IBIS

Executive Summary
Undergraduate Design Team
University of Maryland, College Park

41st Annual Vertical Flight Society Student Design Competition

Sponsored by DEVCOM ARL

Introducing *Ibis*

The University of Maryland undergraduate team presents ***Ibis*** as its solution to the Vertical Flight Society's 41st annual student design competition Request for Proposal (RFP). ***Ibis*** is named after the american White Ibis, which, according to native american folklore, is the last bird out and first one back after a storm. With the capability of nearly 11 hours in loiter, payload carrying capacity of almost 60 kg, and a versatile yet reliable design, ***Ibis*** is truly unlike any other UAV on the market. The robust structures and user-friendly mechanisms allows ***Ibis*** to pinpoint victims and offload lifesaving supplies without the need for special training or tools on the ground.

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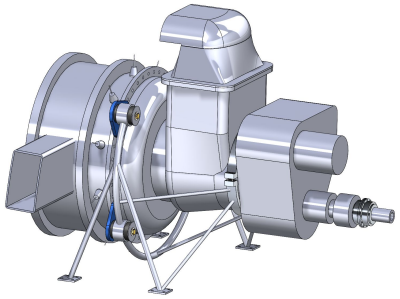
Ibis: First Bird Out, Last One Back

Proven and Available Technologies

- High Technological Readiness for All Components



Highly Efficient Aerodynamic Design Enables Exceptional Performance

- High Performing Rotor
- Streamlined Fuselage
- Low Drag Hub Fairing

Single Aircraft Configuration

- Rapid Multi-Mission Reconfiguration

Safe Autonomous Flight

- Controllable from Anywhere in the World
- Fly Safely in Unmapped Territories

Accessible for Untrained Operators

- Simple to load with minimal experience

Max Payload	59 kg (130 lbs)
Max Endurance	10.8 hours
Empty Weight Fraction	55%
Installed Power	36.8 kW (50 HP)
Cruise L/D	5.23

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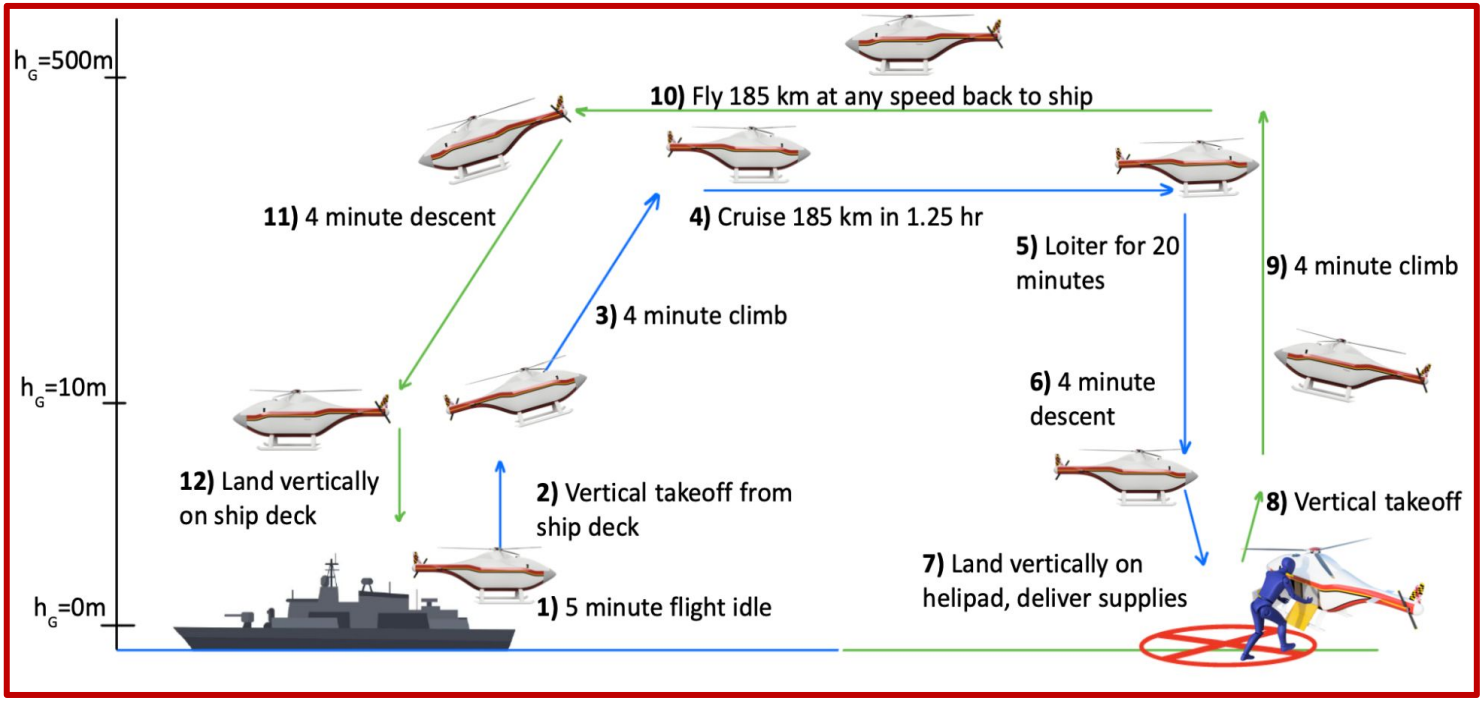
One Configuration, Two Missions



Supplies Delivery Requirements

- 50 kg Payload

Ibis Capabilities

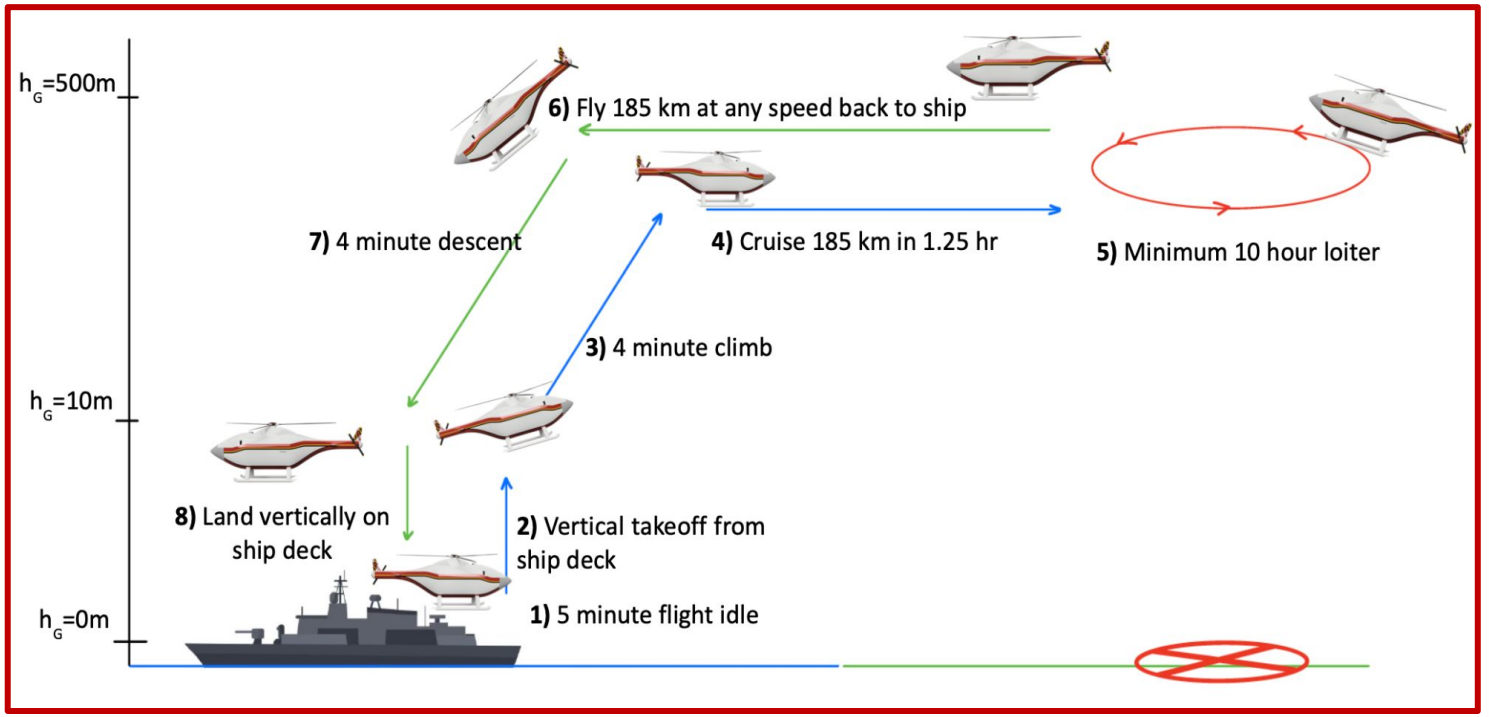
- 59 kg Payload
- 684 km Range

Long Endurance Requirements

- 10 Hour Loiter
- 20 kg Payload

Ibis Capabilities

- 10.8 Hour Loiter



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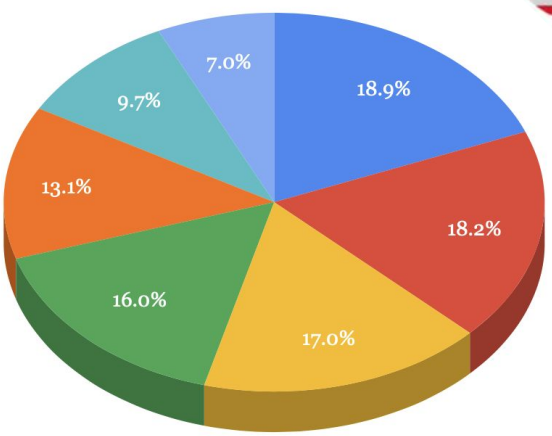
Vehicle Configuration Selection

Configuration Space



DOWNSELECTION

Single Main Rotor vs. Tandem

FINAL SELECTION

Single Main Rotor

- Mechanically Simple
- Reliable
- Proven Technology
- Industry Standard

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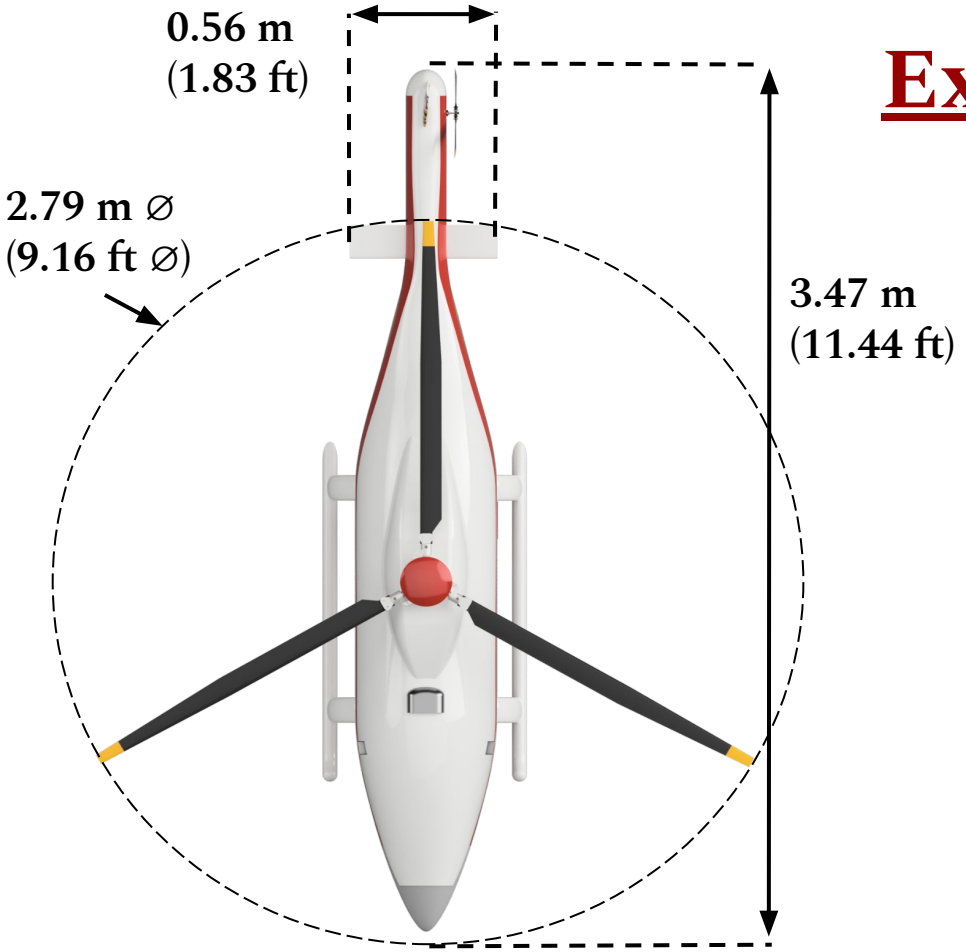
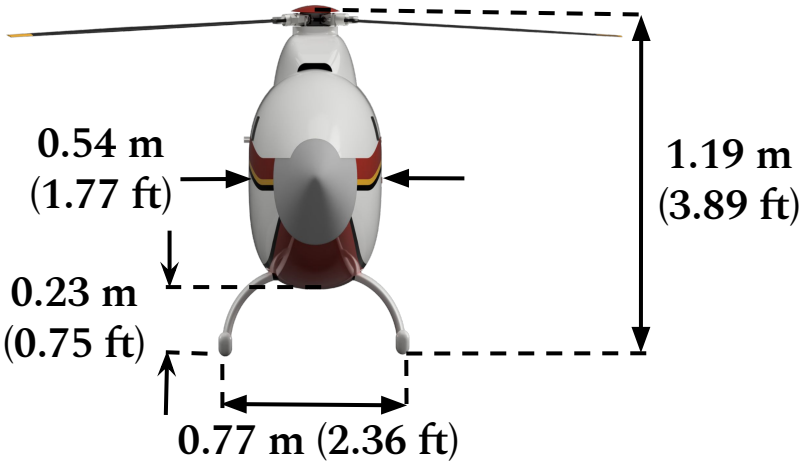
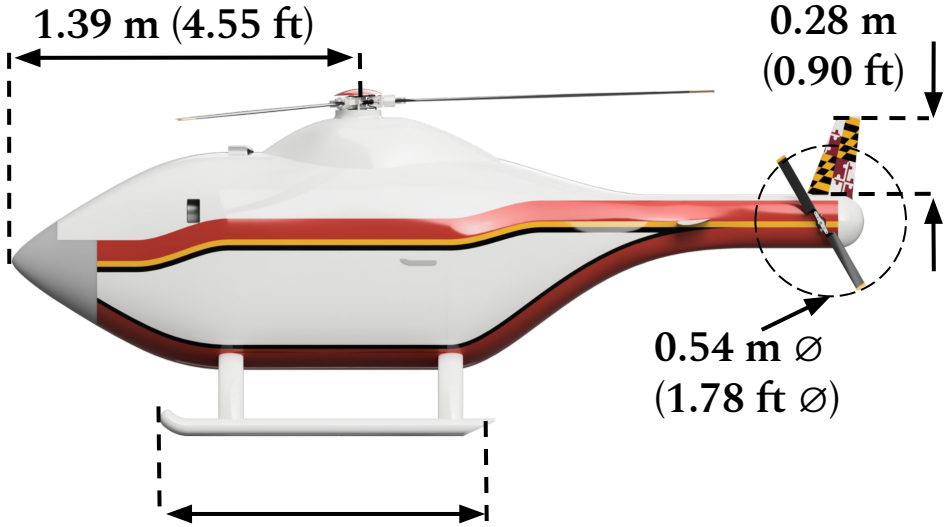
External Dimensions





Footprint: 2.79 m x 3.47 m
(9.16 ft x 11.44 ft)



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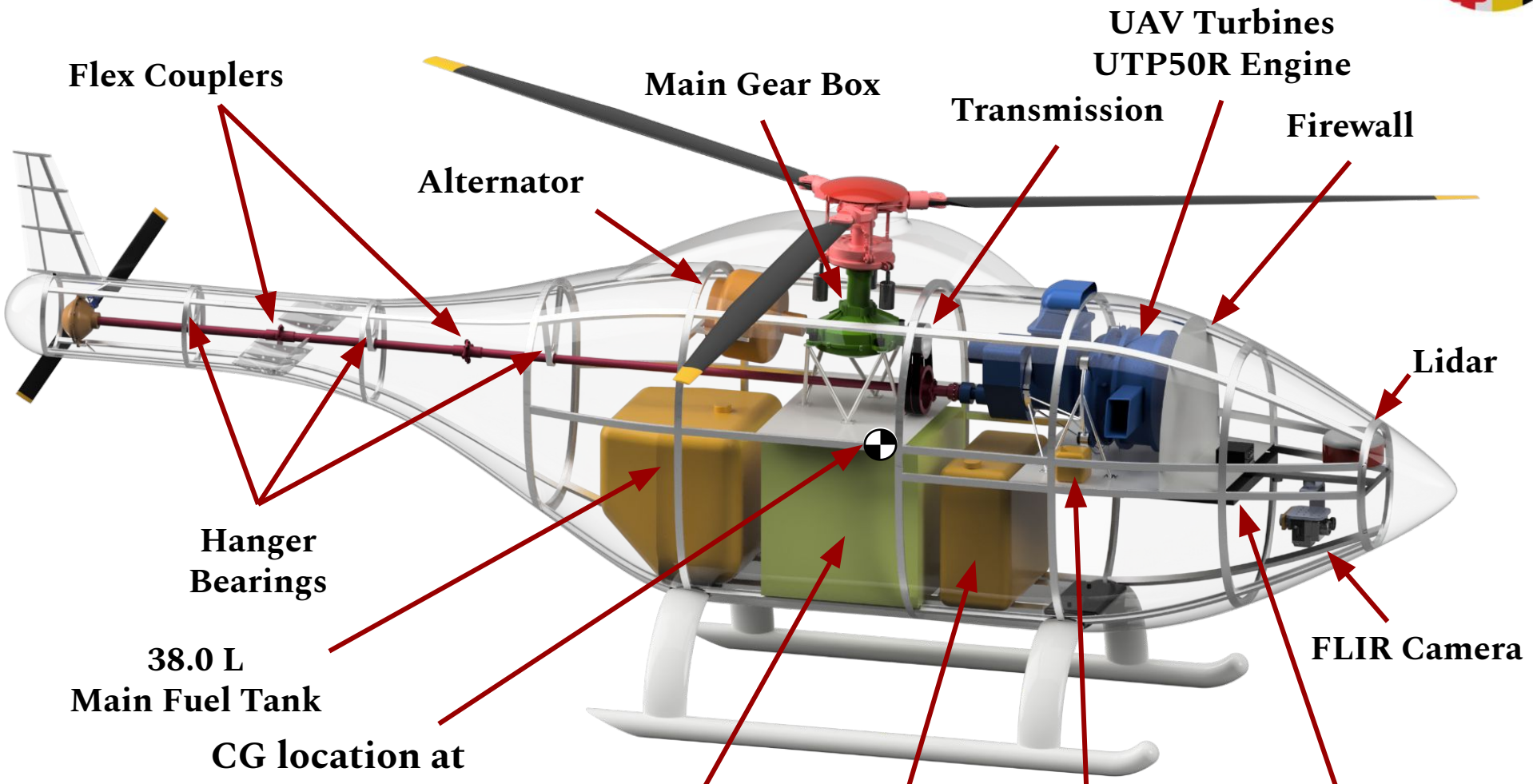
Compact Internal Packaging



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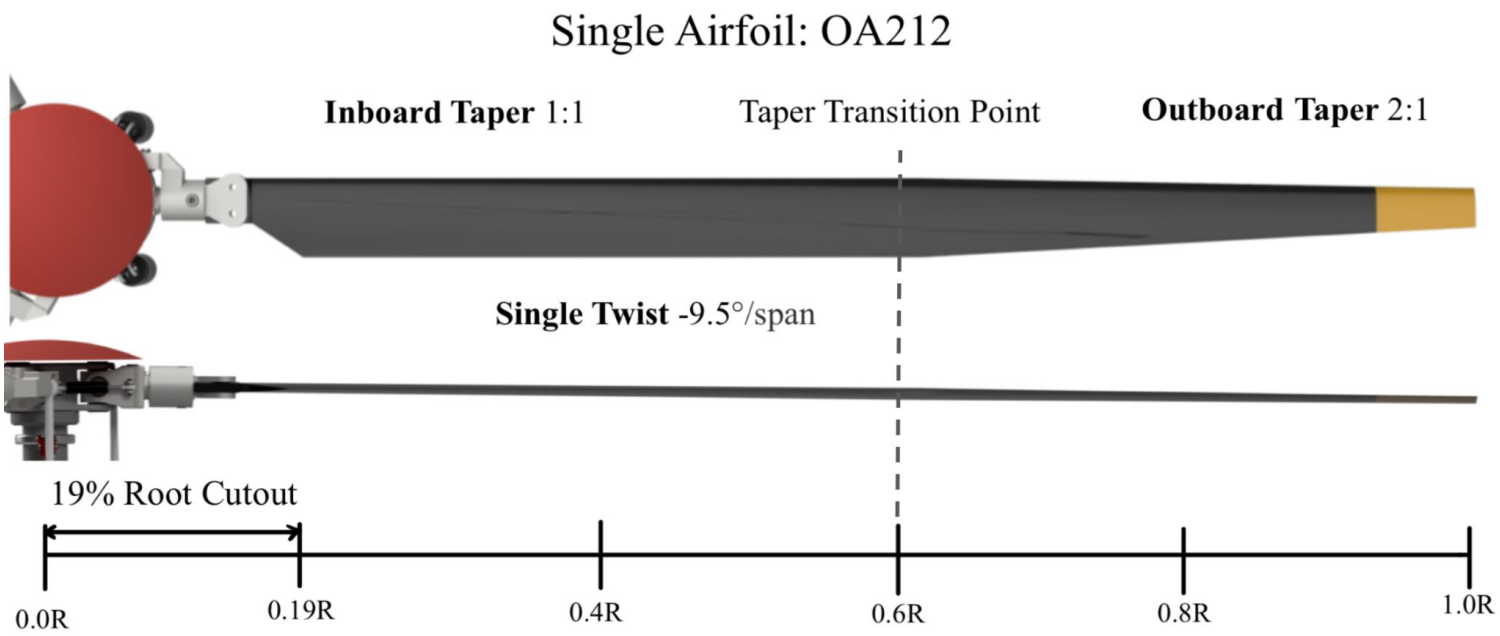
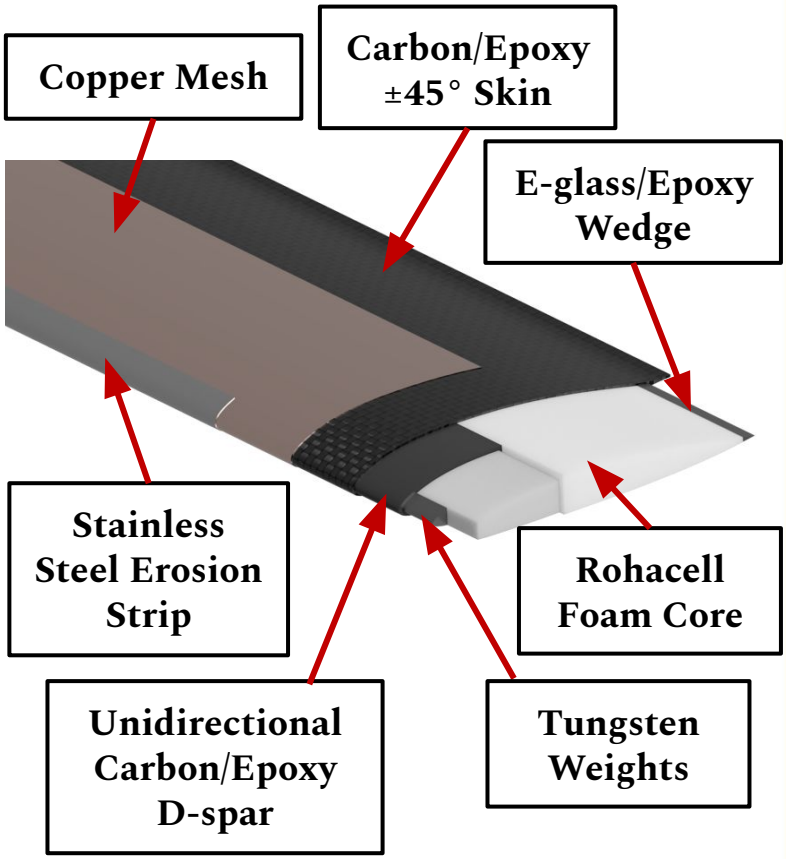
High performance and Durable Rotor Blades



Highly effective design to enable exceptional vehicle lift-to-drag ratio

Main Rotor	
Blade Number	**3**
FM	**0.82**
L/D_{Cruise}	**5.23**
C_T/σ	**0.12**
M_{tip} in Cruise	**0.68**
Disk Loading	**23.92 kg/m^2 (4.9 lb/ft^2)**
Power Loading	**8.55 kg/kW (14.05 lb/HP)**



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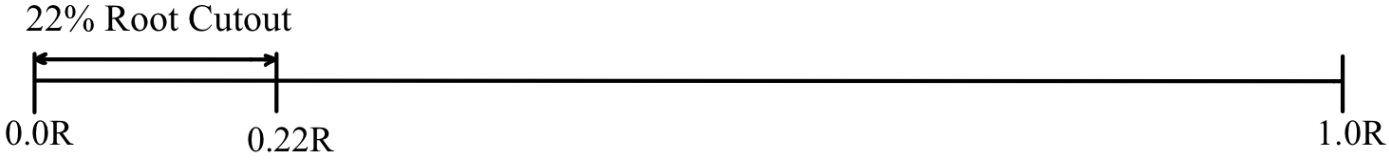
Proven Technology Tail Rotor and Empennage

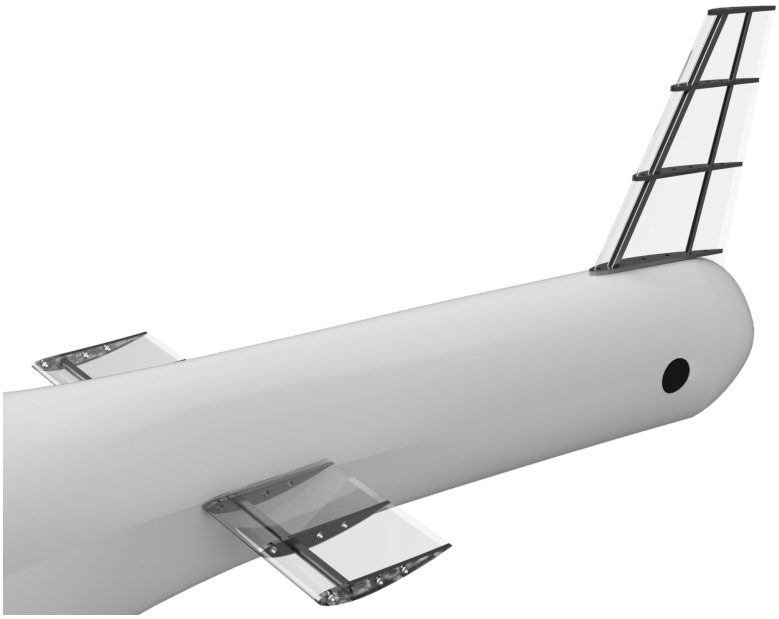
Single Airfoil: OA209

Single Twist: -10°/span



Tail Rotor	
Blade Number	**2 - Teetering**
Aspect Ratio	**6.77**
FM	**0.765**
C_T/σ	**0.093**

Simple blade design for easy manufacturing



Empennage	
Selected Airfoil	**NACA4412**
Incidence Angle	**6° (Max L/D)**

- **Vertical tail fully counters main rotor torque in cruise**

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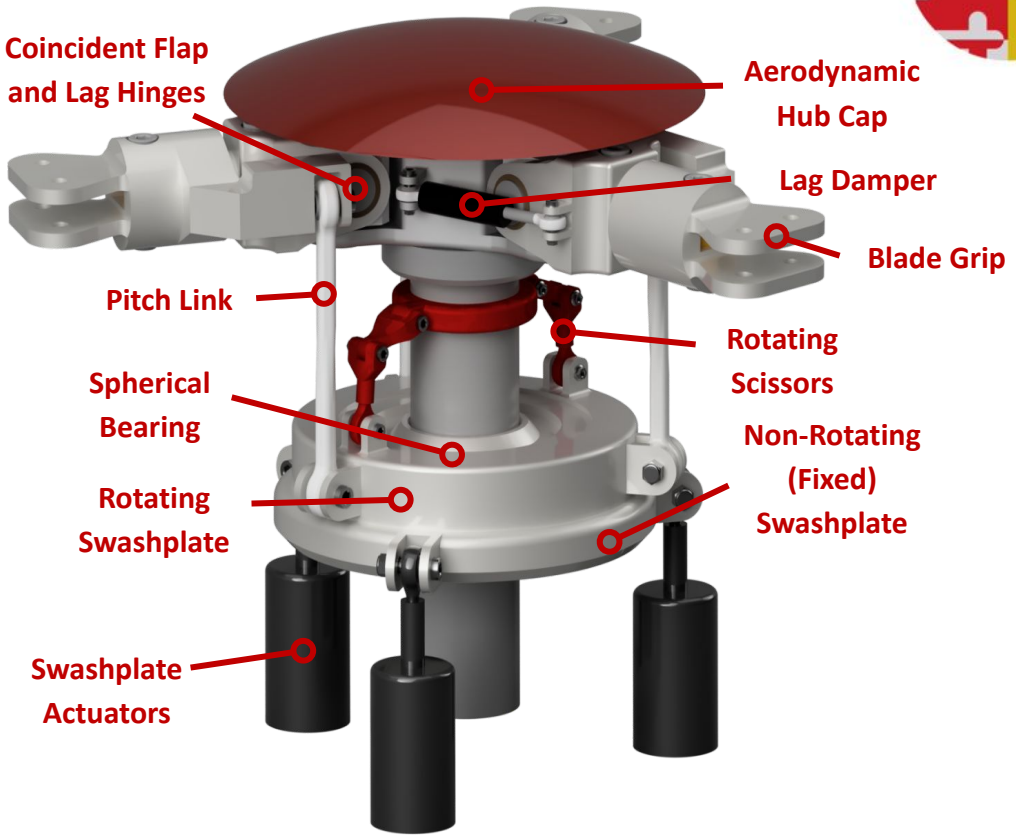
Hub Design

Proven, Reliable, and Gust Tolerant

- Articulated 3-bladed Rotor Hub
- Commercially Available Components

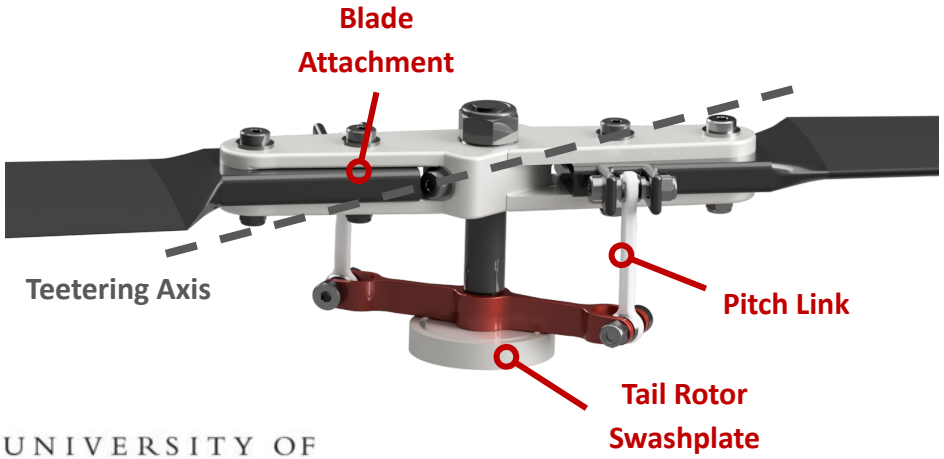
Flap Frequency	Lag Frequency
1.05 /rev	0.31 /rev

Main Rotor Hub



- Teetering 2-bladed Tail Rotor
- 45° δ_3 angle to limit blade flapping

Tail Rotor Hub



Simple Design

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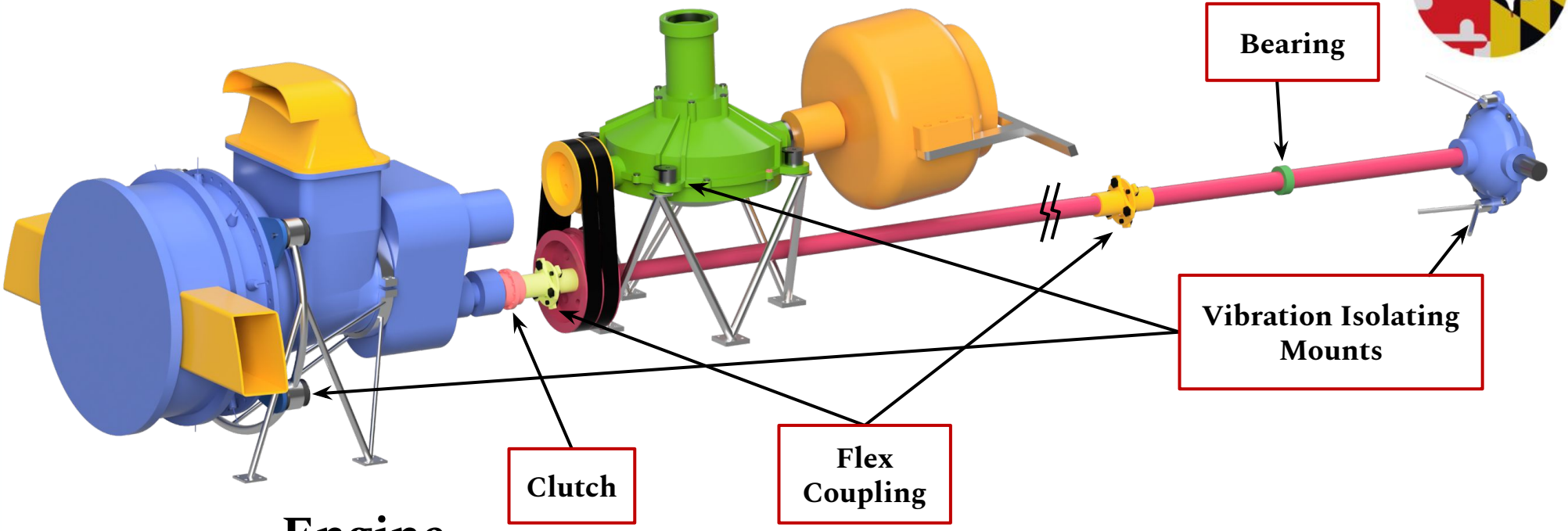
Reliable Transmission Design



UAV Turbines - UTP50R

- Recuperating gas-turbine engine improves efficiency by recovering exhaust gasses to boost efficiency
- Produces 37 kW at 31.8 kg (1.16 kW/kg) with a SFC of 0.25 kg/(kW*hr).

Main Transmission

- Reliable belt drive system for low weight and
- Easy maintenance and Disassembly
- Large transmission components supported on vibration isolators
- Transmission shaft supported with elastomeric bearings
- Aluminum casting suitable for marine environment

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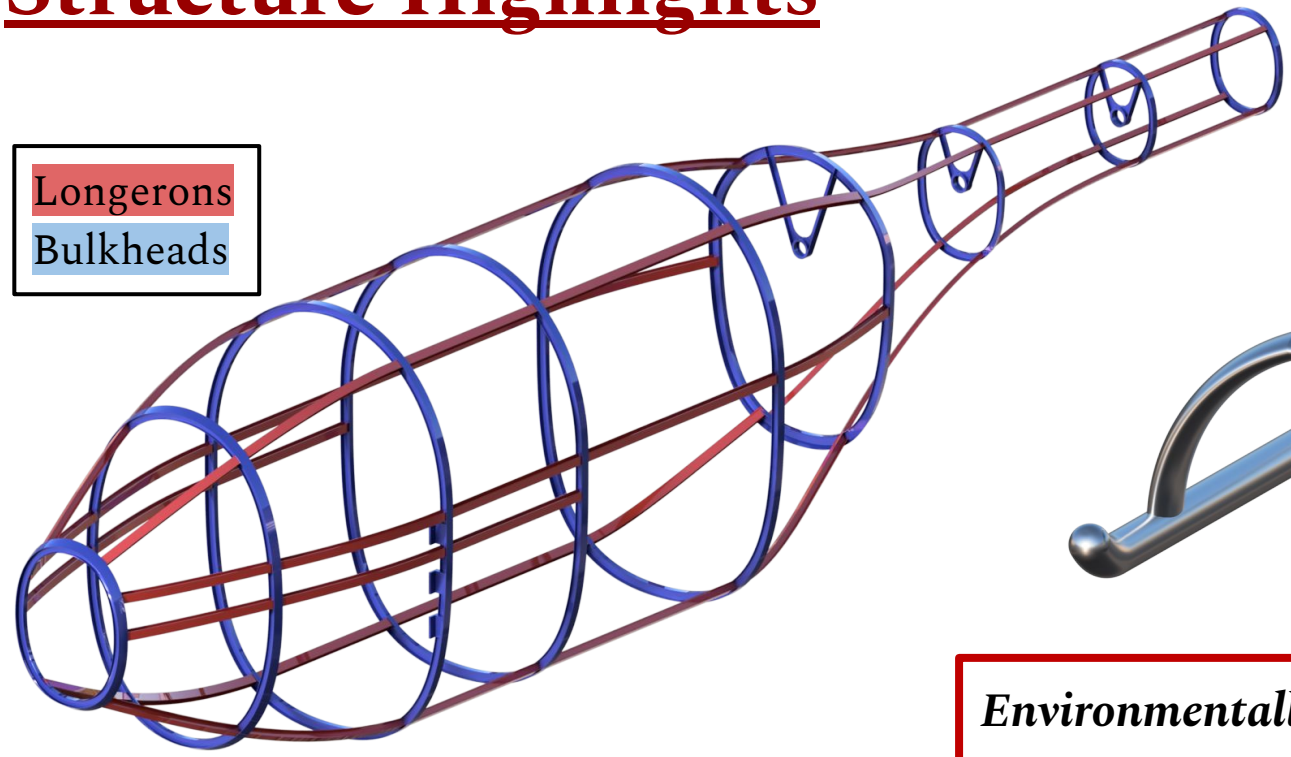
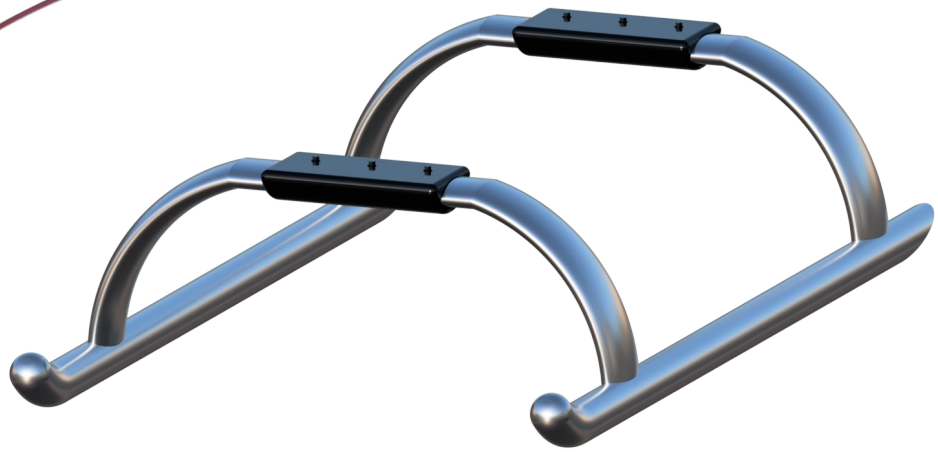
Structure Highlights

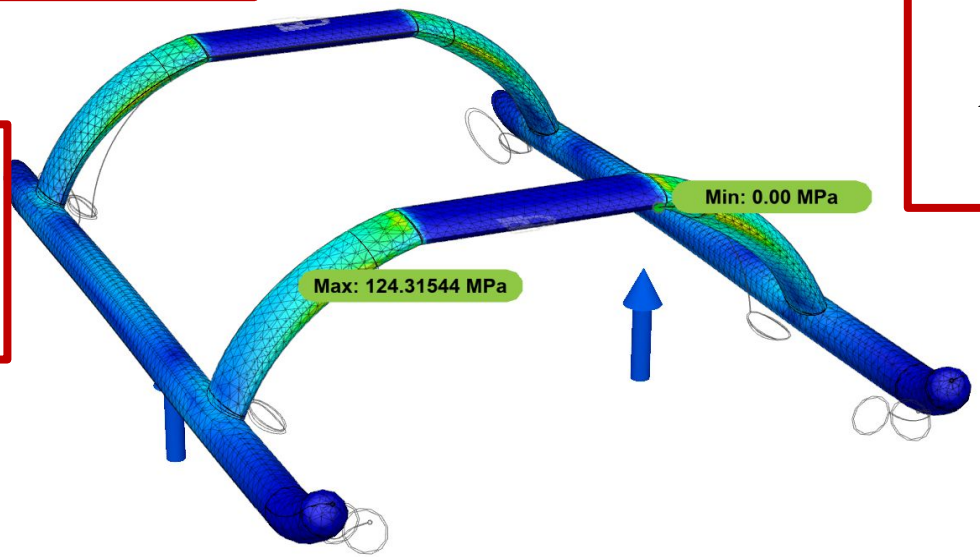
Longerons
Bulkheads





Environmentally Adaptable Skid Landing Gear

Supportive Airframe Structure



Designed to AR-56 Loading Standards for Ship Deck Landing

Materials Chosen to Withstand the Marine Environment

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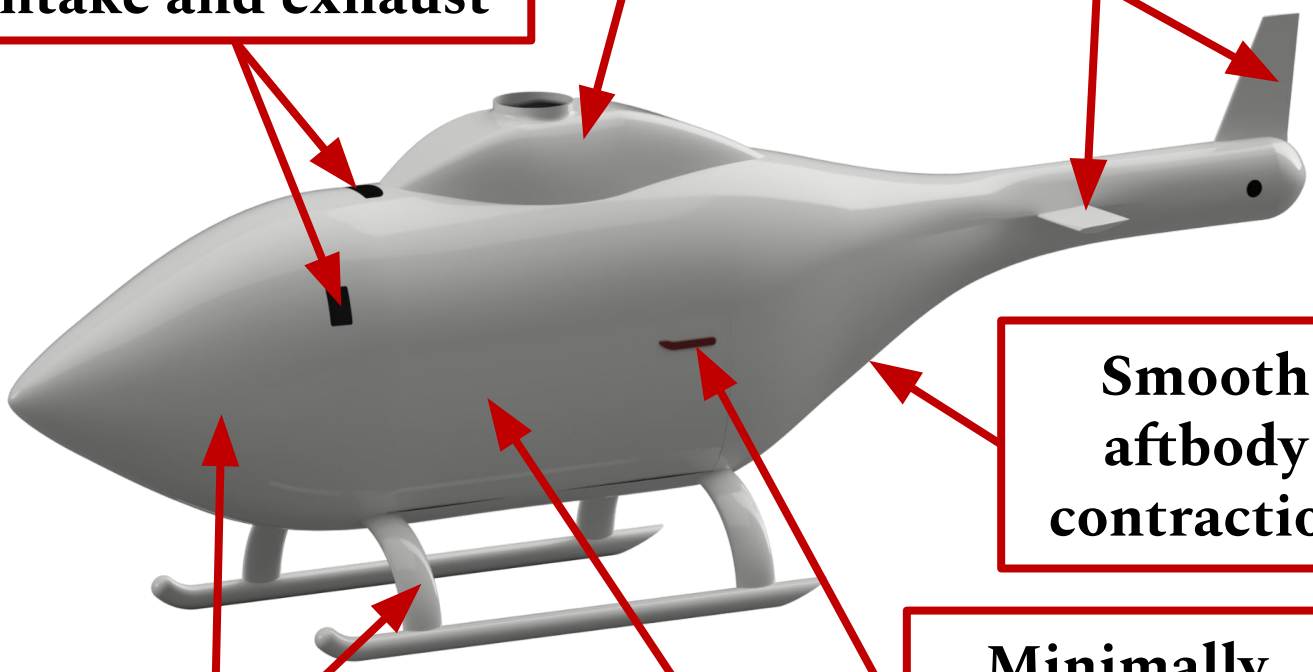
Streamlined, Aerodynamic Aircraft

Vehicle Equivalent Flat Plate Area	0..117 m^2 (1.26 ft^2)



Hub drag reducing shroud

Minimized openings for engine intake and exhaust

NACA4412 empennage airfoils

Smooth aftbody contraction

Minimally protruding door handle

Low drag nose cone and landing gear

Door flush with fuselage

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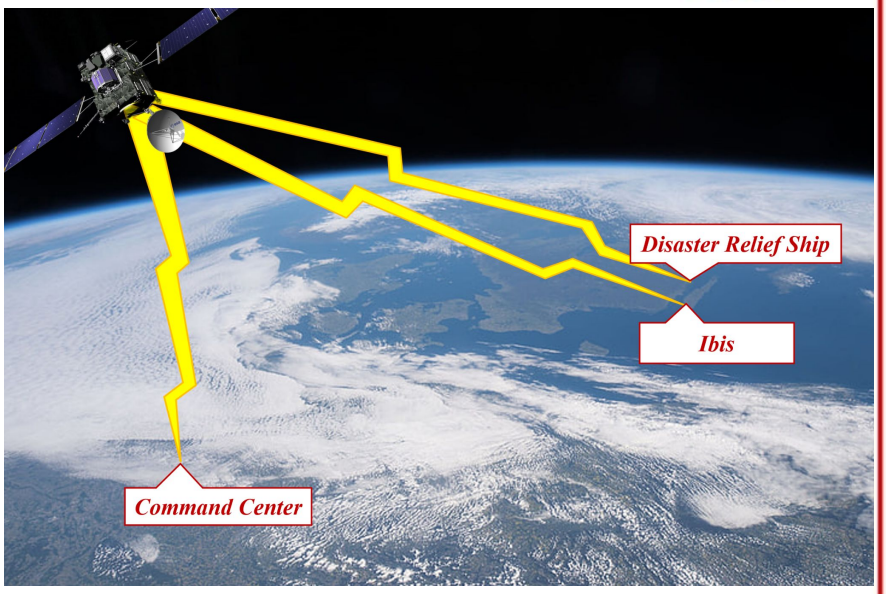
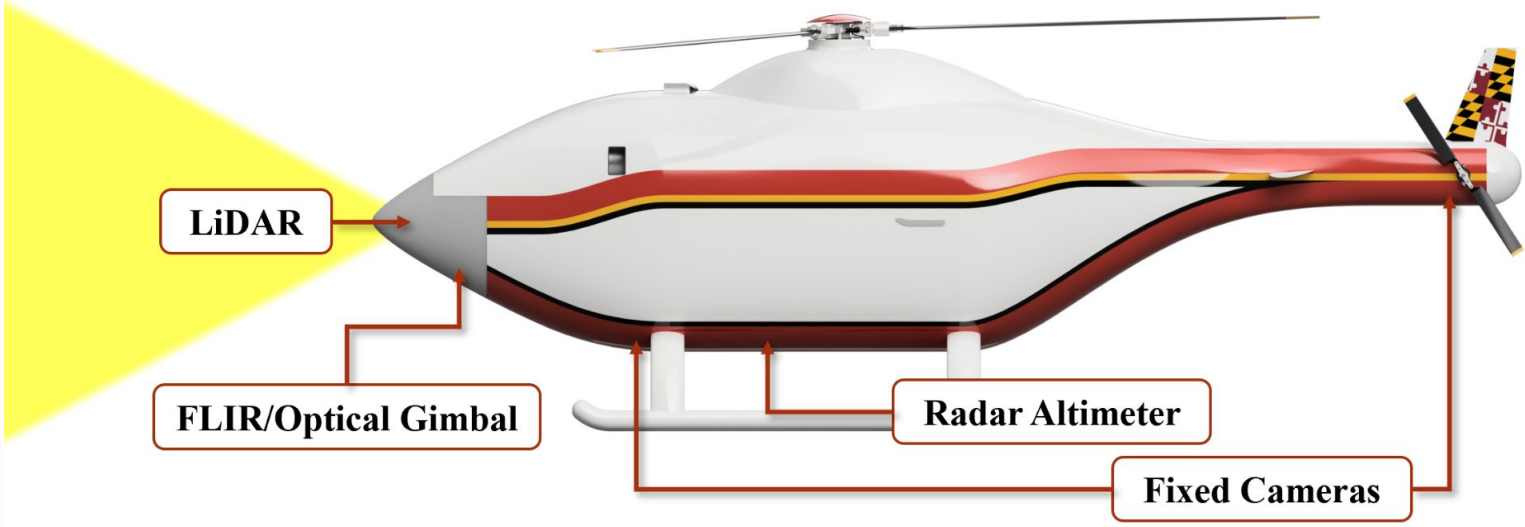
Avionics: Fly Without Pilot Intervention

- Wide viewing sensors and onboard processing allow *Ibis* to navigate unmapped terrain autonomously
- Communication equipment to maintain contact anywhere
- Sensing to see and avoid other aircraft





Ibis's Sensor Locations

- **Autopilot:** GPS/INS/ADS-B
- **FLIR/Optical Camera:** Aids in search and rescue
- **LiDAR:** Enables object avoidance
- **Flight Control Computer:** fuses sensor data
- **Fixed Cameras:** For landing
- **Radar Altimeter:** Accurate altitude measurement

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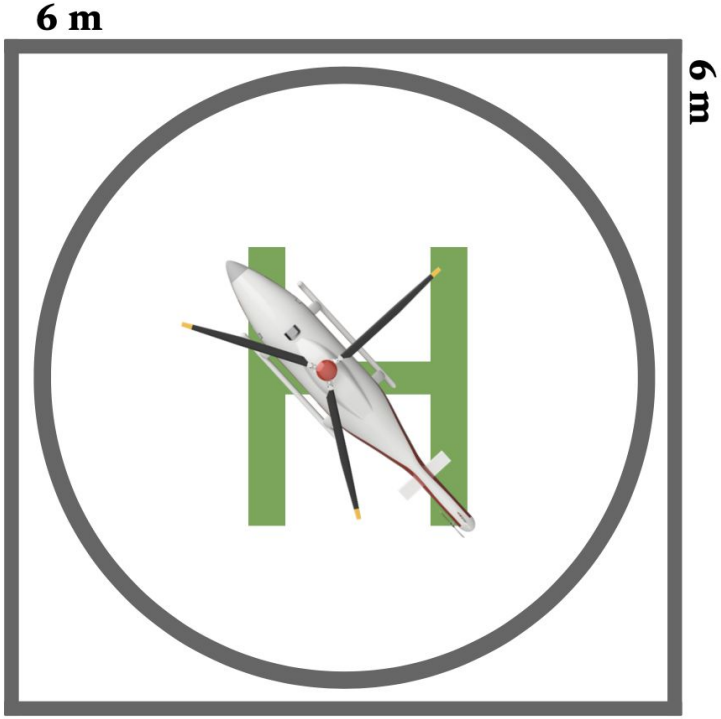
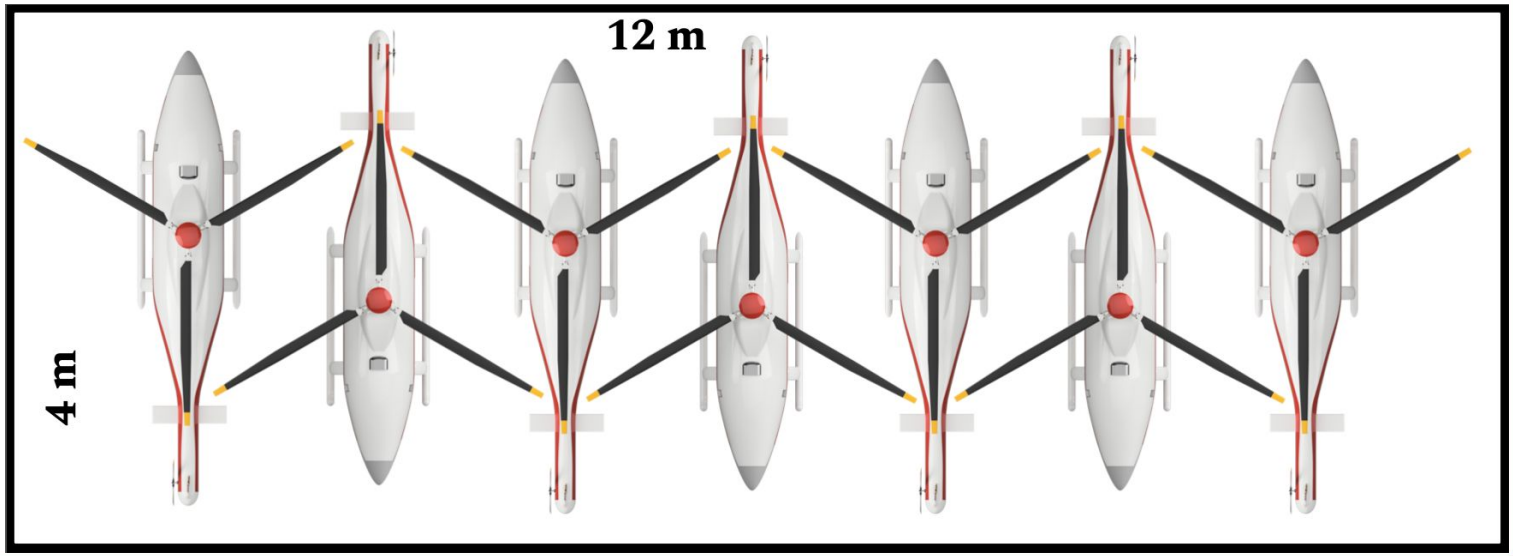
Seamless Integration into Shipboard Environment



Minimal Ground Equipment for Ease of Maneuvering

Comfortably Lands within Confined 6x6 m Landing Zone

7 UAS within Storage Dimensions



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Single Configuration, Modular Tailoring

Removable Payload Ramp keeps Supply Receivers Safe

Removable Fuel Tank Allows Adjustable Empty Weight

More Room = More Missions

Audio and Visual Warnings Reduce Risk for both Trained and Untrained Operators

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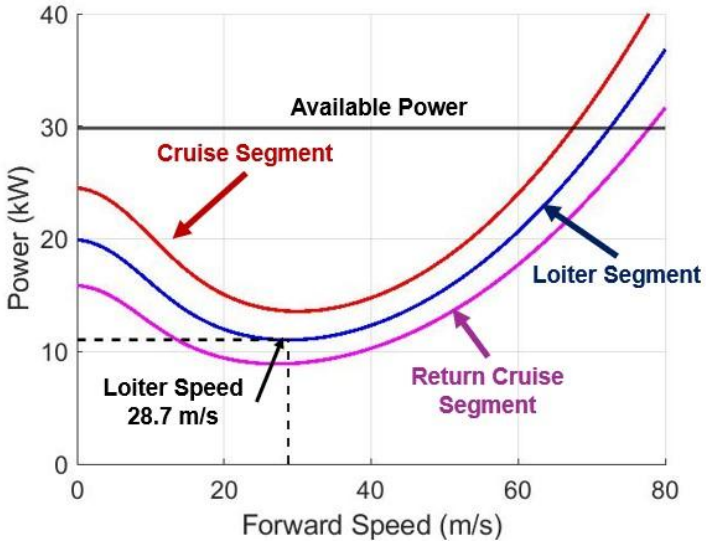
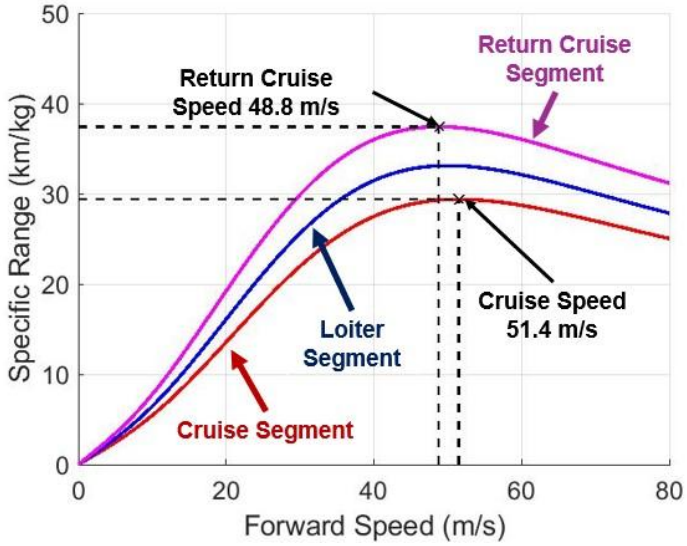
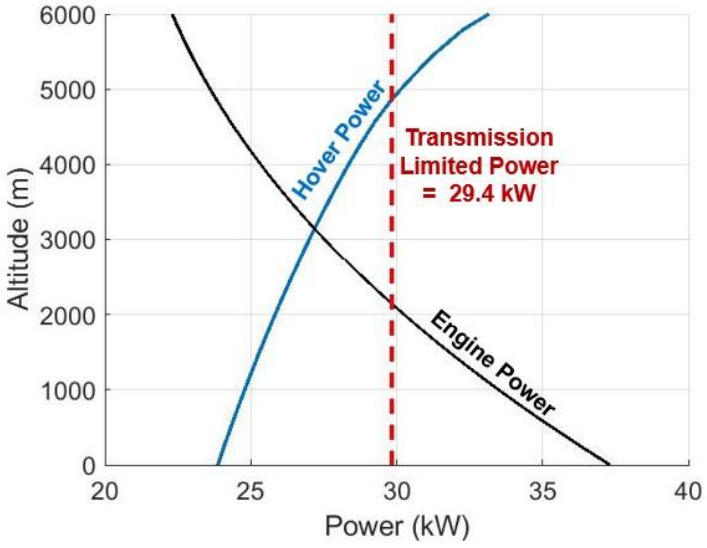
Exceptional Vehicle Performance

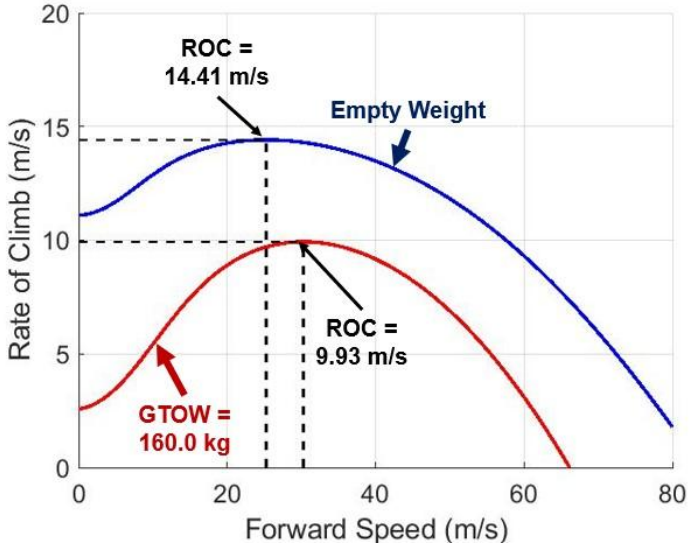




Loiter Speed: 28.7 m/s (56 kts)
Low Power, Long Loiter

Cruise Speed: 51 m/s (100 kts)
Low Fuel, Fast Response





High hover ceiling of 3040 m (10000 ft)

Quickly climb to operating altitude

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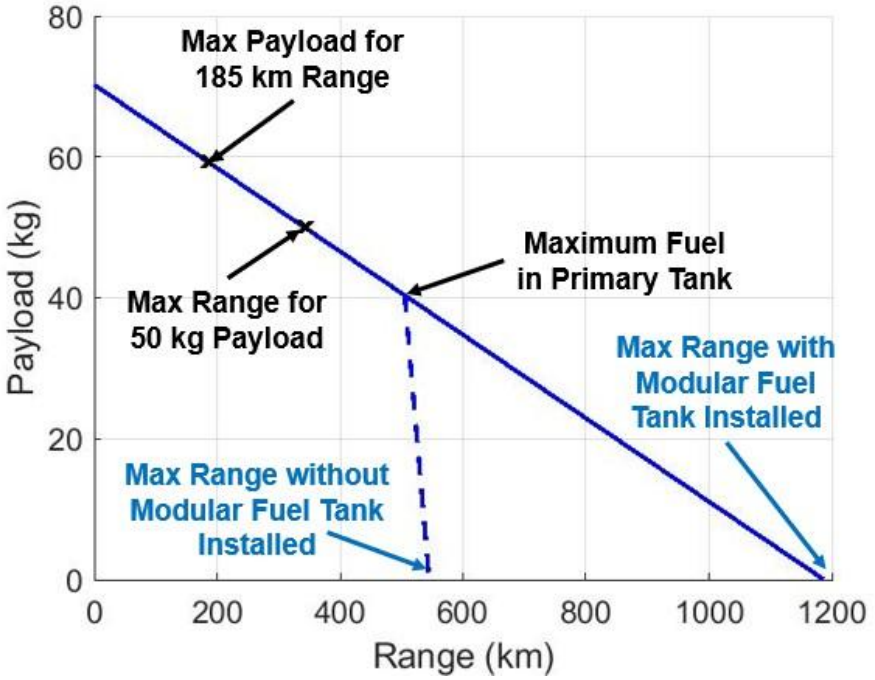
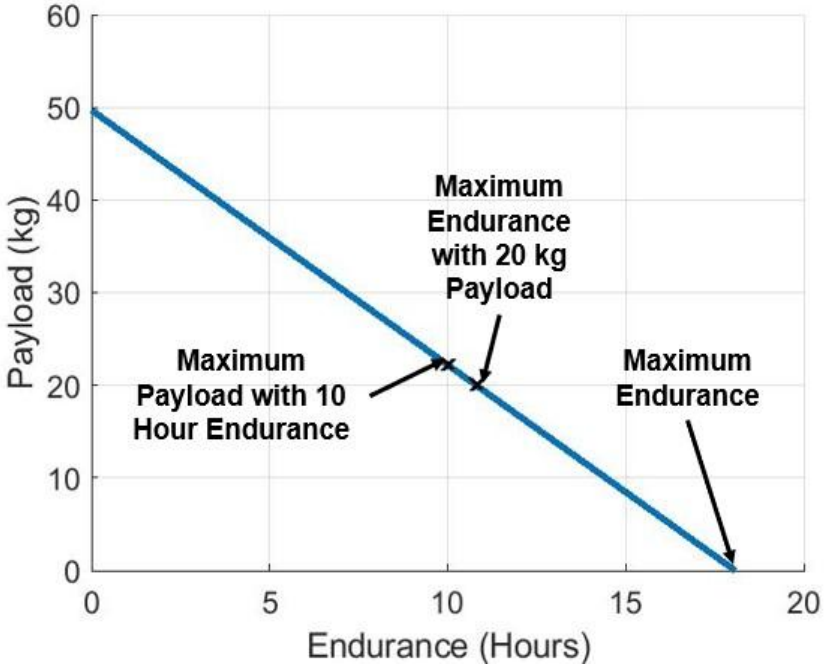
Superior Mission Capabilities

Ibis' **performance surpasses the needs of both missions with a single efficient design.**

Supplies Delivery Mission	
Maximum Range	342 km (213 miles)
Largest Supplies Payload	59.3 kg (130.7 lbs)





Long Endurance Mission	
Maximum Loiter Time	10.8 Hours
Largest Communications Package	22.2 kg (48.9 lbs)

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Cost and Weight Breakdown

Component		Weight - kg (lb)	% of Empty Weight
Rotors	Main	6.93 (15.27)	7.88
	Tail	0.11 (0.24)	0.12
Airframe	Skin	8.73 (19.25)	9.94
	Frame	7.74 (17.08)	8.82
	Paint	0.38 (0.83)	0.43
	Door	2.78 (6.12)	3.16
	Horizontal Tail	0.16 (0.34)	0.18
	Vertical Tail	0.12 (0.26)	0.13
Landing Gear		5.59 (12.32)	6.36
Propulsion	Engine	34.85 (76.85)	39.67
	Alternator	4.04 (8.90)	4.59
	Firewall	0.19 (0.41)	0.21
Fuel System	Fuel Tank Main	0.29 (0.64)	0.33
	Modular Fuel Tank	0.18 (0.40)	0.21
	Collector	0.01 (0.02)	0.01
Drive System	Main Gear Box	6.69 (14.75)	7.61
	Tail Drive Shaft	1.77 (3.89)	2.01
	Tail Gear Box	0.47 (1.03)	0.53
Avionics		6.86 (15.12)	7.80
Empty Weight		**87.86 (193.73)**	100.00
Fuel Weight - Supplies		12.00 (26.45)	
Fuel Weight - Endurance		48.87 (107.74)	
Payload - Supplies		50.00 (110.25)	
Payload - Endurance		20.00 (44.10)	
*Additional Fuel + Payload - Supplies		10.14 (22.35)	
*Additional Fuel + Payload - Endurance		3.27 (7.21)	
GTOW		**160.00 (352.80)**	

55% Empty Weight Fraction

Aircraft Subsystem	Cost ($)
Main Rotor	8,860
Tail Rotor	1,170
Avionics	55,000
Airframe	50,700
Powerplant	37,000
Final Assembly	50,000
Total Cost:	**202,730**

***Ibis** offers an Affordable, Market-Competitive Cost: $202,730*

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Summary

In response to the RFP for the 2023-2024 VFS Student Design Competition, sponsored by ARL, the University of Maryland undergraduate team presents the *Ibis*. Taking to the skies mere minutes after natural disasters ravage coastlines and cities, *Ibis* stands ready to provide aid to those left at the mercy of mother nature. *Ibis* is capable of delivering payloads of over 55 kg of life-saving supplies 185 km away from its takeoff point and acting as a temporary communications relay for over 10 hours in the critical time frame after a natural disaster.

Ibis uses proven single main rotor/tail rotor technology with a maximum takeoff weight of 160 kg. It boasts a lightweight, mechanically simple structure and uses proven technology in every aspect of the design. Able to tolerate wind gusts in all directions with a 3-bladed, fully articulated rotor and with its marinized landing gear and outer skin, *Ibis* sails the high seas, ready to be deployed at a moment's notice.

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