



38th Annual VFS Student Design Competition

2025 Unmanned Vertical Lift for Medical Equipment Distribution

Sponsored by Boeing



Alfred Gessow Rotorcraft Center
Department of Aerospace Engineering
University of Maryland
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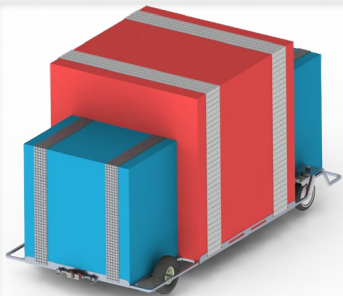
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To the Vertical Flight Society:

The members of the University of Maryland Graduate Student Design Team hereby grant VFS full permission to distribute the enclosed Executive Summary and Final Proposal for the 38th Annual Design Competition as they see fit.

Thank you,
The UMD Graduate Design Team

Alicorn: Designed for Swift Medical Delivery



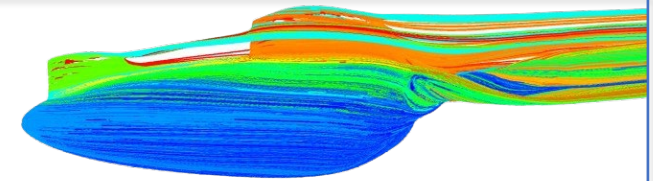
Safe, convenient and quick delivery

- Lightweight, reliable loading and unloading mechanism
- Payload is autonomously delivered with a wheeled cart for convenience



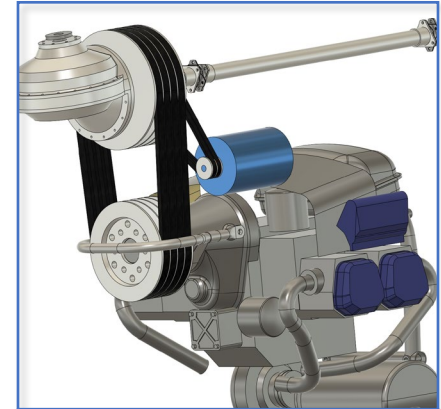
Efficient Rotor Blades

- 3 bladed rotor with efficient overlap
- optimized for high-speed cruise and hover



Streamlined for exceptionally high speeds

- Optimized after >20 iterations



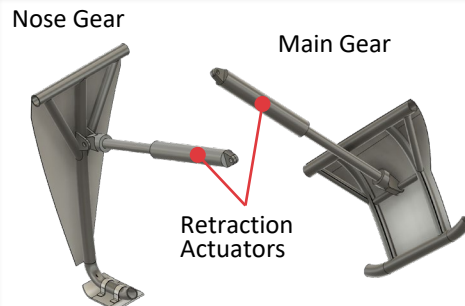
Powerful Propulsion

- High power for high speeds



State-of-the-art avionics

- Long-range, robust sensing and powerful processing for high-speed navigation and situational awareness



Retractable Skids

- Reduces aircraft drag
- Large base area for exceptional stability on uneven terrain
- Facilitates gravity-based unloading

Empty Weight	221 kg (487 lb)
Max Payload	100 kg (220 lb)
Max Speed	90 m/s (175 kts)
Installed Power	104 kW (141 hp)
Cruise Noise	63.1 dB(A)
Rotor Radius	1.565 m (5.13 ft)

Alicorn: Mankind's Lifeline



The unicorn's horn, also known as **Alicorn**, was considered as one of the most valuable assets a person could possess in the early European and Asian cultures, due to its magical healing powers. According to legend, **Alicorn** has water purification properties and was recommended against contagious



diseases. **Alicorn** also refers to a combination of a unicorn and a winged horse or Pegasus with the ability to fly. They are said to represent the forces of good that protects the world from evil.

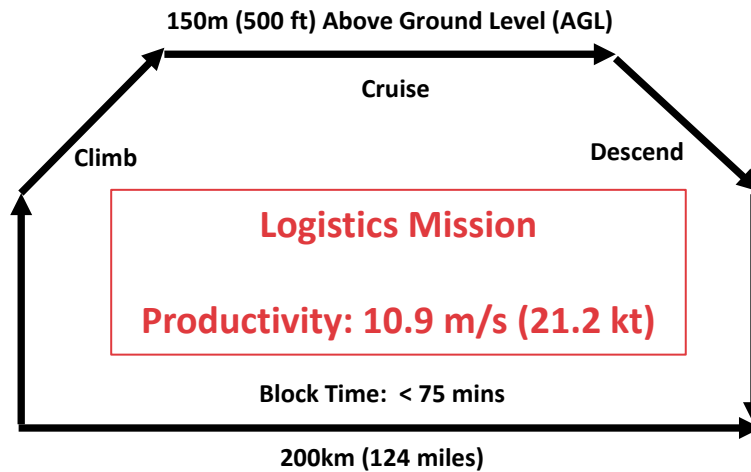
Alicorn, the tandem rotor **autonomous unmanned air vehicle**, designed by the University of Maryland Graduate Design Team, was designed to provide relief in pandemics and natural disasters by delivering essential medical supplies to affected communities at a **high speed**. The **streamlined** aircraft offers an exceptional productivity for the bulky payload requirement. **System safety** and **customer satisfaction** are at the very heart of **Alicorn**. **Superior payload handling** and **autonomous loading** and **unloading** provides ground personnel with **convenience**, while ensuring the **safety** of the **package** and the **surroundings**. **Alicorn's** multi-mission capability keeps it from idling between disasters.

With its remarkable speed and high capacity, **Alicorn** is on standby to save the world in any disaster, giving mankind a true lifeline.

Mission Profile



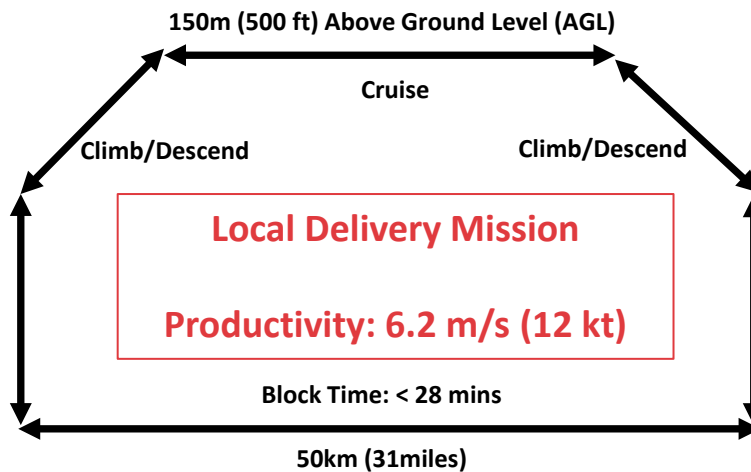
Launch Site:
 Load Package: 5 minutes
 Warm Up: 5 minutes
 Takeoff HOGE: 2 minutes



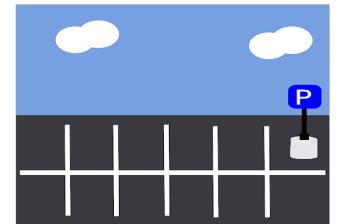
Destination:
 Land: 1 minute
 Unload Package



Launch Site:
 Load Package: 5 minutes
 Warm Up: 5 minutes
 Takeoff HOGE: 2 minutes
 Land: 1 minute



Destination:
 Land: 1 minute
 Unload Package
 Takeoff HOGE: 1 minute



Alicorn far exceeds RFP specifications with its exceptional capabilities:

	Requirement	Alicorn's Capability
Block Time (Local Delivery)	28 min	23 min
Block Time (Logistics Mission)	75 min	51 min
Operational Size	6.1 x 6.1 m (threshold)	4.6 x 4.6 m (objective)
Safe flight after failure	15 min followed by landing (threshold)	Return to launch site abort for Local Delivery (objective)

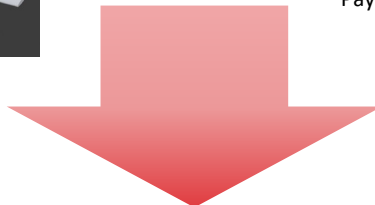
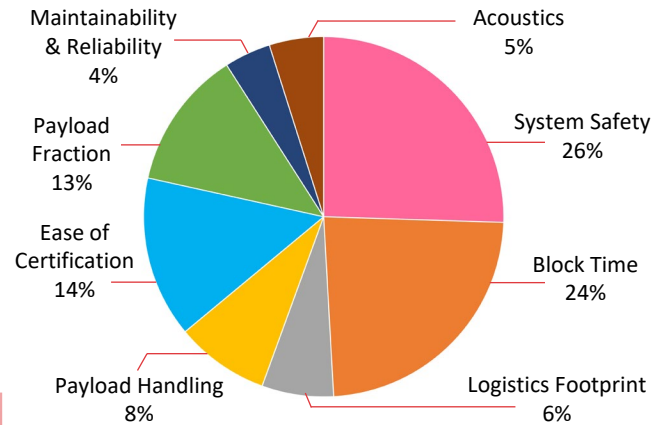
Vehicle Configuration



Configuration Space



Design Drivers



Downselection

Single Main Rotor

Tandem



Final Selection

Tandem Configuration

- Compact Design
- Low Disk Loading
- High CG tolerance
- High payload capacity
- Streamlined body
- Loading/Unloading from rear



Aerodynamically Optimized Fuselage

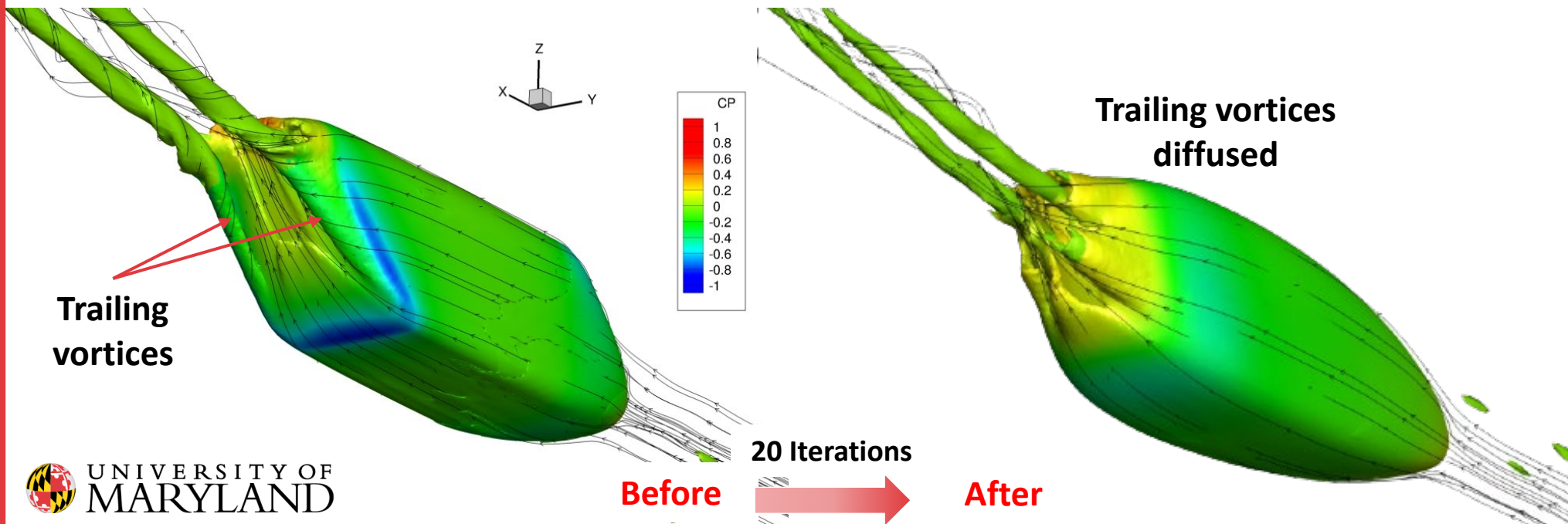


- » Streamlined fuselage obtained using advanced CFD analysis
 - **56%** reduction in drag after more than **20 iterations**
 - Optimized nose shape
- » Exceptionally low flat plate area of **0.182 m² (1.96 ft²)**
- » Rear clamshell doors designed to diffuse the twin trailing vortices

Final fuselage shape

Optimized Nose

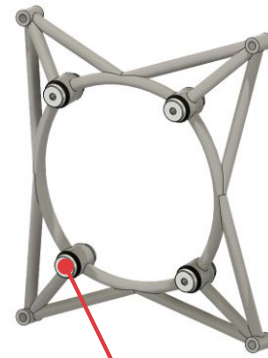
Clamshell doors



Sturdy Structure

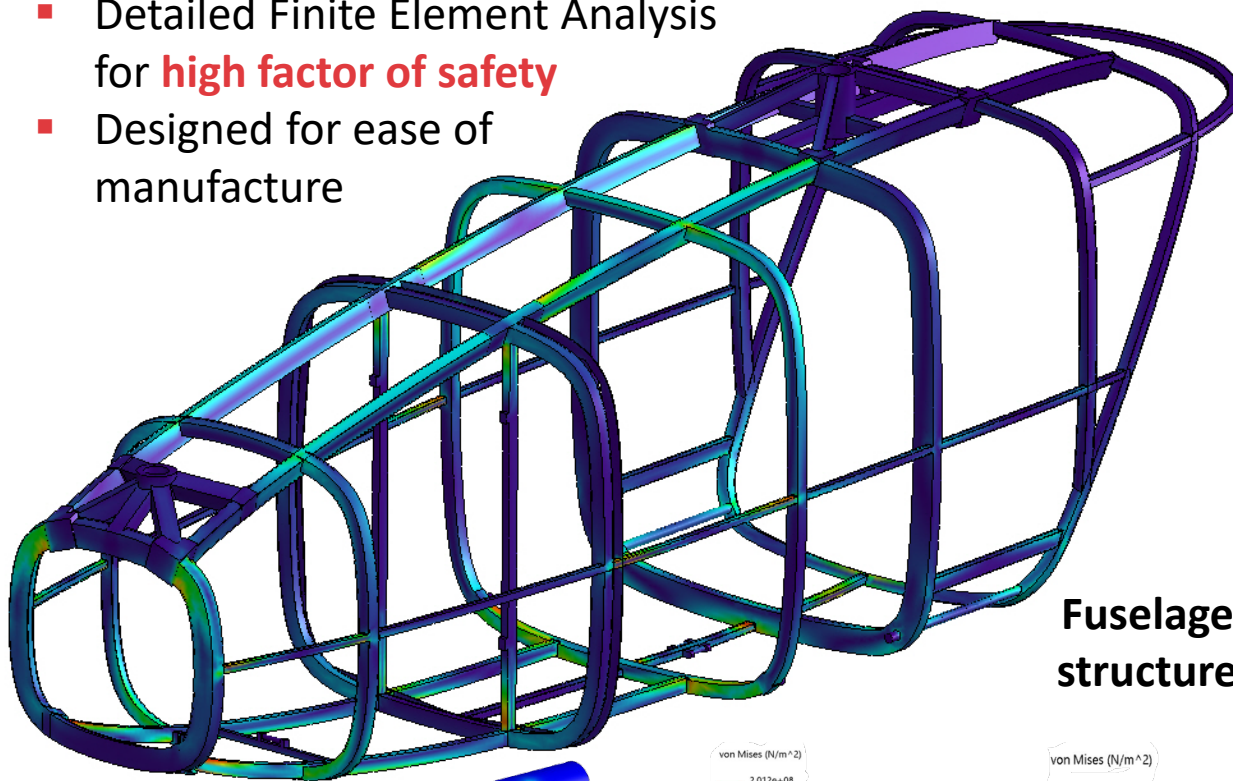


- Use of advanced **Carbon Fiber** materials
 - Celion 3000/E7K8
- **Ultralight** Fuselage structure
 - Weight: 22 kg
- **Retractable** Landing gears designed for crash energy absorption
 - Weight - 2.7 kg each
 - Aluminum 2024-T361 alloy
- Detailed Finite Element Analysis for **high factor of safety**
- Designed for ease of manufacture

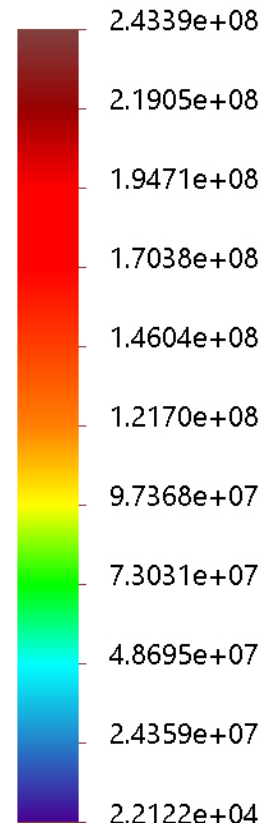


Engine Mount
Designed to diffuse the engine load and vibration

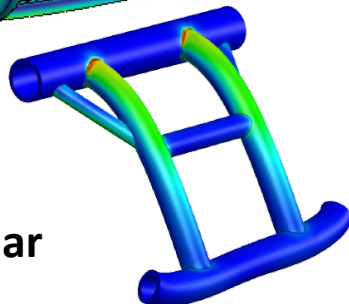
Shock mounts



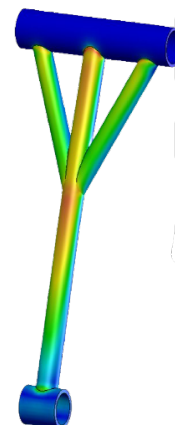
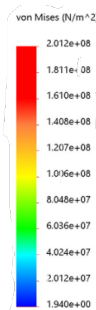
von Mises (N/m²)



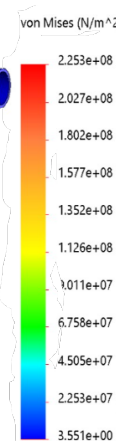
Fuselage structure



Main gear



Nose gear

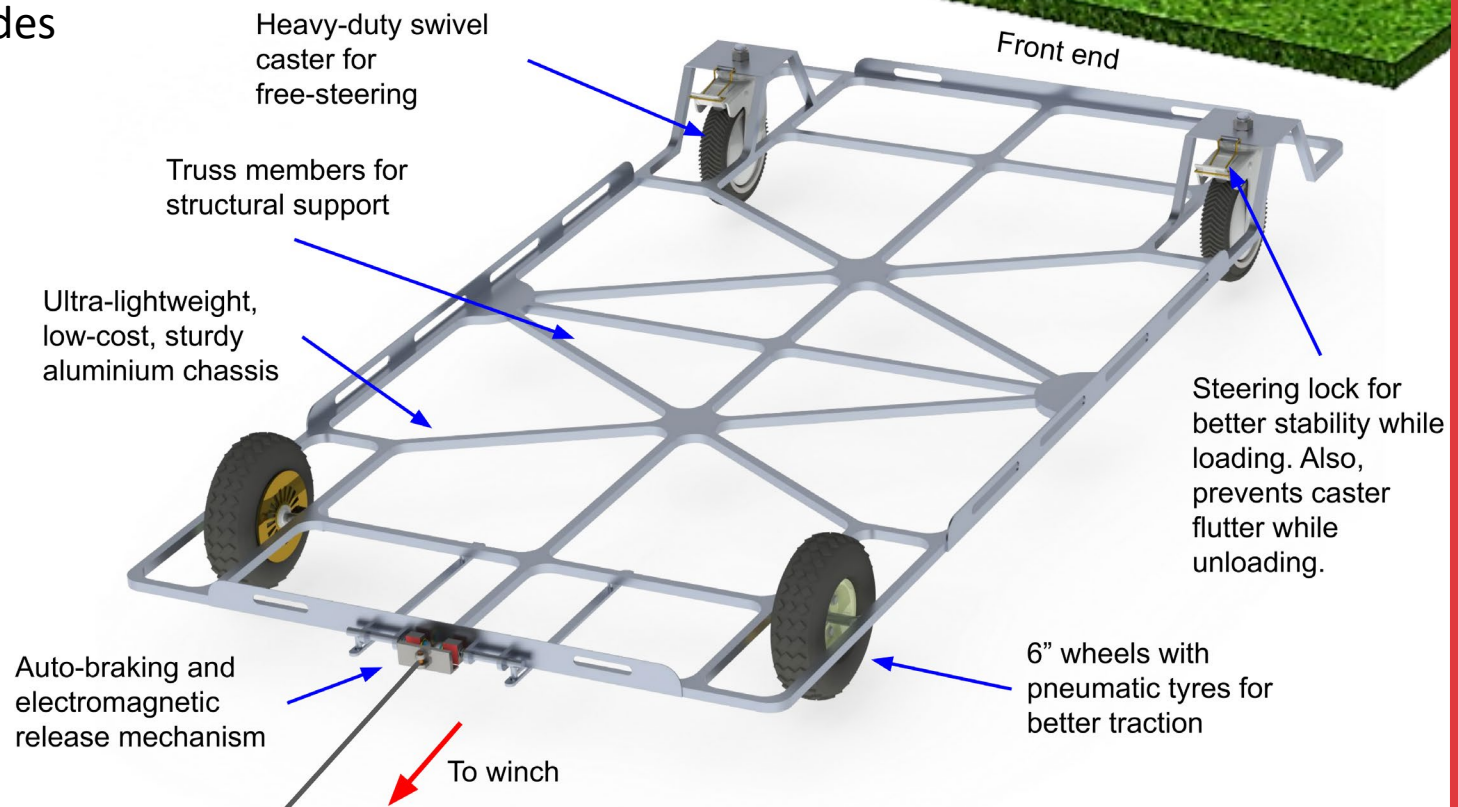
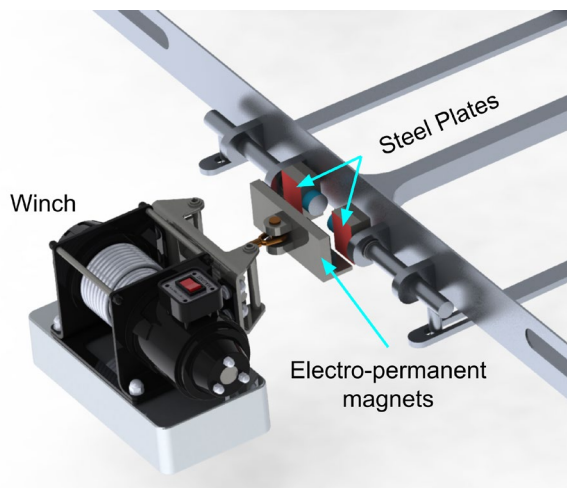
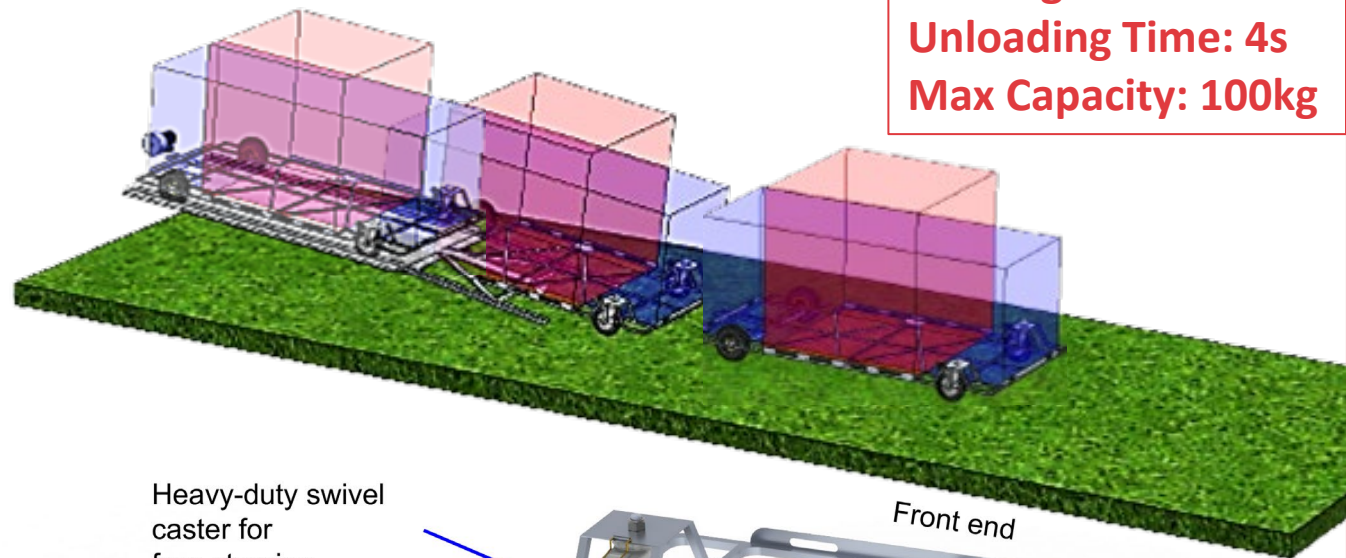


Convenient Payload Handling



Loading Time: 10s
Unloading Time: 4s
Max Capacity: 100kg

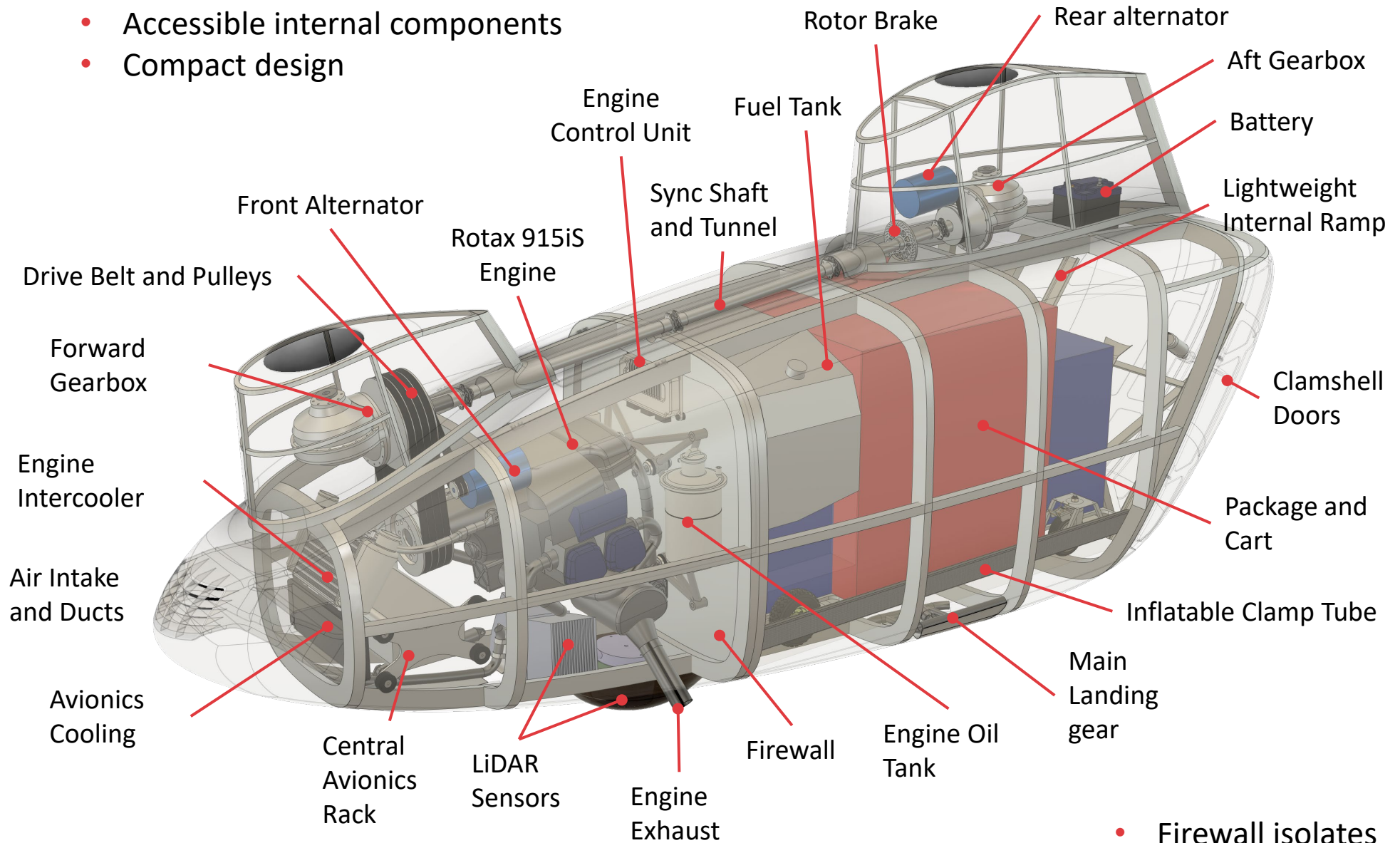
- Rapid Loading and Unloading Mechanism
- Ultra-lightweight design
 - Weight: 4.7 kg
- Low-cost components
- Large wheels to handle all types of terrain
- Wheeled cart provides ground transport convenience



Internal Layout



- Accessible internal components
- Compact design

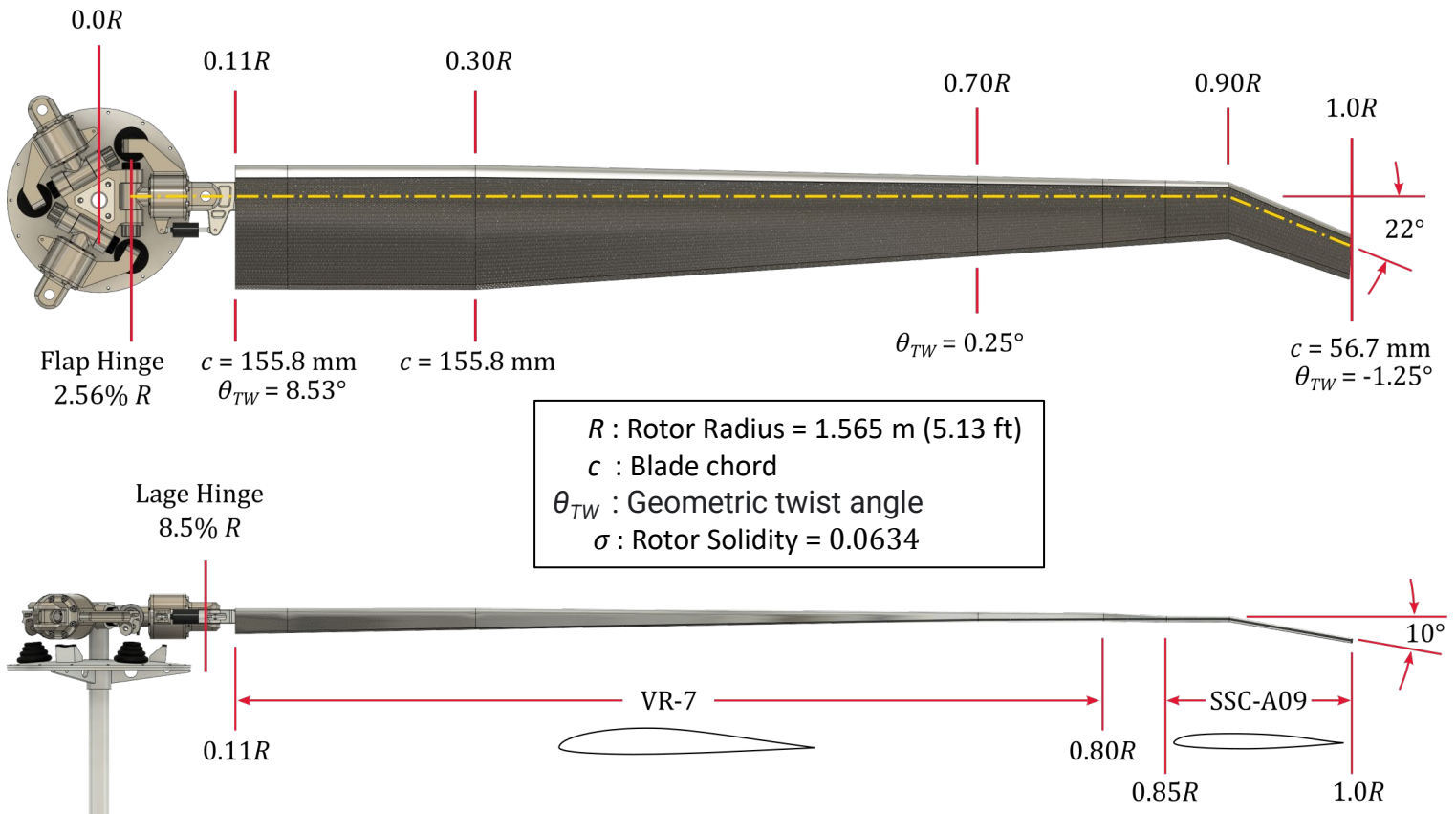
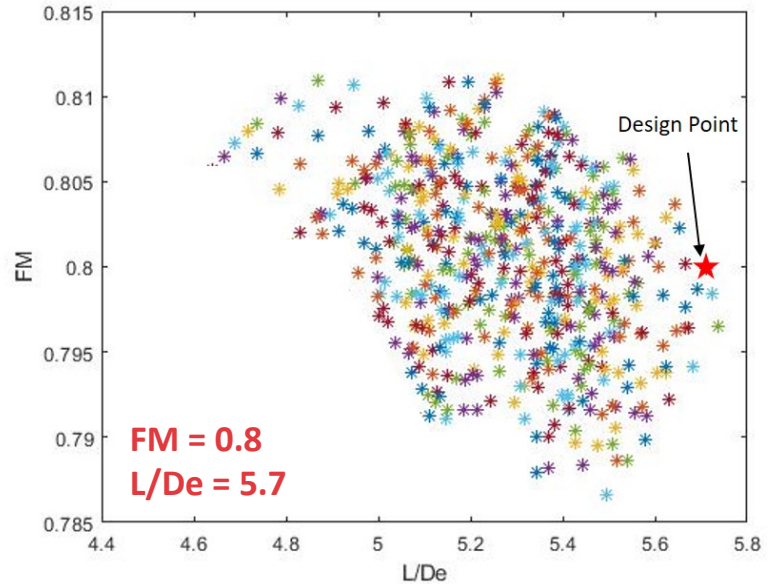
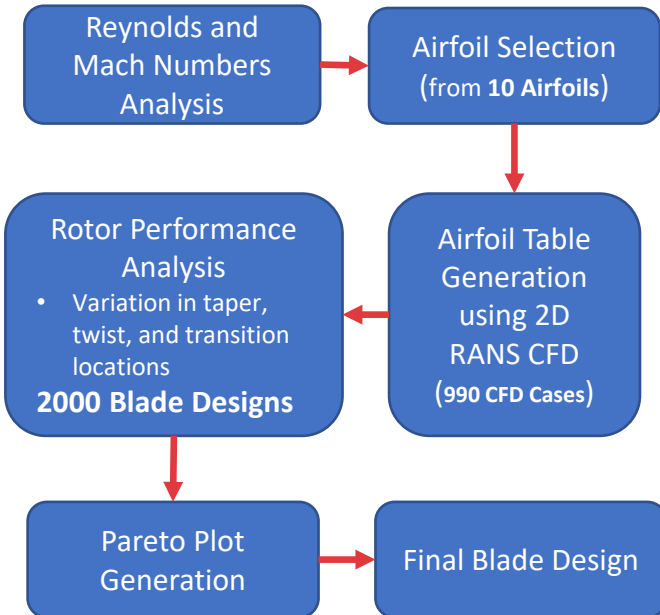


- Firewall isolates the cargo bay

High Efficiency Rotor Blades



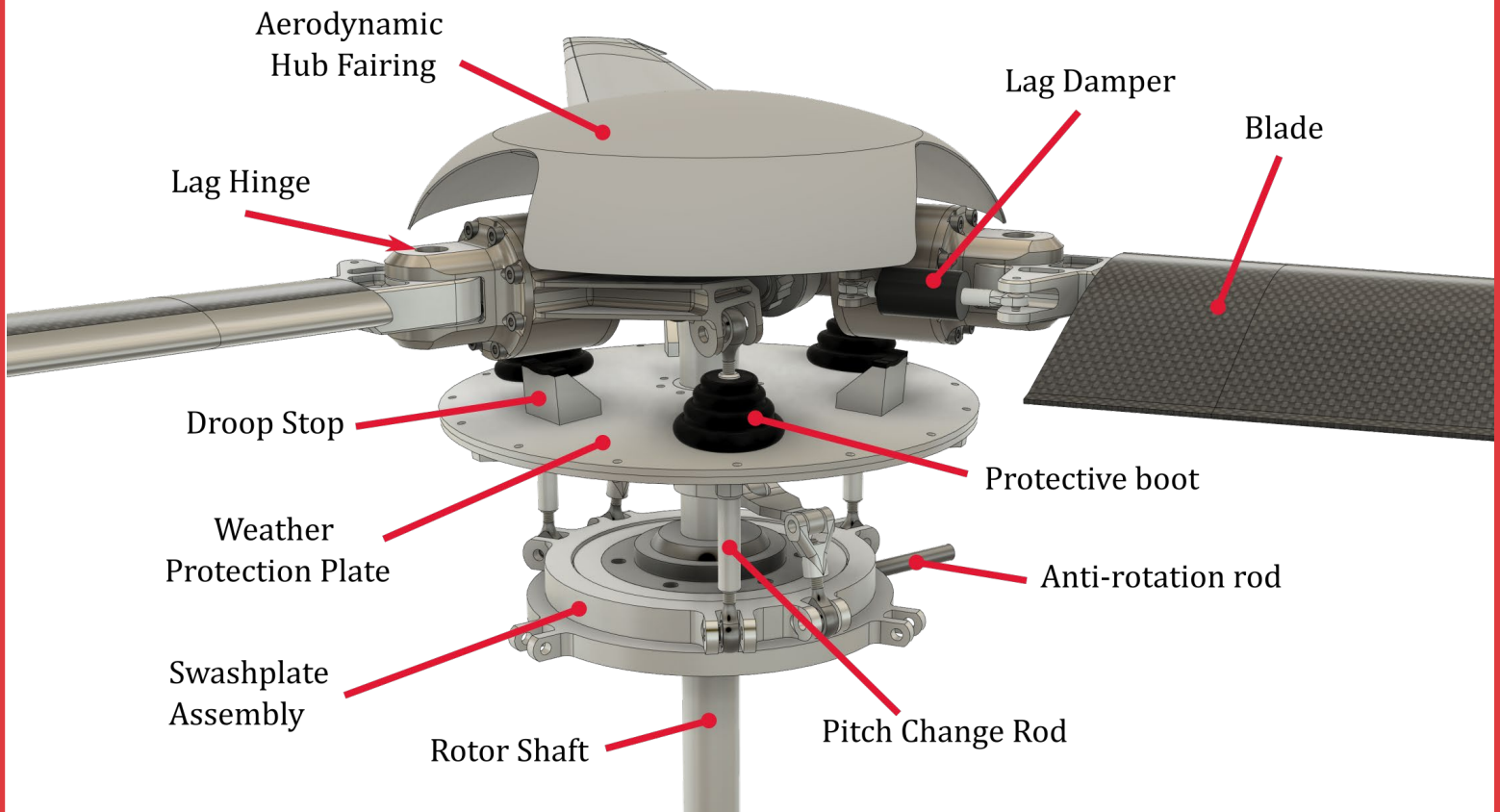
Alicorn's blades are aerodynamically optimized for both **hover** and **high-speed cruise**.



Articulated Hub Design

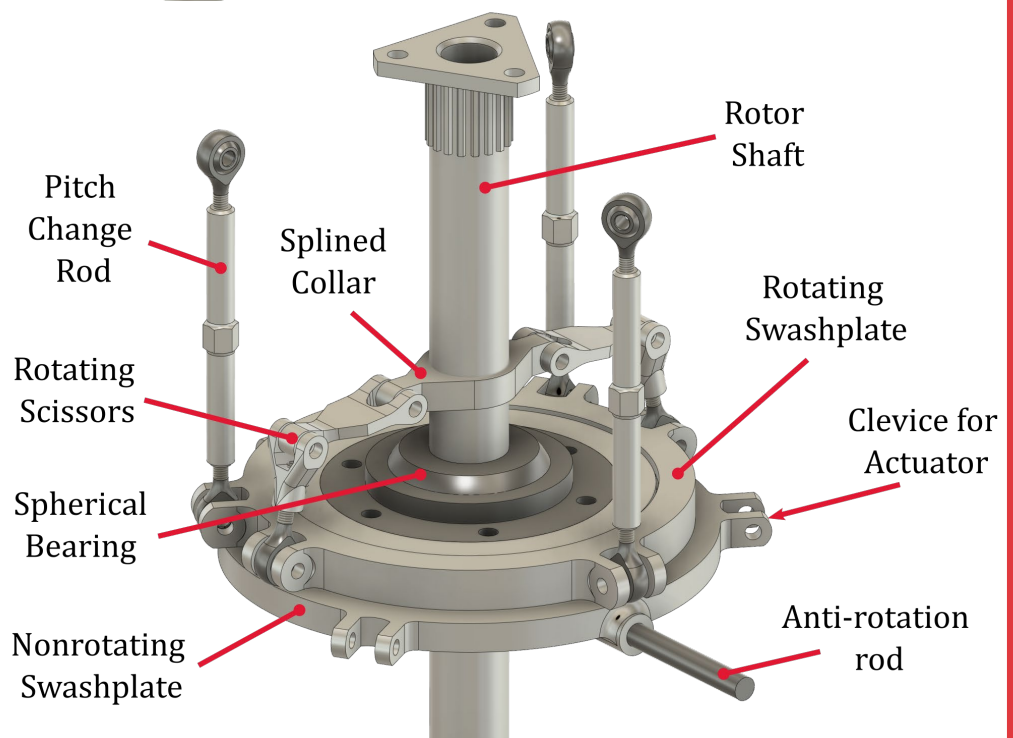


- Low flap hinge for better yaw control authority for tandem rotors
- Fairing to reduce hub drag
- Low cost, commercial off-the-shelf hub components



Flap Frequency
1.02 /rev

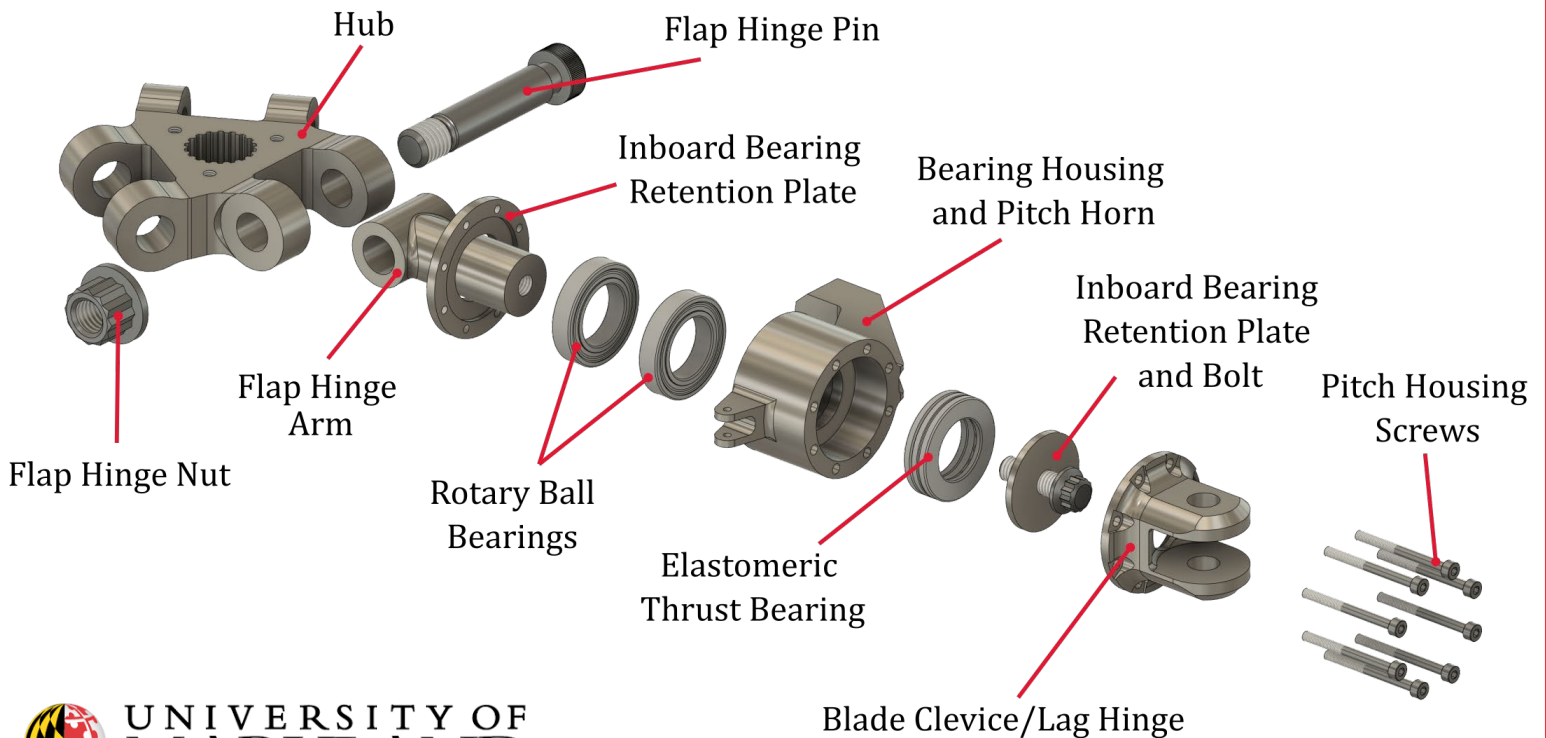
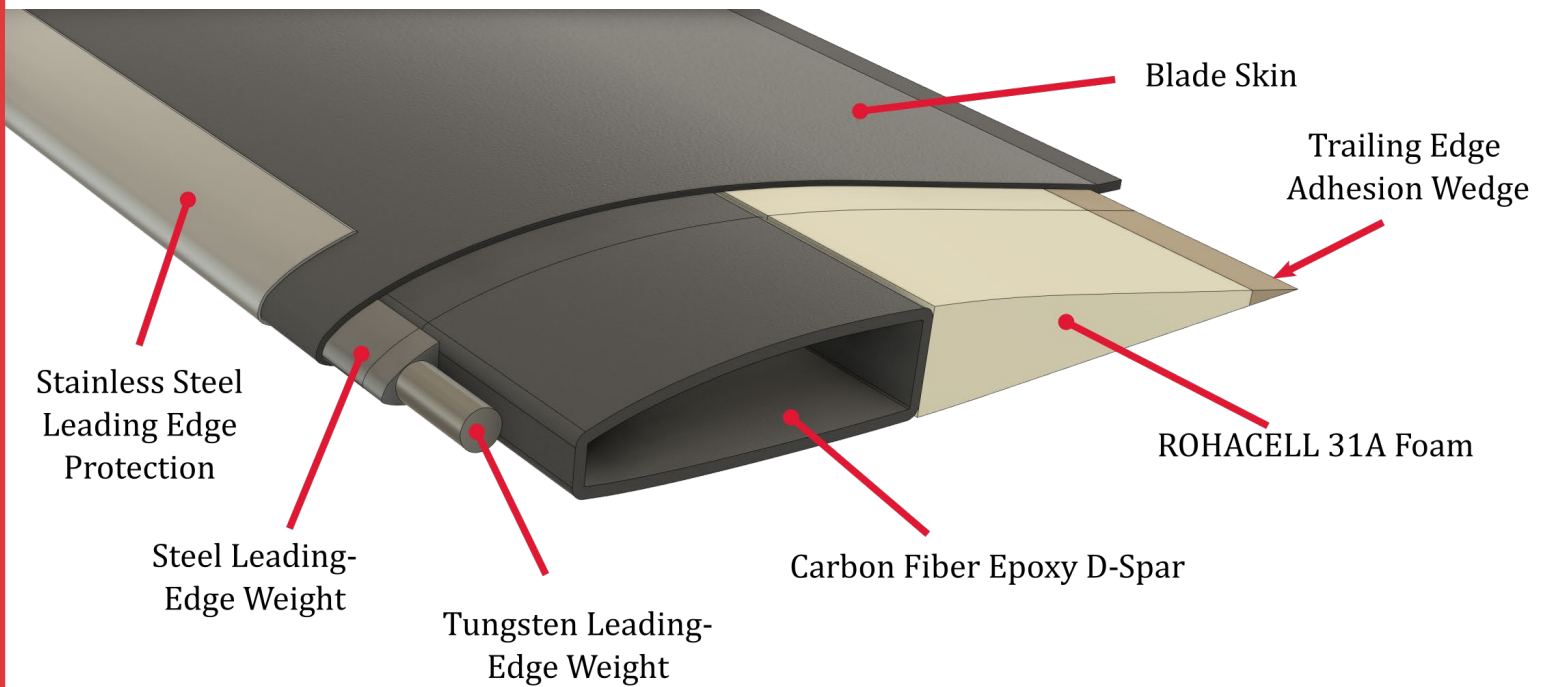
Lag Frequency
0.37 /rev



Rotor Blade Structure



Alicorn's blades are easy to manufacture...!



Mighty Powerplant



Rotax 915 iS

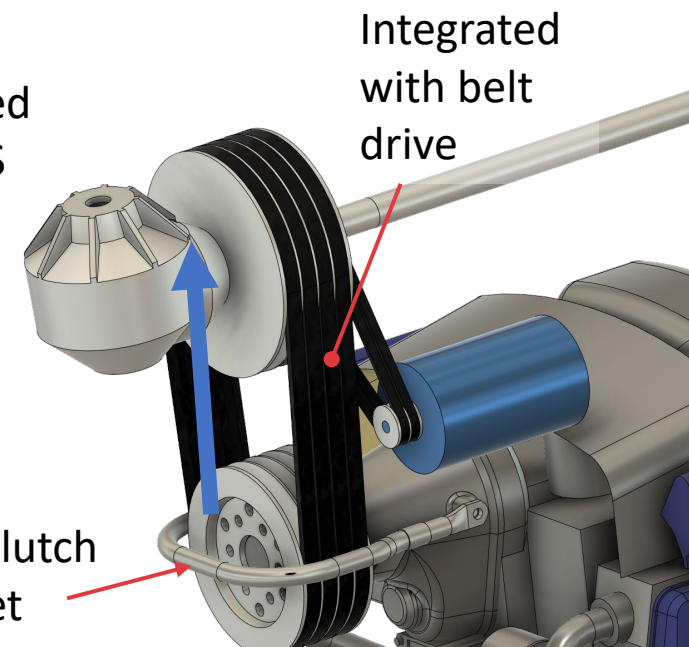


Source: flyrotax.com

Upgraded version of the well-regarded engine used in Dynali helicopters, MQ-1 Predator, and other aircraft

Powers Alicorn's 90 m/s (175 kt) cruise speed and excellent performance at high density altitudes

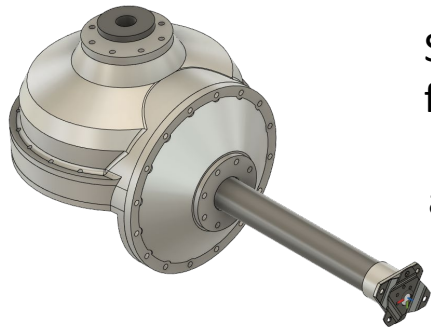
- **Certified and mature:** 4 cylinder, turbocharged, air/liquid cooled
- **Versatile and inexpensive fuel:** U.S. 91 octane gasoline/ AVGAS
- **Maximum Rated Power:** 104 kW (141 HP)
- **Maximum Continuous Power:** 99 kW (135 HP)
- **Critical Altitude:** 4,600 m (15,000 ft)
- **Service Ceiling:** 7,000 m (23,000 ft)
- **Specific Fuel Consumption:** 0.32 kg/kW-hr (0.52 lb/HP-hr)
- **Specific Power:** 1.23 kW/kg (0.75 HP/lb)



Lightweight, Reliable and Robust Transmission

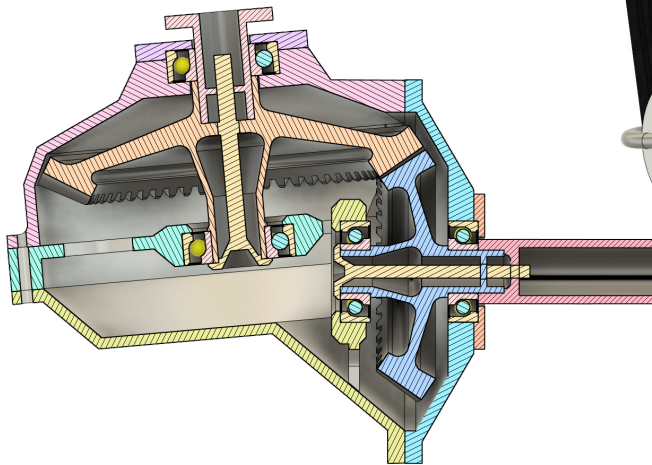


4.47:1 overall reduction: 5,500 RPM @ engine = 1,231 RPM @ rotor; blade tip speed of 202 m/s (662 ft/s)



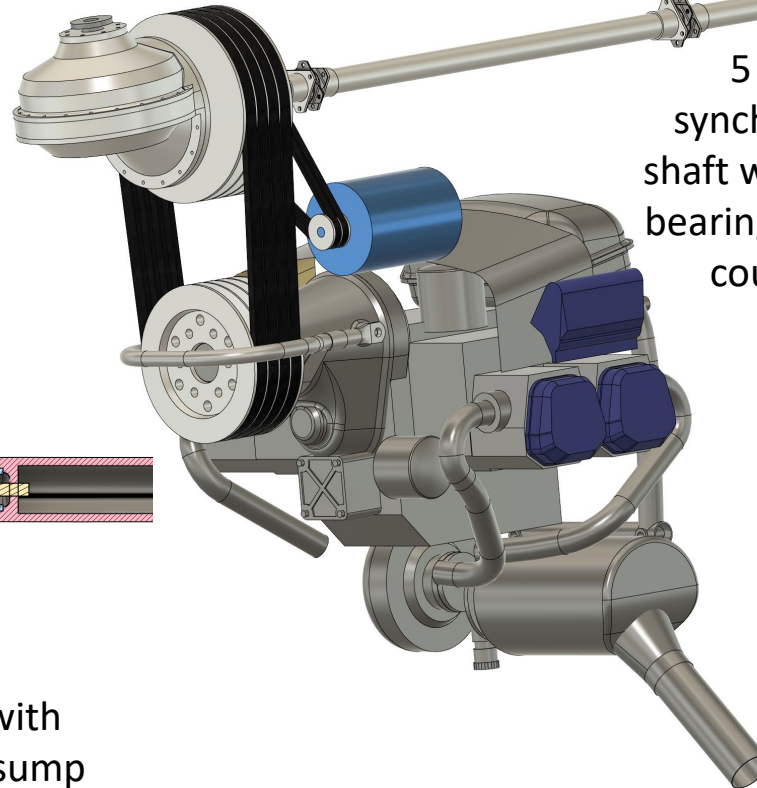
Sprag clutch/
freewheeling
unit for
autorotation

8,000+ hour gearbox
and belt life

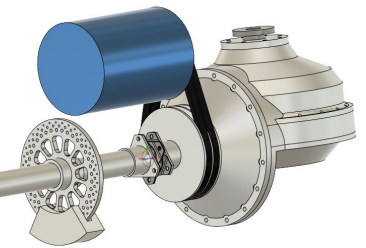


Splash type lubrication with
aircraft attitude-tolerant sump
and chip detection

V-belt pulley system provides
lightweight torque transfer, shock
absorption, electrical power
generation, and engine clutching



5 stage
synchronizing
shaft with grease
bearings and flex
couplings



Redundant 1.7 kW
alternators driven by
transmission for failsafe
flight controls and avionics—
and extra power for more
mission equipment

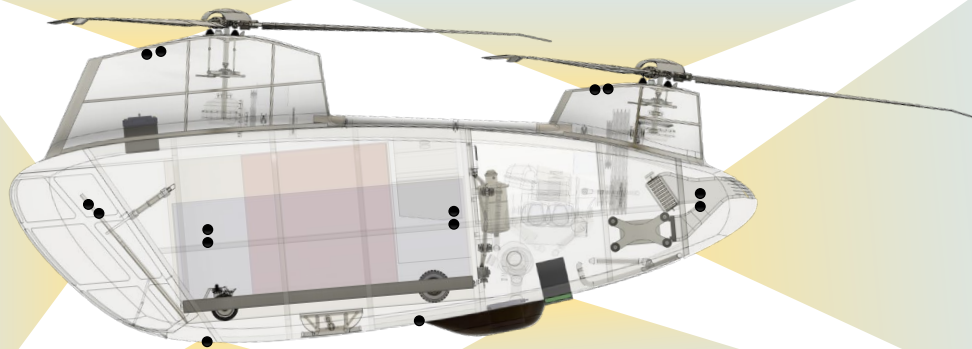


Transmission only requires single-stage bevel gears in
addition to pulleys and a small engine-mounted gearbox

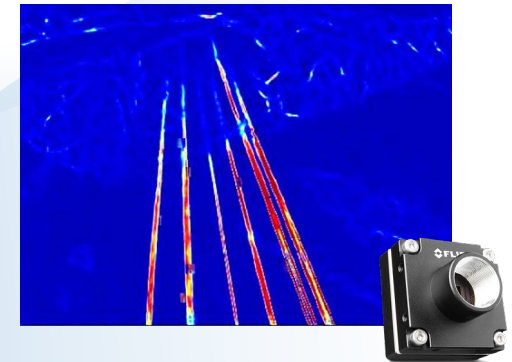
Avionics: Long Range, Omnidirectional, Intelligent Sensing



- Top-notch **situational awareness** for **obstacle avoidance**
- Provides high quality measurements in all environmental conditions to ensure healthy runtime of the **autonomy** software
- **Unprecedented safety** through sensor fusion and failure detection



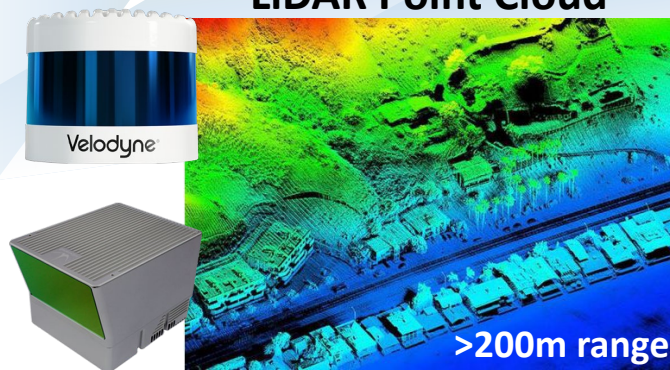
Wire Detection



Bird Detection



LiDAR Point Cloud

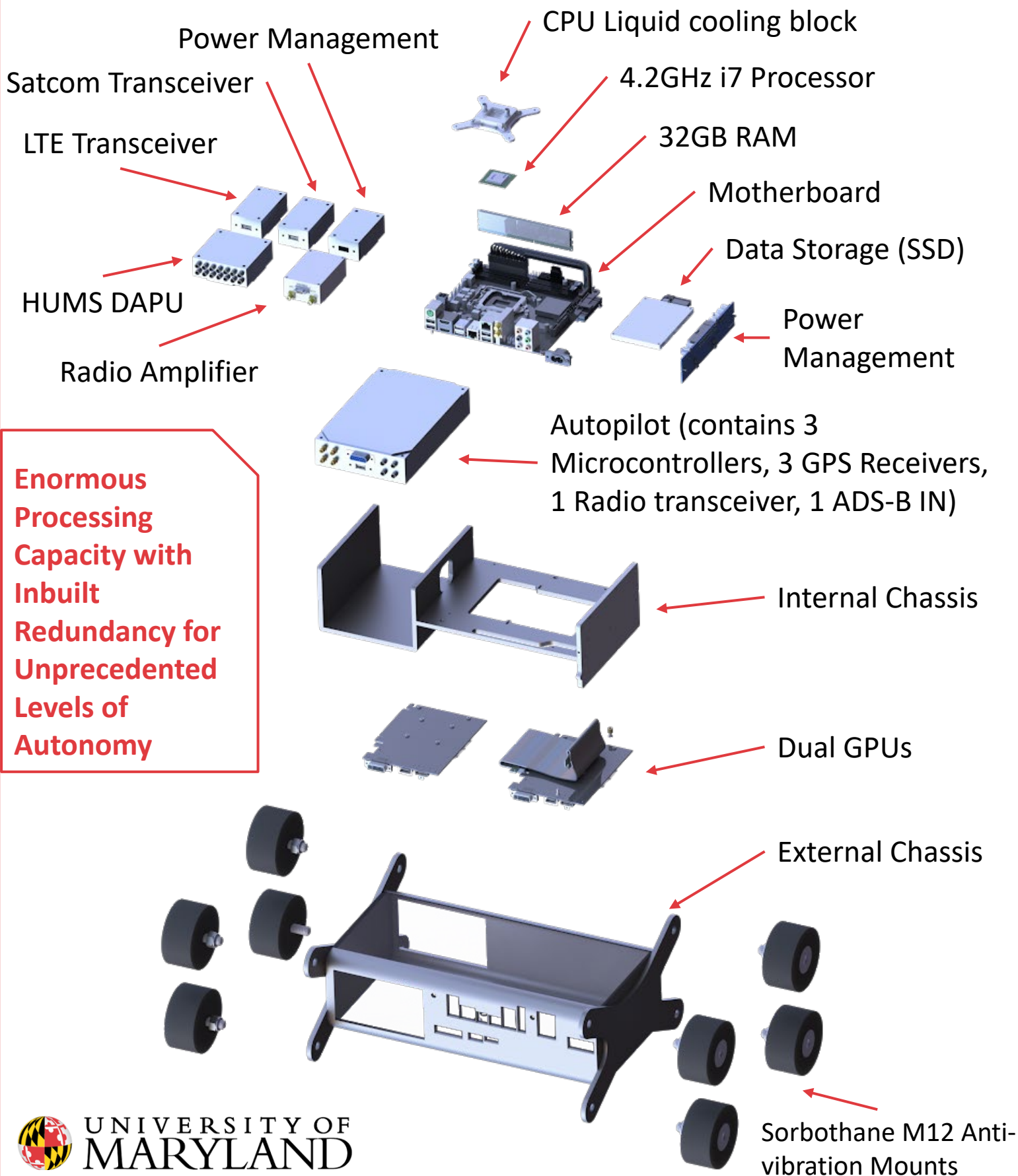


Thermal Imagery



Animal & Human Detection

Avionics: Central Processing Rack



Communications and Ground Control



Long range, triple-redundant BVLOS radio control, telemetry and video:



- **pMDDL Radio with 10W Amplifier**
- 4G LTE using **Botlink XRD**
- **Satellite** communication
- Repeaters with high-gain parabolic antennas



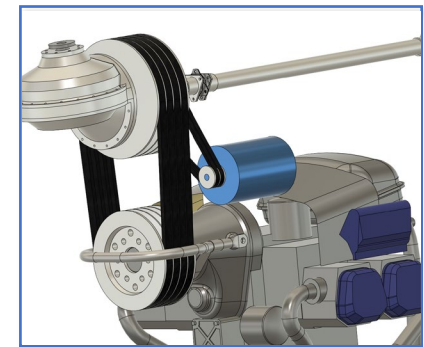
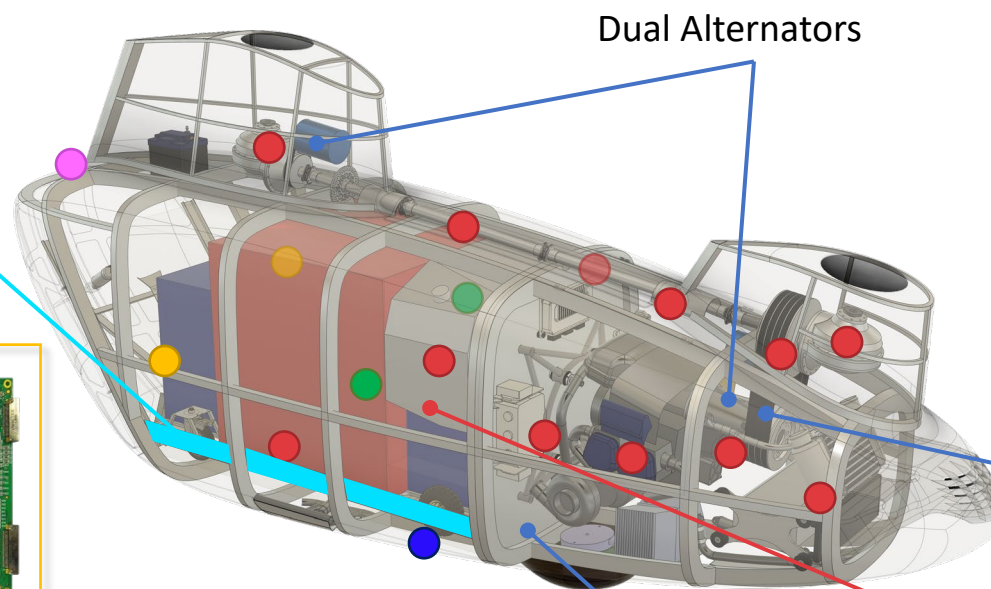
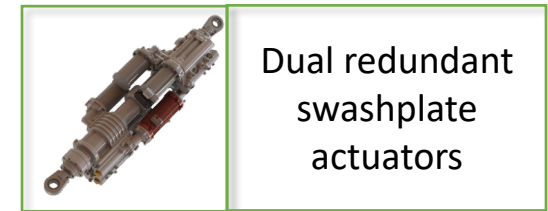
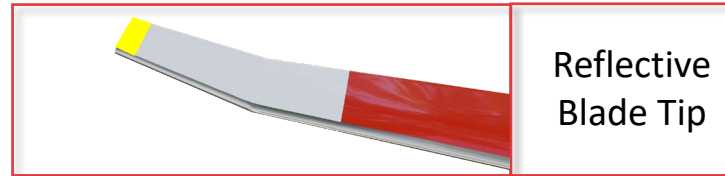
Source: d3.xlrs.eu



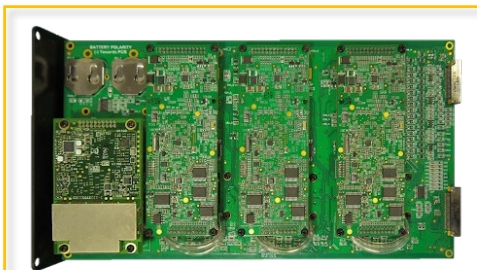
Safety Features



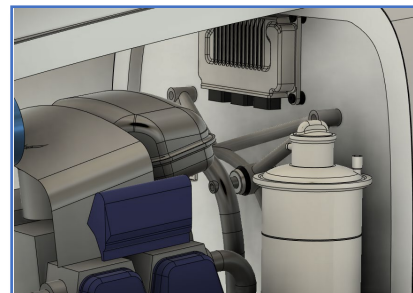
- HUMS Sensors
- Anti collision lights
- Landing lights
- Rotary beacon
- Warning speakers



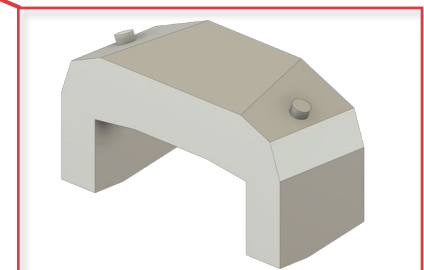
Inflatable Clamp Tubes to secure cargo in flight



Triple redundant Autopilot, GPS and Datalink with wiring redundancy to critical components



Firewall Insulation prevents engine heat from transmitting to fuel tanks and cargo bay

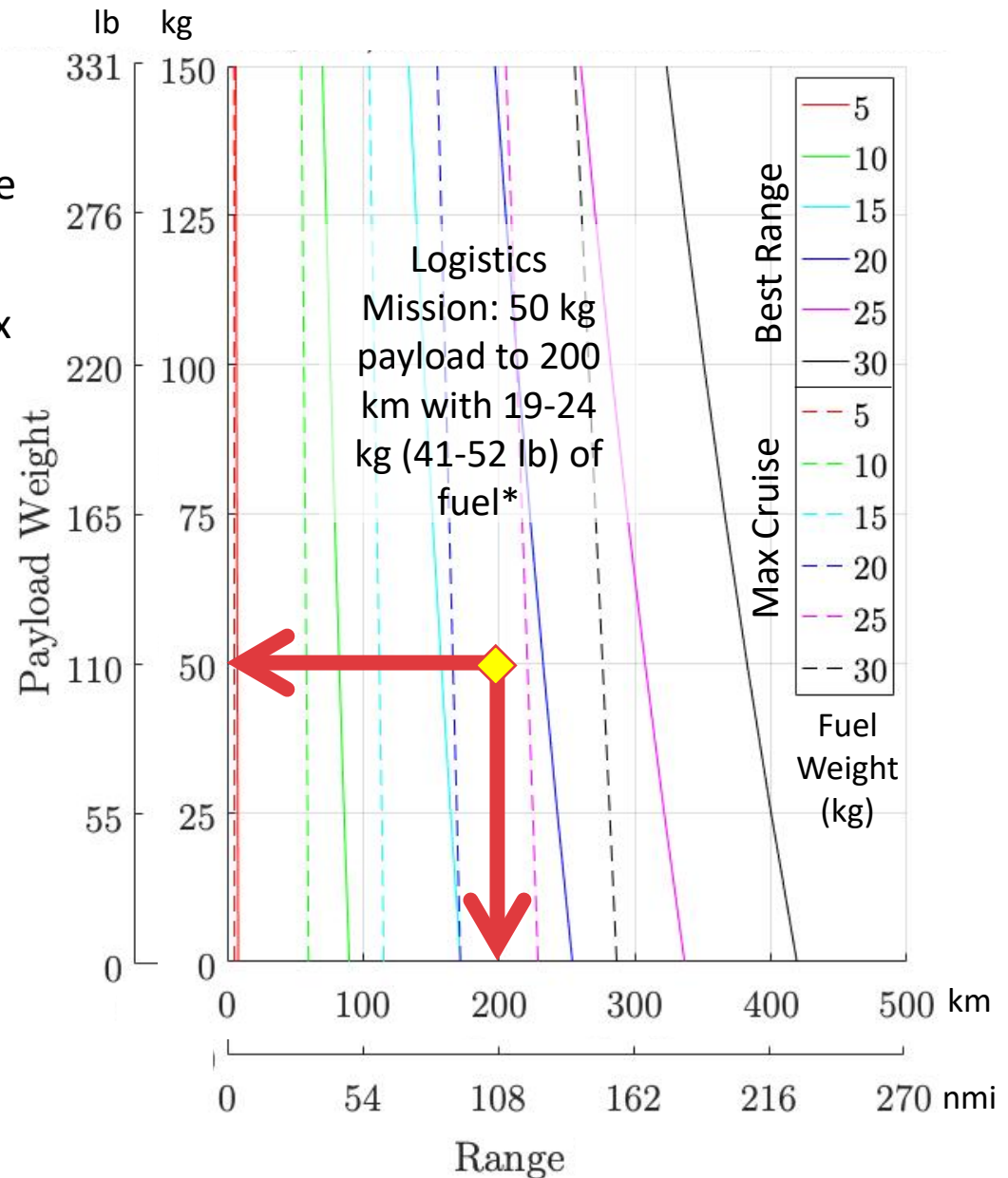
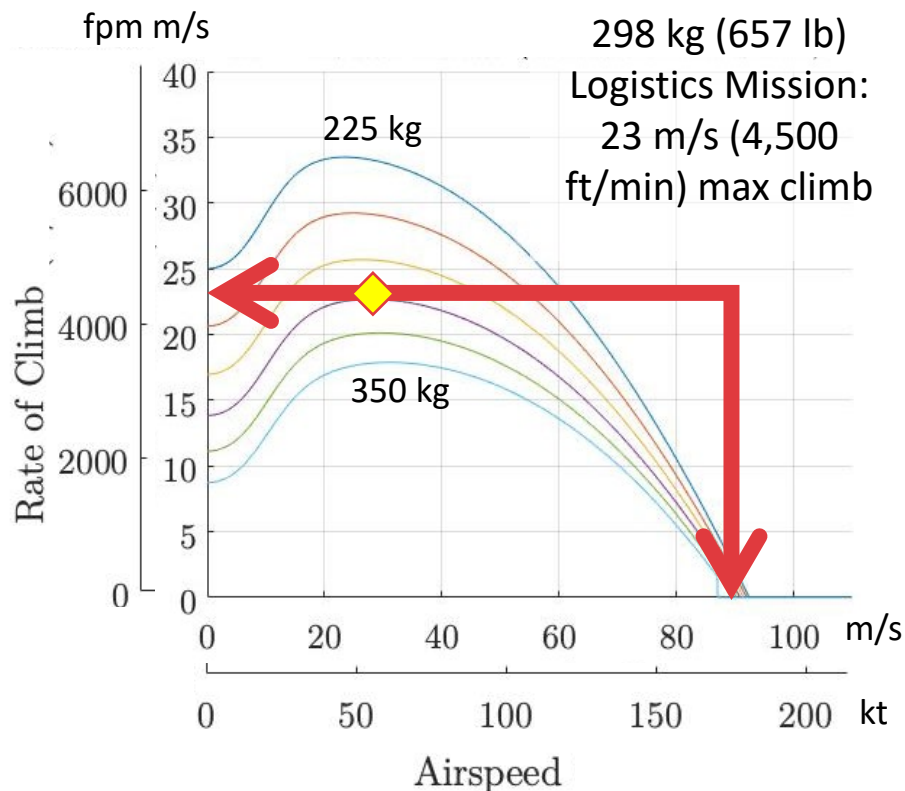


Crashworthy fuel tanks

High Performance: Speedy Delivery with a Safety Margin



- **90 m/s (175 kt)** cruise speed
- Payload capacity of over **100 kg (220 lb)**
- Unrestricted hover ceiling, superb climb rate for confined areas and avoiding obstacles
- Low blade loading, good **Autoration** Index



*Fuel includes start, 3 min HOGGE, 20 min reserve

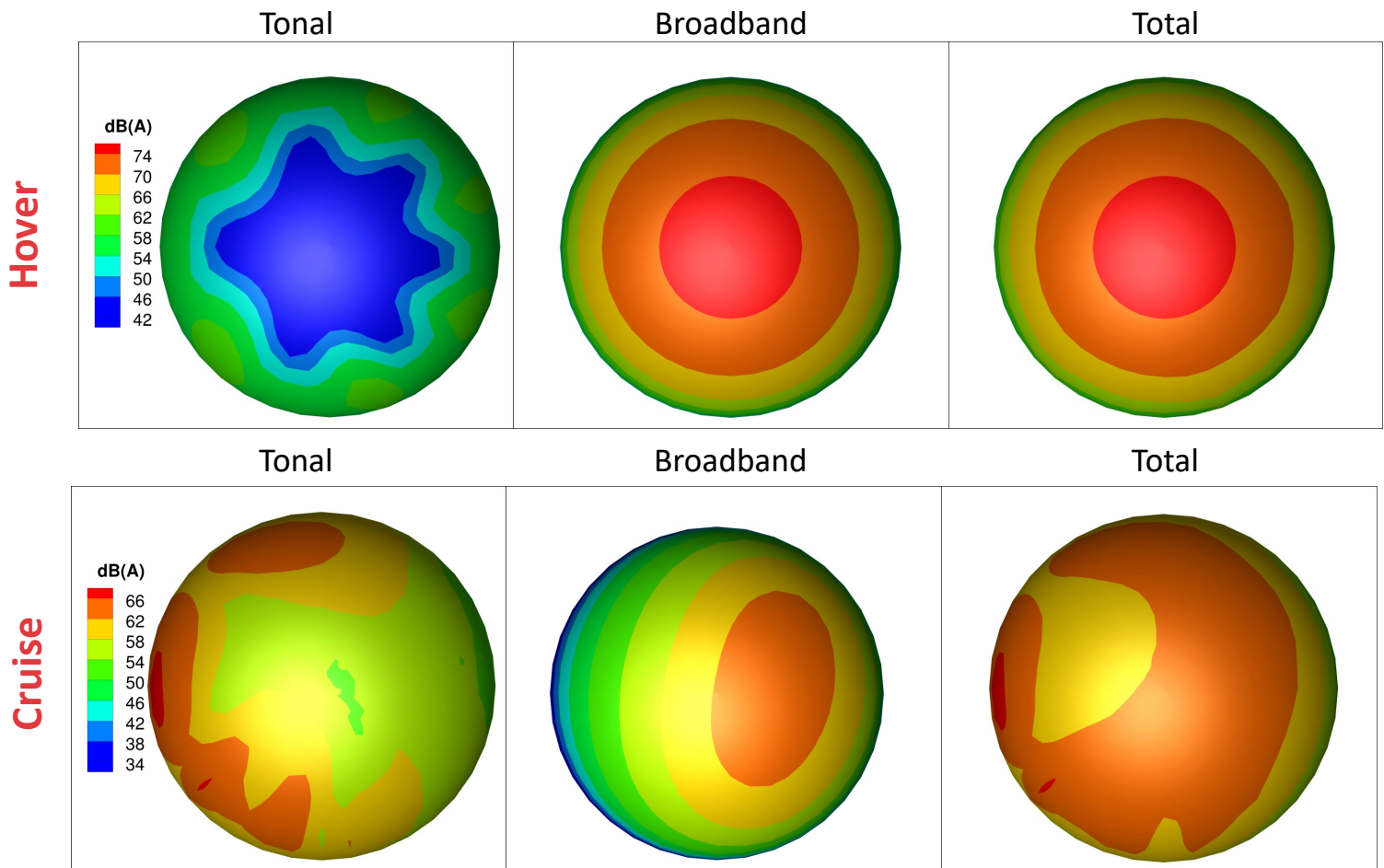
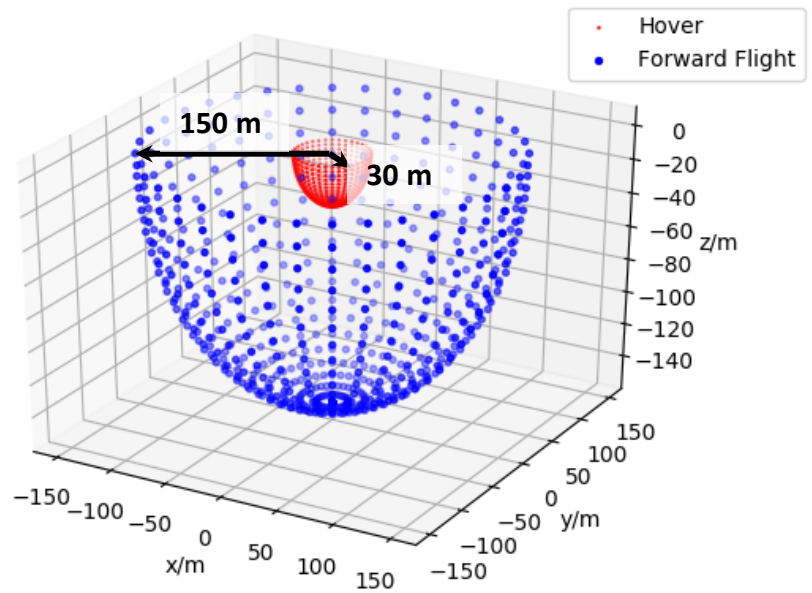
Acoustics: Low Noise Signatures



Maximum overall sound pressure level (OASPL)

Hover	Cruise
75.6 dB(A)	63.1 dB(A)

< 78.5 dB(A)
Acceptable limit



A Myriad of Possibilities



Agriculture



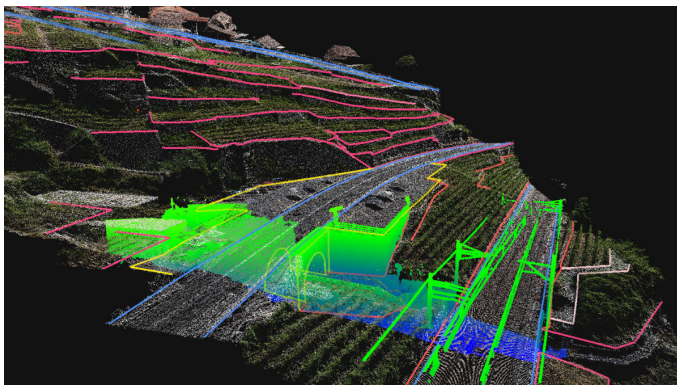
Search and Rescue



Shipboard Supplies



Geographical survey



Airborne communications



Infrastructure Inspection

