BALTO

Executive Summary

Graduate Design Team
Georgia Institute of Technology

39th Annual VFS Student Design Competition

eVTOL Air Taxi for Passengers with Reduced Mobility

Sponsored by Bell

Georgia Tech

BELL

Introduction

- In response to the Vertical Flight Society's 39th annual student design competition Request for Proposal (RFP), the Georgia Tech graduate design team presents Balto. Named for **the lead sled dog that carried the life-saving antitoxin to Nome in 1925, Balto** provides help to people when other means of transportation fall short.

Design Capabilities

- Balto is a **lift+cruise multirotor configuration**. It features a reconfigurable cabin that can either accommodate 2 passengers with reduced mobility (PRM) and their caregivers, or 4 passengers without wheelchairs. **Balto is specifically designed for the safety and comfort of people with disabilities, both visible and hidden**

Configuration Selection

Design Objectives

From the RFP and a survey of people with disabilities' needs, **10 cabin design objectives and 8 configuration design objectives** were defined

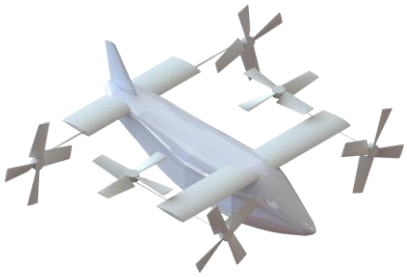
AHP Analysis

Design drivers weighted based on importance

Pugh Matrix

Twelve configurations were evaluated, with three selected for further analysis

Lift + Cruise Multirotor



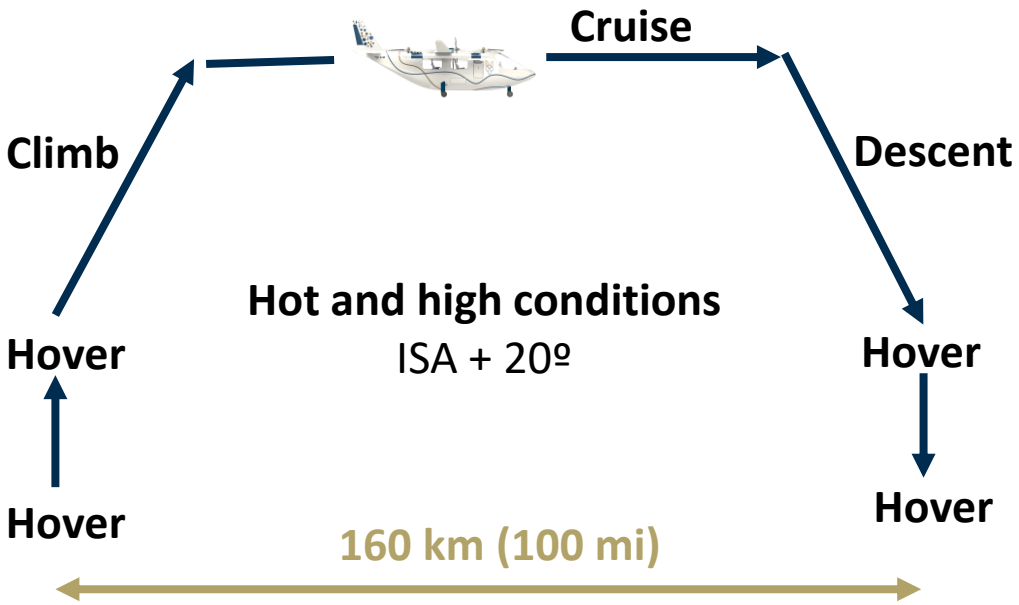
Tilt Rotor

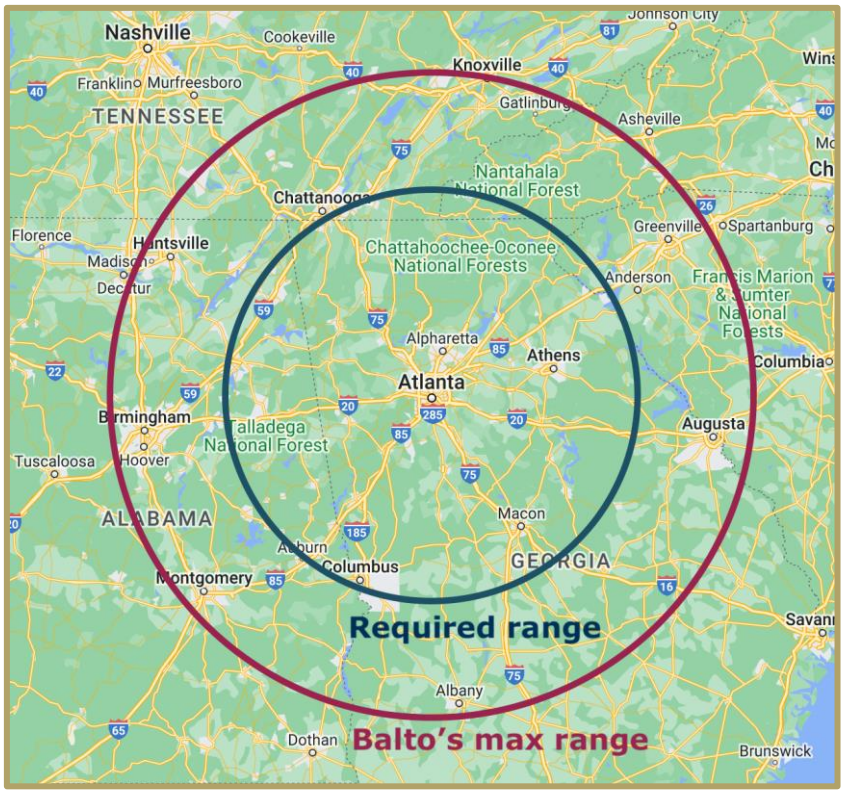
SMR Compound

The lift+cruise multirotor

- **Enhanced Safety**
- **Hover / Cruise Decoupling**
- **Zero-tilt flight "The Flying Platform"**

Mission Profile





Balto shall operate like an air taxi for passengers with reduced mobility.

Payload:

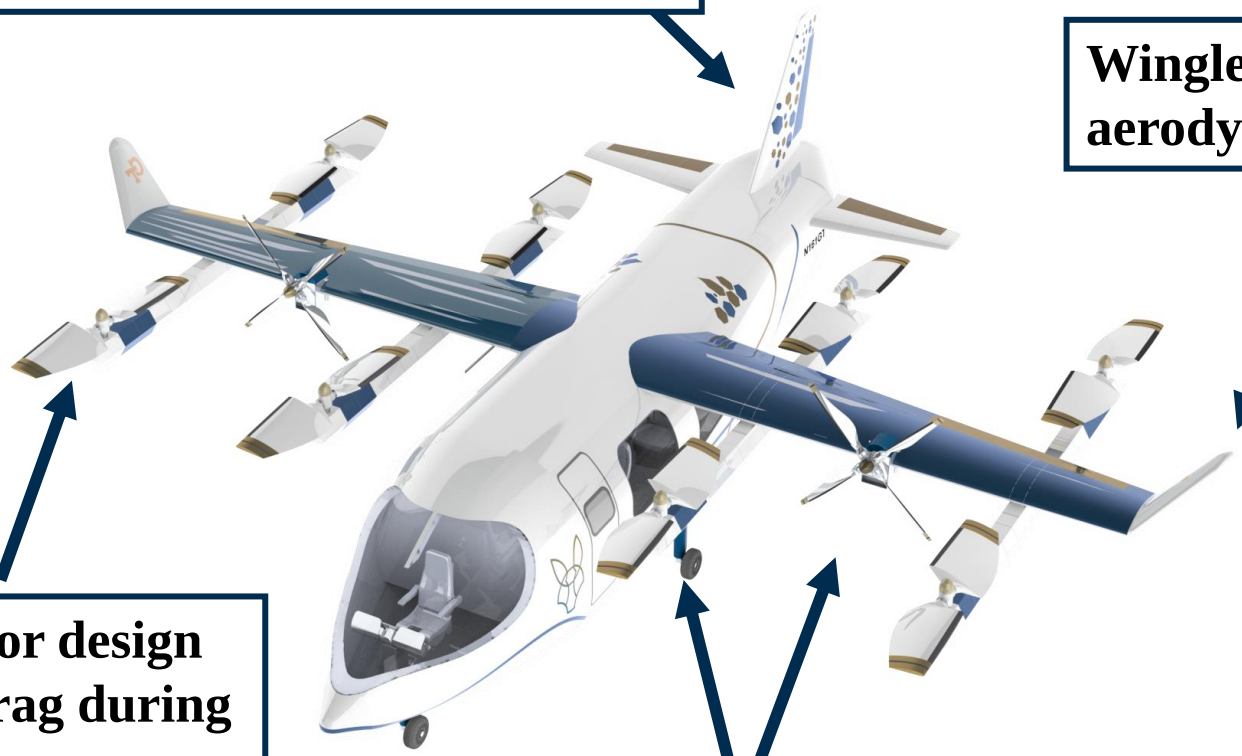
Four passengers with checked bag, carry-on, personal items, and medical equipment

Mission range	**160 km (100 mi)**
Balto's range	**252 km (156 mi)**
Balto's cruise speed	**105 knots**
Mission completion time	**49 min**

Balto's Key Features

Aerodynamically enhanced empennage focused on maximizing loading ramp area

Winglets for increased aerodynamic efficiency,



Optimized rotor design for minimal drag during cruise

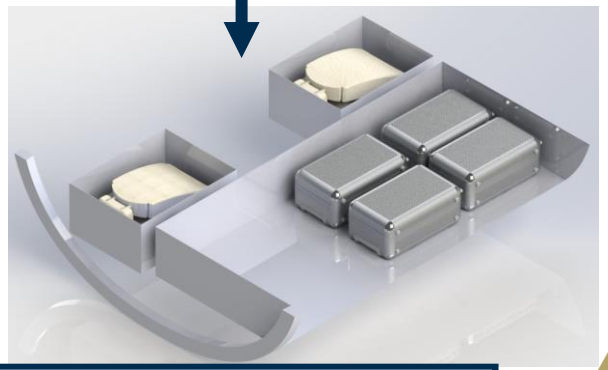
Extreme energy absorbing landing gear

Completely de-coupled lifting and cruise mechanisms for enhanced performance and safety

Featuring FIRST disability friendly cabin in the skies

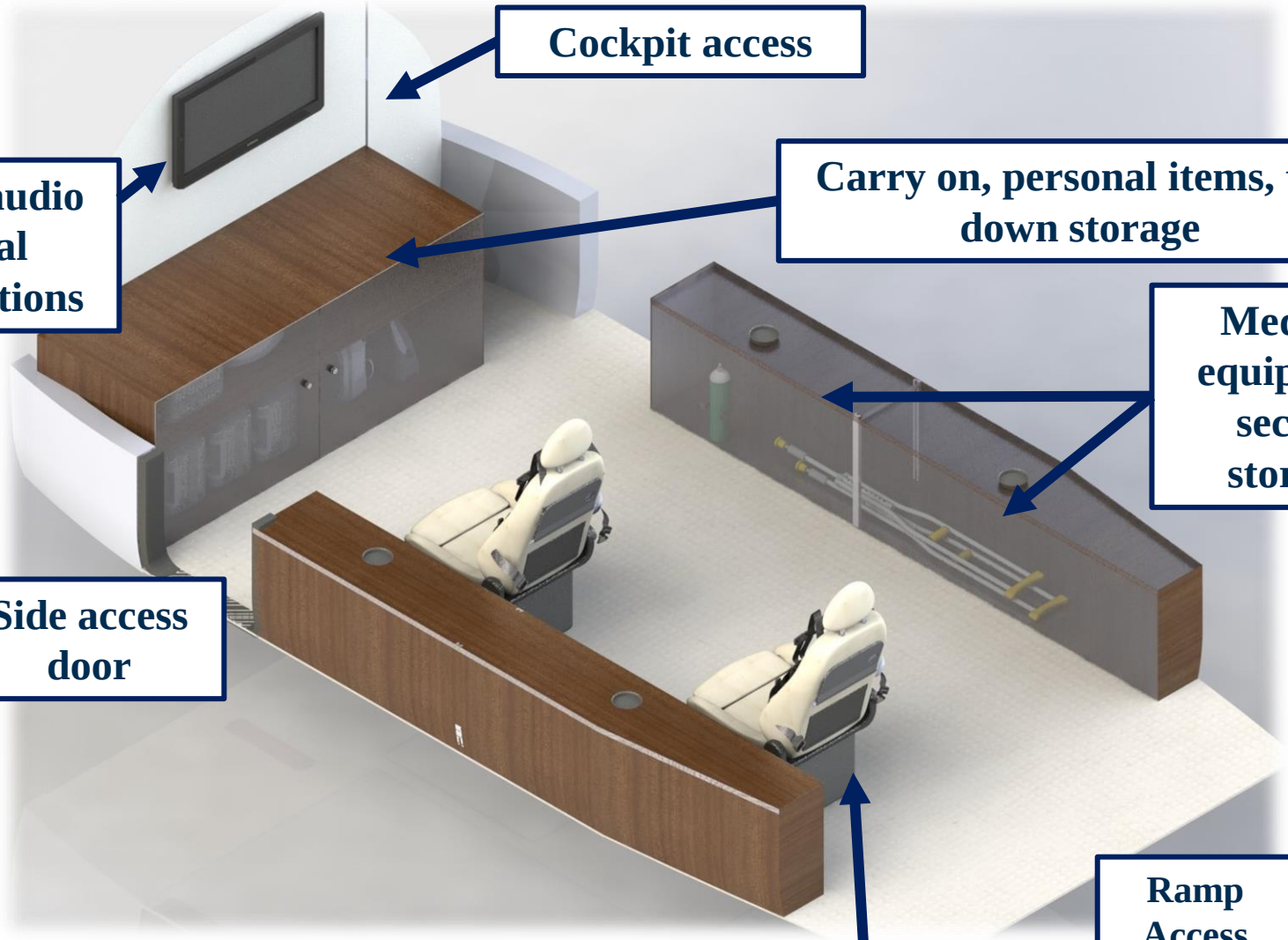
Full glass cockpit and wide windshield

All included - fully reconfigurable cabin to cater to the entire world: PRM friendly

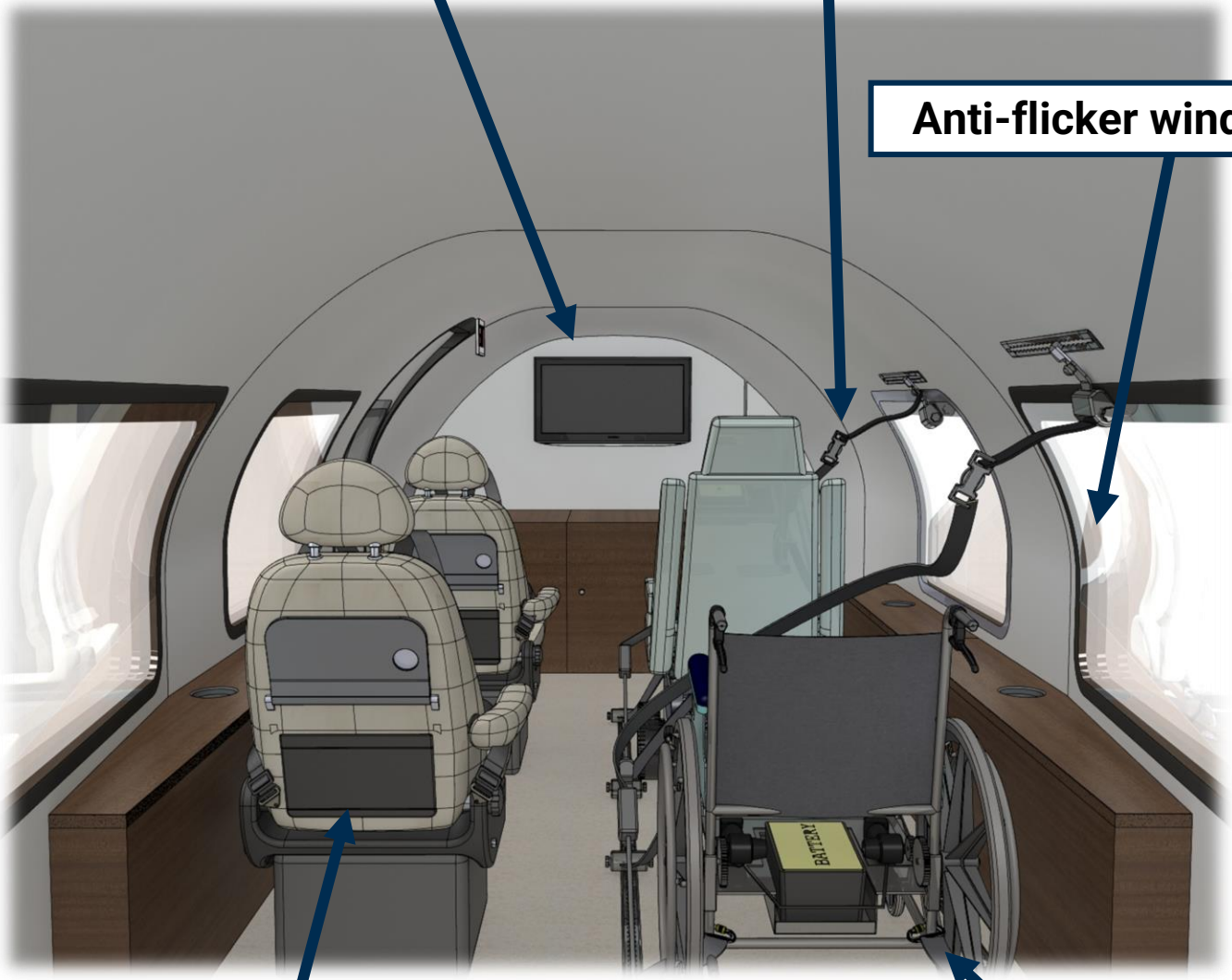


Large Storage for Checked Bags and More

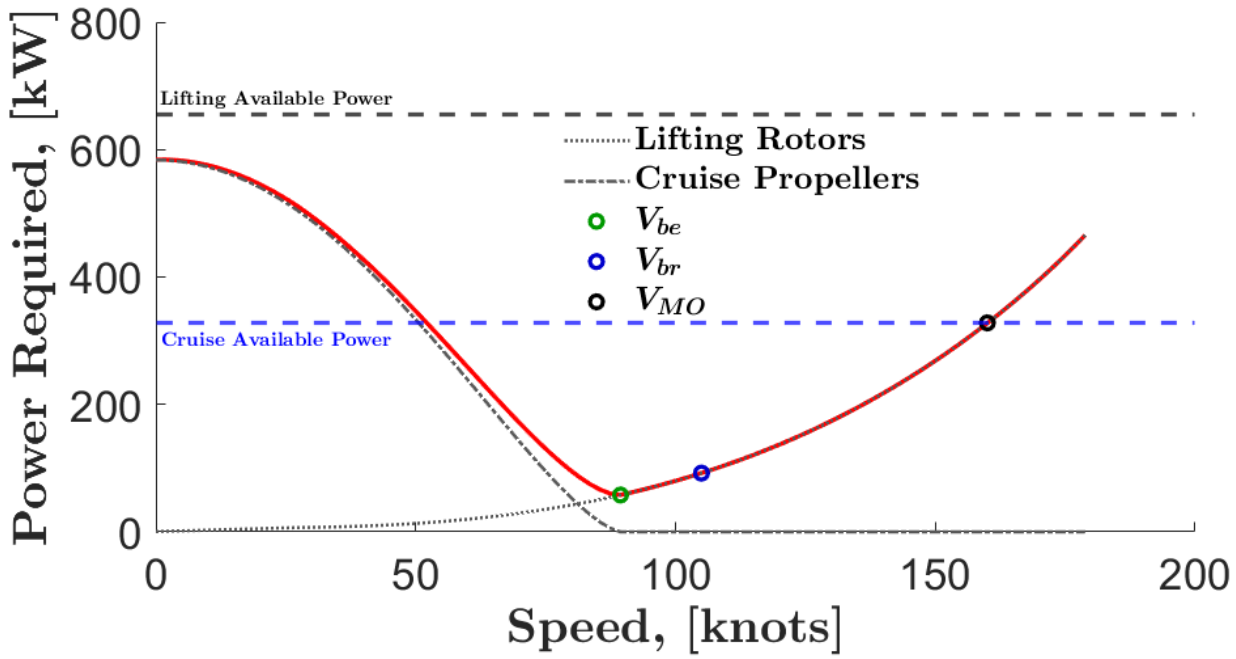
A cabin designed with your needs in mind

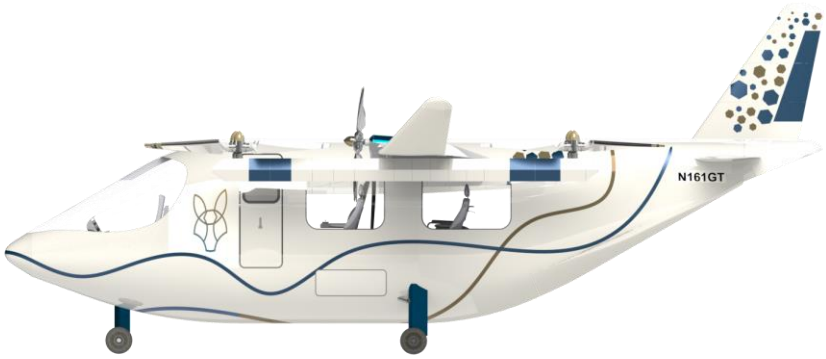


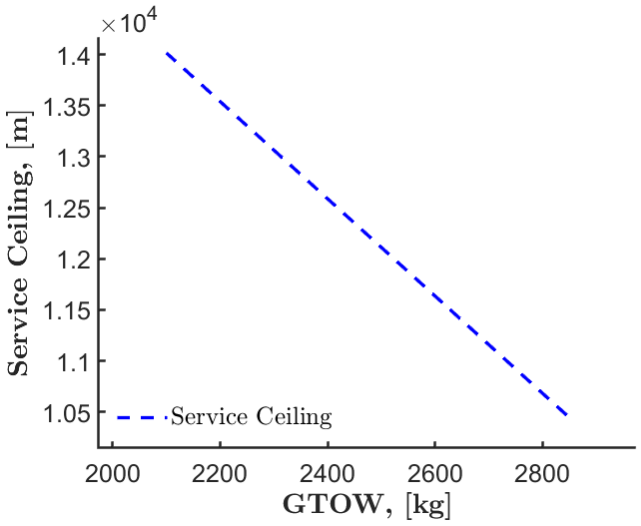
Special considerations for special needs



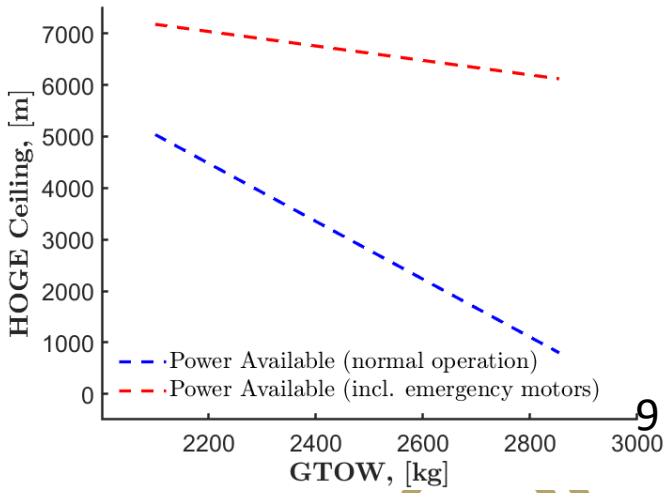
Performance Overview



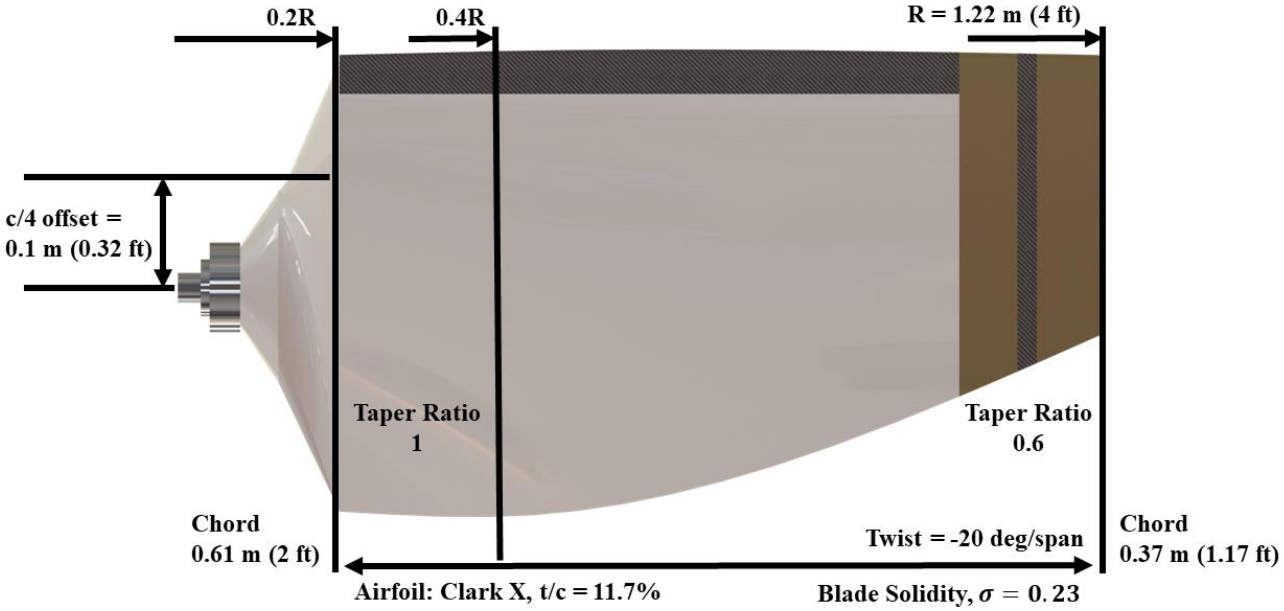




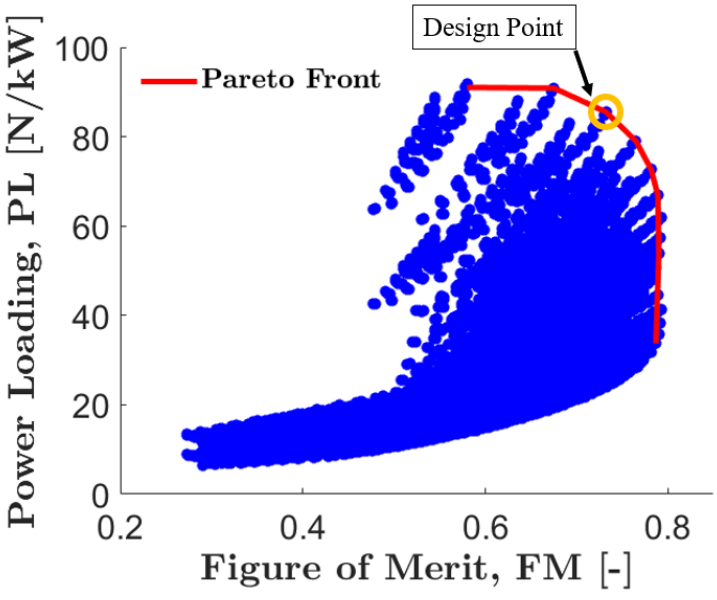
Metric	
Vbe	90 knots
Vbr	105 knots
VMO	160 knots
Max Service Ceiling (density altitude)	14,000 m (45,900 ft)
Max Takeoff Altitude (density altitude)	7,100 m (23,300 ft)



Efficient Hover Rotors

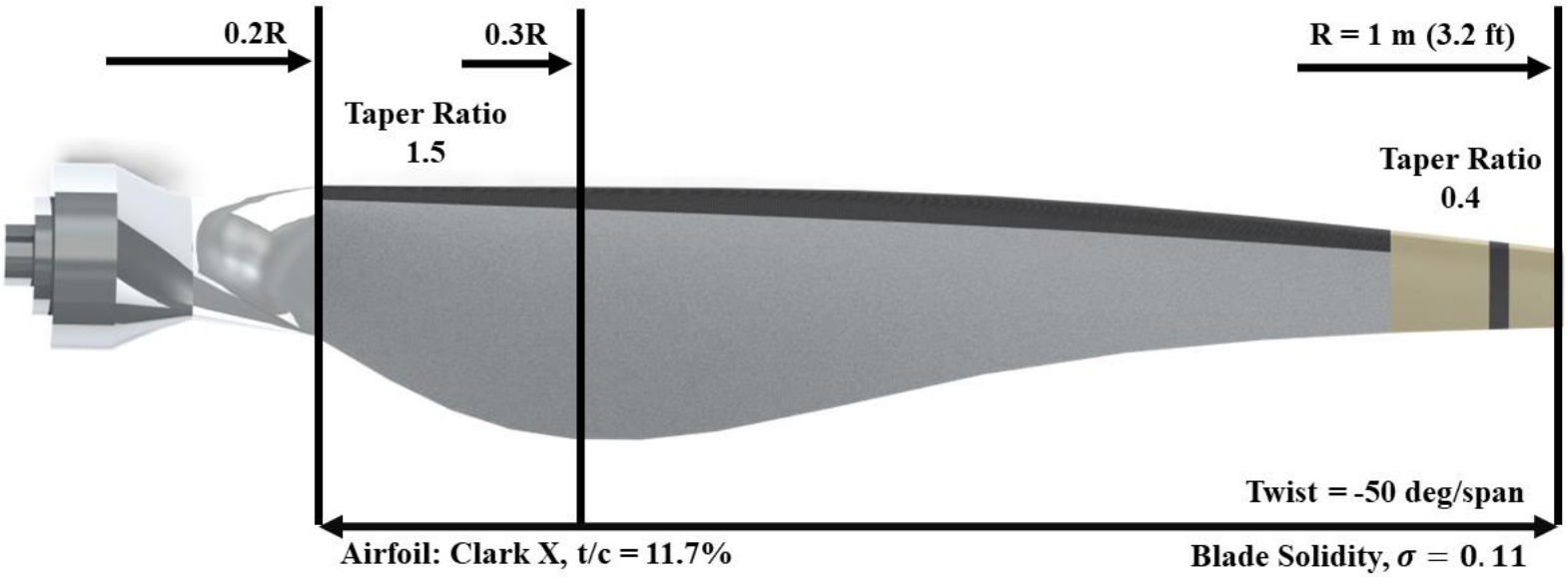


Characteristic	Value (SI)	Value (English)
Tip Speed (Hover)	158 m/s	520 ft/s
Disk Loading (DL)	622 N/m^2	13 lb/ft^2
Power Loading (PL)	43.30 N/kW	7.27lb/HP
Blade Loading, C_T/σ	0.0965	0.0965
Induced Power Factor, k	1.305	1.305
Figure of Merit (FM)	0.74	0.74
C_T	0.0247	0.0247
C_Q	0.0028	0.0028
C_P	0.0036	0.0036

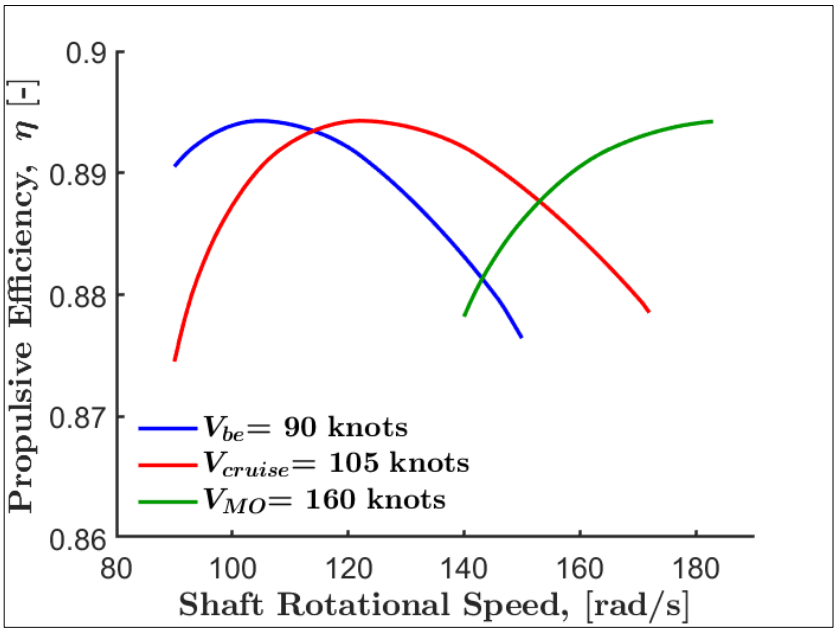


Over **500,000 blade planforms studied** to find the optimal for the Balto

Efficient Cruise Propellers



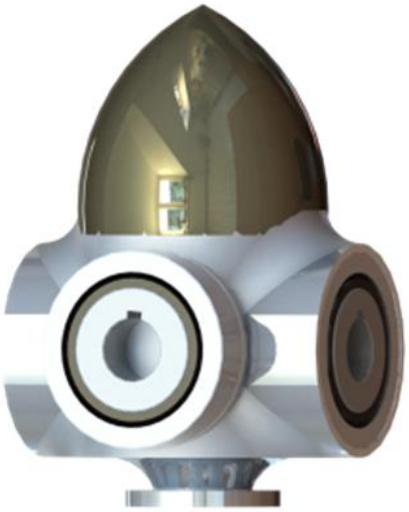
Characteristic	Value (SI)	Value (English)
Tip Speed	120 m/s	393.7 ft/s
Helical Tip Mach Number, M_h	0.38	0.38
Advance Ratio, J	1.42	1.42
Propulsive Efficiency, η	0.89	0.89
Thrust Coefficient, $C_{T_{Prop}}$	0.136	0.136
Torque Coefficient, $C_{Q_{Prop}}$	0.034	0.034
Power Coefficient, $C_{P_{Prop}}$	0.215	0.215

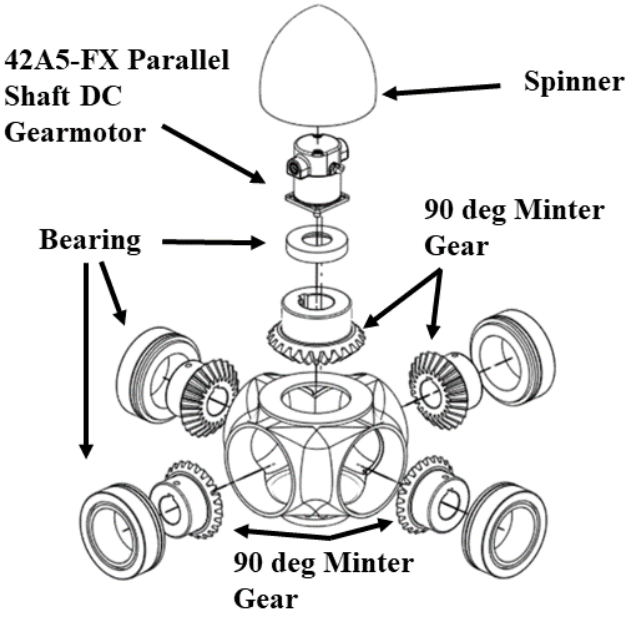


Variable pitch and variable RPM control for enhanced propulsive efficiency in all stages of flight

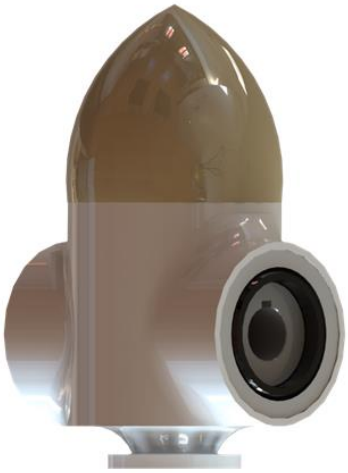
Hub and Variable Pitch Actuation

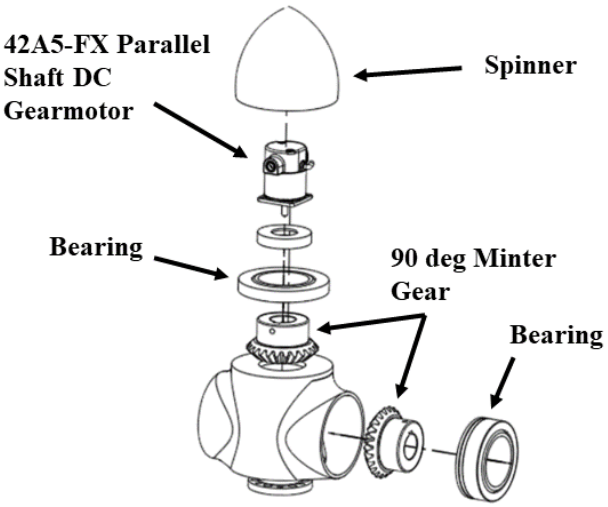
Cruise Propeller

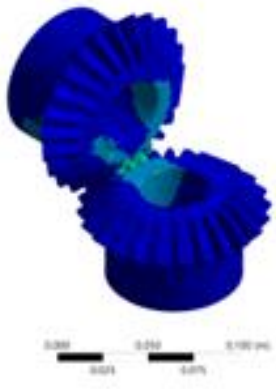




Lifting Rotor



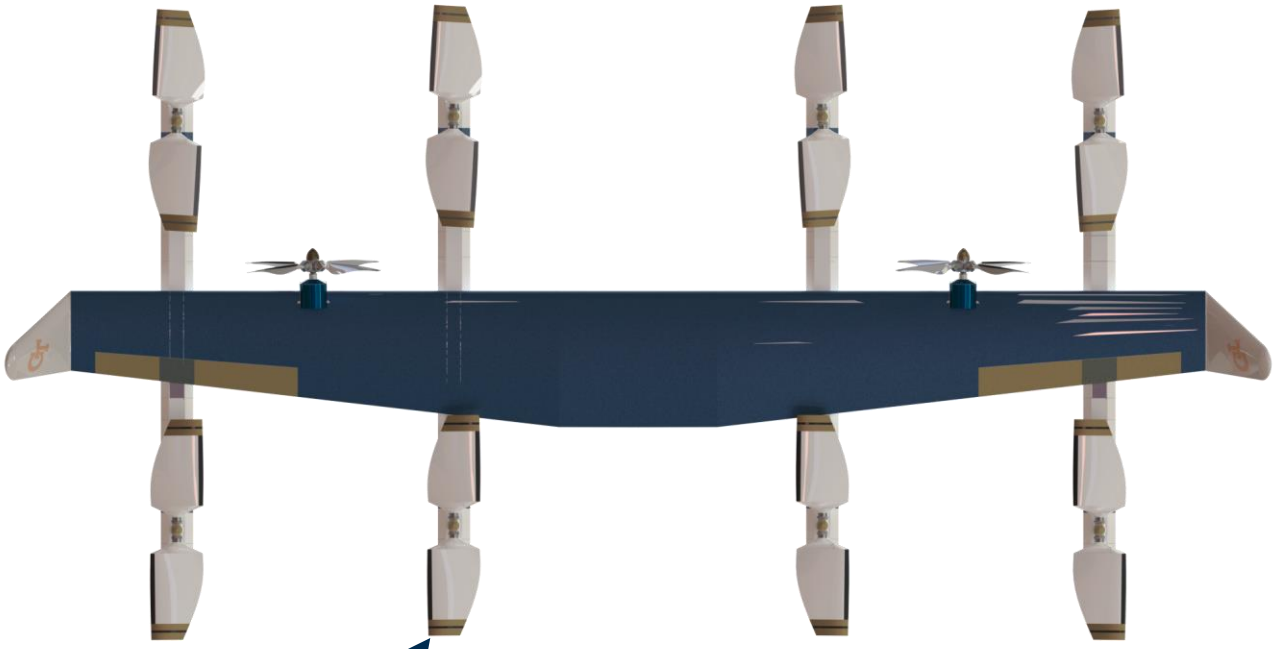




Weight Optimized using Nylon 66 gears

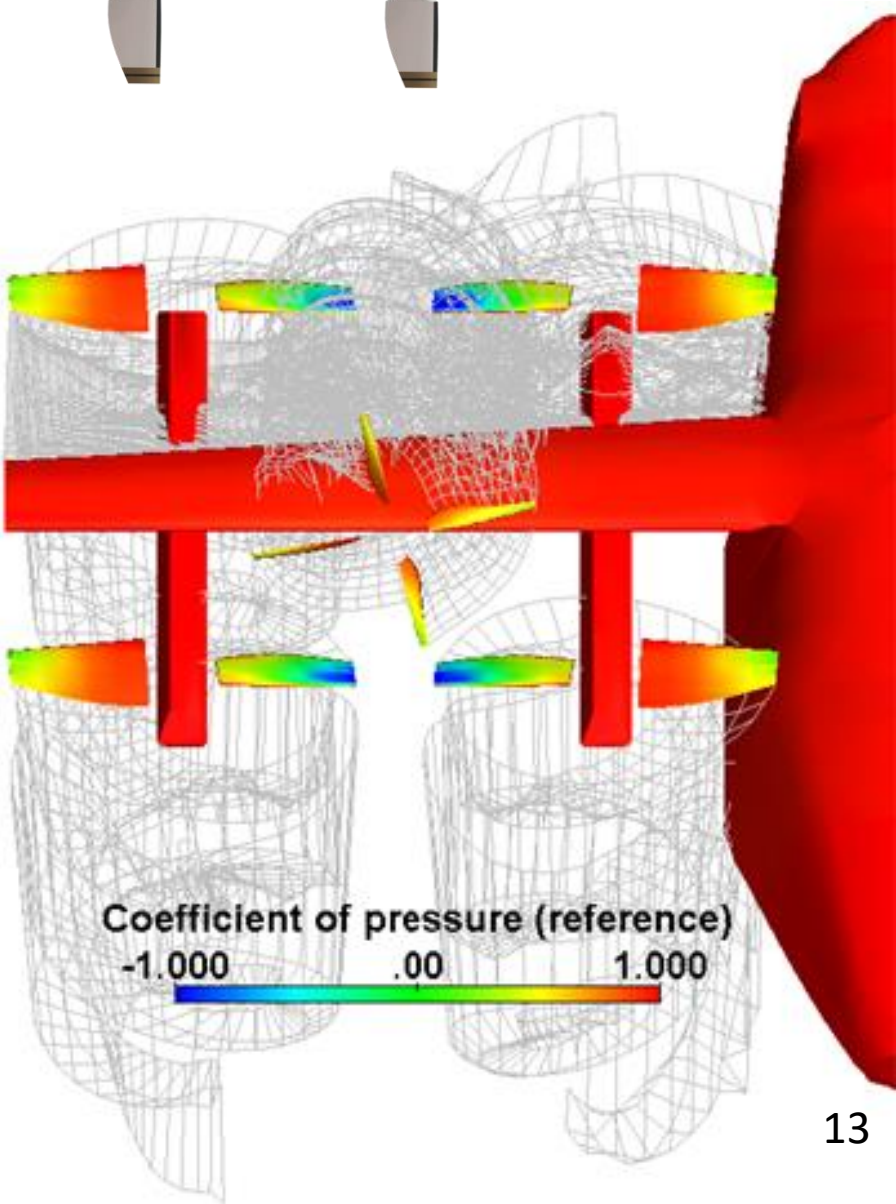
155% weight saved on the system

Interactional Aerodynamics



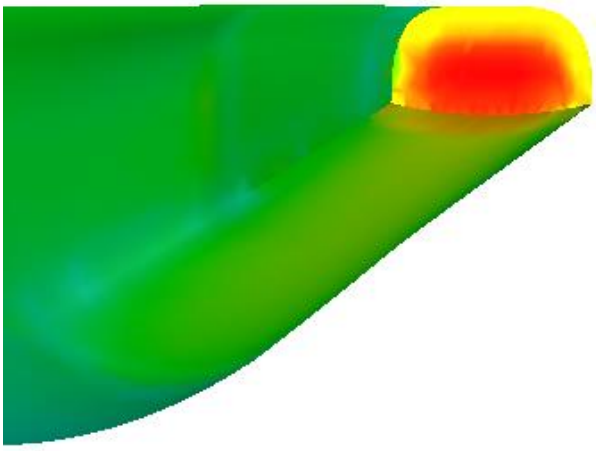
Lifting Rotors lock in parallel to the flow during cruise for drag reduction and clean propeller wake

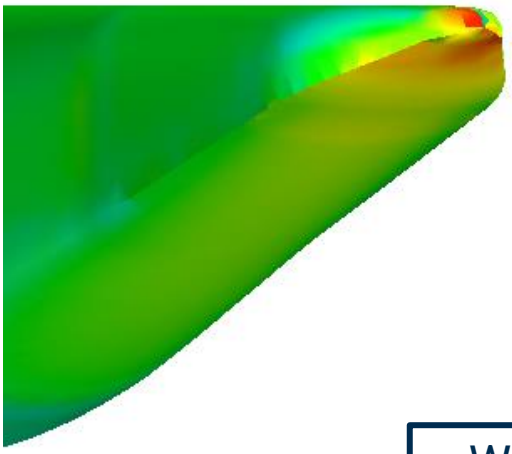
Rotor placement and rotation enhanced for reduced interactional effects in cruise and isolation of retreating side during transition



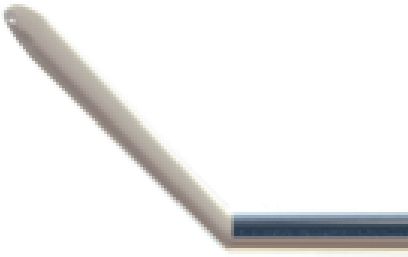
Wing & Fuselage Aerodynamics

Enhanced tail to fit large ramp and maintain aerodynamic integrity



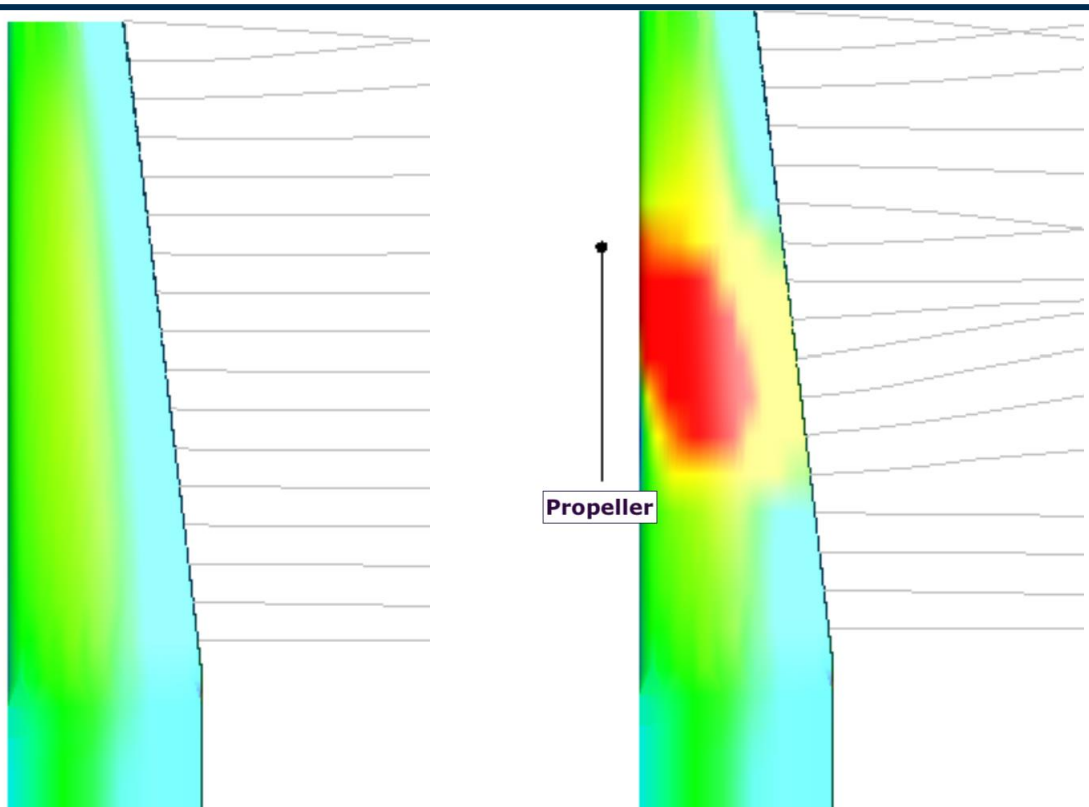


13 % Drag Reduction

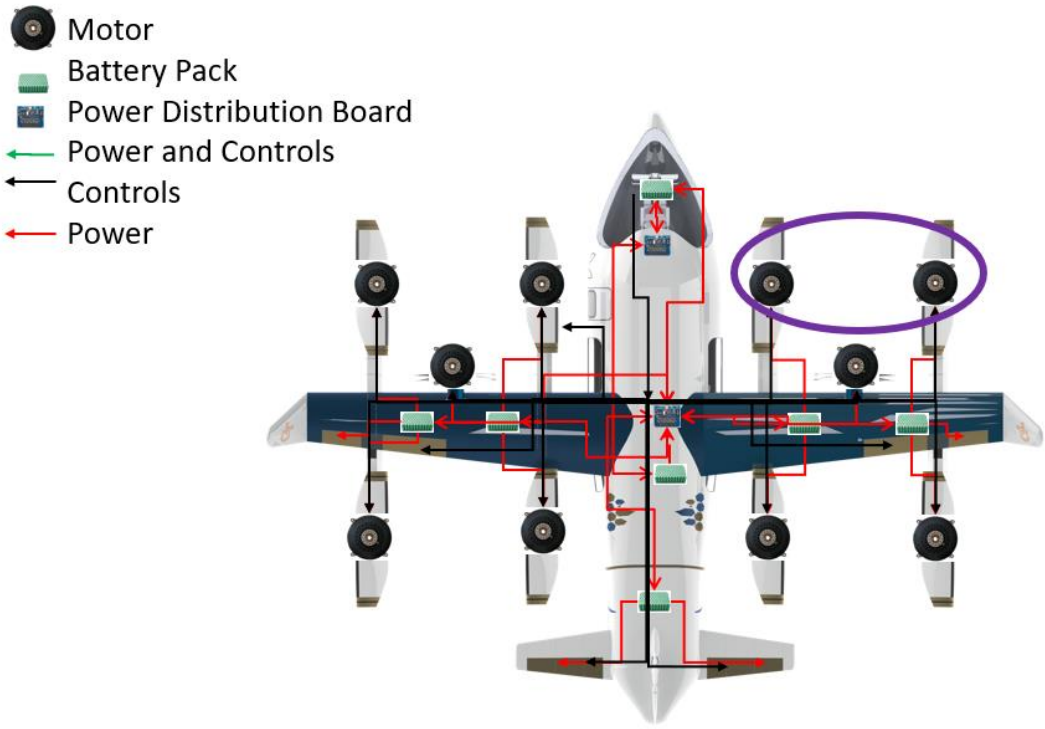


Wing tip, effective AR increased by 24.7%

Rotor Blow wing for enhanced performance

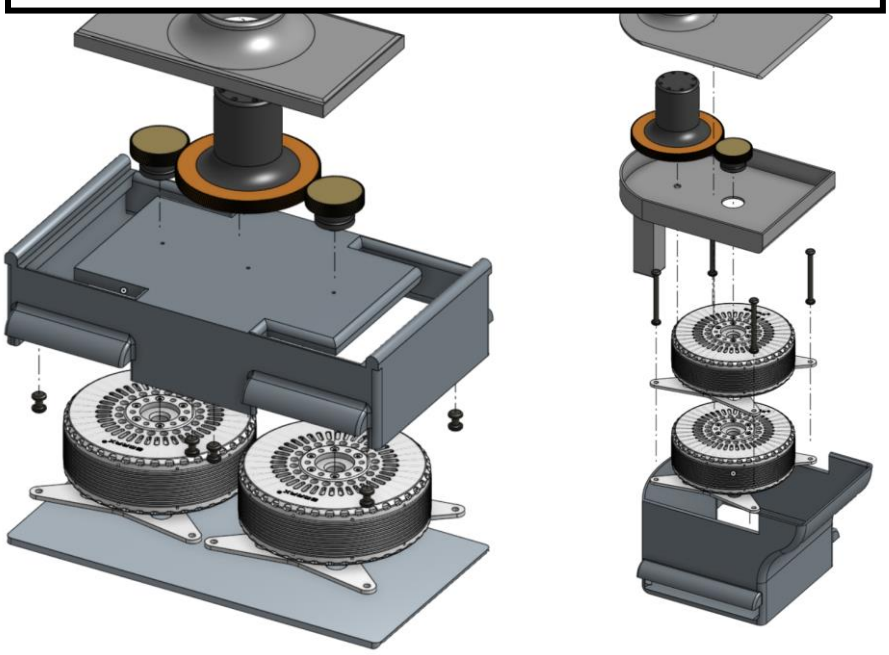


Propulsion System



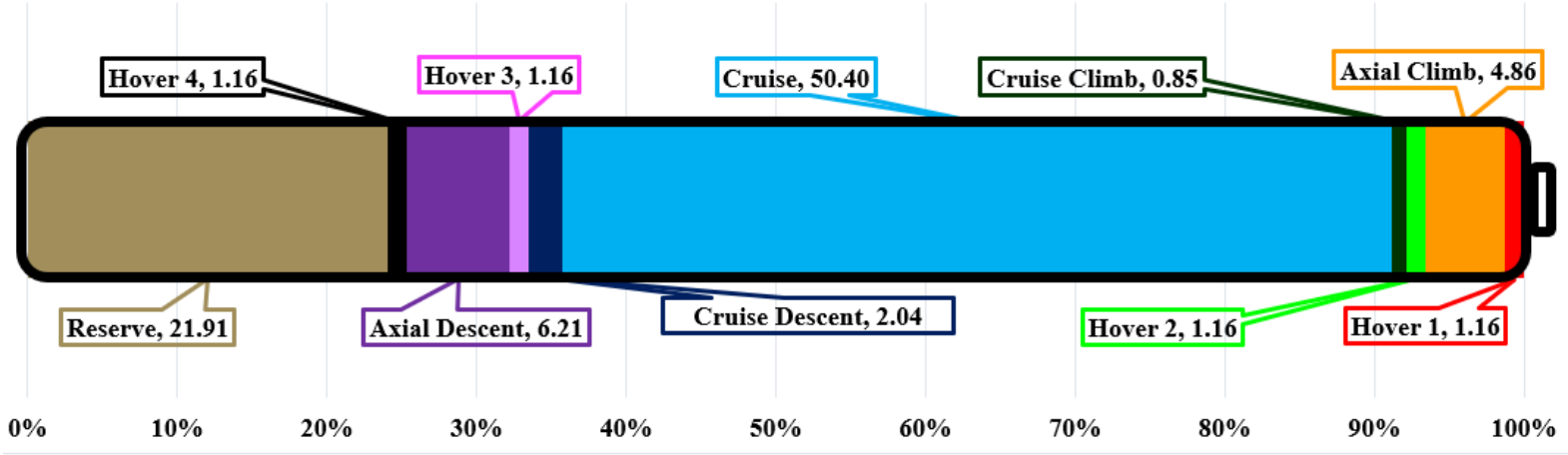
Cross wiring for enhanced safety and redundancy

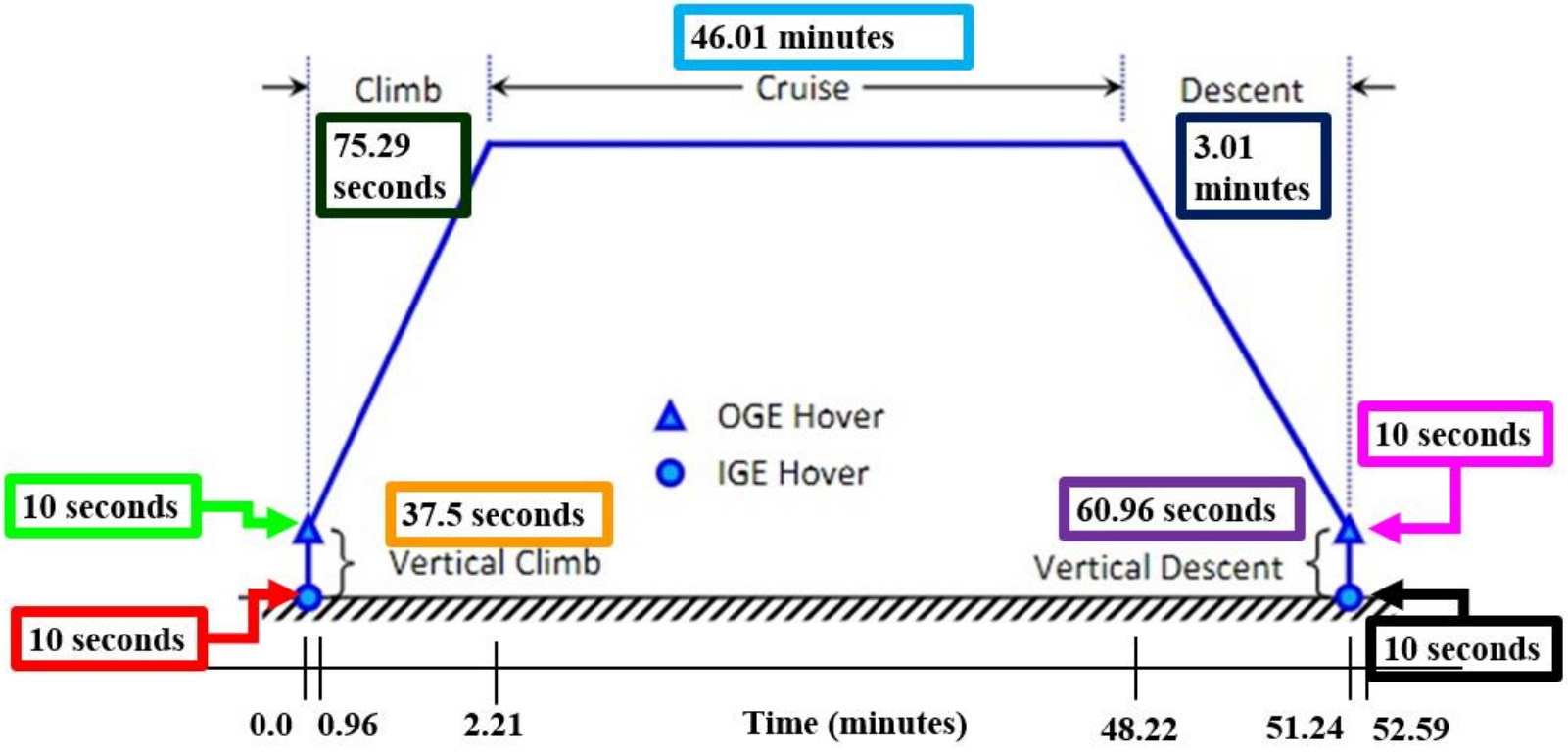
Two Different Motor assemblies



EMRAX 268 Motor with 109 kW of ideal Power Available

Energy Consumption

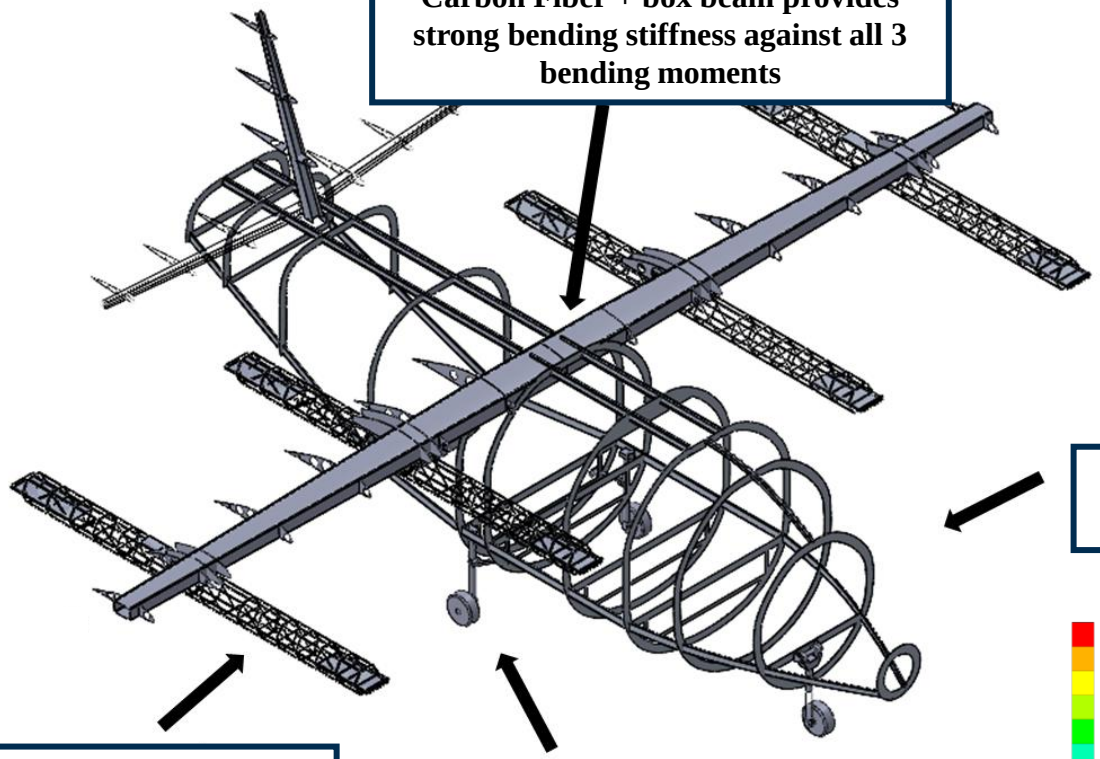


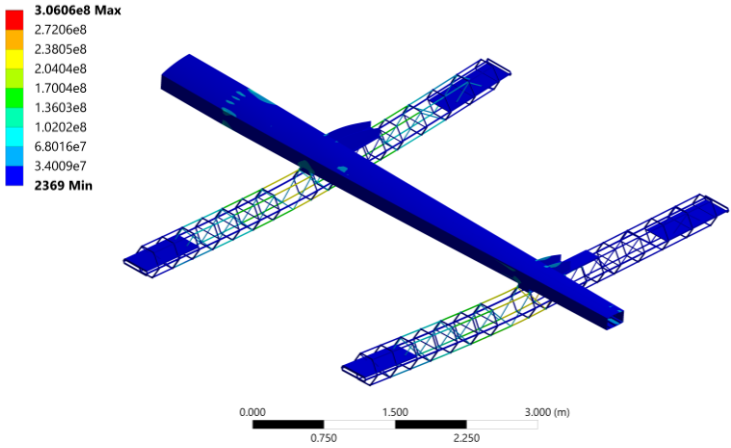


Total Energy Required: 138 kW/hr
Charging time: 45 mins

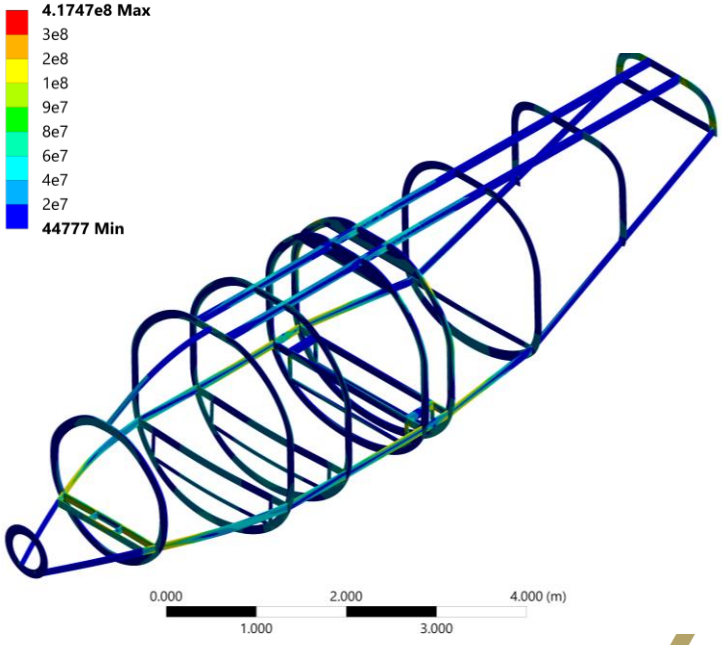
Structures Highlights

Wing torque box:
Carbon Fiber + box beam provides strong bending stiffness against all 3 bending moments





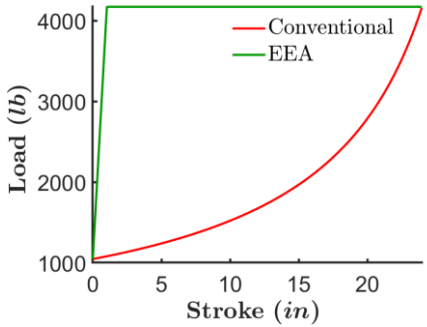
Airframe:
Safe even under most extreme cases



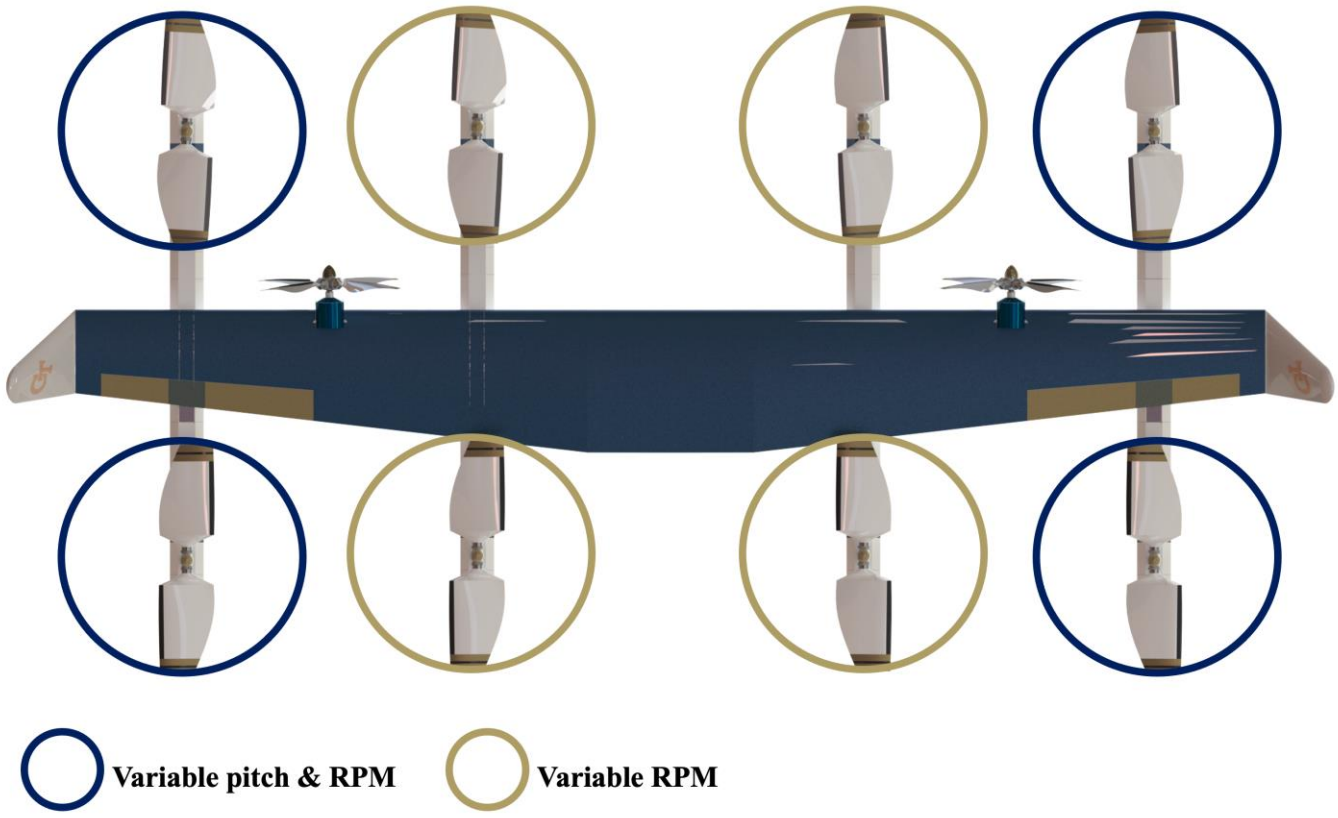
Motor Boom:
Lightweight and sturdy – incredible safety even in failure

Extreme Energy Absorbing LG:
provides the smoothest landing, regardless of descent speed

Smart strut capable of detecting impact velocity and adjusting pressure to maintain constant deceleration



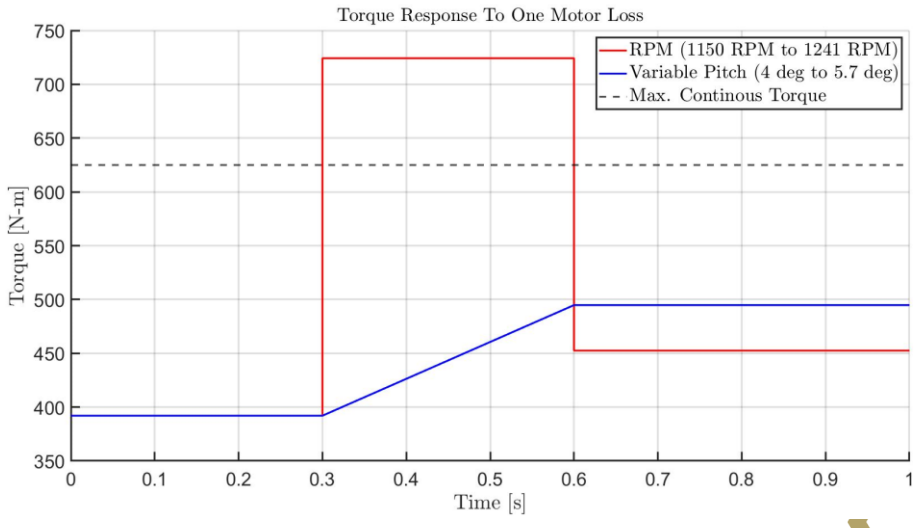
Enhanced Control with Variable pitch and RPM



Variable pitch for quick roll over response on outboard lifting rotors

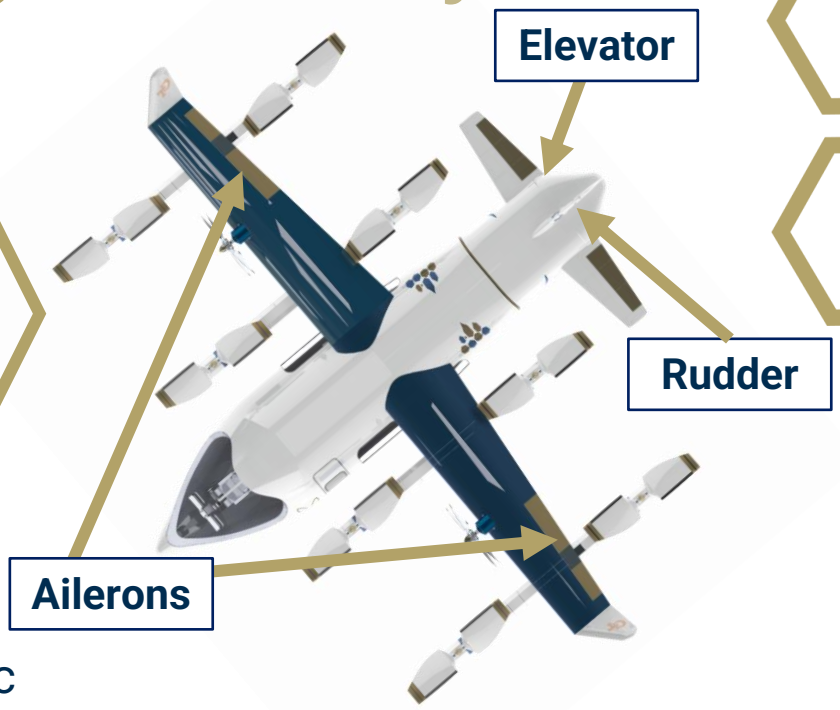
Variable RPM not sufficient due to torque spike

82% weight reduction by not implementing in all rotors



Cruise: Comfort, Simplicity and Safety

In cruise, Balto's flight controls are akin to that of a classical fixed wing aircraft making it simple for the pilot, comfortable for the passengers and safe for everyone



COMFORT

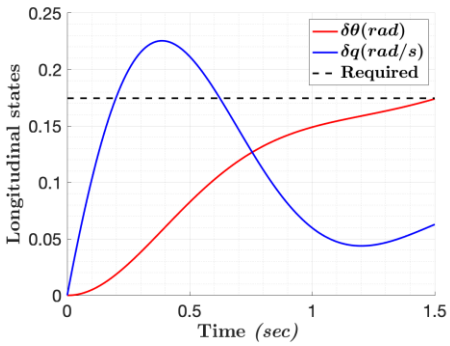
- ✓Longitudinal and Lateral dynamic stability
- ✓Good handling qualities
- ✓Capable of 10-deg pitch, 10 deg roll Lor 6 deg heading changes within less than 1.5 seconds
- ✓Balto can maintain symmetry of flight even with one failed engine

SIMPLICITY

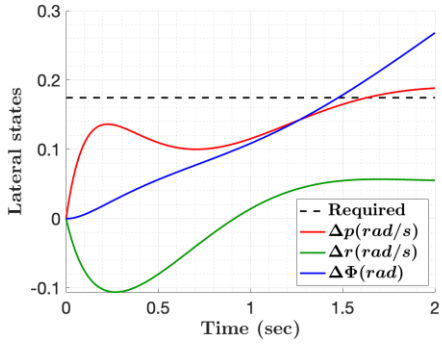
- ✓Regular fixed-wing pilot can fly Balto in cruise with minimal training

SAFETY

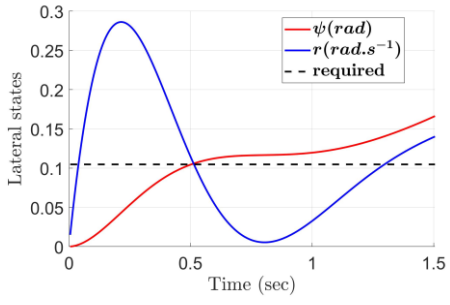
- ✓Twin propellers minimalizes risk of engine-out emergency landing
- ✓In the unlikely event of a double engine failure, Balto can glide to provide a gentler landing



Response to elevator deflection



Response to ailerons deflections



Response to rudder deflection

BALTO

Thank You for Reading