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
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.

DesignCapabilities

• 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”
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

<table>
<thead>
<tr>
<th>Mission range</th>
<th>160 km (100 mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balto’s range</td>
<td>252 km (156 mi)</td>
</tr>
<tr>
<td>Balto’s cruise speed</td>
<td>105 knots</td>
</tr>
<tr>
<td>Mission completion time</td>
<td>49 min</td>
</tr>
</tbody>
</table>
Balto’s Key Features

- Winglets for increased aerodynamic efficiency,
- Aerodynamically enhanced empennage focused on maximizing loading ramp area
- Optimized rotor design for minimal drag during cruise
- Completely de-coupled lifting and cruise mechanisms for enhanced performance and safety
- Extreme energy absorbing landing gear
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

- Cockpit access
- Carry on, personal items, tie-down storage
- Medical equipment secure storage
- Side access door
- Screen for audio and visual communications
- Ramp Access
- Crashworthy Executive Seats
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

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{be}$</td>
<td>90 knots</td>
</tr>
<tr>
<td>$V_{br}$</td>
<td>105 knots</td>
</tr>
<tr>
<td>$V_{MO}$</td>
<td>160 knots</td>
</tr>
<tr>
<td>Max Service Ceiling</td>
<td>14,000 m (45,900 ft)</td>
</tr>
<tr>
<td>Max Takeoff Altitude (density altitude)</td>
<td>7,100 m (23,300 ft)</td>
</tr>
</tbody>
</table>
Over 500,000 blade planforms studied to find the optimal for the Balto
Efficient Cruise Propellers

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
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