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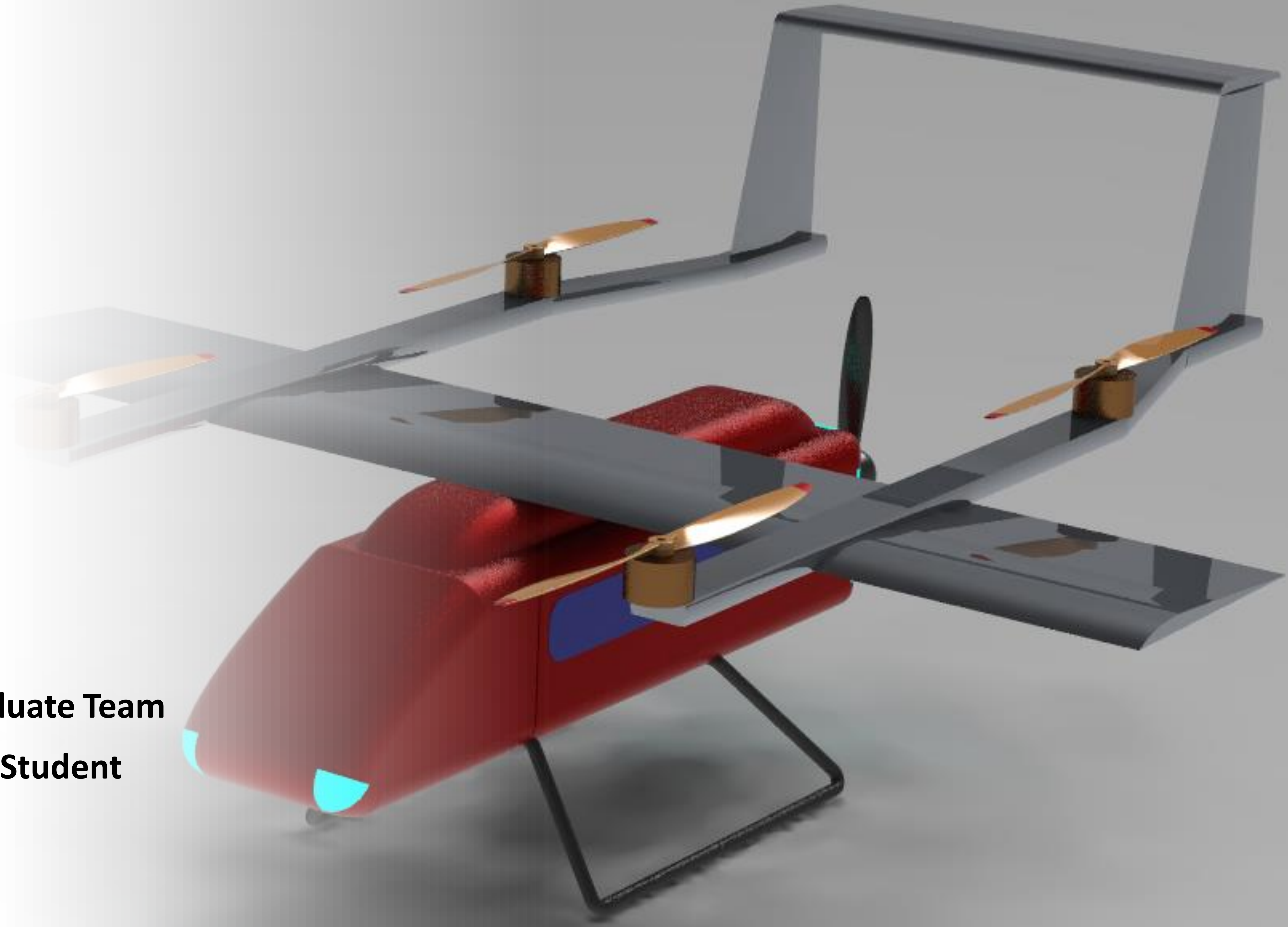
Hermes Executive Summary



RMIT University Undergraduate Team

38th Vertical Flight Society, Student Design Competition

Document.2

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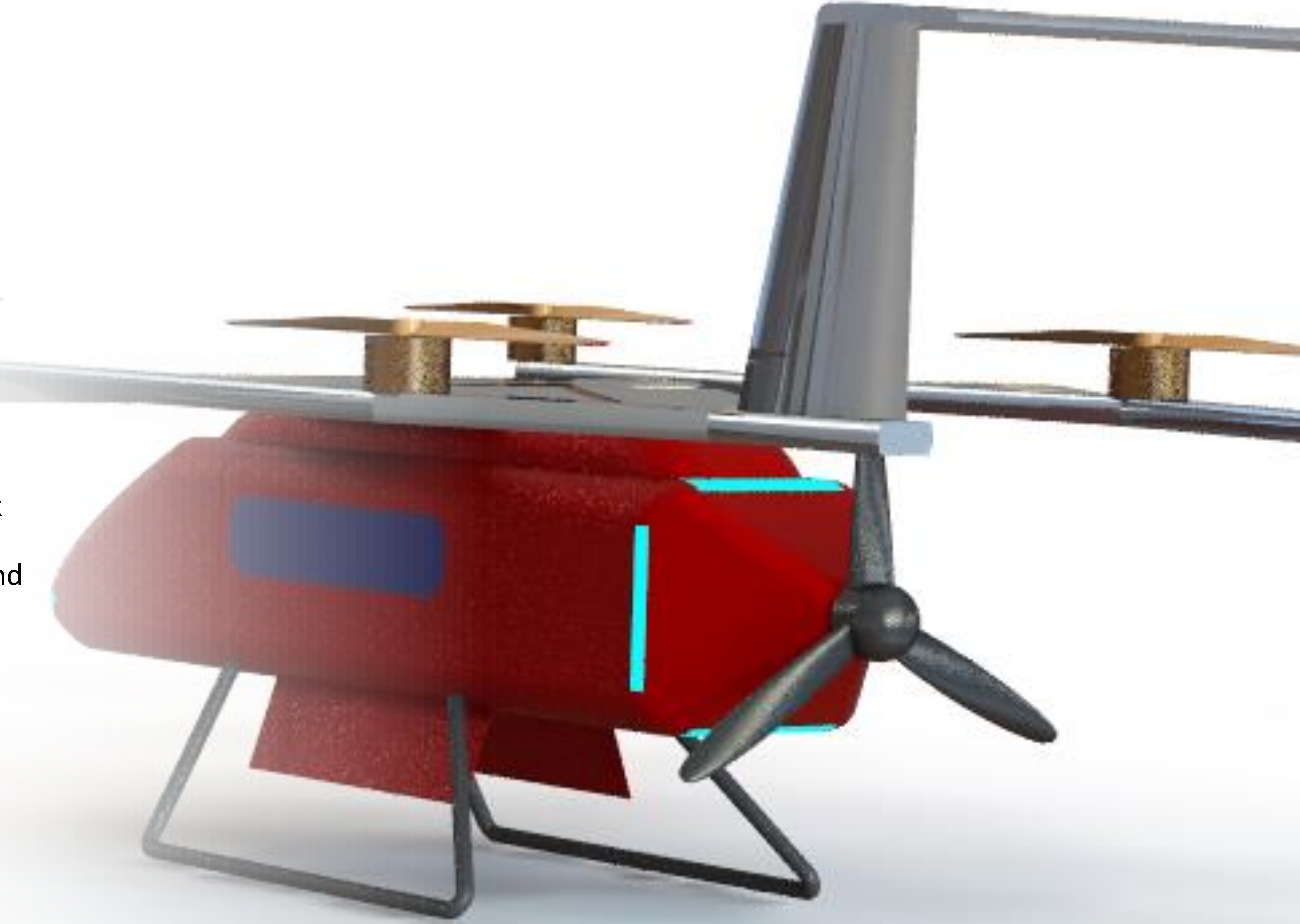
Introduction

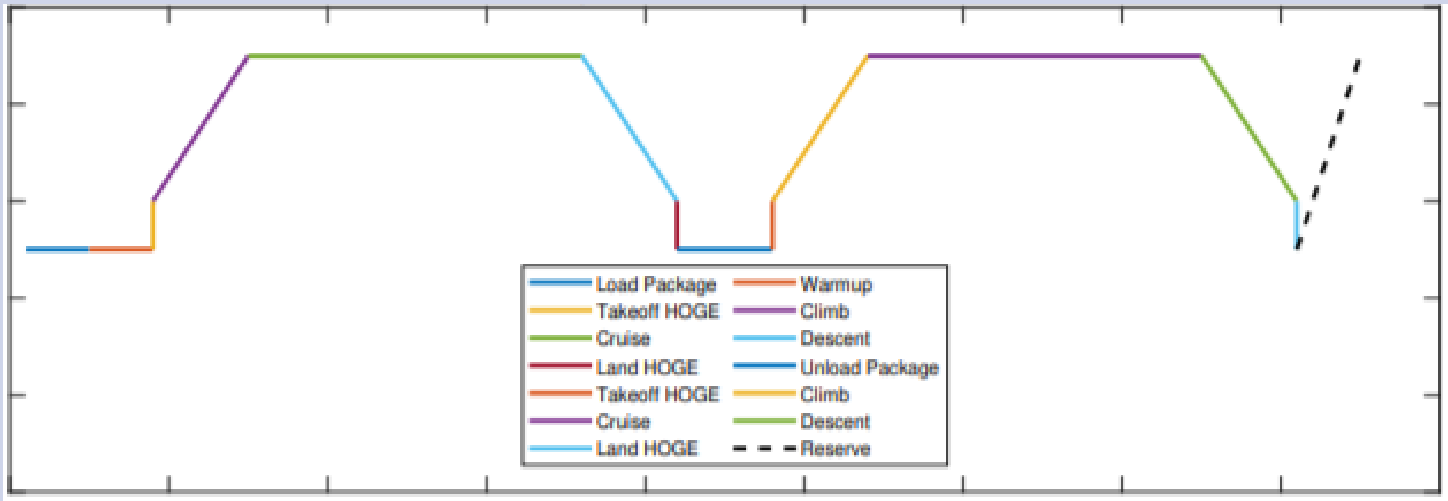
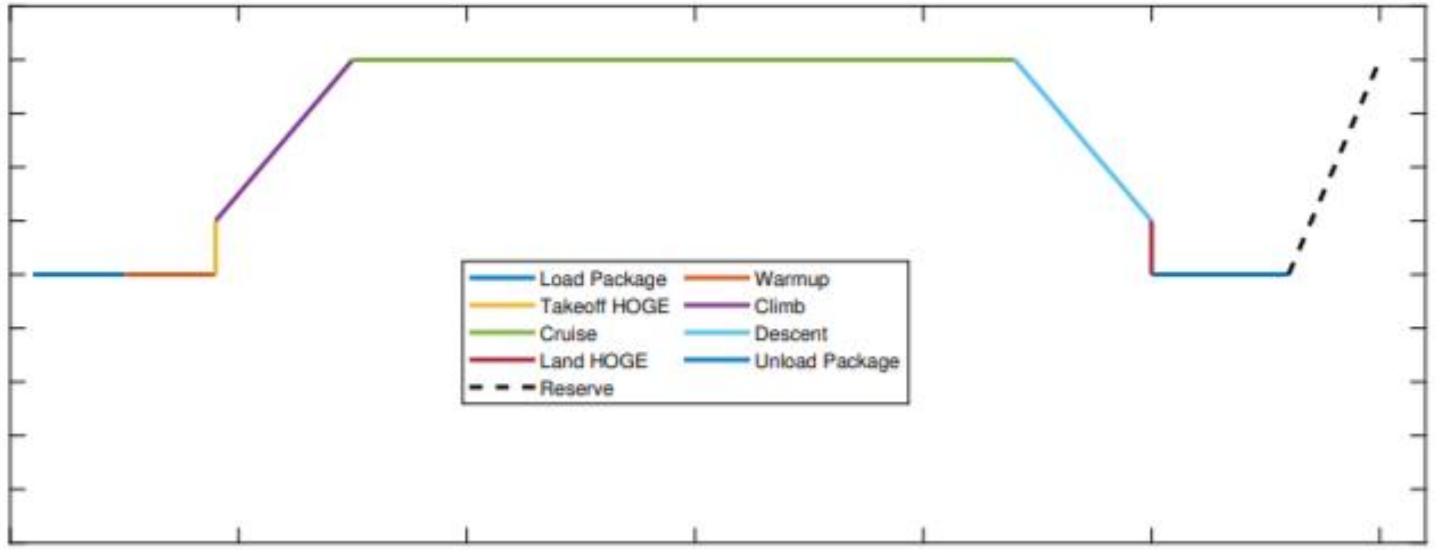
The world is undergoing rapid change in the face of new challenges that occurs everyday. One of those challenges is effective logistical supply in areas that deem regular aircrafts inoperable or inefficient.

Hermes UAV platform, named after the Greek God of Speed and the emissary of God is a fitting name for a platform that goes above and beyond in delivering goods with precision, speed and for a variety of terrains.

The aircraft is a Quadrotor Compound System Hybrid Electric VTOL aircraft capable of achieving cruise speeds of 230 km/h and carrying a payload of 55 kgs. It has a total endurance of 90 minutes at cruise speeds.



Mission Requirements

Mission	Profile Description	Profile Schematic
Local Delivery Mission	• Vertical Take off • Cruise 13 minutes • Vertical Landing, Deliver Package • Vertical Take off from Delivery Site • Cruise 13 minutes • Land Back at Airbase	
Logistics Mission	• Vertical Take off • 70 minute cruise Limit • Vertical Land at Logistics Base • Reserve 20 minutes	

Aircraft RFP Requirements

RFP Requirement	Design
Continued safe flight in the event of a failure	Fail Safe design practices adopted
Multi-Mission capability without reconfiguration	Compound multirotor configuration sized to satisfy Logistics and Local delivery mission
VTOL operation	
Vehicle no larger than 6.1m x 6.1m	
Operation over populous areas	'Path to certification' under CASA part 101
Autonomous operation	Autopilot System paired with LIDAR and a high-quality camera gives Hermes the ability to fly safely without a pilot, day or night.
Operation in day and night VFR conditions	
Delivery to precise location	
Obstacle Detection	

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Design Approach

Configuration selection → Mission analysis → Powerplant selection → Aircraft specifications → Certification

Configurations evaluated on:

1. Safety
2. Cost
3. Payload handling
4. Technology readiness

Trade study on mission accomplishment

Powerplant configuration:

1. Electric
2. Internal combustion engine
3. Hybrid

Design specifications:

1. Blade aerodynamics
2. Wing and tail sizing
3. Landing gear

Certifications based on:

1. Civil Aviation Safety Authority
2. Federal Aviation Administration
3. Society for Automotive Engineers

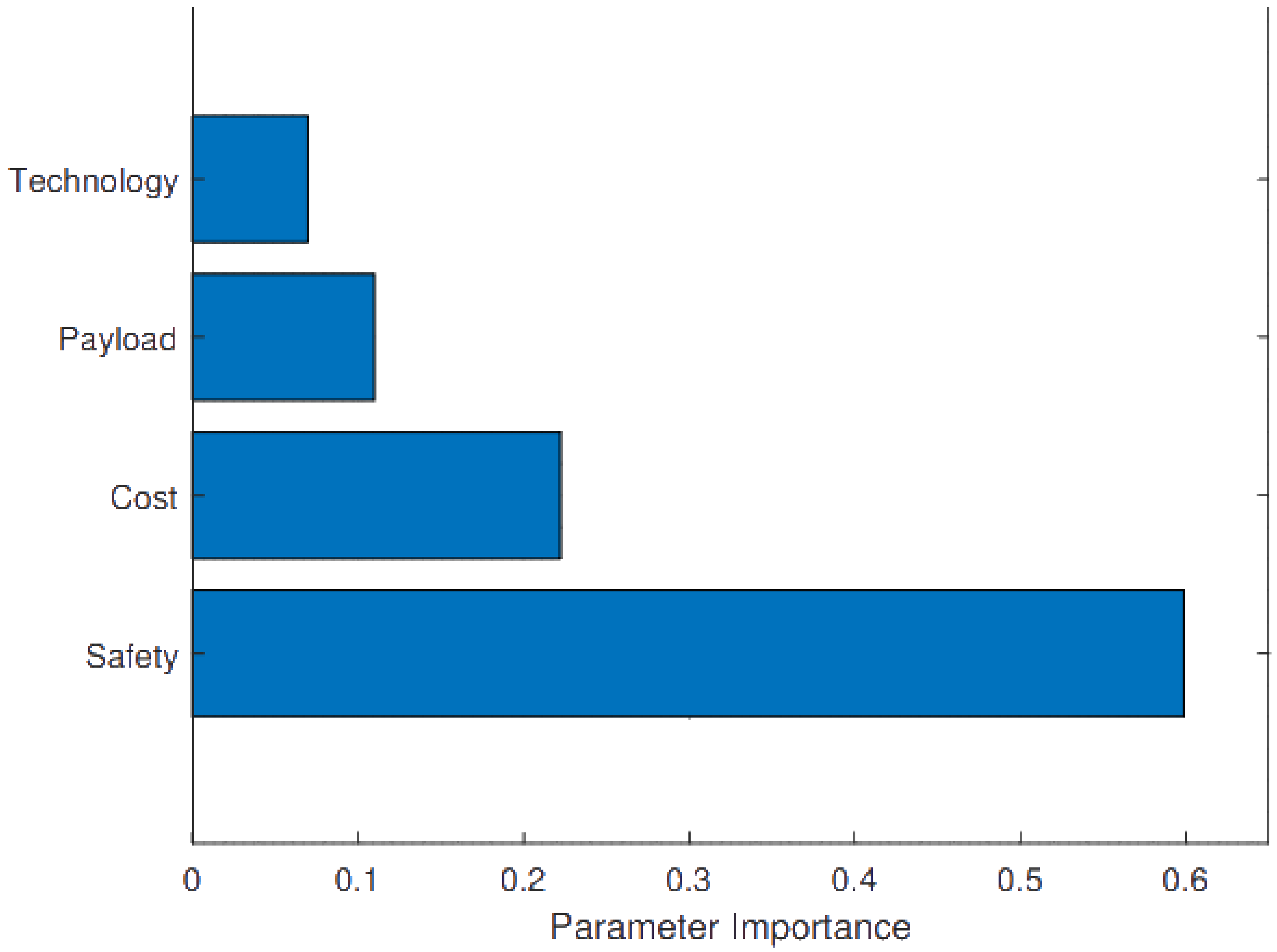
Aircraft Configuration

4 VTOL vehicle configurations were considered for analysis. The configurations were Conventional, Coaxial, Multirotor and Compound.

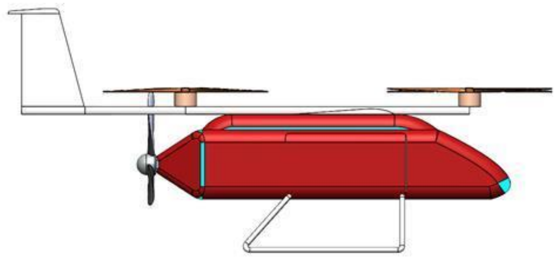
To determine the most appropriate of the 4 options an analytical hierarchy process was performed using the top design parameters in accordance with the RFP. The parameters considered were safety, cost, payload handling and Technology readiness.

From these parameters the most suitable configuration was a quadrotor compound for the advantages it provides in both the VTOL stages and cruise stages of the missions.

This configuration was further optimized to fulfil the RFP requirements to create the VTOL UAV for payload delivery Hermes.

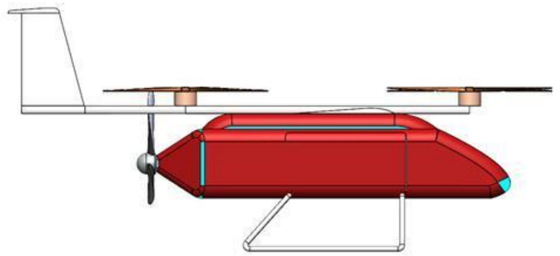


Mission Analysis Take off and Landing

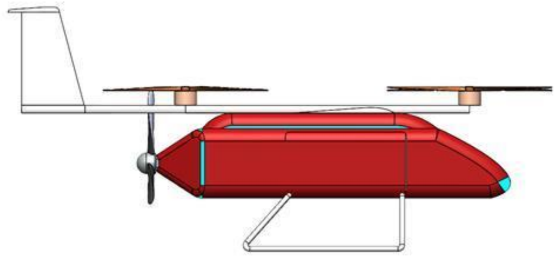


Aircraft on ground VTOL rotors start

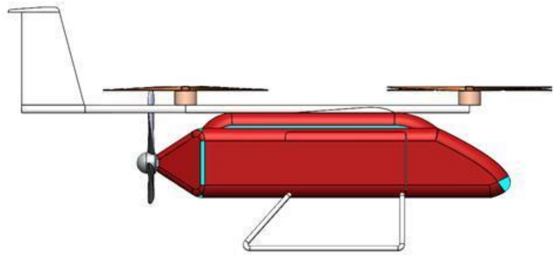
VTOL rotors
Climb mode
2.5m/s



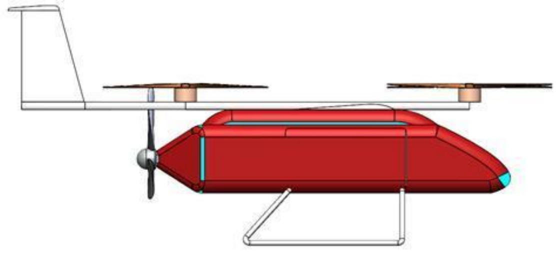
Aircraft 150 m AGL
VTOL rotors hover mode
Pusher propellor in operation



Forward speed for lift attained at 136 km/h
VTOL rotors stop running ,Cruise mode is engaged

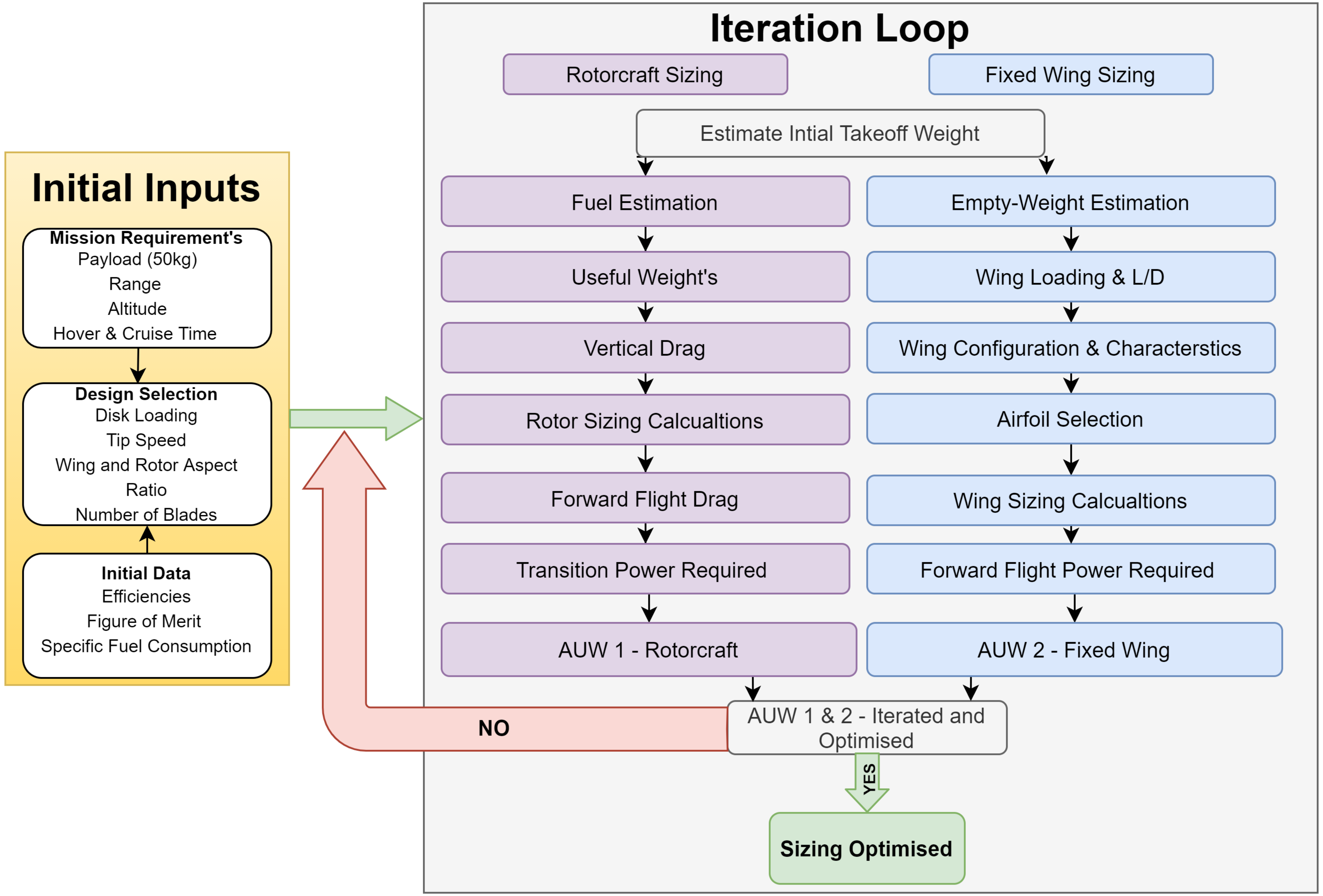


Airspeed reduced
Zero thrust Pusher Prop
VTOL rotors enter hover mode



Vertical Landing
Engines Shut

Design Methodology



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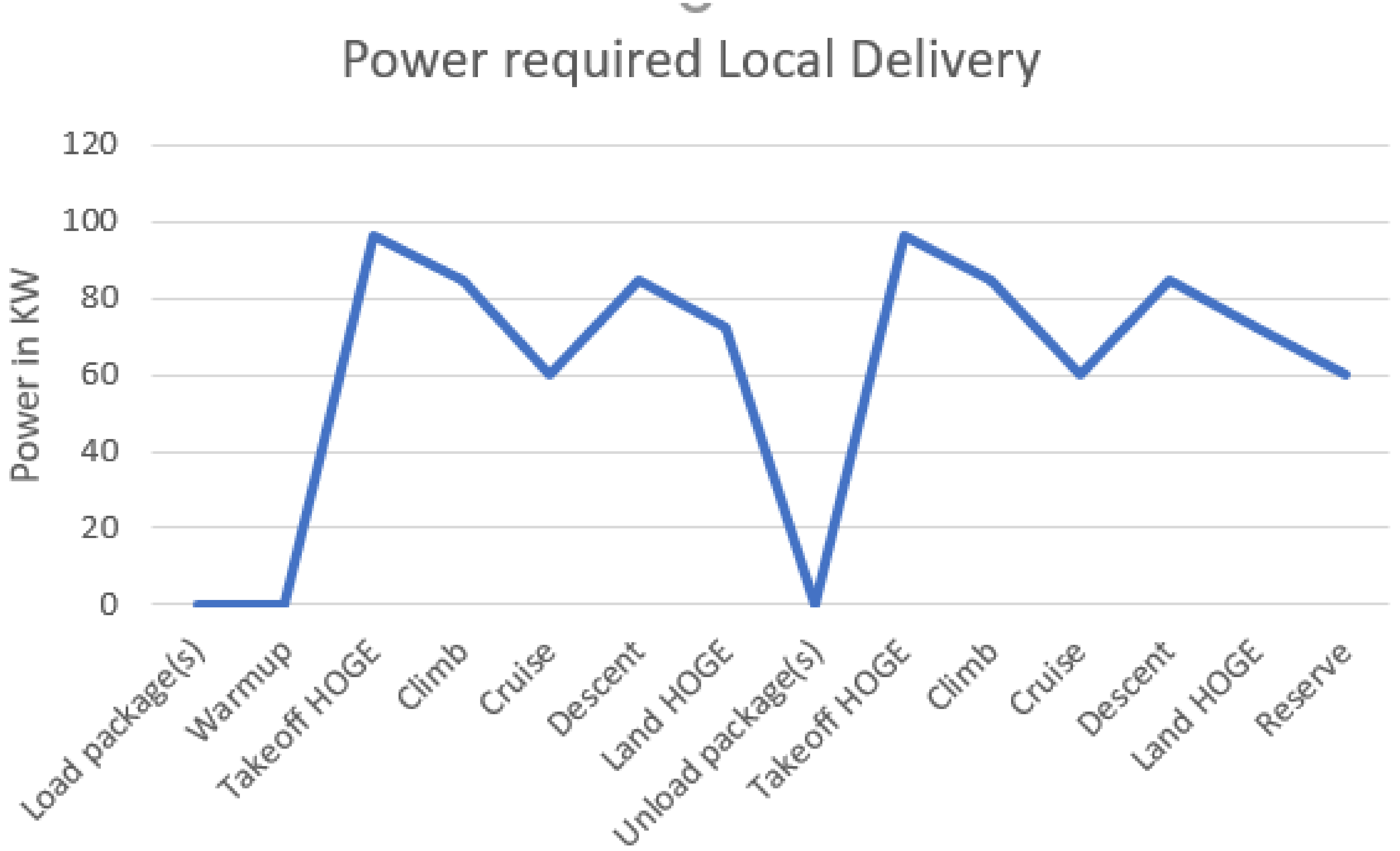
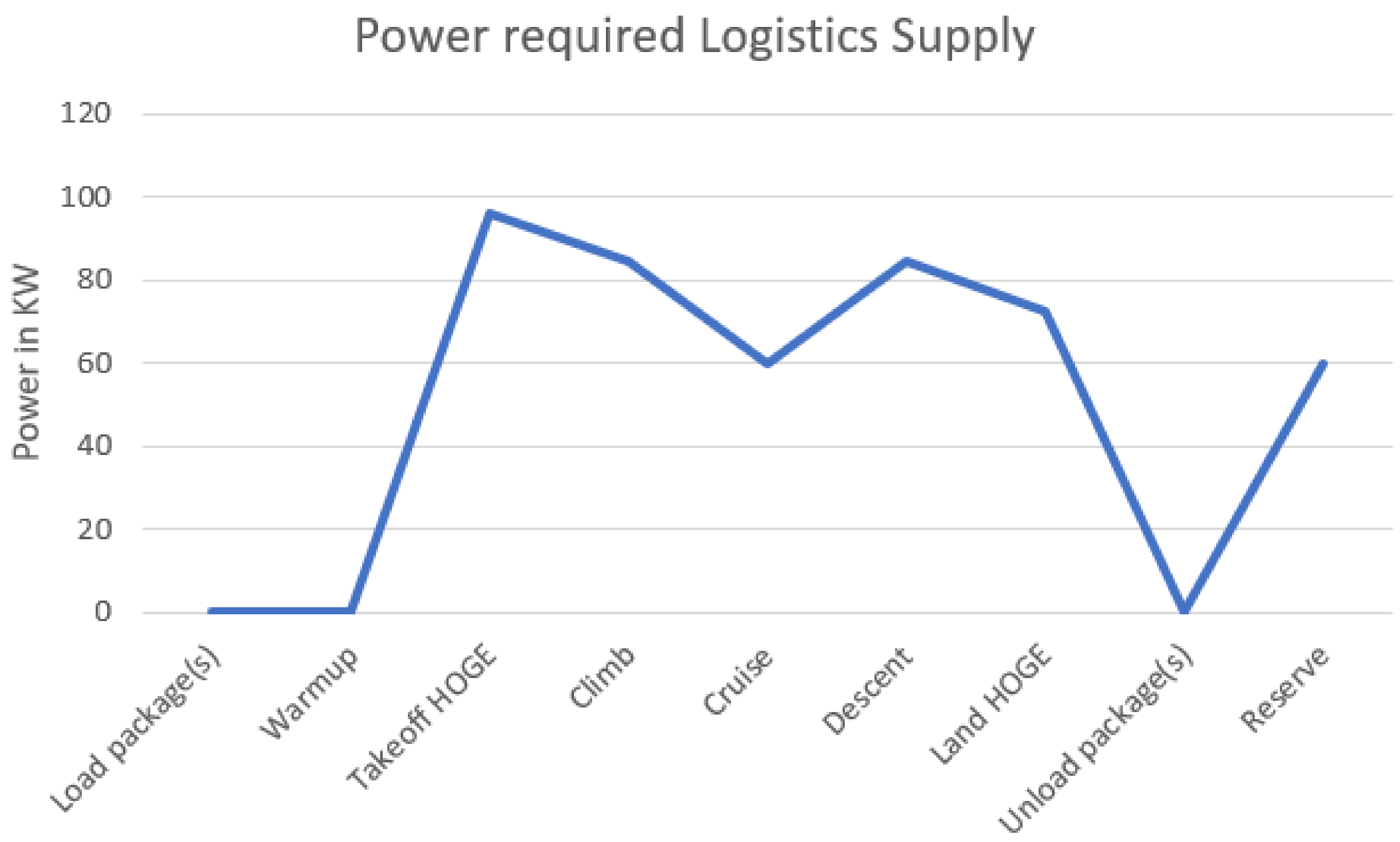
Power Required- Phases of Flight

- The power consumption of the aircraft through the delivery Mission is shown below
- Overall we notice that there is a higher demand of energy from the local delivery mission for VTOL operations



Power Required- Phases of Flight

- The power required for Logistical Delivery is shown
- Overall, the power required by the cruise segment is higher
- Thus, taking both the cases into account the aircraft was designed for both the cases so that it can complete the mission without any reconfiguration



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Conceptual Design

For conceptual design the system selection process was crucial as it determined the final performance of the aircraft.

For the purpose of the RFP off the shelf parts were selected based on the requirements they satisfied. Effective trade studies were also done on all the possible systems. The design choices for the layout, powertrain, payload handling operations and Aircraft electronics/ Avionics have been shown below.

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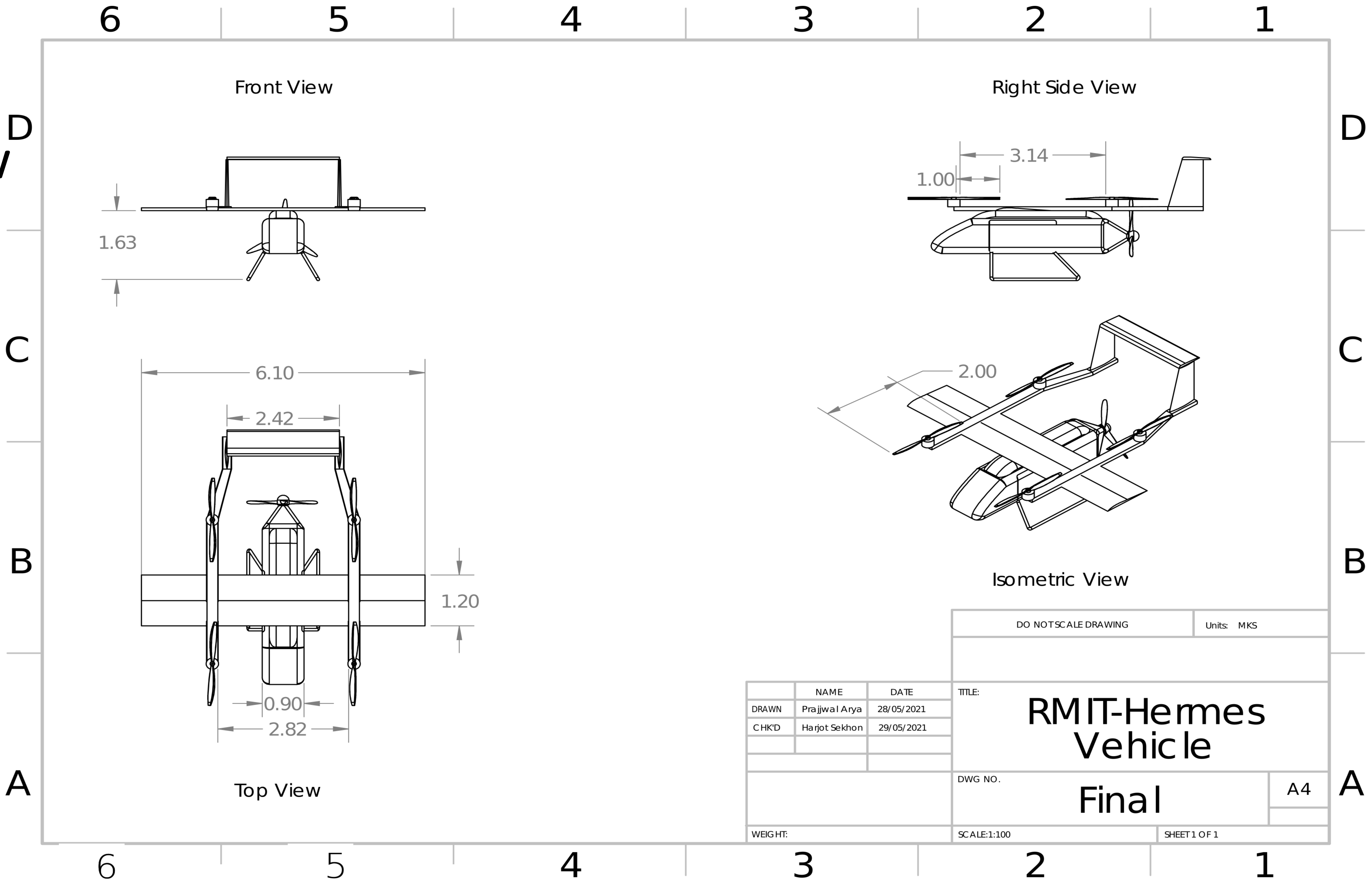
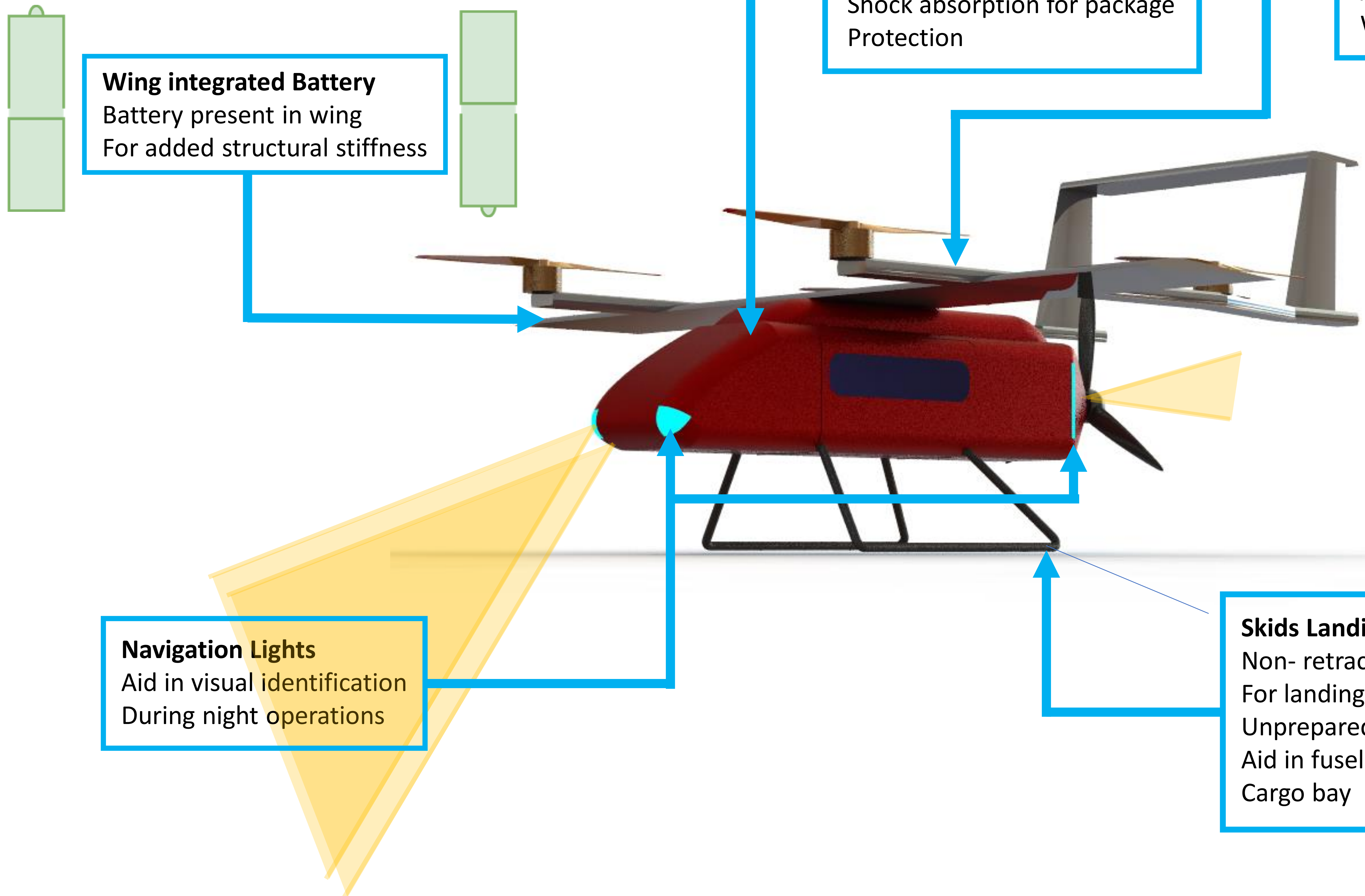
Three View Drawing



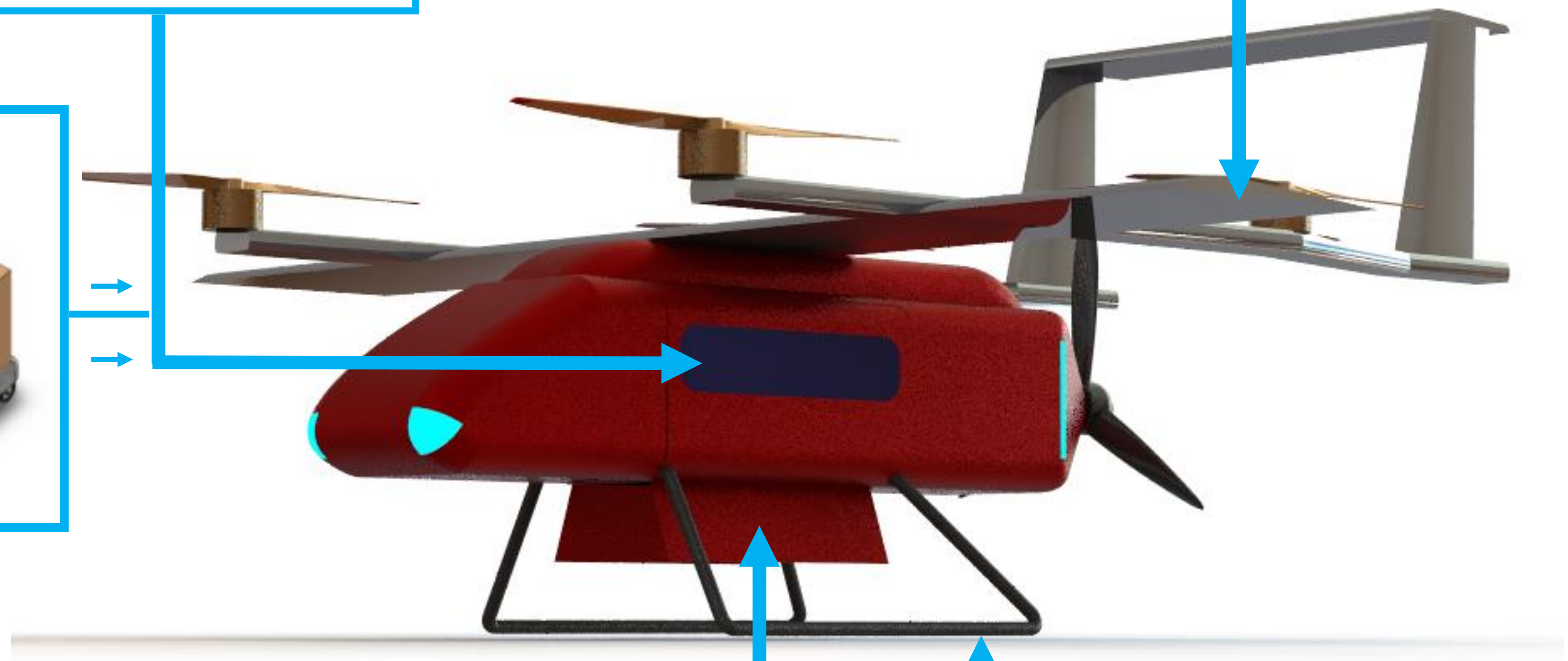
Structural Design



Payload Handling

Side door for loading cargo using payload dolly cart to Transport payload

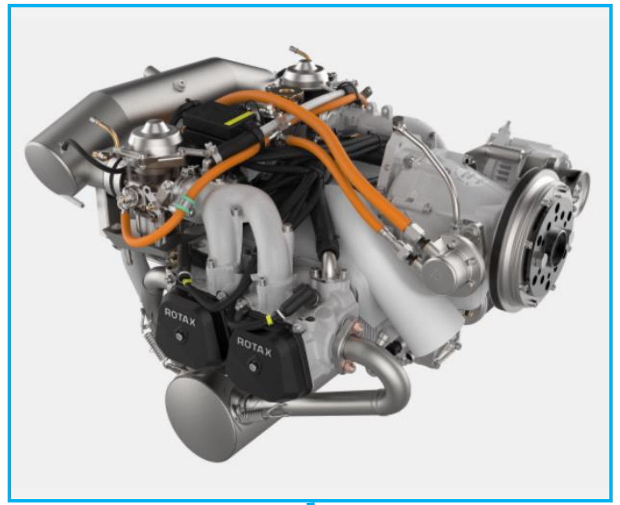
High wing for ease of access During payload loading



Bottom hatch for payload delivery Opens after landing, package has Shock absorptive padding

Skids for ease of landing On unprepared surfaces

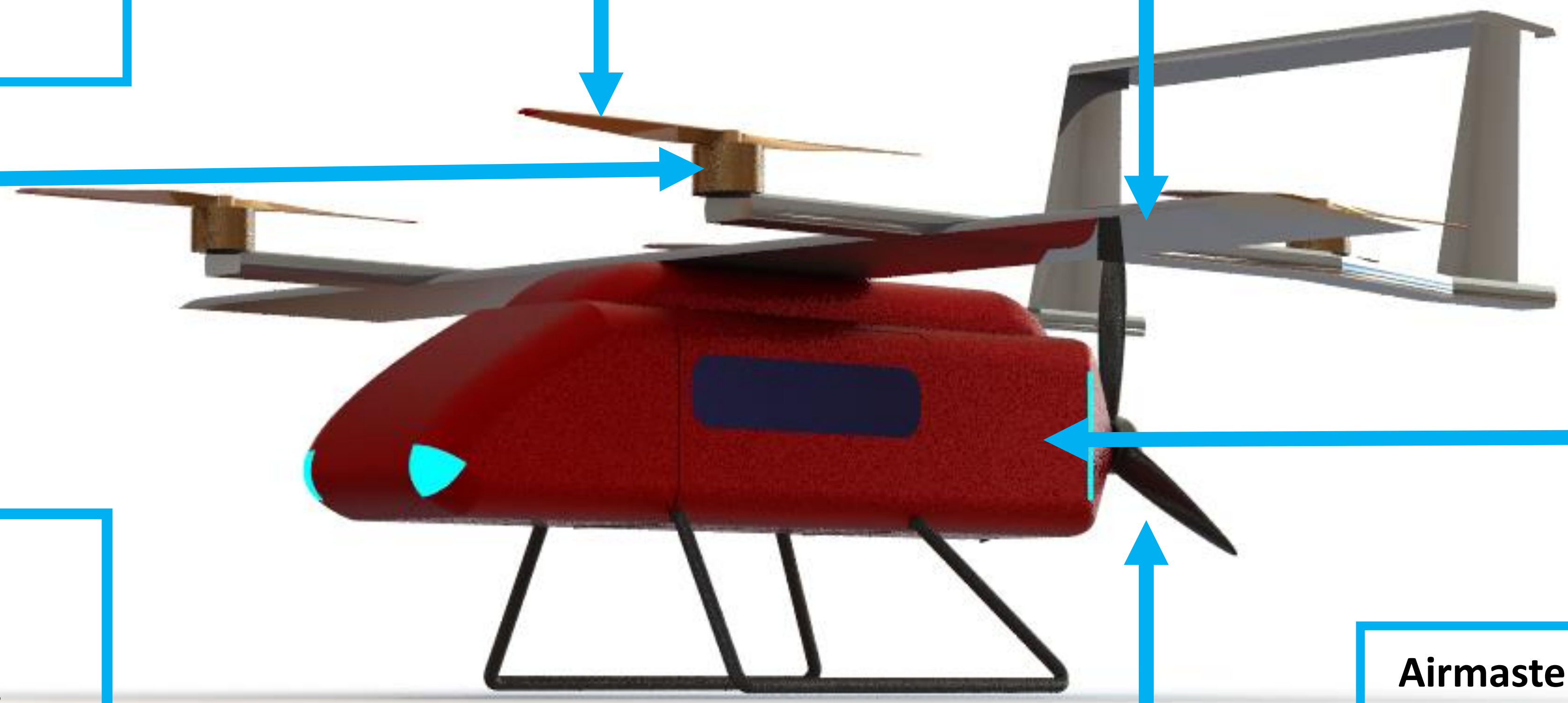
Powerplant



Rotax 912
60 KW
Internal combustion
Piston engine
230 km/h cruise flight
18.5 L/h fuel consumption

Phillips Li-ion battery
245 Wh/kg Li-ion battery
For VTOL operations
20% minimum SOC,
45 Kgs battery Pack

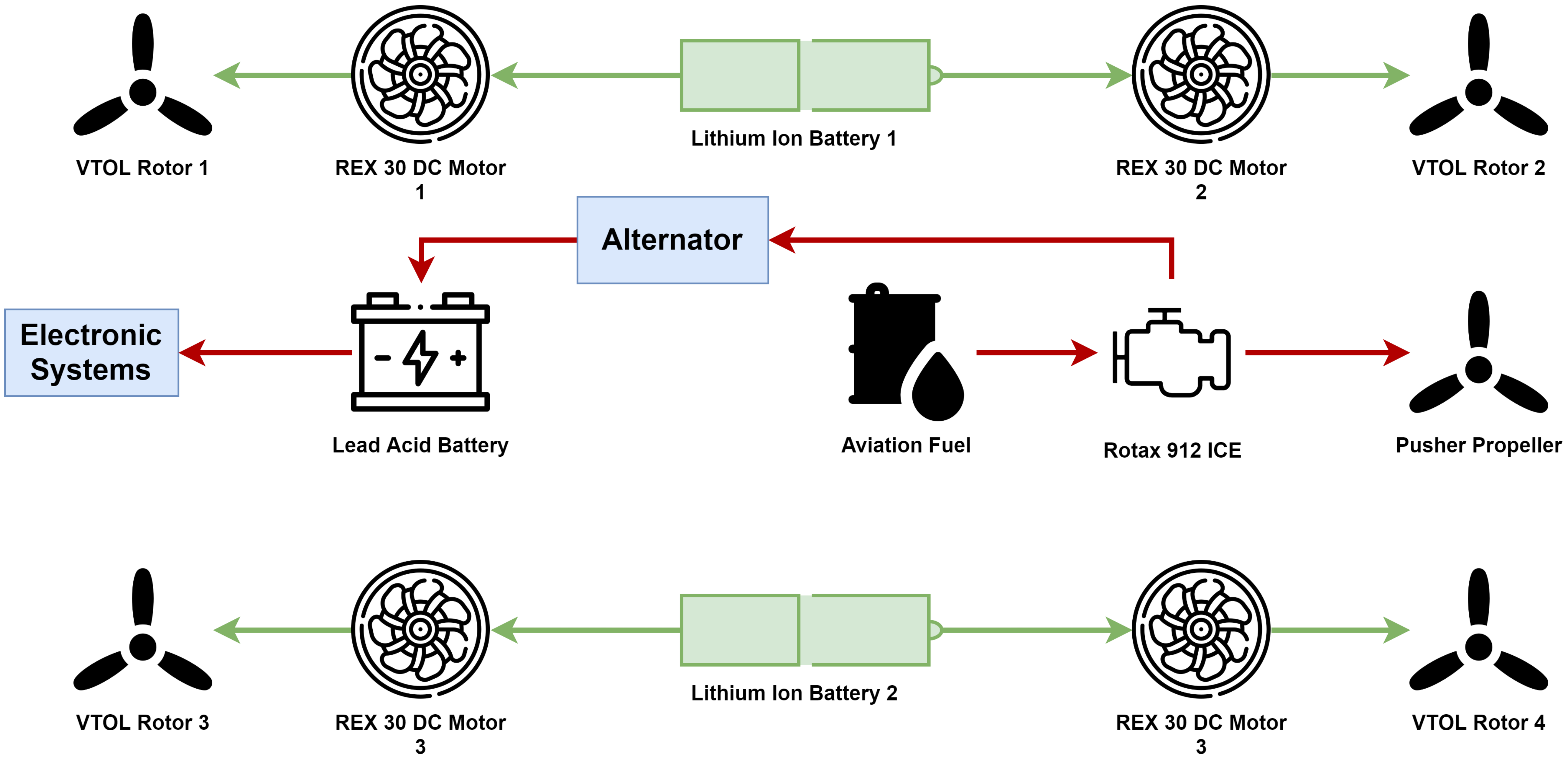
VTOL Rotors
2m diameter
85% VTOL efficiency
Quadrotor configuration
For effective Distributed
Electric Propulsion and high
Area Efficiency



REX 30
Brushless DC motor
17KW power
2X motors per rotor for
Safety considerations

Airmaster WWR68W
Propellor designed to be
Used with Rotax 912

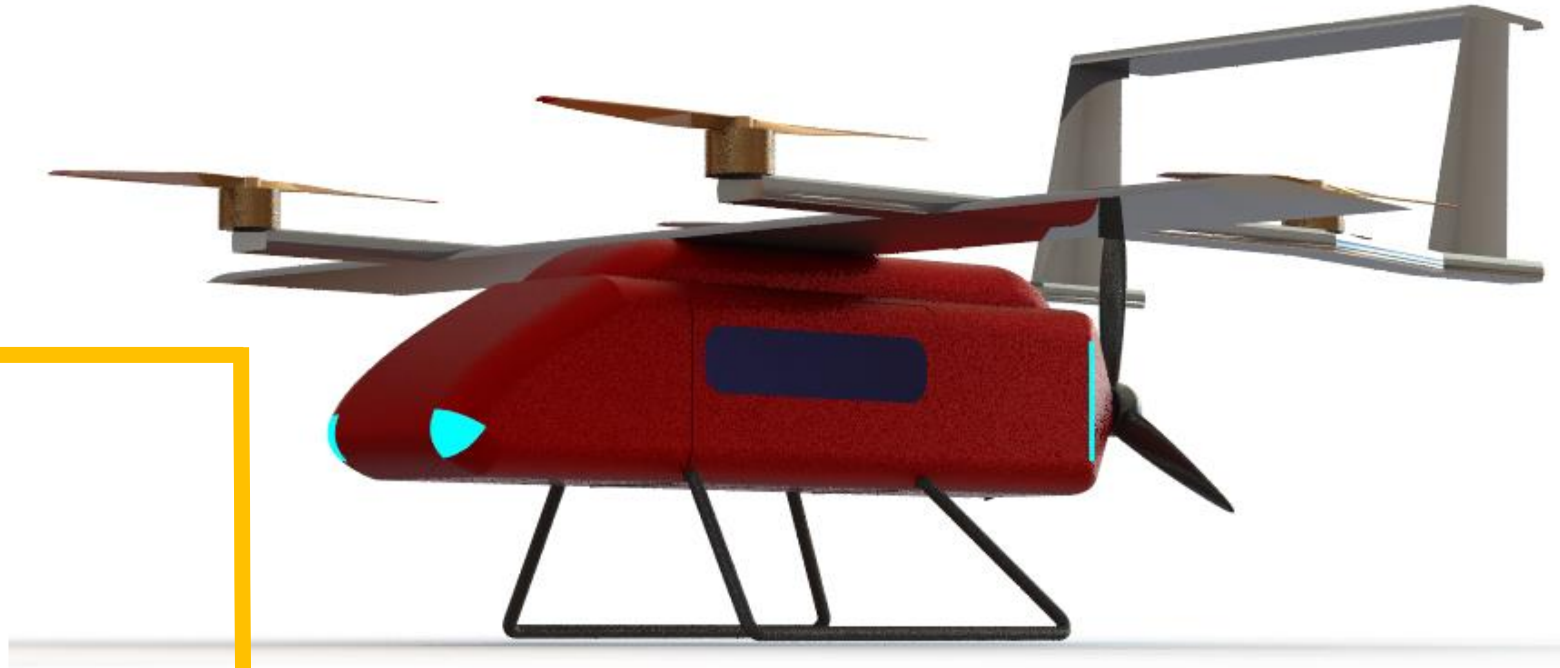
Transmission Layout



Aircraft Systems

Enables autonomous flight overpopulated areas hence fulfilling the mission requirement of autonomous cruise and VTOL.

The **AP 10.1 Automatic Controller System,** is used as the primary navigation and autopilot system.
- Multiple CPU access
- Online sensor failure tolerances
- Integrated GPS



POLAR-500
- Inertial Navigation
- Incorporated GNSS system
- Precise attitude estimation

ODROID-XU4
- Onboard computer
- Backup system for SLAM algorithm

MXR Mode S Interrogator Onboard computer
- Traffic and collision avoidance system
- Omni-directional surveillance

Trimble R12i
- Access to multiple satellite constellations
- Real time data transmission

Accurate navigation of the vehicle can be accomplished with these systems. For precise payload delivery.

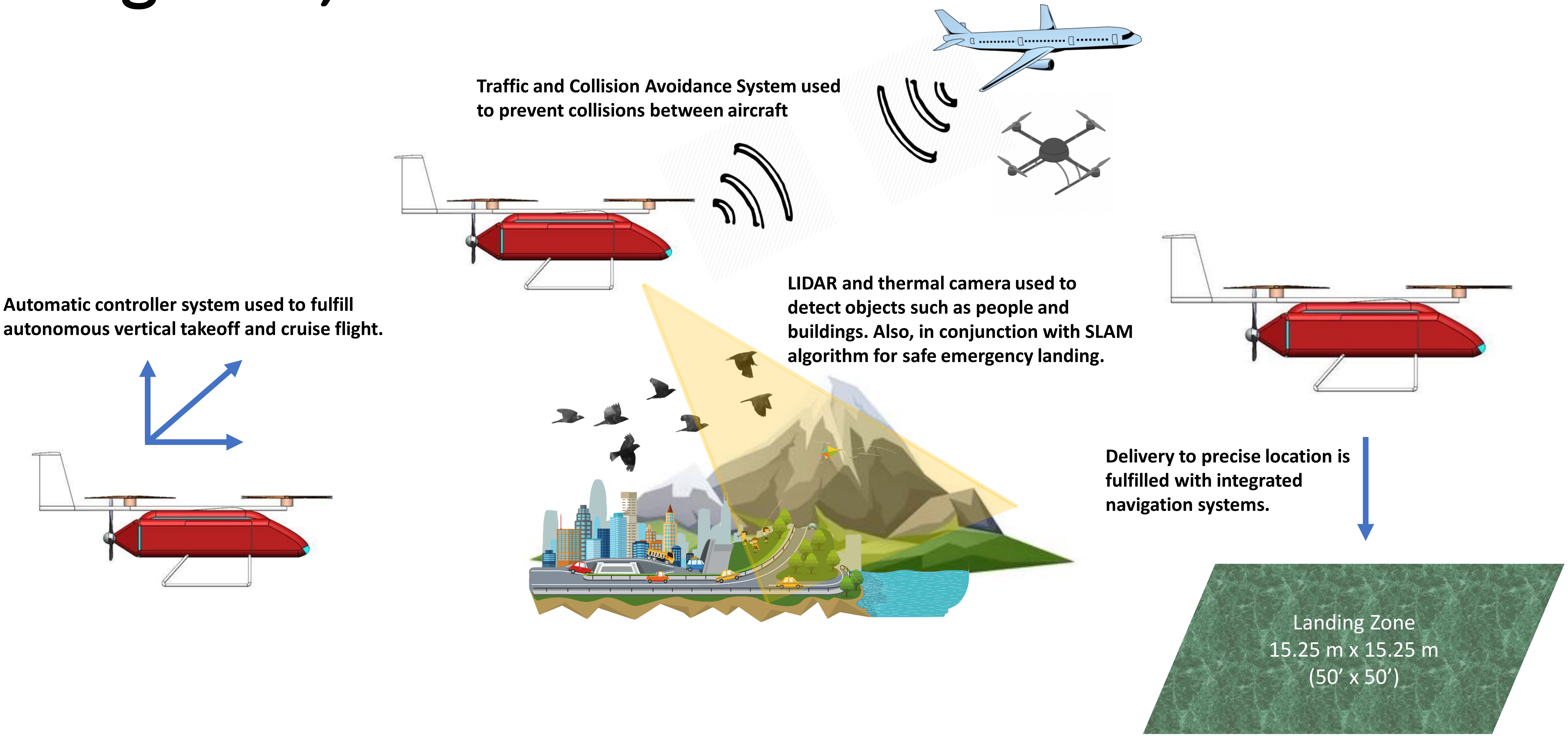
CM142-ISR & Target Acquisition
- High resolution
- Day and night vision using a thermal camera
- Obstacle detection

Ouster OS2 LIDAR sensor
- Obstacle Detection
- 11.25°-33.75° Field of view
- 240m range
- Accuracy of 5.5cm-10.5cm

Hovermap HF1
- LIDAR obstacle detection
- Simultaneous Location Mapping
- Backup to GPS & Primary LIDAR sensor

These integrated systems provide current sense and avoid technology. They also aid in emergency landing and system redundancy.

Navigation, Obstacle Detection & Avoidance



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Path to Certification

The path adopted for certification of the aircraft considers the following regulations:

- Australia's Civil Aviation Safety Regulations (1998) Part 101
- Federal Aviation Administration (FAA) Advisory Circular AC 25.1309
- Society for Automotive Engineers (SAE) ARP4761

An initial Functional Hazard Assessment (FHA) was competed to identify and classify all failure conditions associated with aircraft functions.

FHA - Key safety features identified:

- ➢ Two redundant motors driving each rotor
- ➢ Redundant and proven autonomous flight control system
- ➢ Backup obstacle detection and navigation sensors