

**BALTO**



# **Executive Summary**

**Graduate Design Team  
Georgia Institute of Technology**

**39<sup>th</sup> Annual VFS Student Design Competition**

**eVTOL Air Taxi for Passengers with Reduced Mobility**

*Sponsored by Bell*





BALTO



# Introduction

- In response to the Vertical Flight Society's 39<sup>th</sup> 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**



## 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

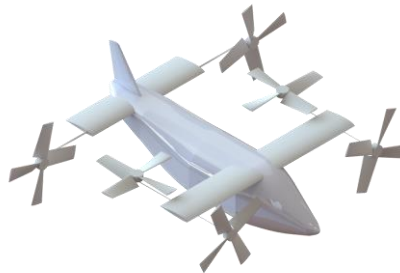
Design drivers weighted based on importance

## Pugh Matrix

**Twelve configurations were evaluated**, with three selected for further analysis



Lift + Cruise Multirotor



Tilt Rotor



SMR Compound

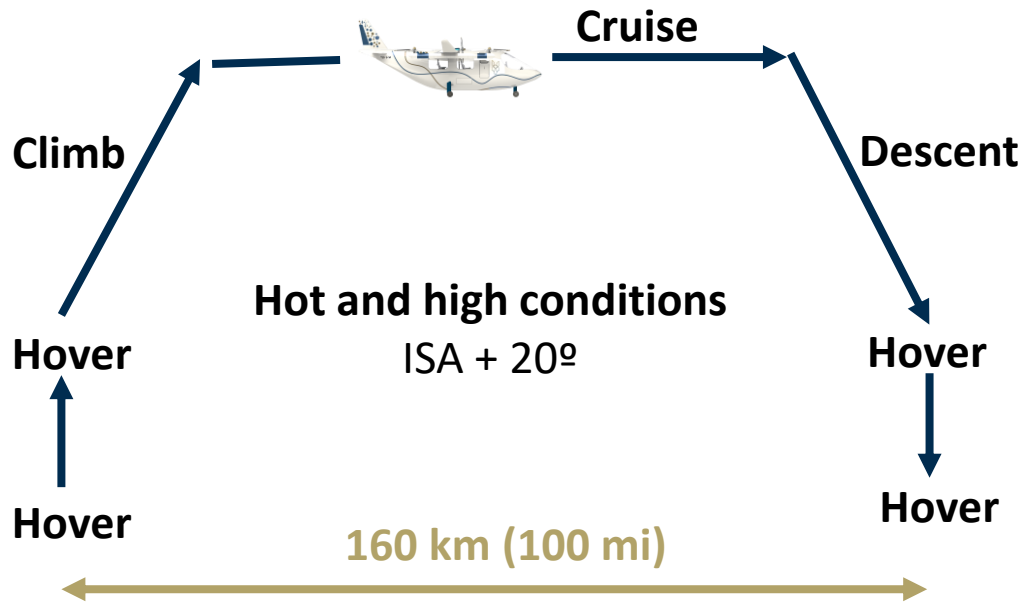


The lift+cruise multirotor

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



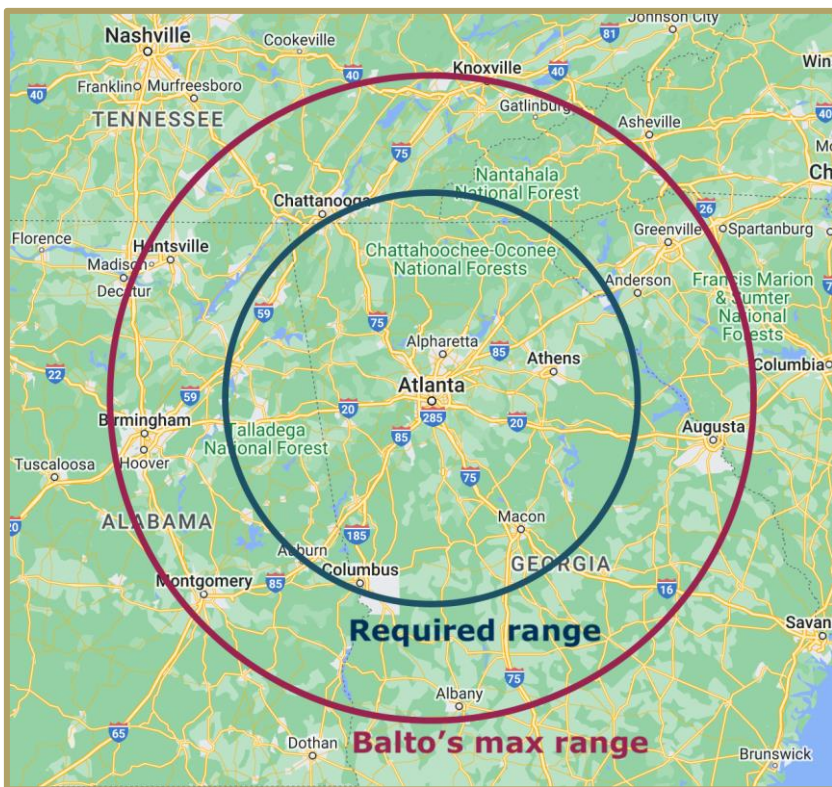
# Mission Profile



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



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



# Balto's Key Features



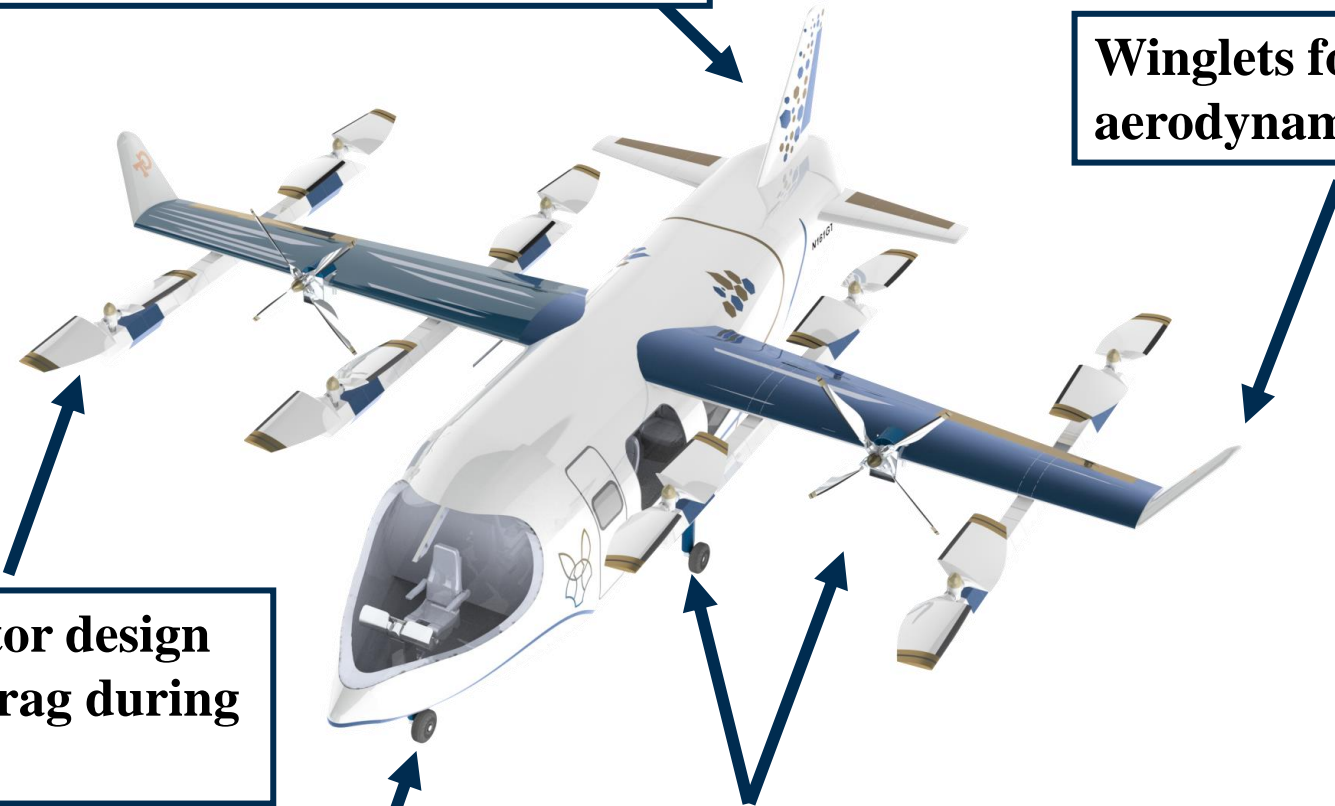
**Aerodynamically enhanced empennage focused on maximizing loading ramp area**

**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**





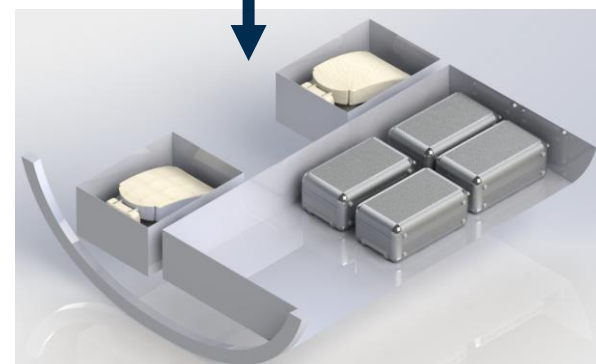
# Featuring **FIRST** disability friendly cabin in the skies



**Full glass cockpit and wide windshield**



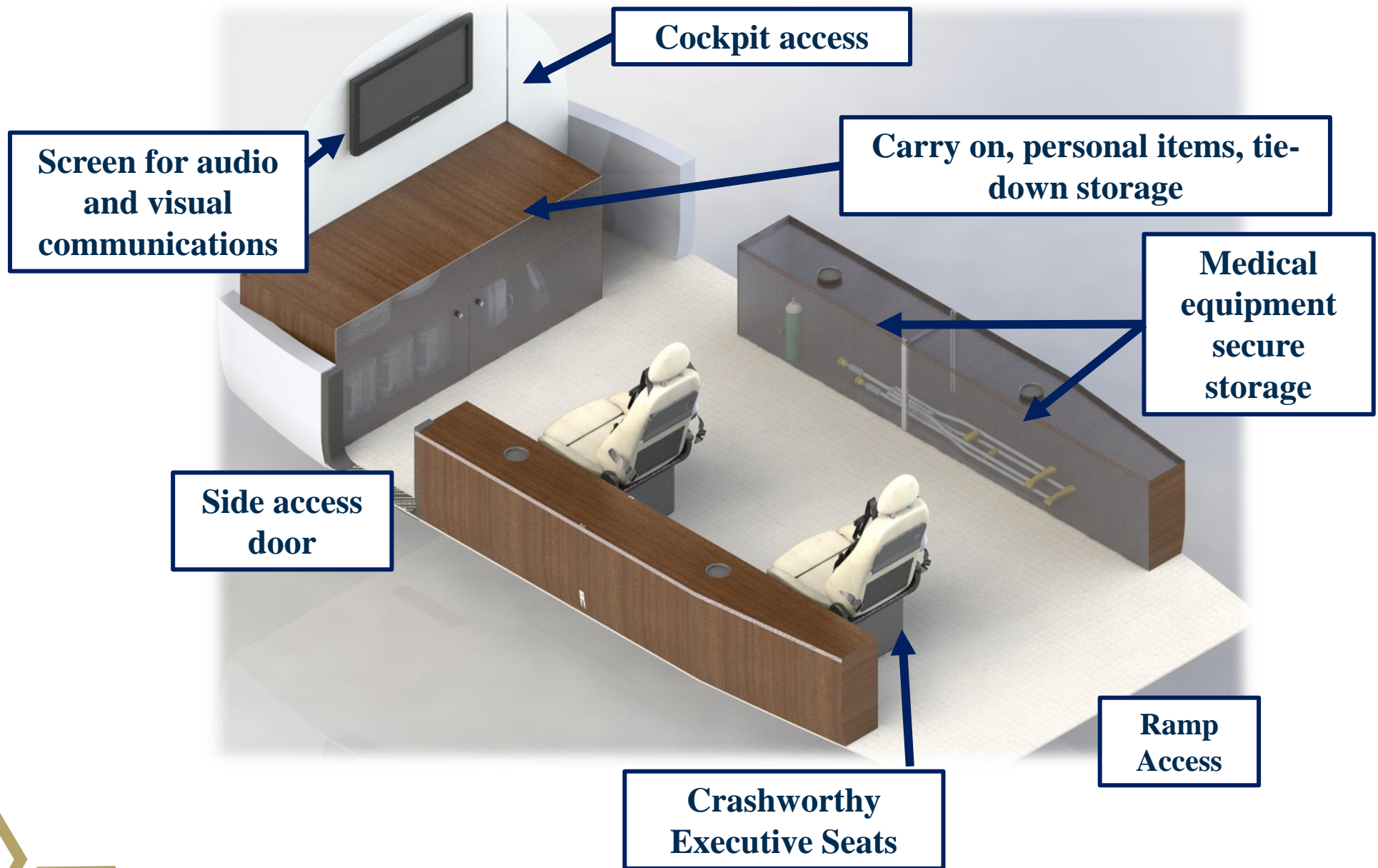
**All included - fully reconfigurable cabin to cater to the entire world: PRM friendly**



**Large Storage for Checked Bags and More**



# A cabin designed with your needs in mind

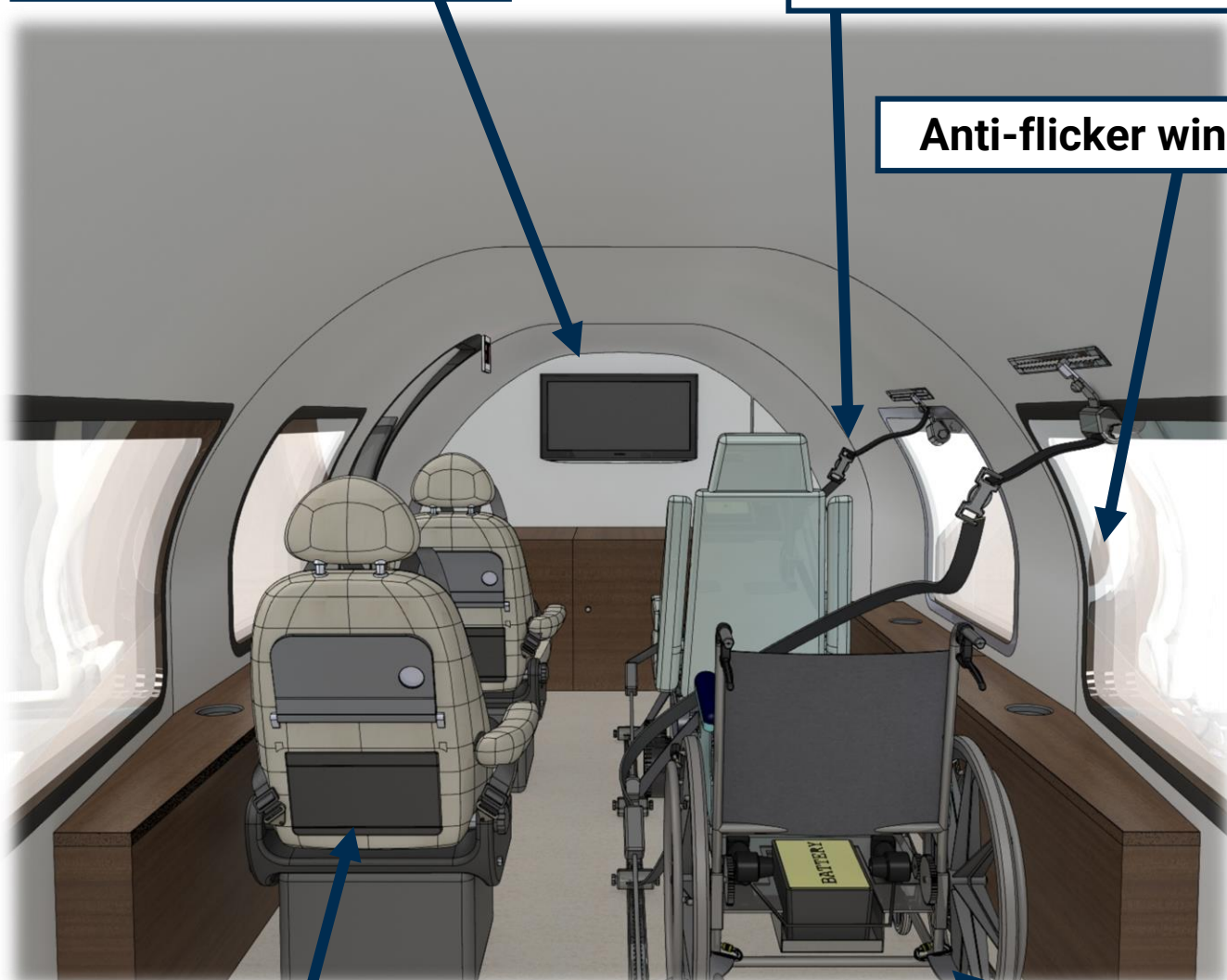


# Special considerations for special needs

**TV for entertainment  
and Safety**

**Harness for safety and  
comfort**

**Anti-flicker windows**

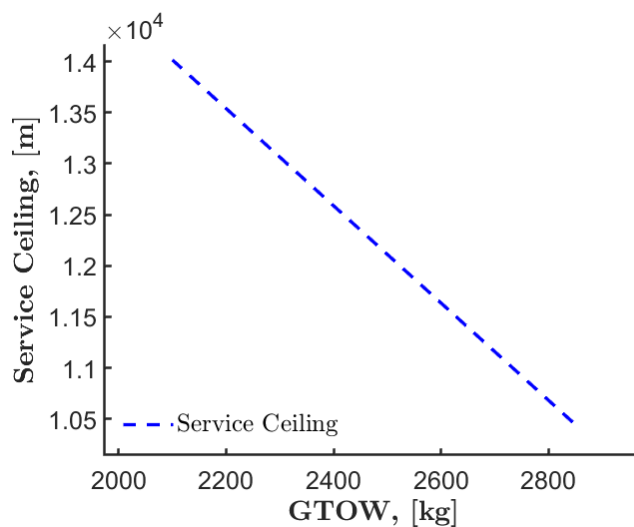
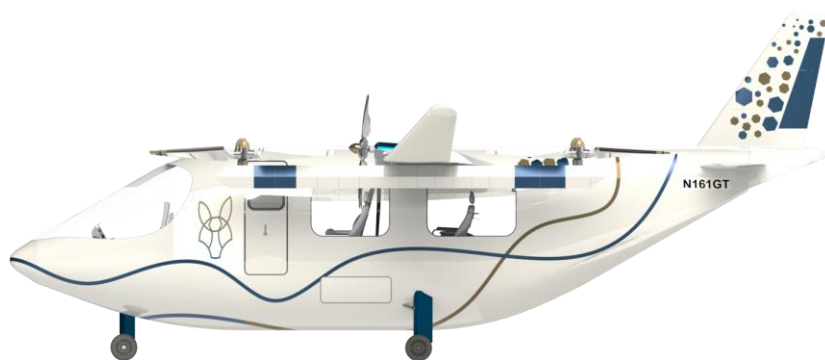
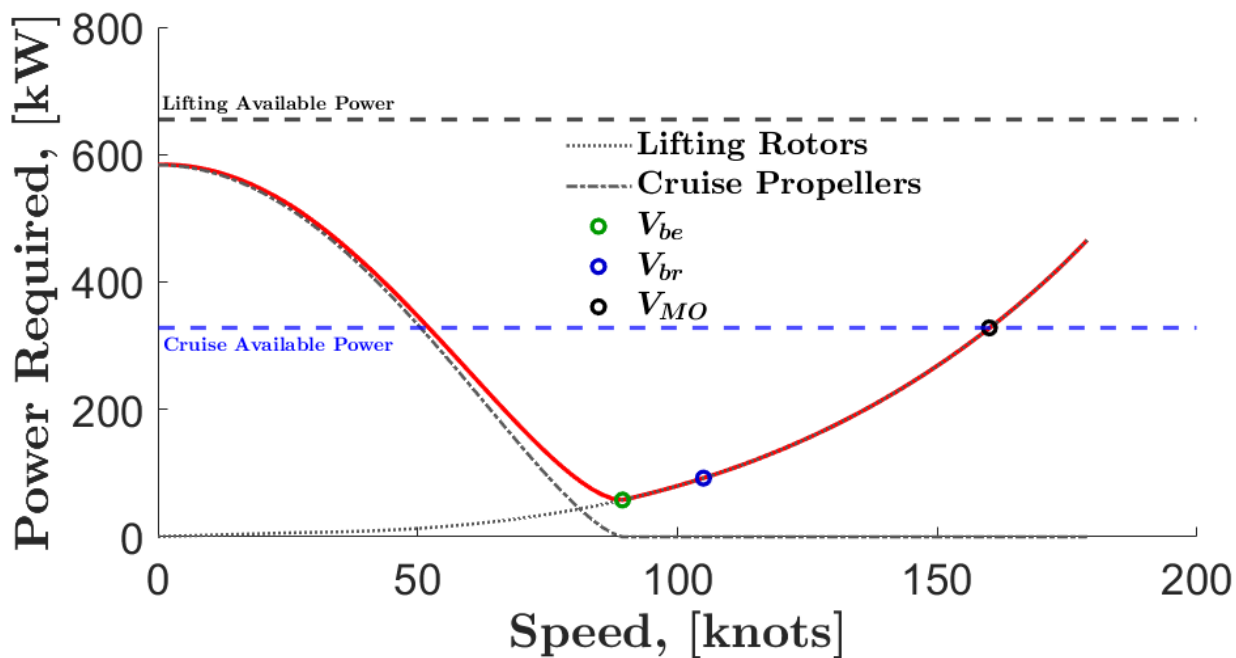


**Executive Seats for maximum  
comfort and crashworthiness**

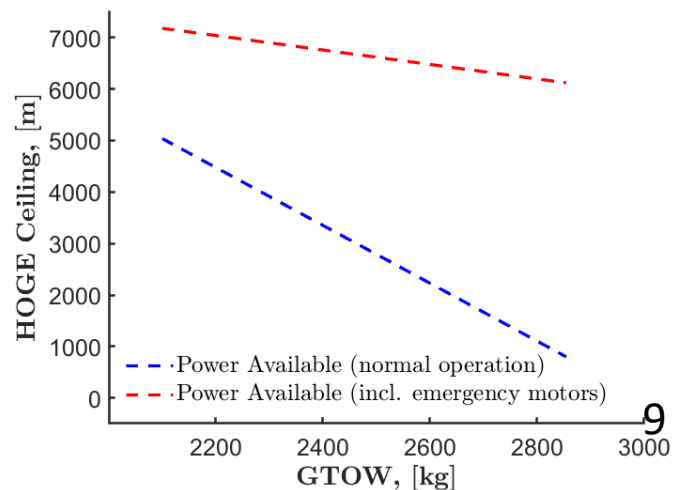
**Maximized aisle width  
and legroom**

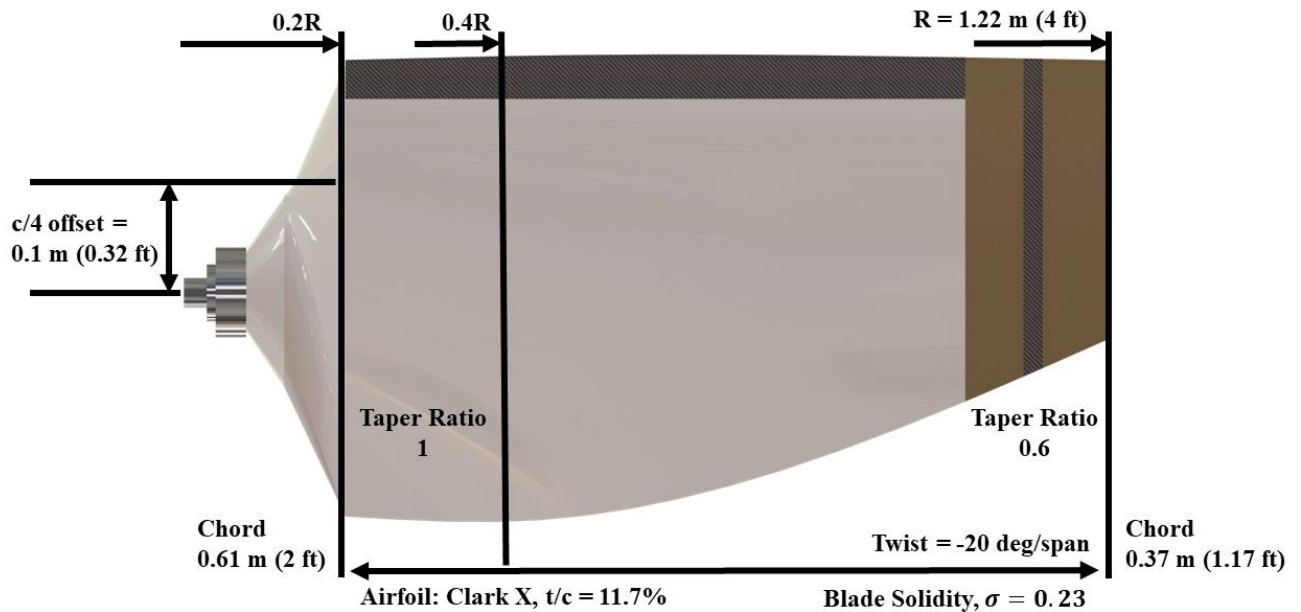


# Performance Overview

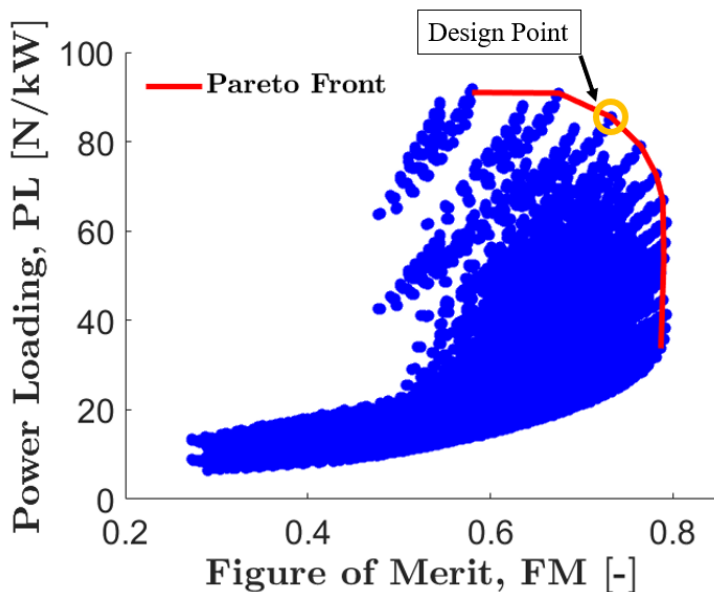


Metric	
$V_{be}$	90 knots
$V_{br}$	105 knots
$V_{MO}$	160 knots
Max Service Ceiling (density altitude)	14,000 m (45,900 ft)
Max Takeoff Altitude (density altitude)	7,100 m (23,300 ft)

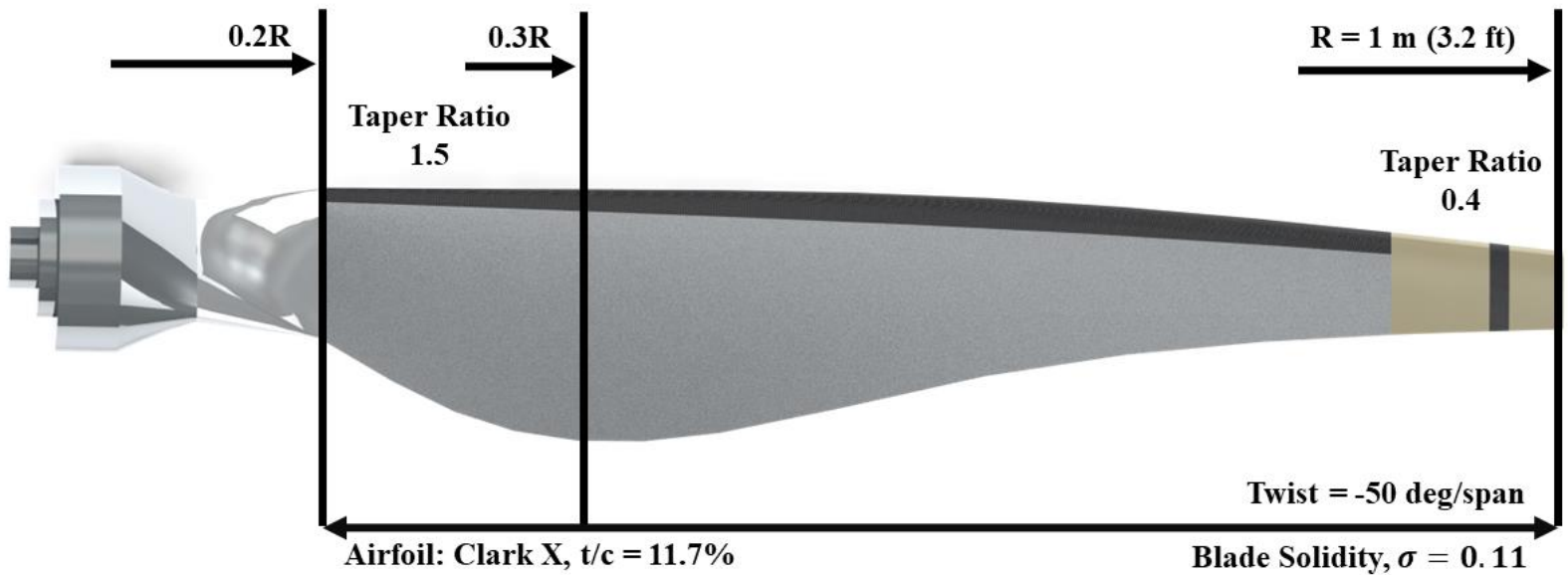




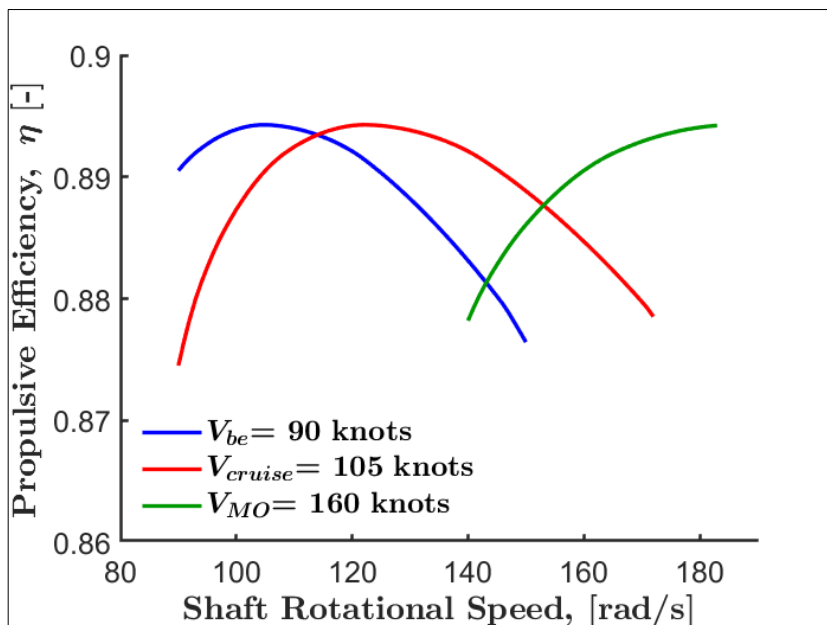
Characteristic	Value (SI)	Value (English)
Tip Speed (Hover)	158 m/s	520 ft/s
Disk Loading (DL)	622 N/m <sup>2</sup>	13 lb/ft <sup>2</sup>
Power Loading (PL)	43.30 N/kW	7.27lb/HP
Blade Loading, $C_T/\sigma$	0.0965	0.0965
Induced Power Factor, $k$	1.305	1.305
Figure of Merit (FM)	0.74	0.74
$C_T$	0.0247	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

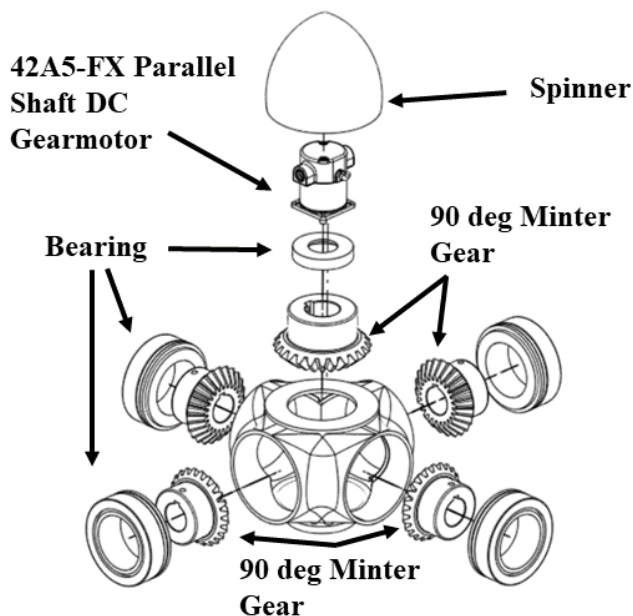
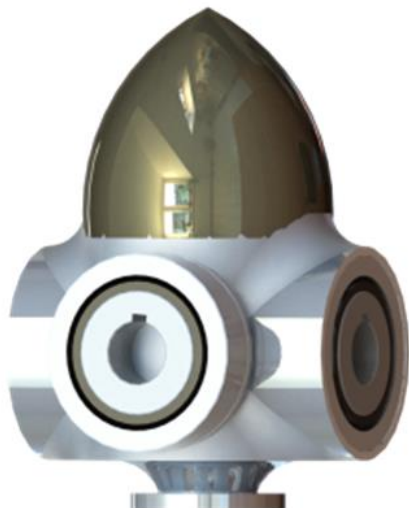


Characteristic	Value (SI)	Value (English)
Tip Speed	120 m/s	393.7 ft/s
Helical Tip Mach Number, $M_h$	0.38	0.38
Advance Ratio, J	1.42	1.42
Propulsive Efficiency, $\eta$	0.89	0.89
Thrust Coefficient, $C_{T_{Prop}}$	0.136	0.136
Torque Coefficient, $C_{Q_{Prop}}$	0.034	0.034
Power Coefficient, $C_{P_{Prop}}$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

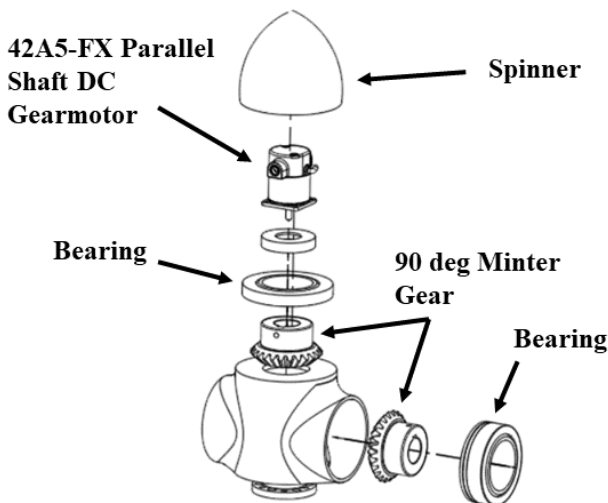


Variable pitch and variable RPM control for enhanced propulsive efficiency in all stages of flight

## Cruise Propeller



## Lifting Rotor

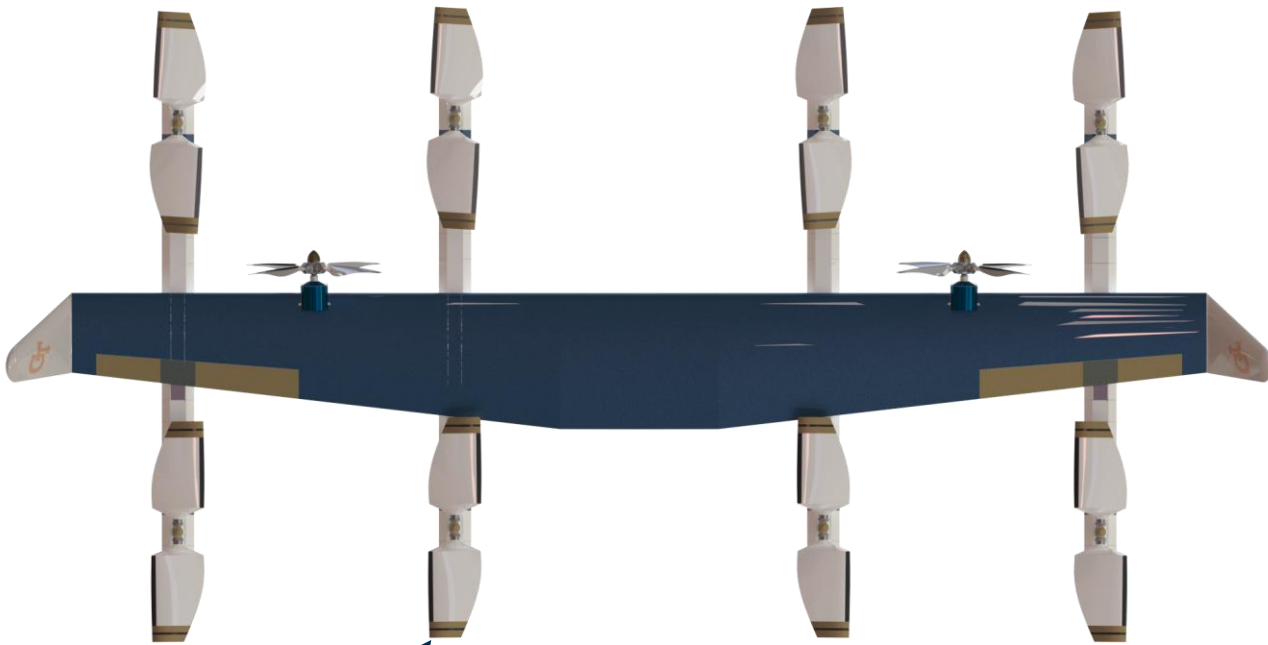


**Weight Optimized  
using Nylon 66 gears**

**155% weight saved  
on the system**

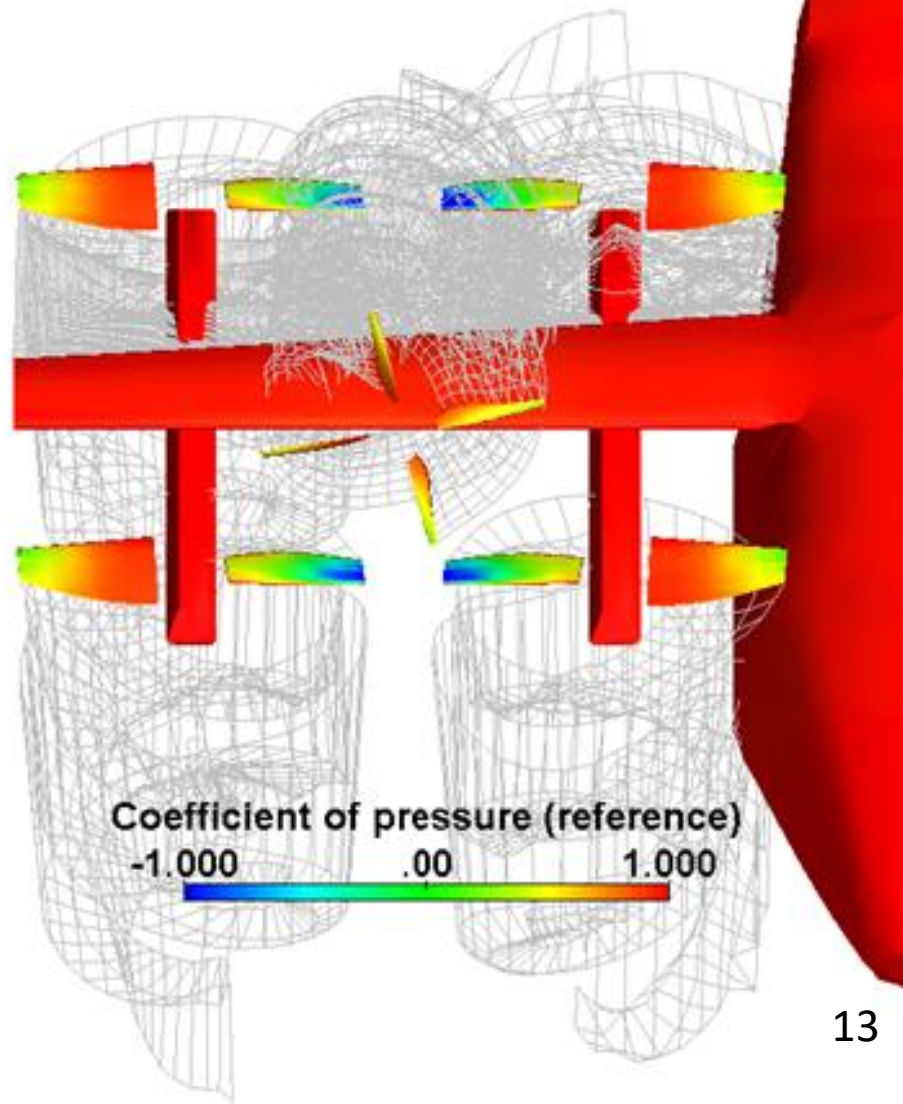
Static Structural  
Equivalent Stress  
Type: Equivalent (von-Mises) Stress  
Unit: Pa  
Time: 1



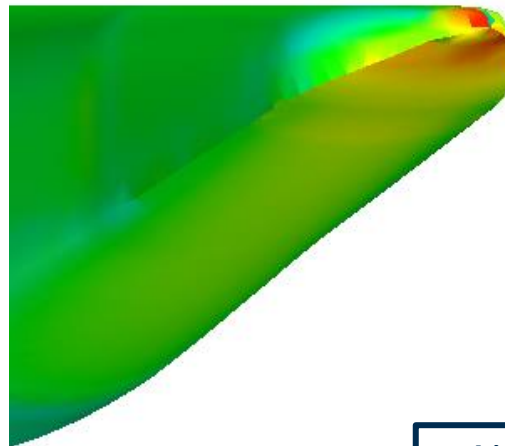
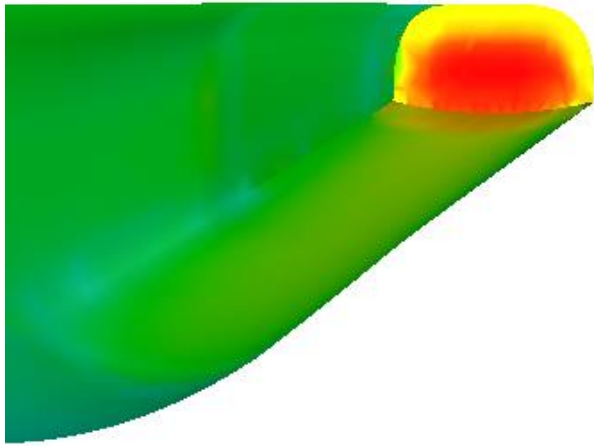


Lifting Rotors lock in parallel to the flow during cruise for drag reduction and clean propeller wake

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



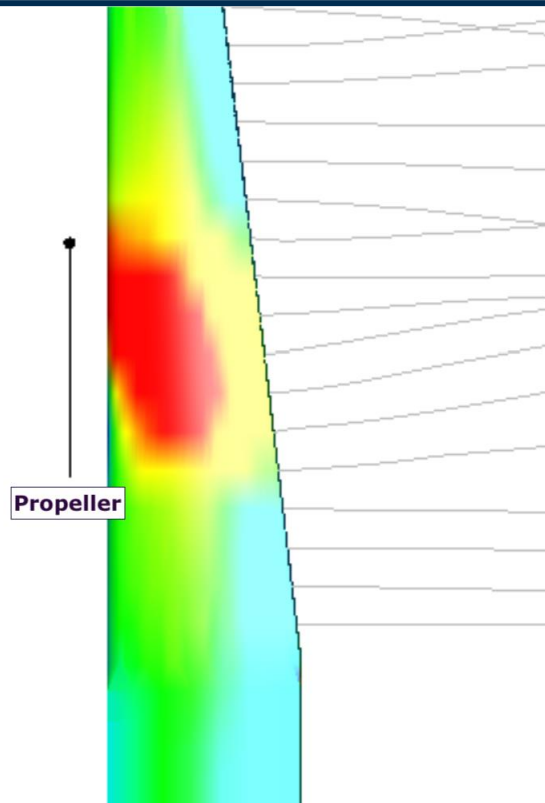
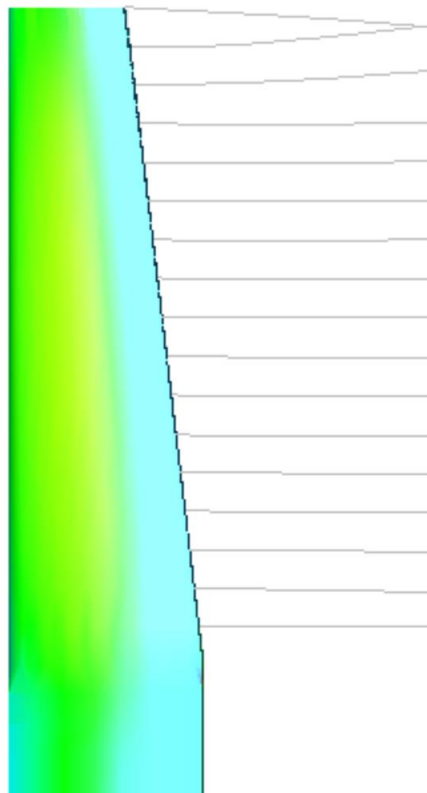
Enhanced tail to fit large ramp and maintain aerodynamic integrity









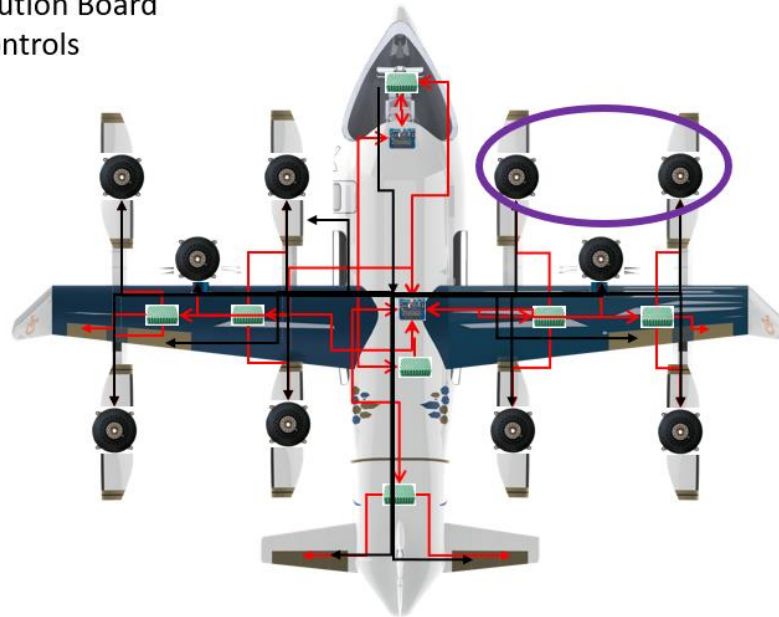
13 % Drag Reduction

Wing tip, effective AR  
increased by 24.7%

Rotor Blow wing for enhanced performance

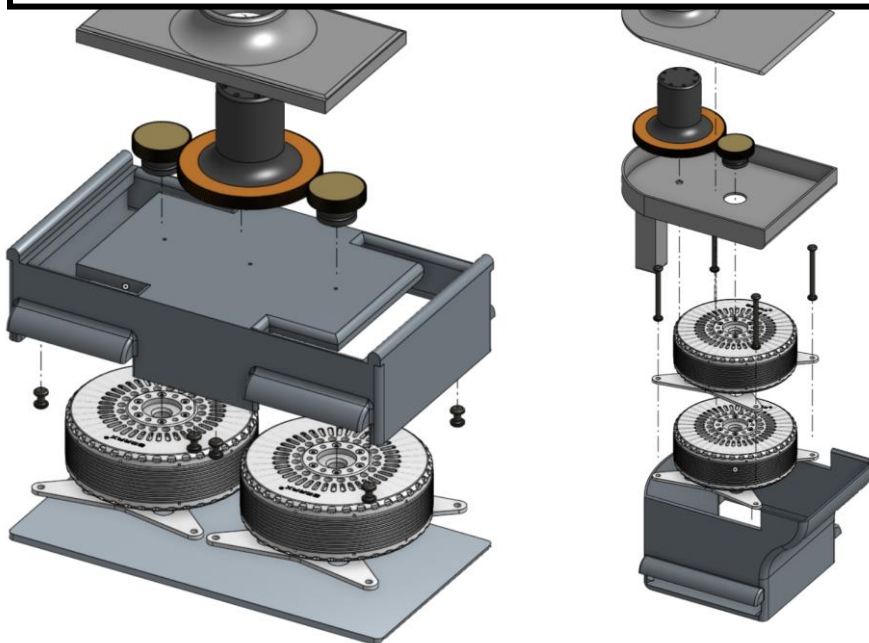


-  Motor
-  Battery Pack
-  Power Distribution Board
-  Power and Controls
-  Controls
-  Power



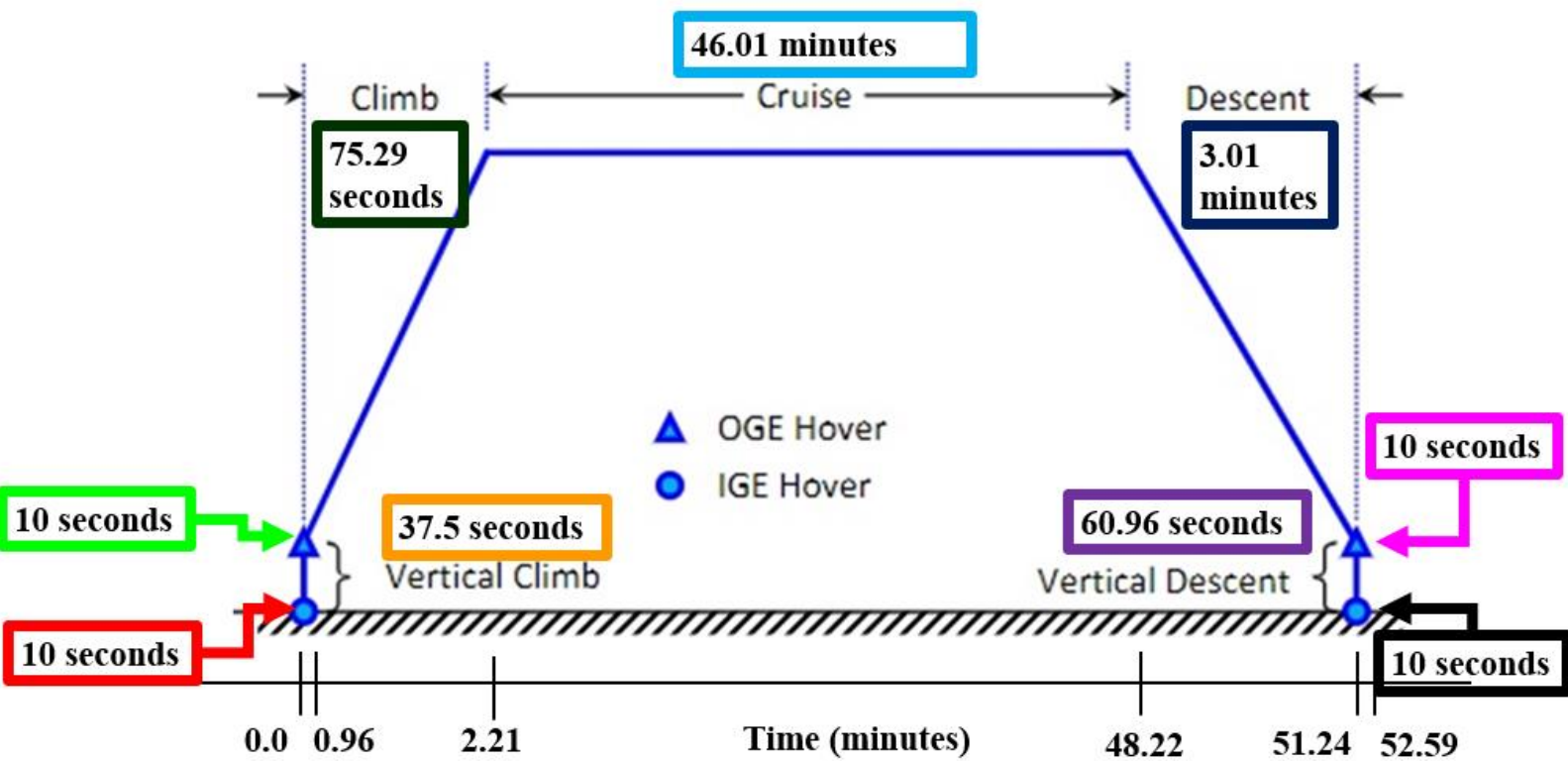
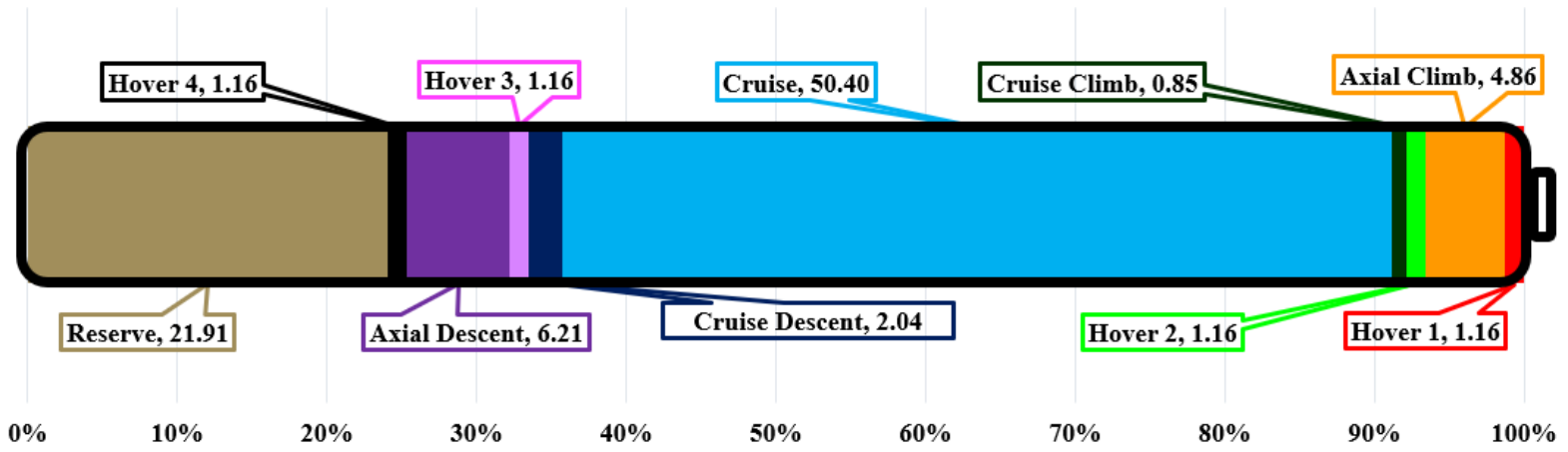
Cross wiring for enhanced safety and redundancy

Two Different Motor assemblies



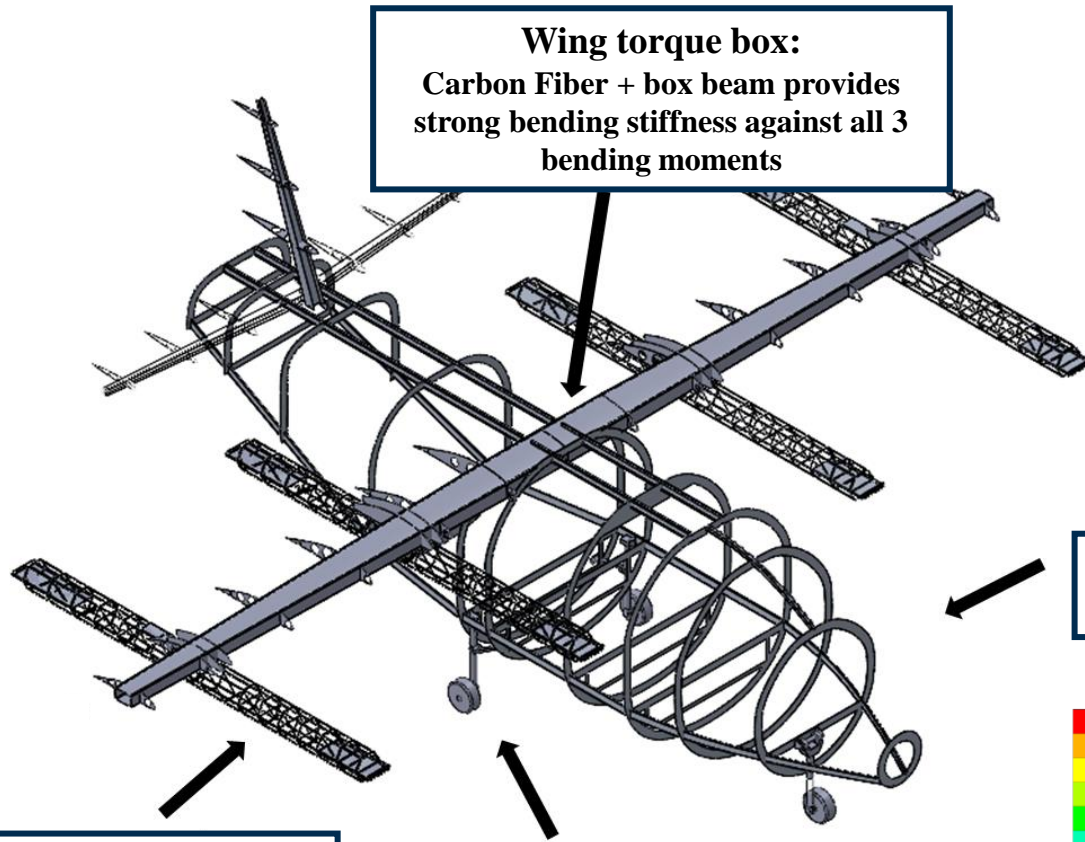
EMRAX 268  
Motor with 109  
kW of ideal  
Power Available

# Energy Consumption

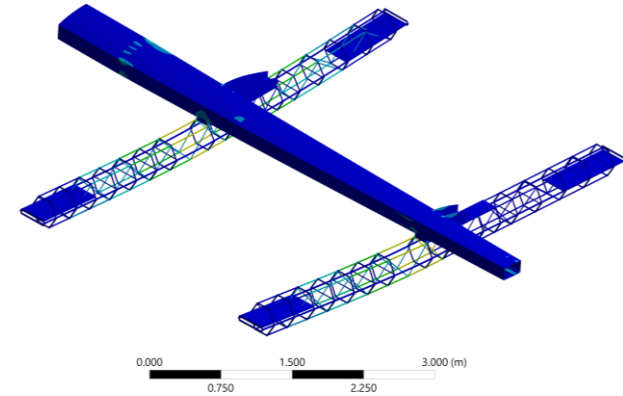
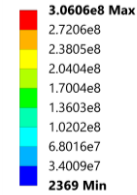


Total Energy Required: 138 kW/hr  
 Charging time: 45 mins

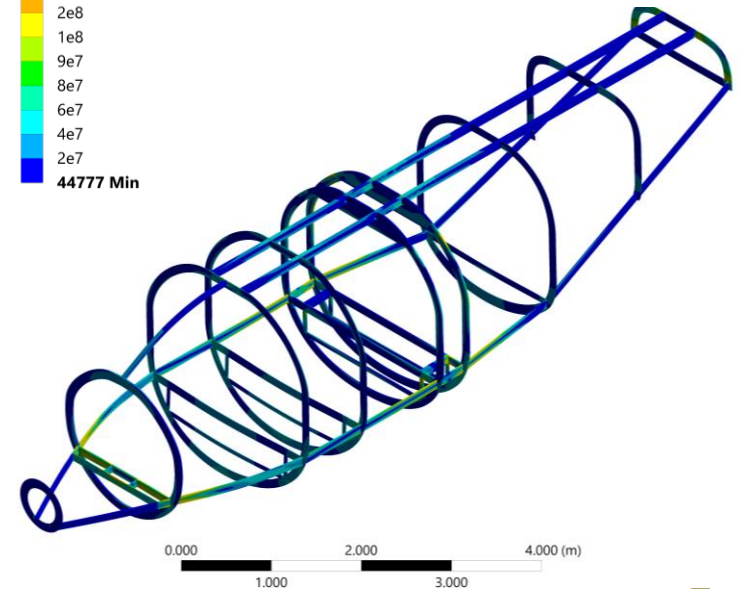
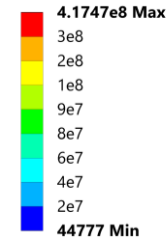




**Wing torque box:**  
Carbon Fiber + box beam provides strong bending stiffness against all 3 bending moments



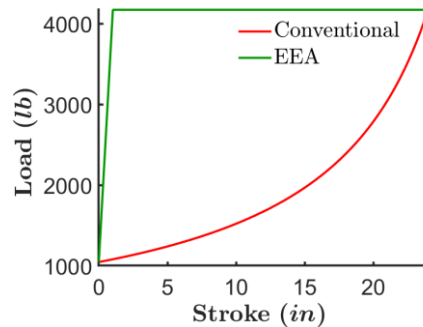
**Airframe:**  
Safe even under most extreme cases

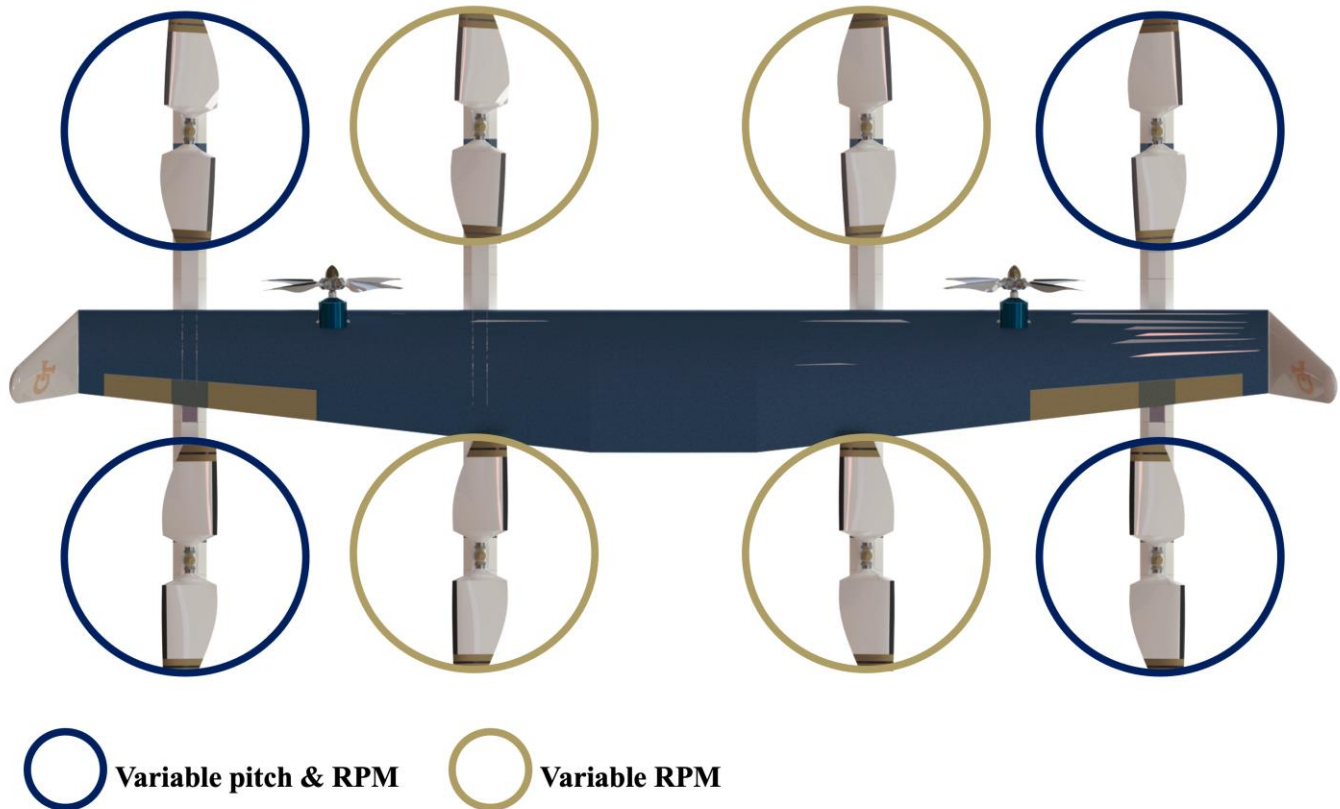


**Motor Boom:**  
Lightweight and sturdy – incredible safety even in failure

**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**

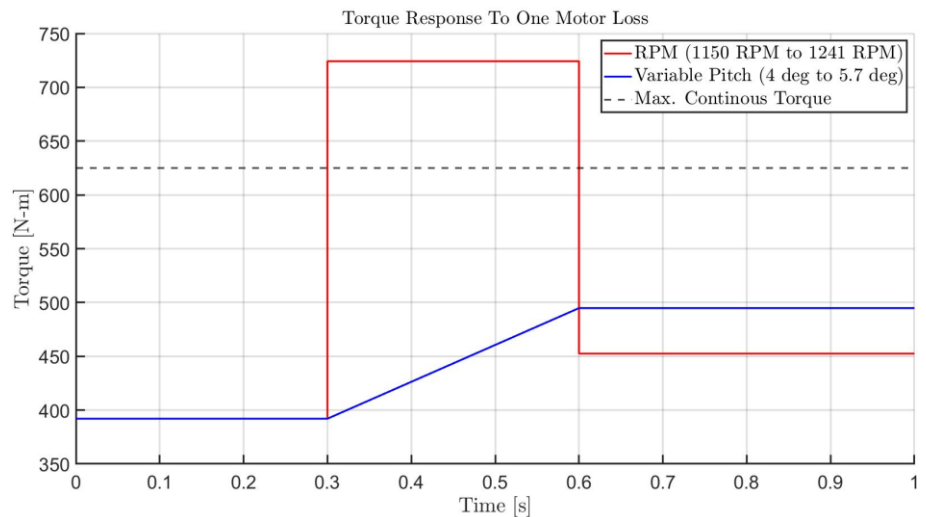




Variable pitch for quick roll over response on outboard lifting rotors

Variable RPM not sufficient due to torque spike

82% weight reduction by not implementing in all rotors

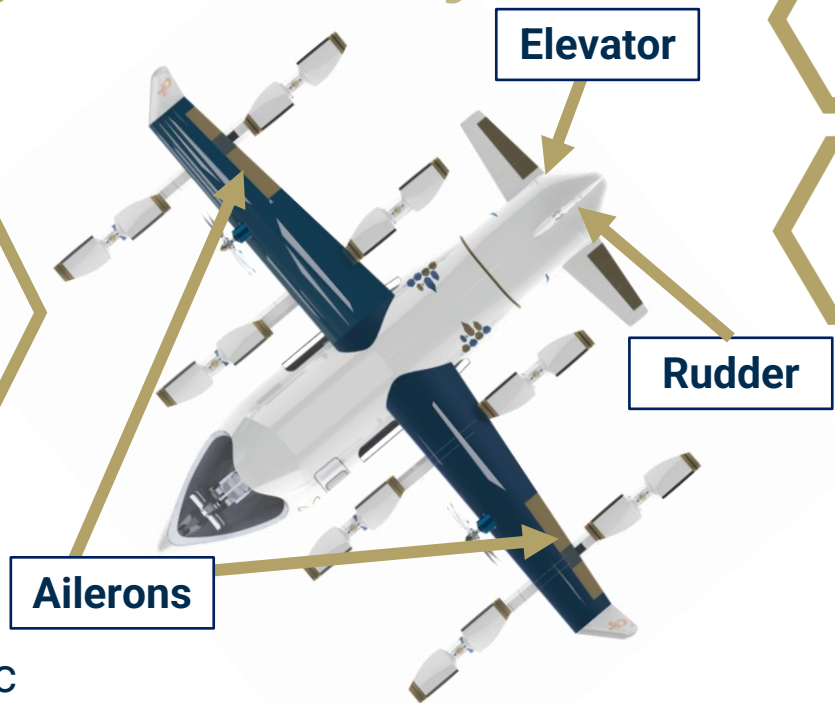




# Cruise: Comfort, Simplicity and Safety



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

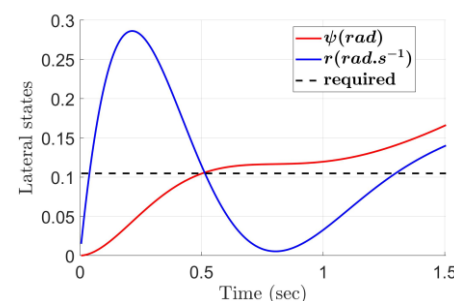
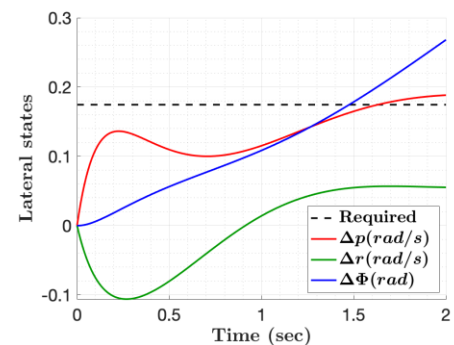
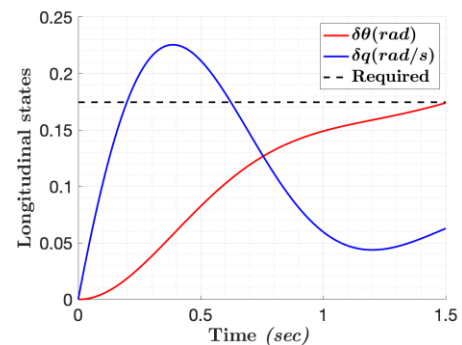
- ✓ Longitudinal and Lateral dynamic stability
- ✓ Good handling qualities
- ✓ Capable of 10-deg pitch, 10 deg roll or 6 deg heading changes within less than 1.5 seconds
- ✓ Balto can maintain symmetry of flight even with one failed engine

## 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





**Thank You for  
Reading**