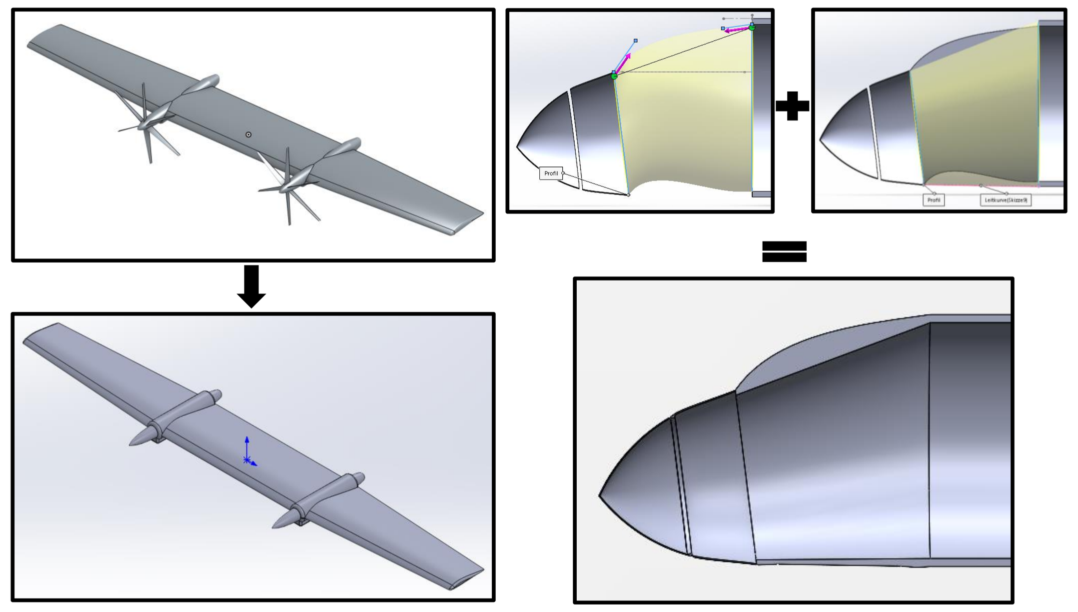
Boeing required our aircraft to adhere to the following requirements. We also had to adhere to ICAO Code B and C, as well as all parts of FAA 14 CFR Part 25.

Individual Requirements	50 Seat	75 Seat
Range:	≥ 650 nm	≥ 500 nm
Wingspan:	24 m	36 m
Take Off and Landing Field Lengths:	4000 ft	6000 ft
	General Requirements	
Seat Pitch: 30”	Flight Level: 180 ≤ 100 nm	Seat Width: 17.2”
Cruise Speed: ≥ 225 ktas	Approach Speed: 121 kcas	One-Engine Inoperable Climb
2 Pilots & 1 Crew Per 50 Seats	Pilot/Crew Weight: 190 lb	Passenger Weight: 190 lb
Min Baggage Weight: 35 lb/person	Max Baggage Weight: 50 lb/person	Baggage Volume: 5 cubic feet

Design Process

CAD Modeling

The CAD model was parameterized so that key dimensions could be chosen that adjusted the entire model. The wing was adjusted based on the desired wingspan and motor placement. The cockpit and fuselage were adjusted based on a combination of lofts.



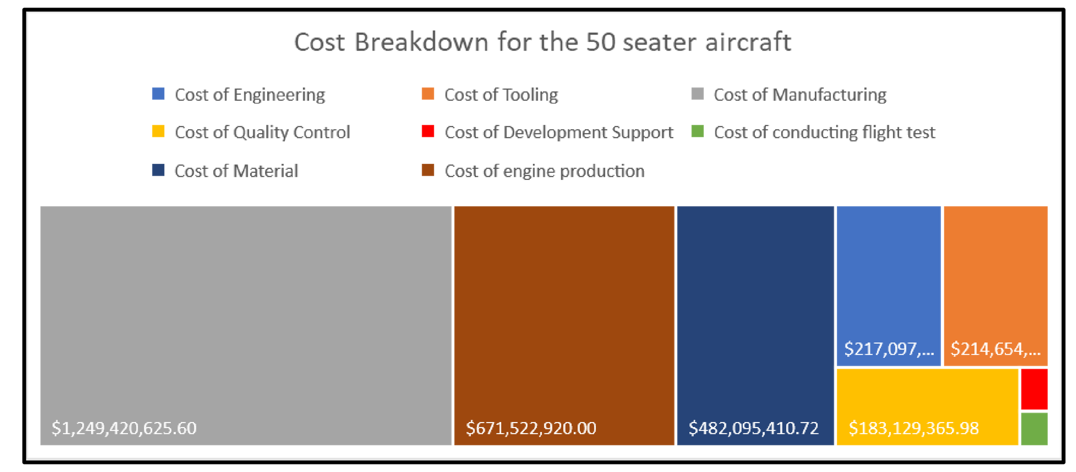
Propulsion and Power

The propulsion system was selected after considering the advantages and disadvantages of each option and trying to achieve the goal of net-zero emission aircraft with the power supply as light as possible while fitting in the aircraft dimensions.

Options	Specific energy (Wh/kg)	Energy density (Wh/L)	Total mass (kg)	Volume (m^3)
SABERS batteries	500	500	41597.11	28.87
Ammonia	6222.27	3194.47	8644.17	16.14
GTL Hydrogen tanks	33333.60	1842.09	2747	29.86

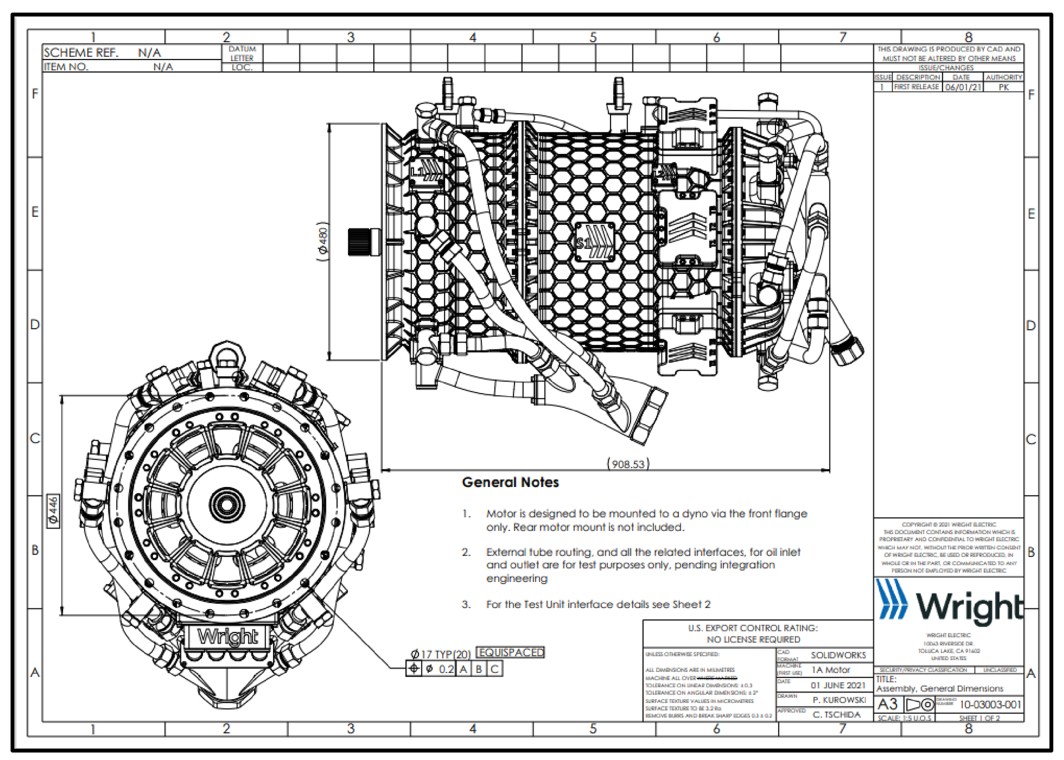
Cost

The costing was completed using the DAPCA-IV model for both the 50 and 75 seat aircraft designs. Cost was calculated based on 300 units sold, 5 years after production begins. Total cost per aircraft was $12.9 million for the 50 seat and $15.6 million for the 75 seat, with a 15% profit margin for both models. Our break-even point was calculated to be 4.34 years after sales start, or 9.34 years from project start.



Design Results

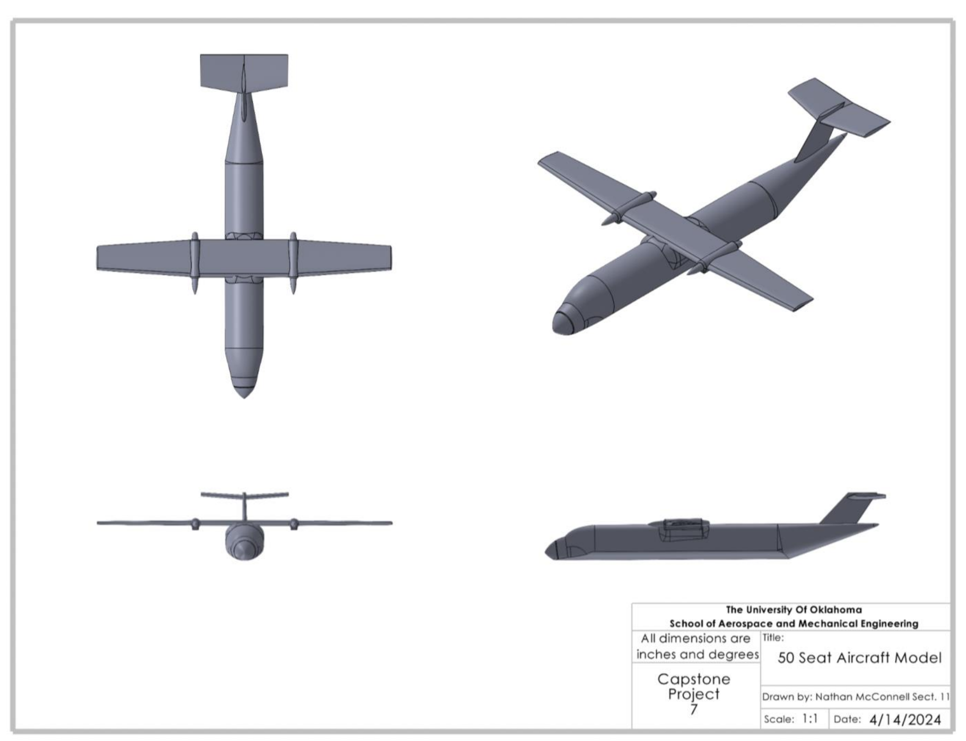
Wright Motor

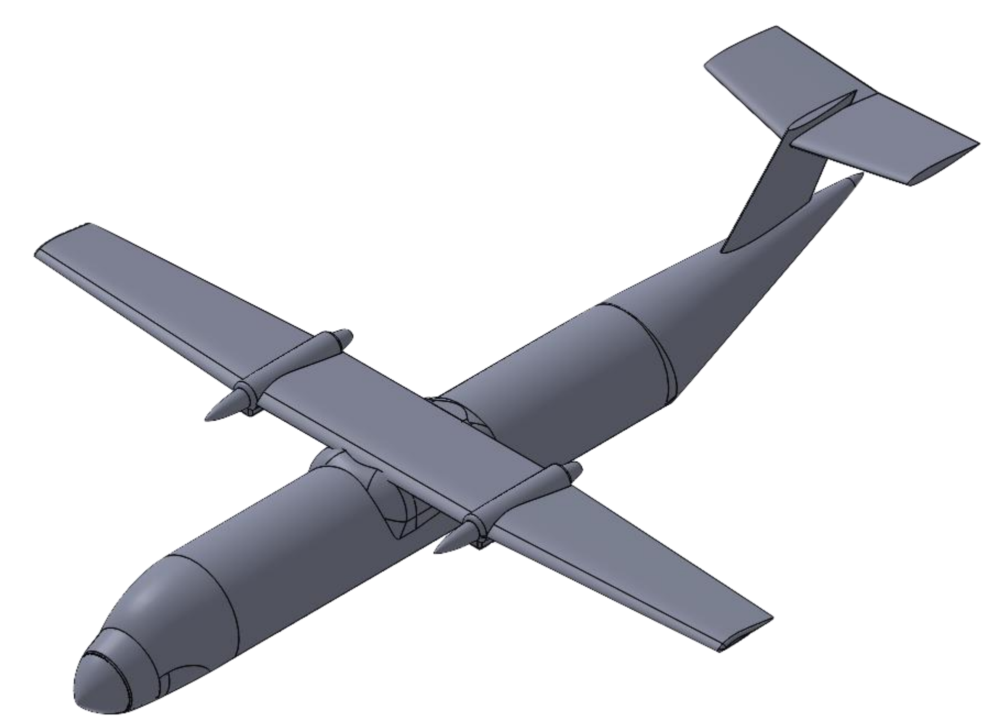


Hydrogen Fuel Cell

A hydrogen fuel cell with equivalent volume to 11 of these GTL hydrogen tanks would supply sufficient energy to power our aircrafts motors for a traditional regional flight between 250 and 500 nautical miles. Batteries, such as the NASA SABERS concept were also considered as a power supply, but our calculations determined they had an energy density far too low to keep their total weight at a reasonable level. Ammonia was also considered but we found it had similar issues.

Finalized CAD Model





Engineering Standards

- International Civil Aviation Organization
  - ICAO Code B and Code C
- Federal Aviation Administration
  - FAA 14 CFR Part 25
- American Society of Mechanical Engineering
  - ASME Y14.5 and Y14.100

Conclusion

To conclude the aircraft designed meet the requirements set out by our sponsor to achieve net zero emissions by 2050. The propulsion system was chosen after a comprehensive study of three different systems was completed. We believe that hydrogen fuel cells paired with an electric motor that meets our needs is the most practical and economically viable solution to achieve our goals. The CAD models showcase the final design of our aircraft, designed to meet the ICAO requirements for regional aircraft of our size with a wing length of 24 meters and 36 meters for the two aircraft, respectively. The fuselage diameter and length are similar to the standards of current market aircraft. Due to the nature of this project, it is important for our sponsor that our solution is economically viable. With a 15% profit margin, our cost estimates for these aircraft match current market prices for aircraft on the current market.