Advanced Aircraft Design Capstone (AAD)

ECOR4907A

BumbleB Aircraft

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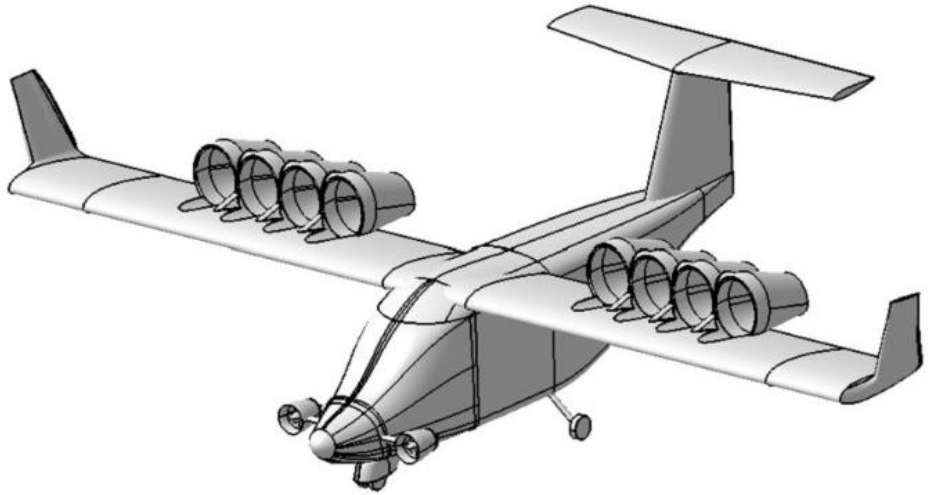
Aircraft Overview

Highlights

- Project Began in 2022-2023
- Design has evolved into a hydrogen powered, multi-mission eVTOL aircraft.
  - Fire Suppression Mission
  - Cargo Mission
- Focus on fully autonomous operations and

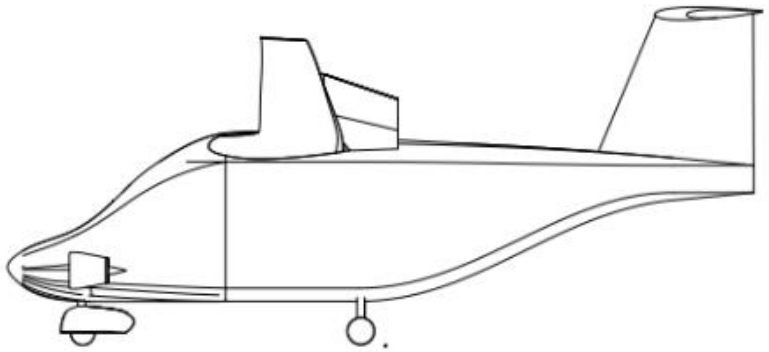
  Beyond Visual Line of Sight Ops (BVLOS)

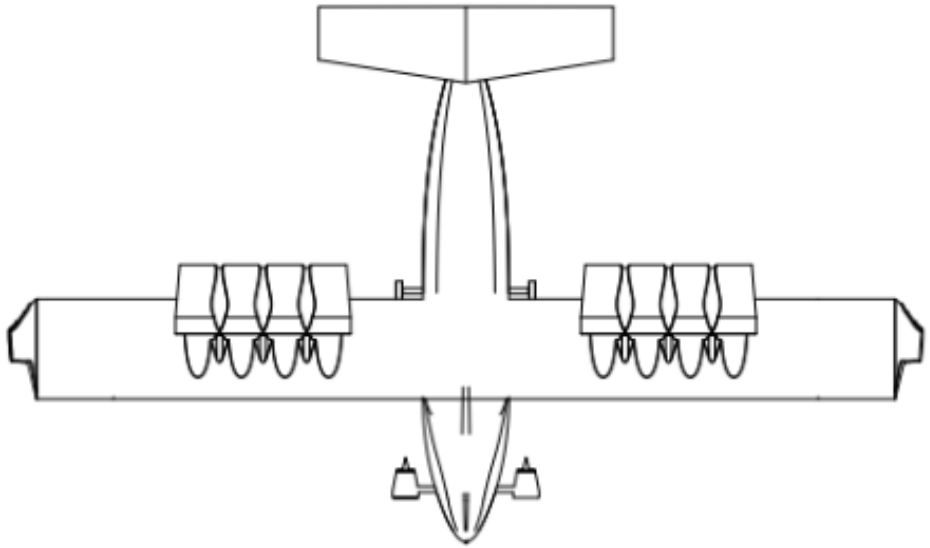


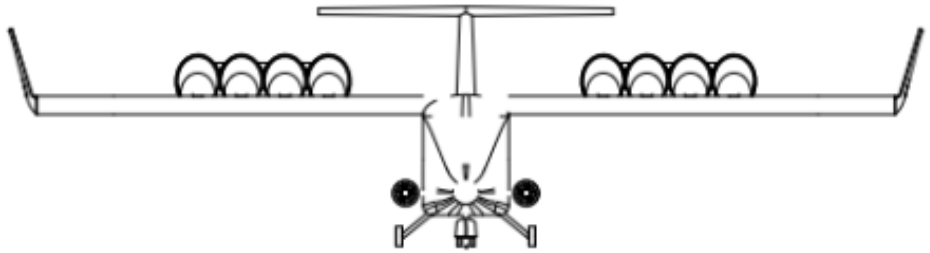
Looking Ahead

Focus for 2025-2026

- **Design** and **Fly** the Forward Flight Sub-Scale Demonstrator
- **Wind Tunnel Testing** for CFD Validation
- Continued Detailed Design







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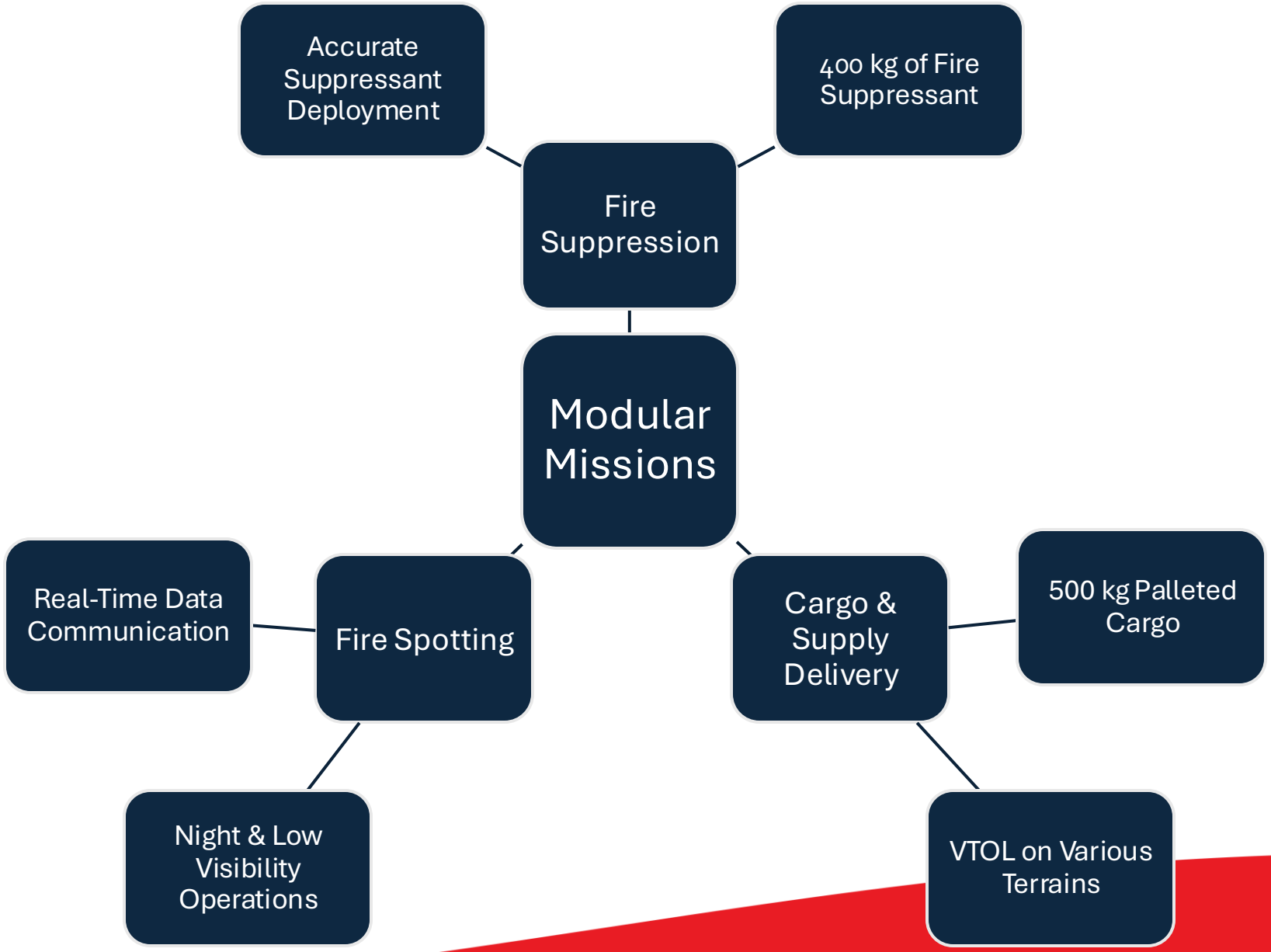
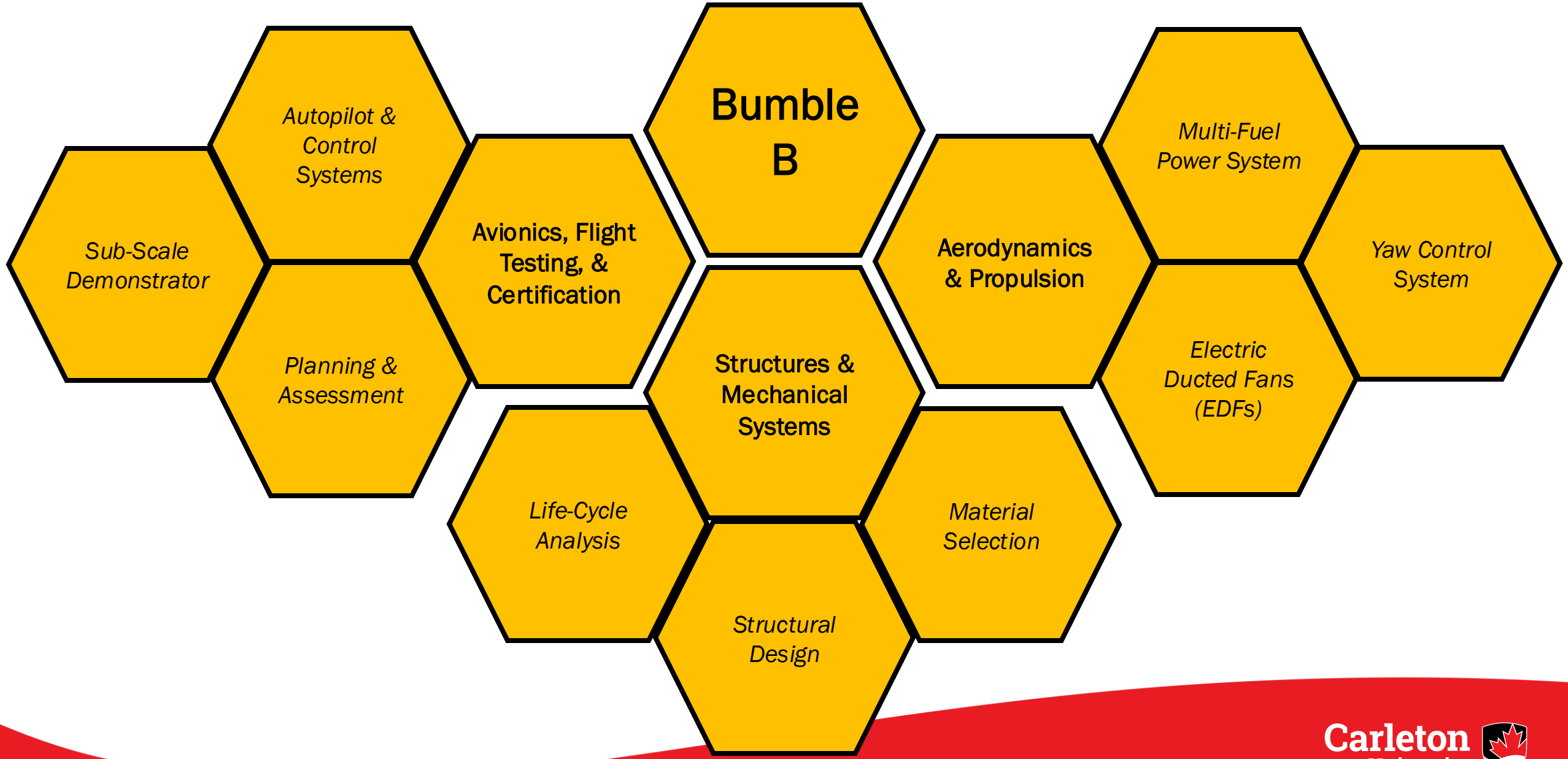

Accurate Suppressant Deployment
400 kg of Fire Suppressant
Fire Suppression
Modular Missions
Real-Time Data Communication
Fire Spotting
Night & Low Visibility Operations
Cargo & Supply Delivery
500 kg Palleted Cargo
VTOL on Various Terrains



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Avionics, Certification, Flight Testing

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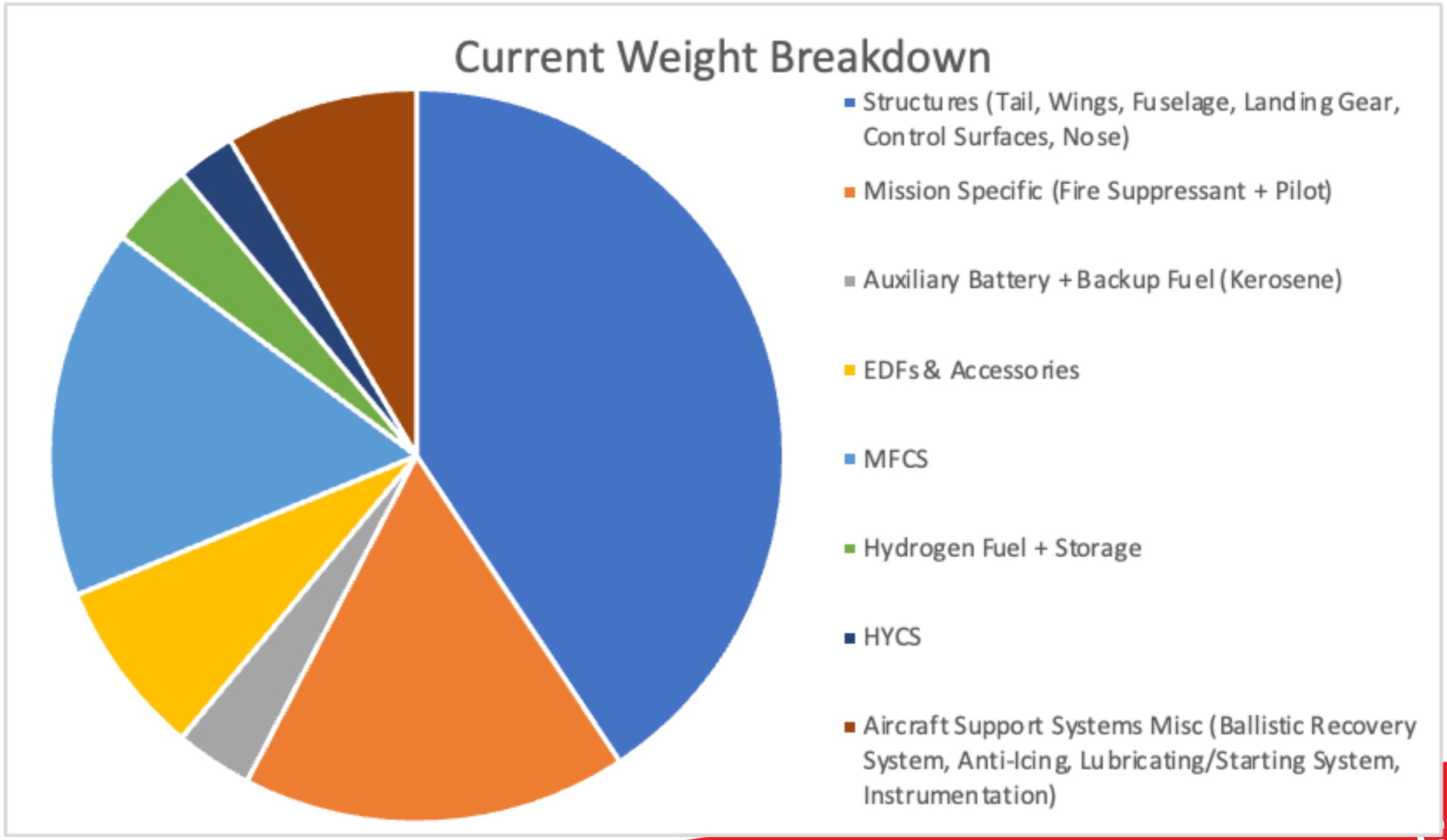
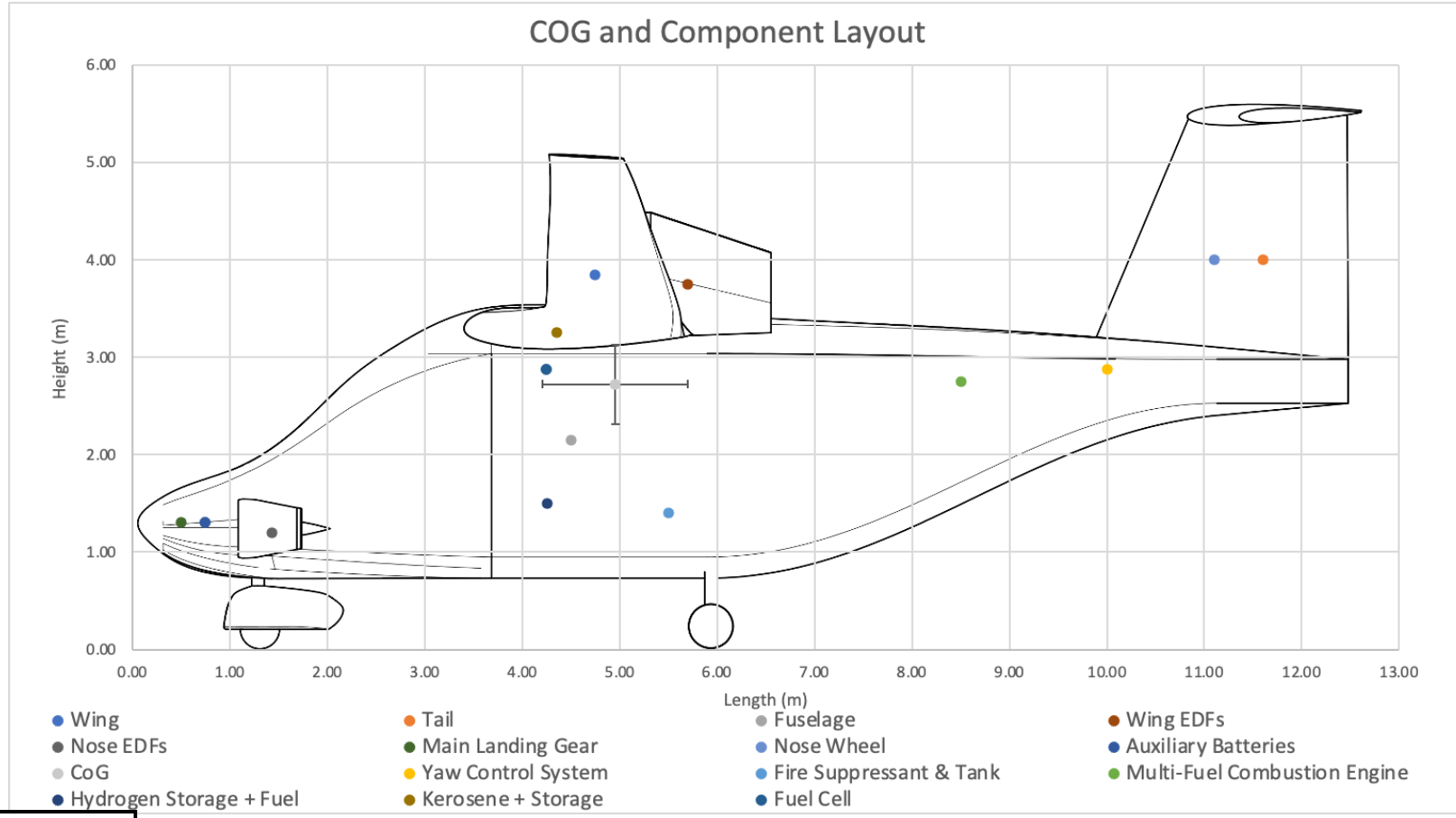
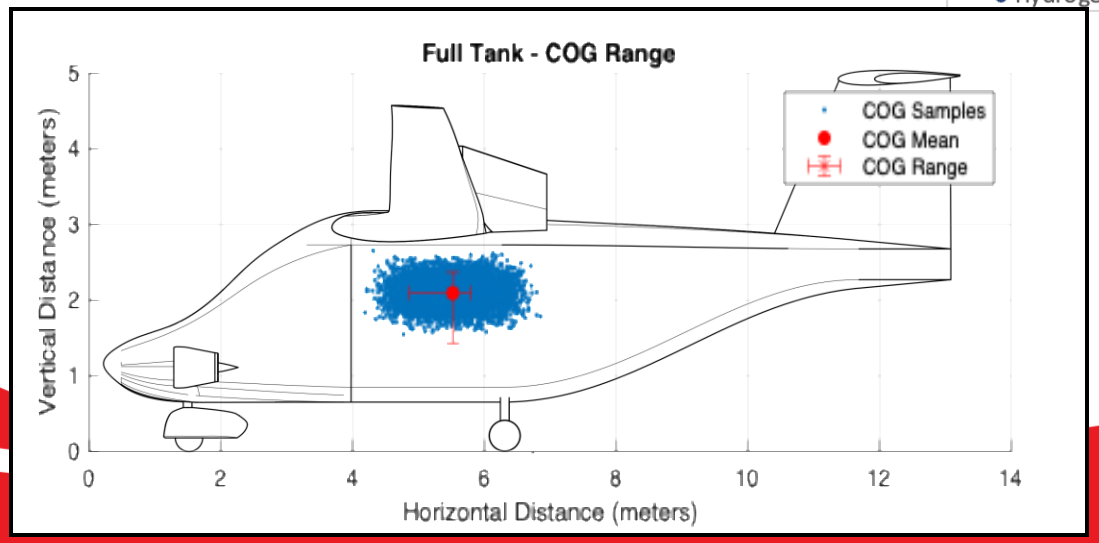
Weights & Balance



Weights & Balance





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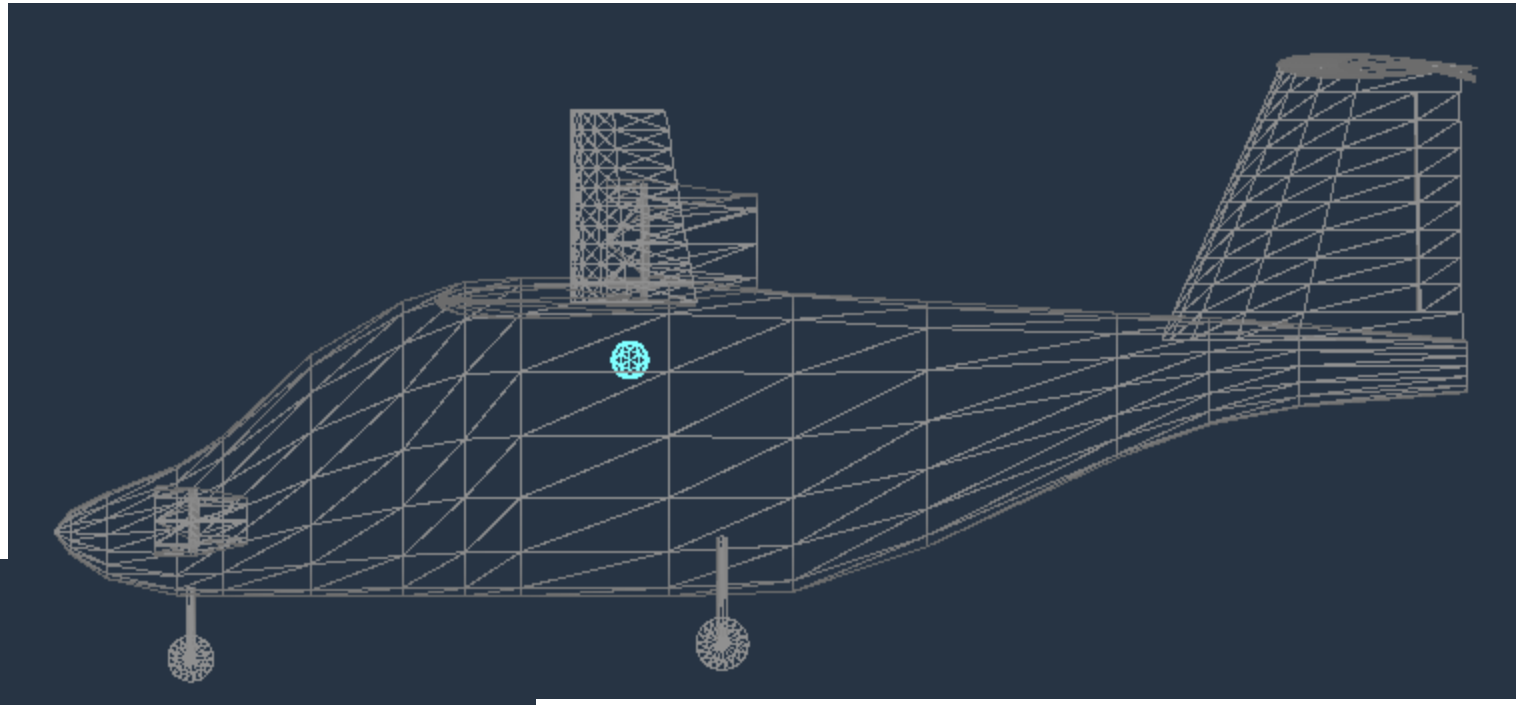
Plane Maker Model



X-Plane 12 Simulator

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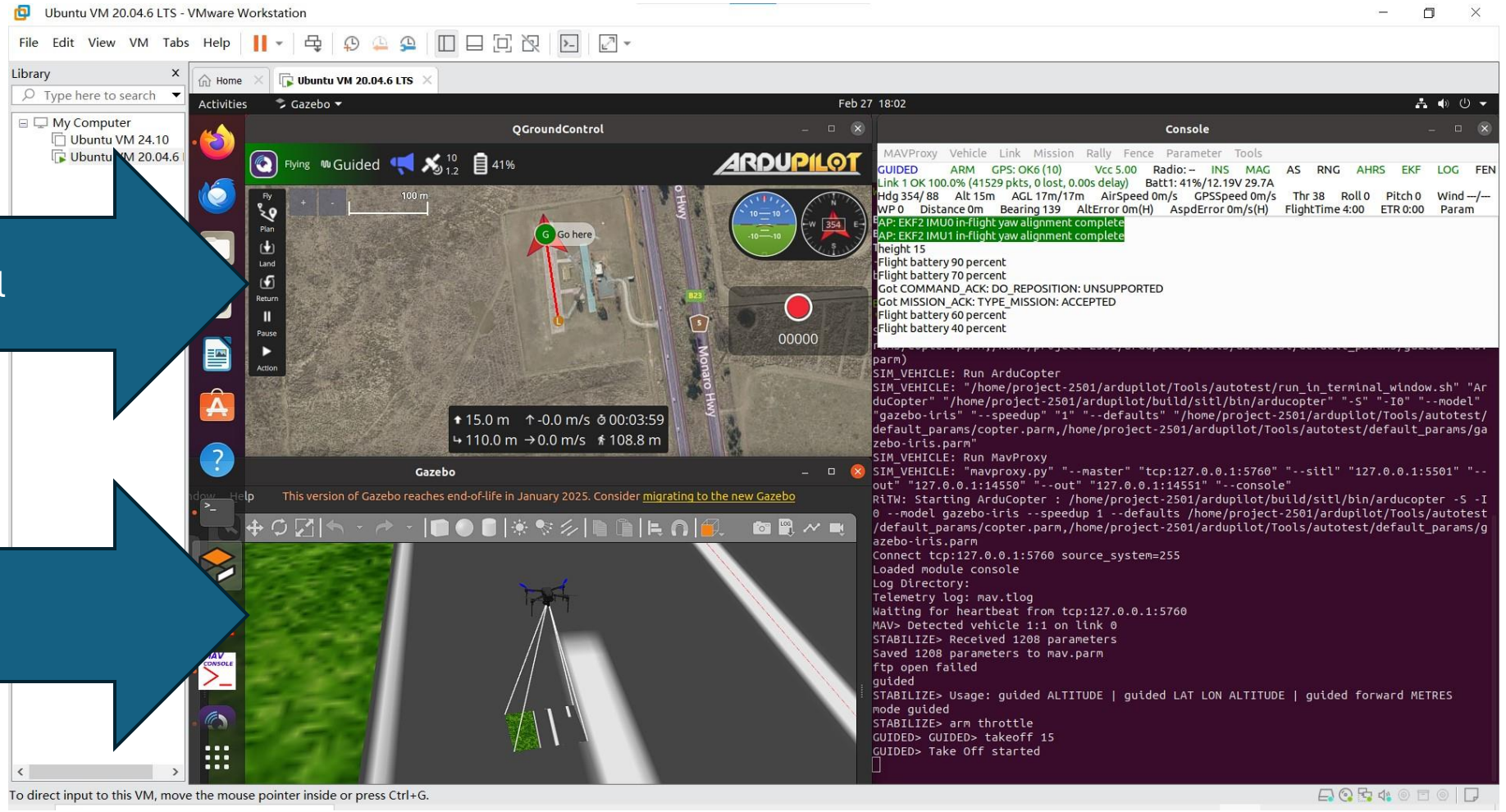
Software-in-the-Loop (SITL) Simulations

QGroundControl

Gazebo Classic



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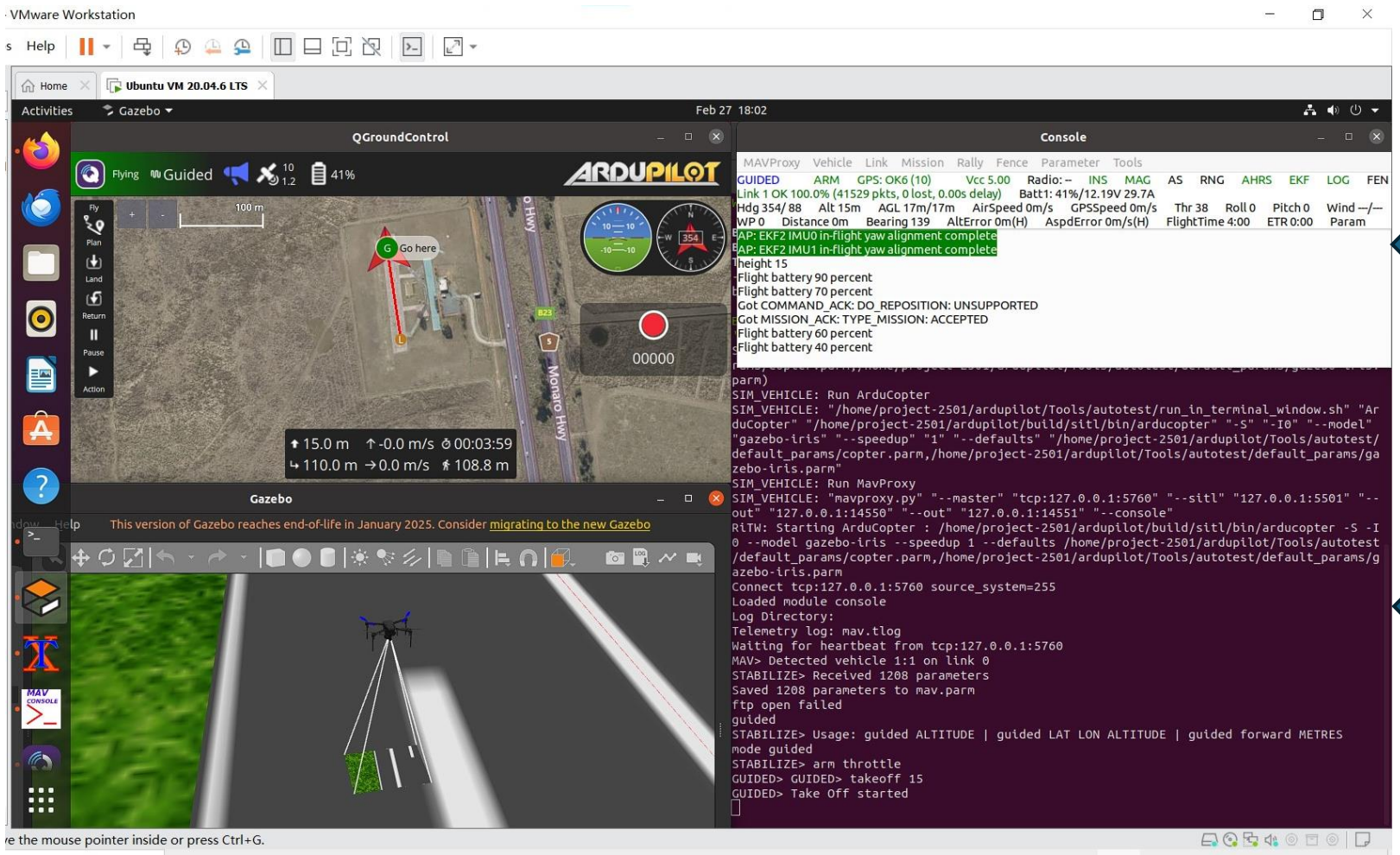
Software-in-the-Loop (SITL) Simulations



MAVProxy

ArduPilot Terminal

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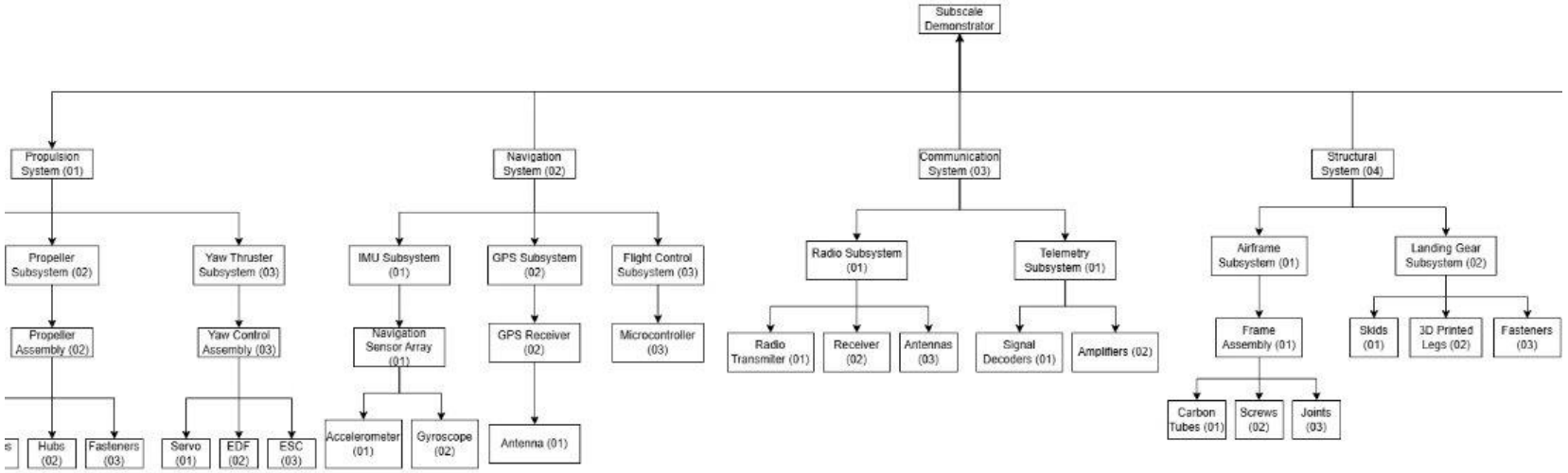
Certification- Aircraft Safety Assessment



System Breakdown Chart

System	Subsystem	Component Identification	Failure Mode	Failure Cause	Failure Event	Mitigation Strategies
Structural	Airframe	Carbon Tubes (04-01-01-01)	Cracking	Excessive load or impact	Reduced structural integrity	- Use reinforced carbon fibre - Conduct load testing
		Screws (04-01-01-02)	Loose fastenings	Vibration during operation	Frame instability	- Use thread-locking compounds - Perform periodic tightening
		Joints (04-01-01-03)	Joint failure	Material fatigue	Loss of structural support	- Use durable materials - Inspect regularly

Failure Modes and Effects Analysis (FMEA)

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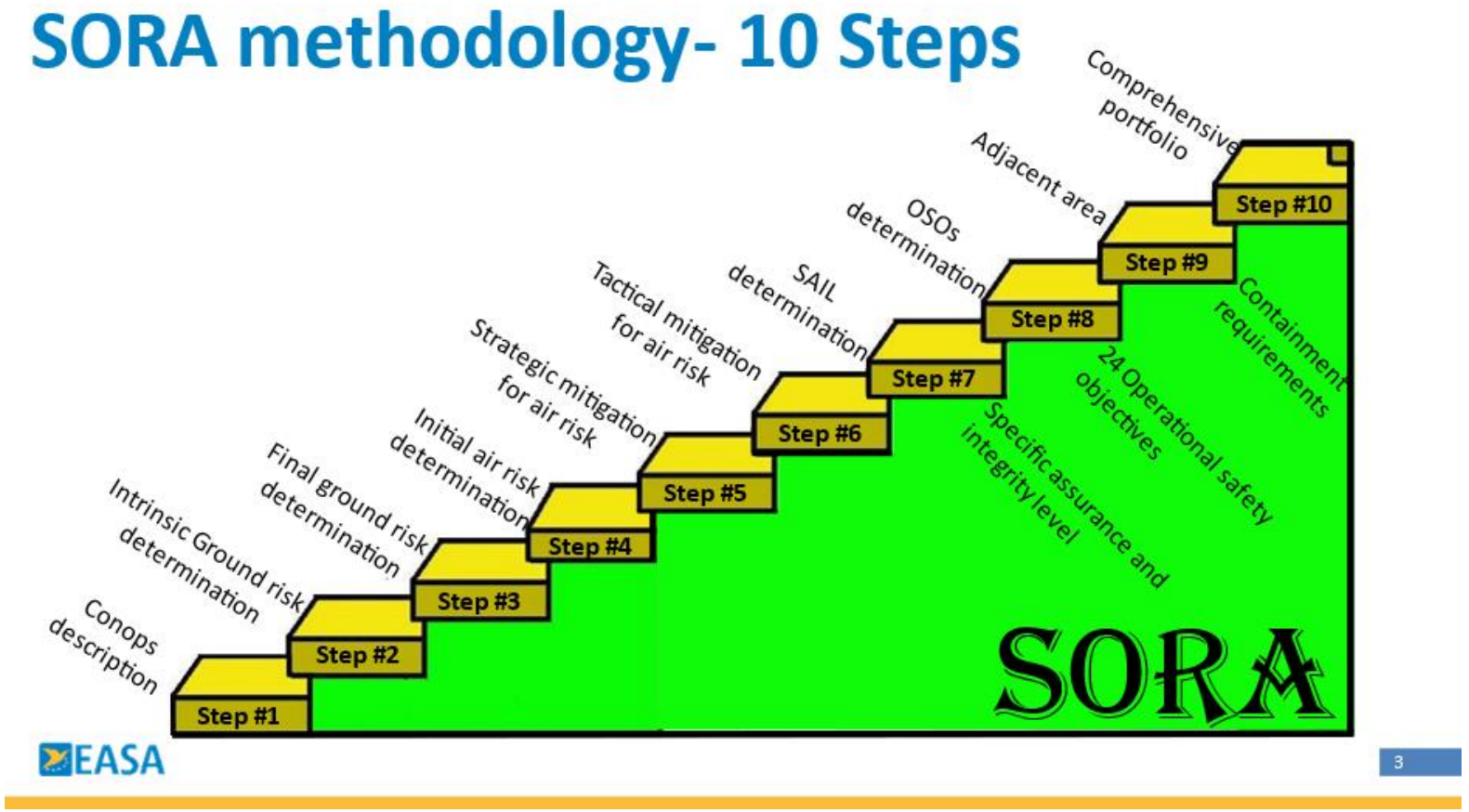
Certification- Aircraft Safety Assessment



Specific Operations Risk Assessment (SORA)

Specific Operations Risk Assessment (SORA) | EASA

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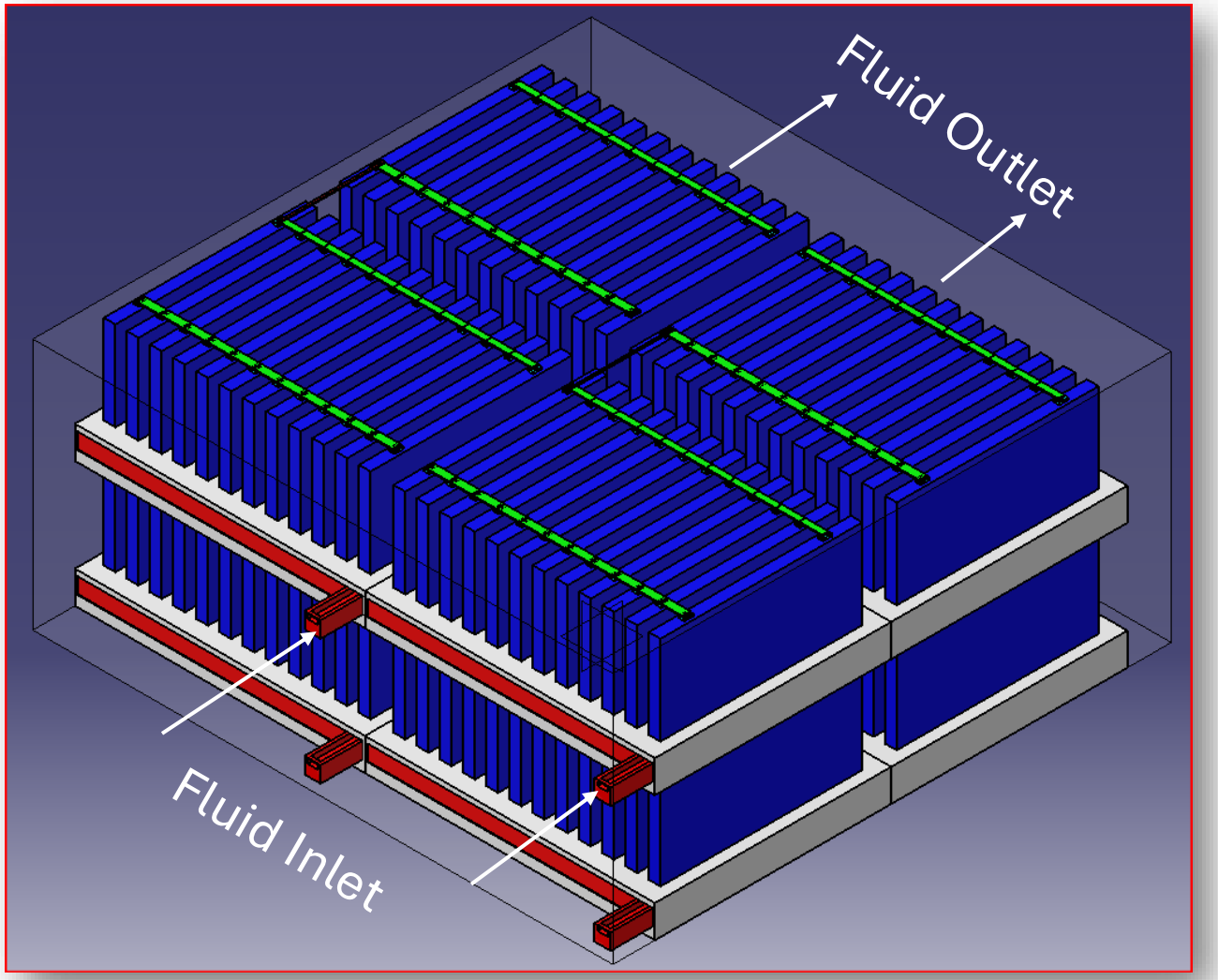
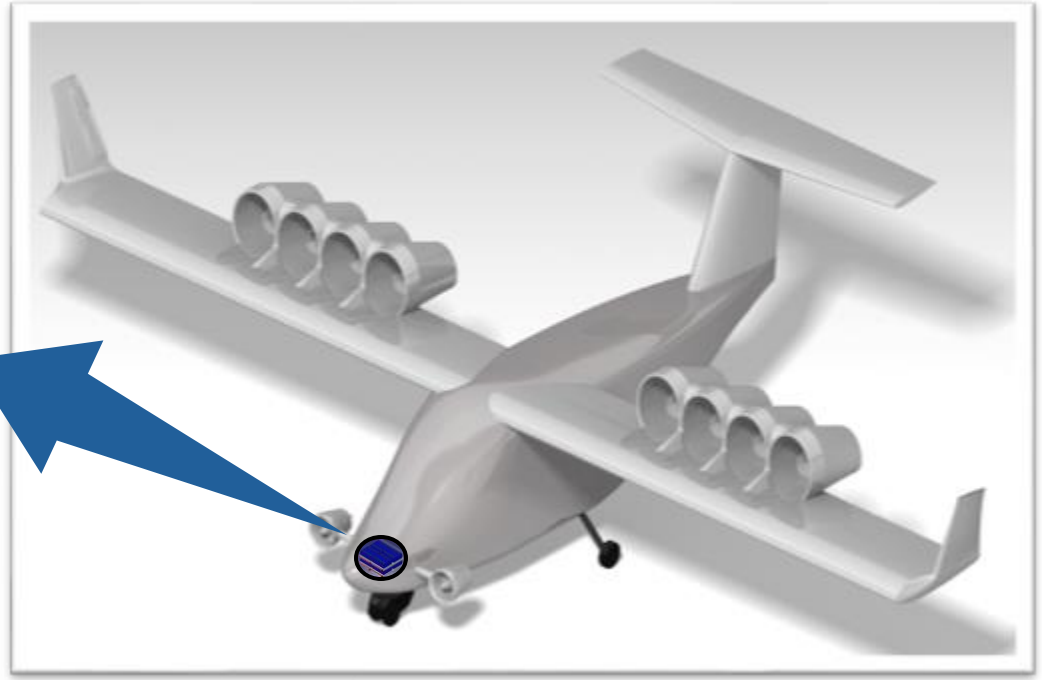
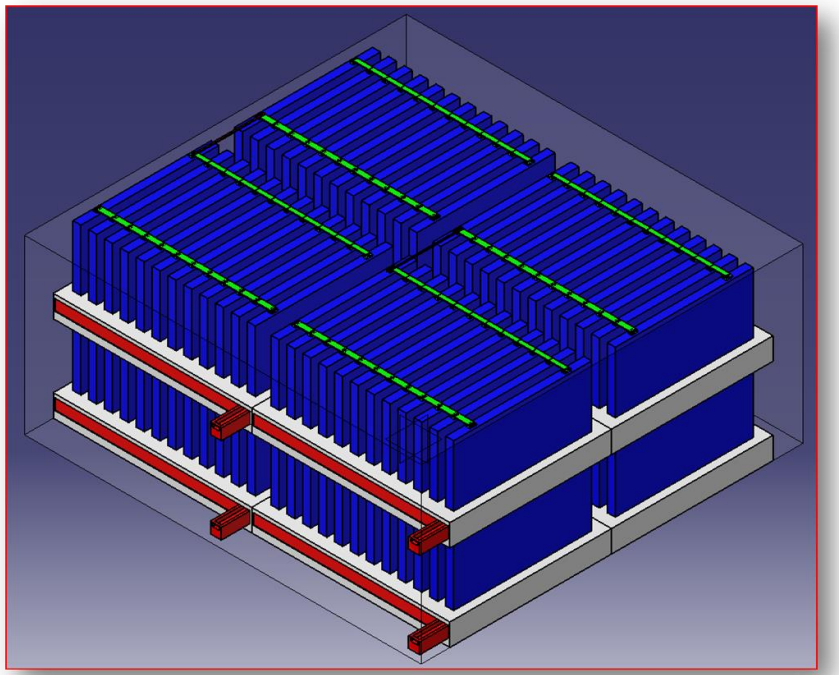
Emergency Power Backup System



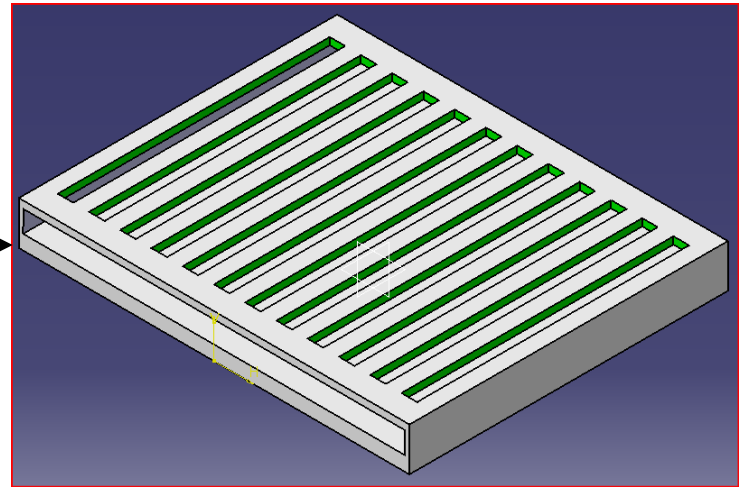
Lithium-ion Battery Pack



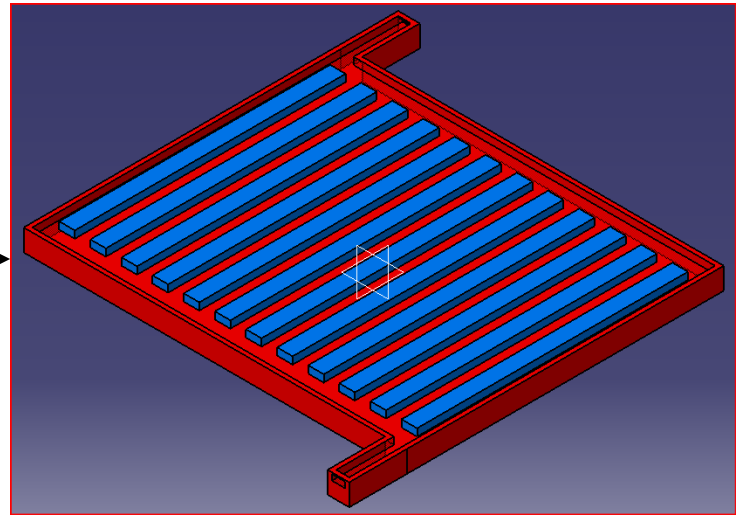
Lithium-ion Battery Pack Parts



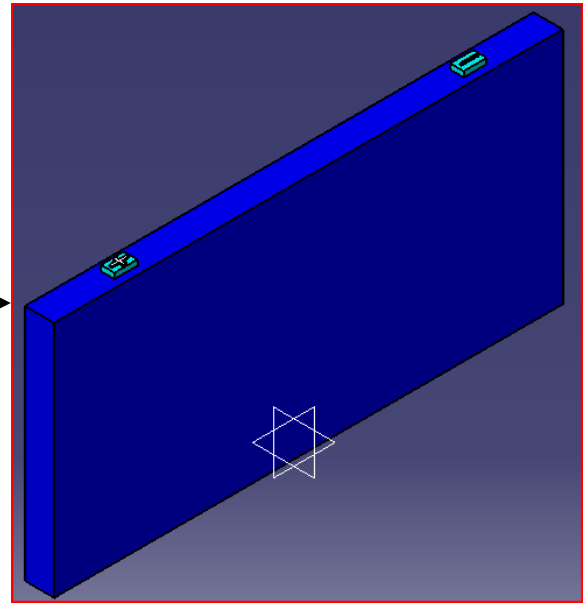
Lithium-Ion Battery Pack



Battery Holder



Cooling Plate



Battery Cells
(Prismatic Cells)

Aerodynamics and Propulsion

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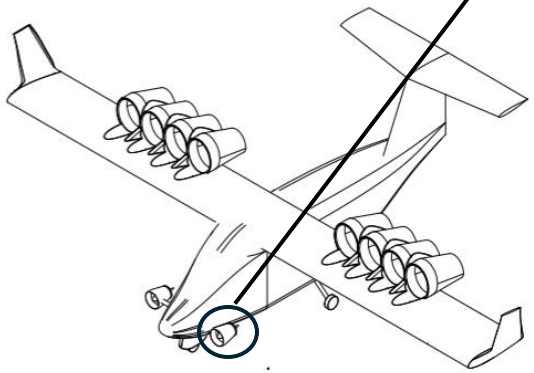
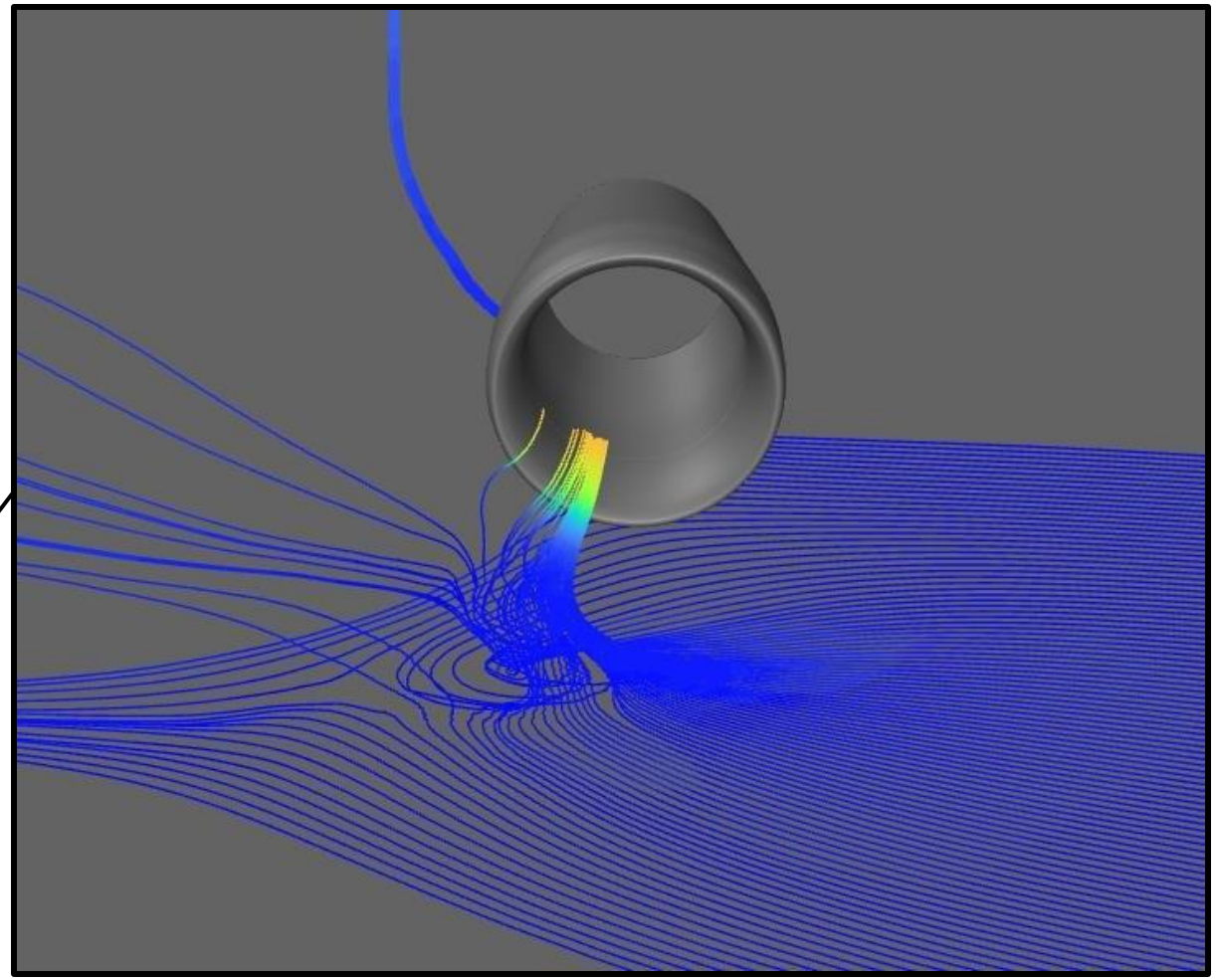
Modelling Ground Vortex Ingestion

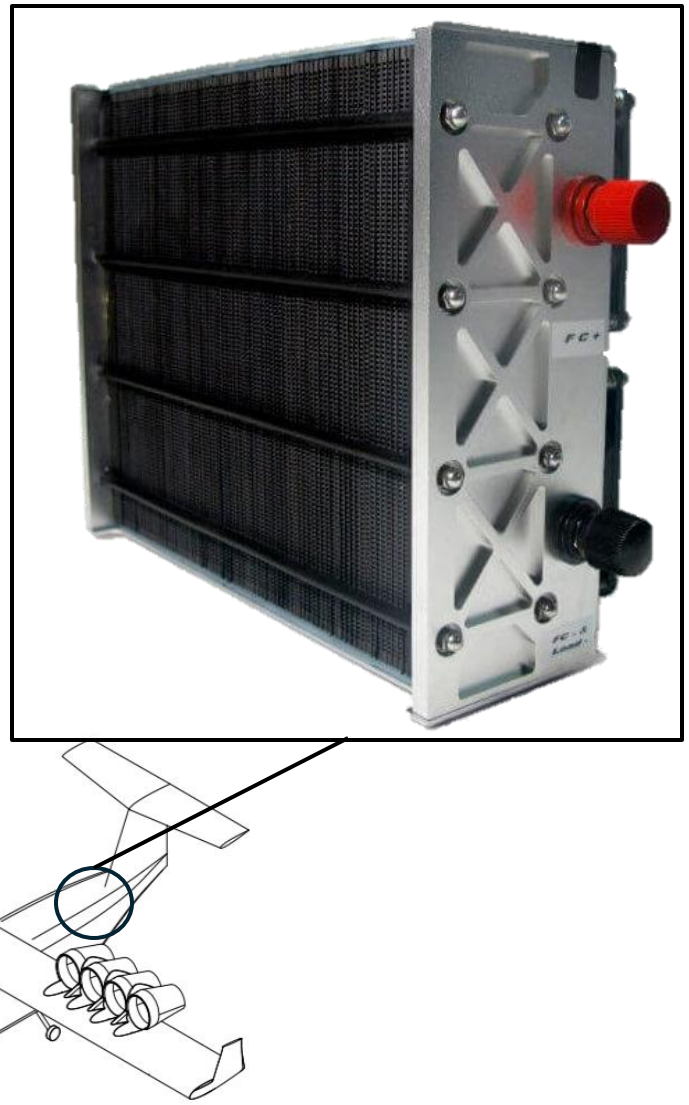
GVI as seen on
A USAF C17



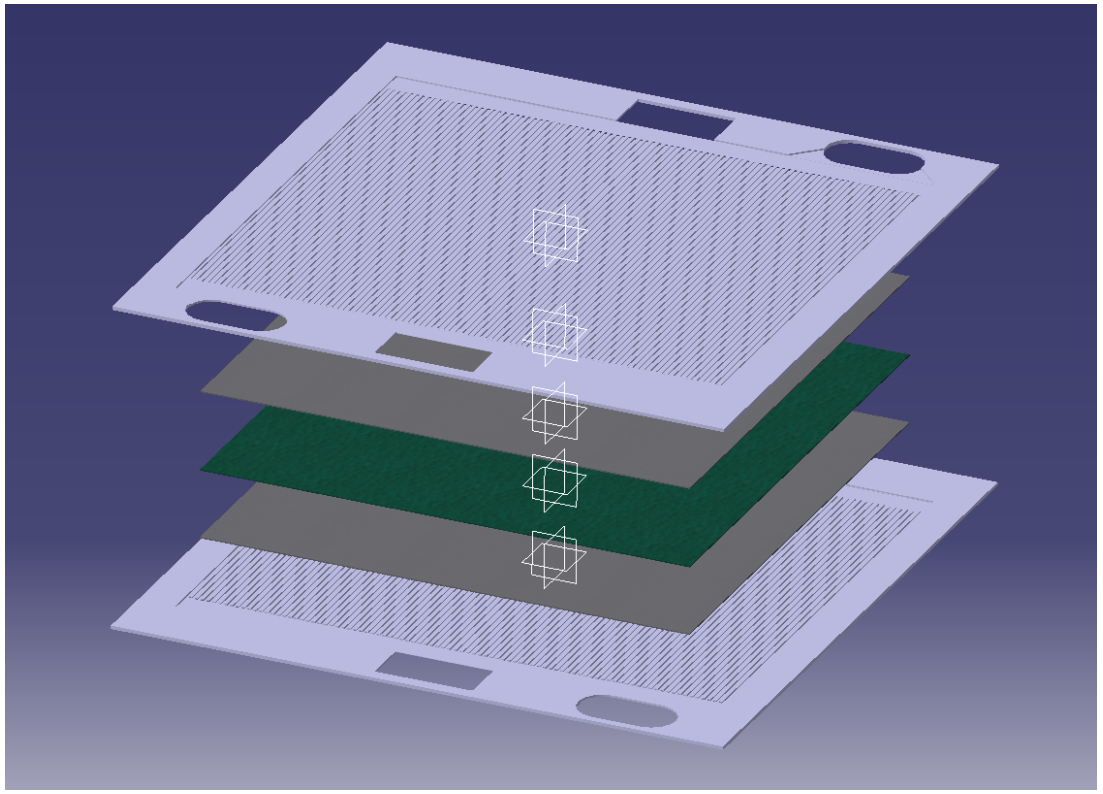


Proton Exchange Membrane Fuel Cell (PEMFC)

PEMFC Stack example

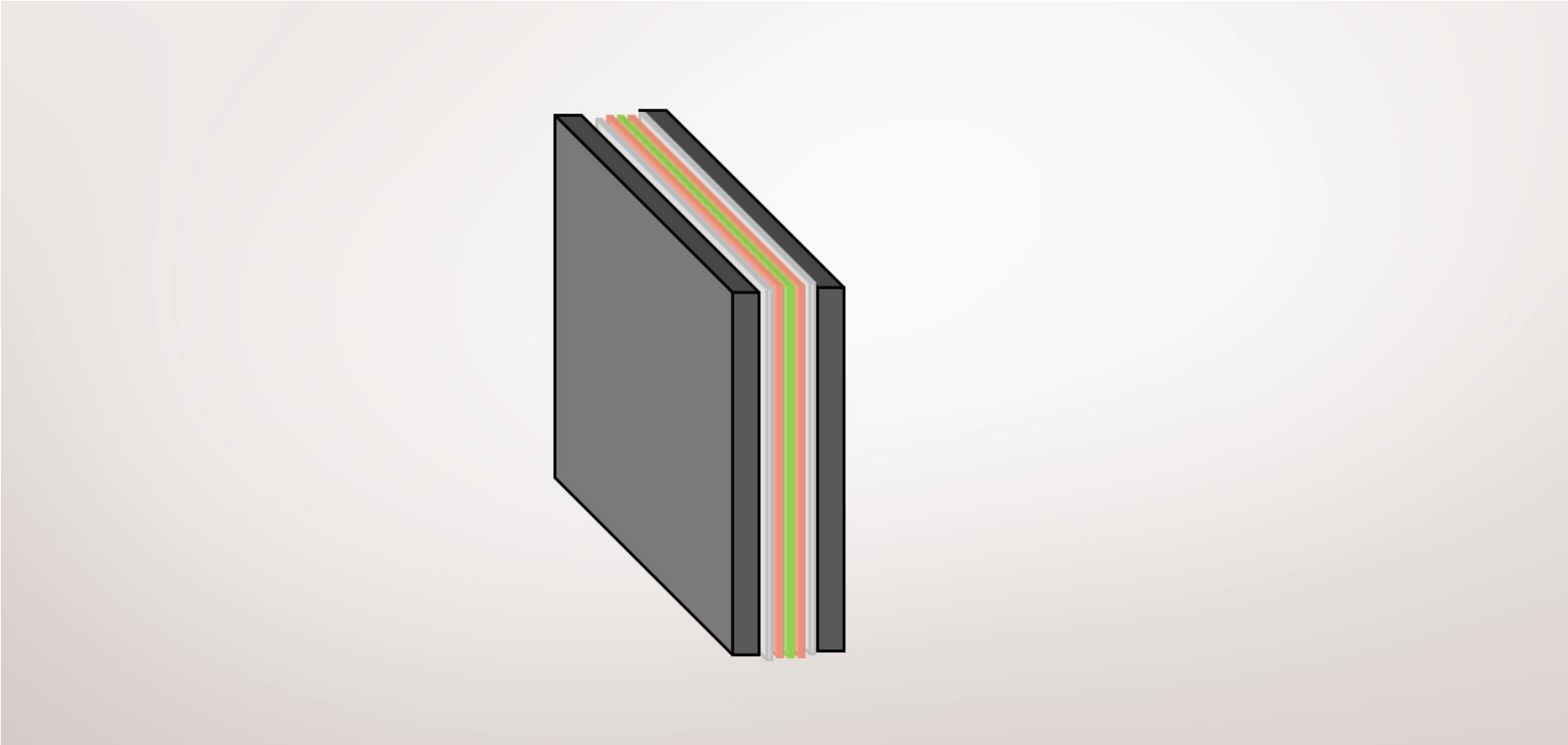


Exploded CAD model of single cell

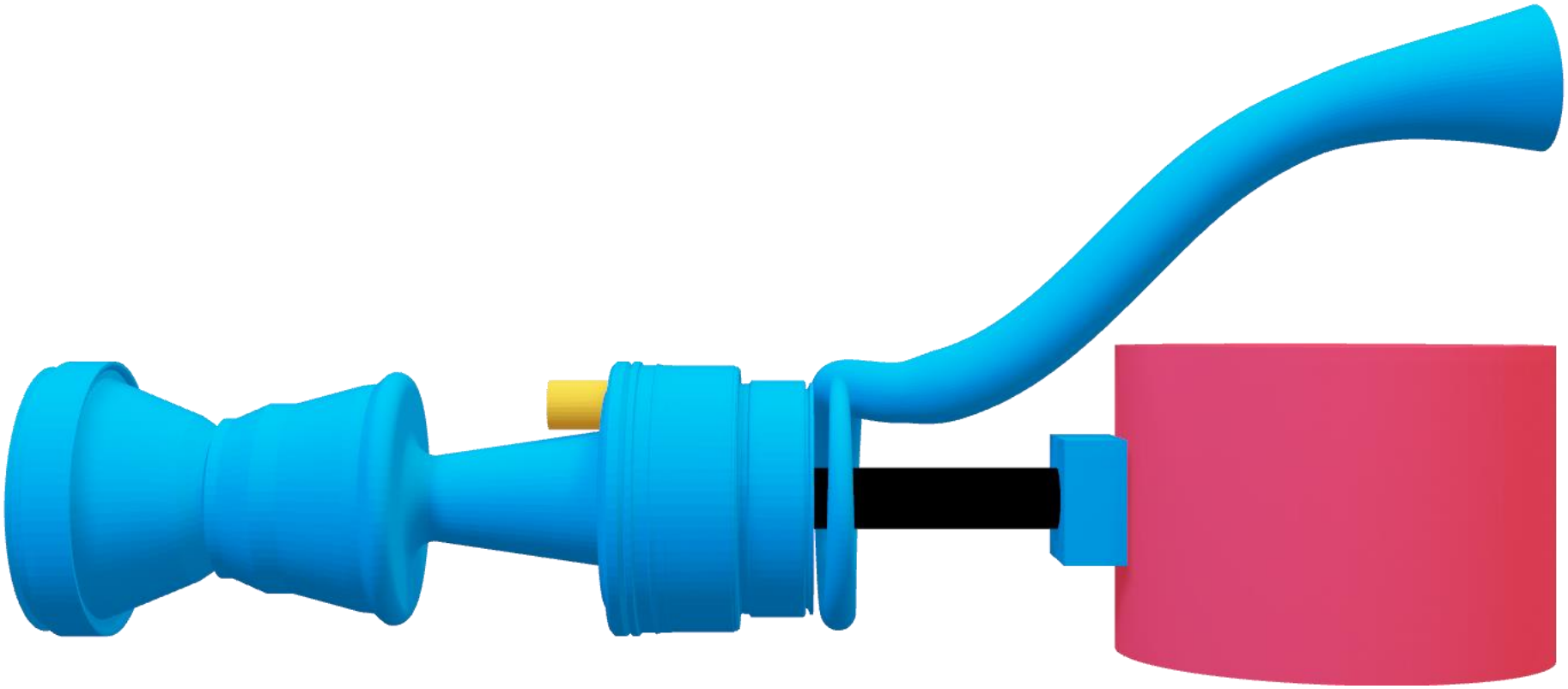


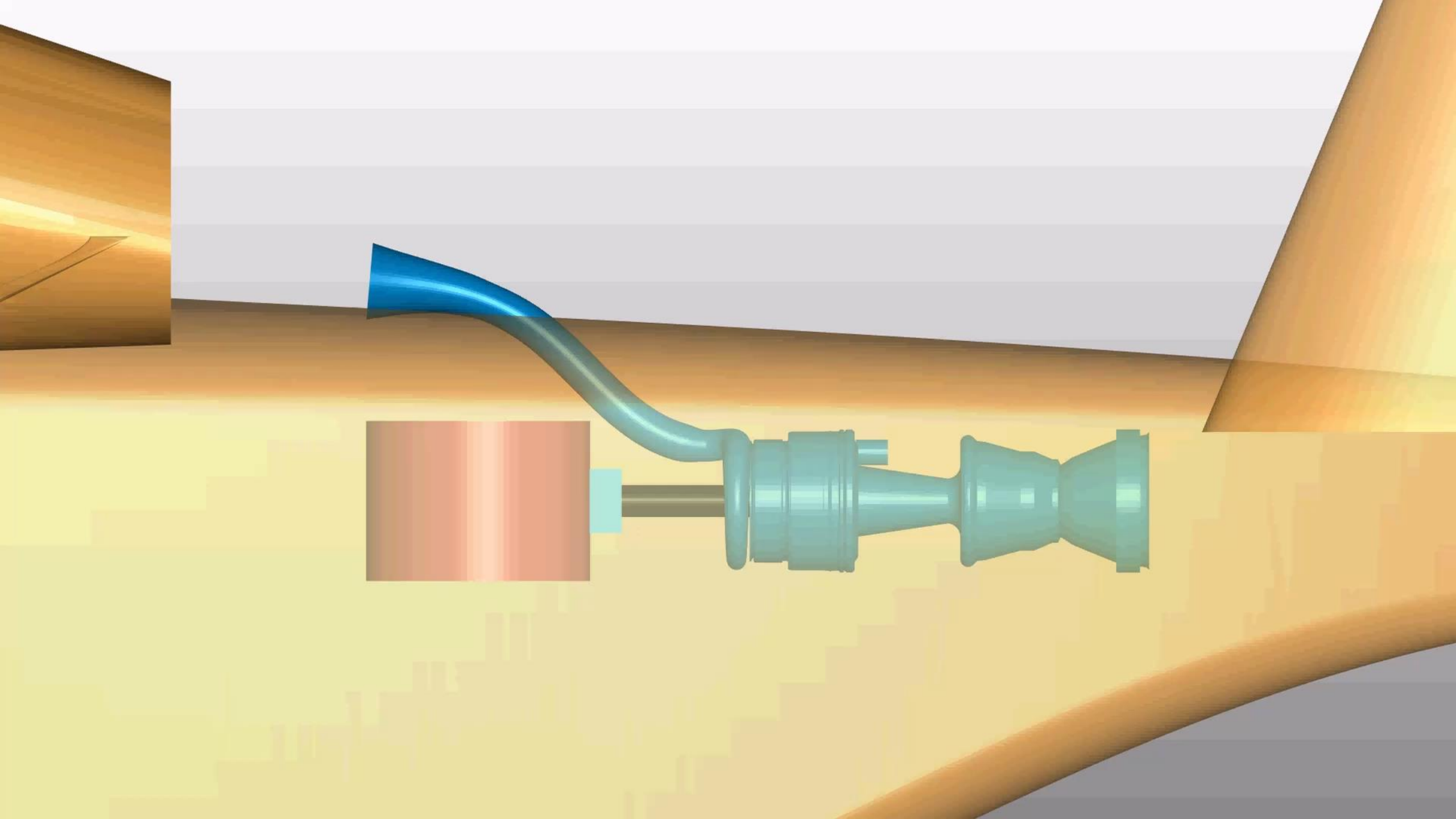
Proton Exchange Membrane Fuel Cell (PEMFC)

How it works:

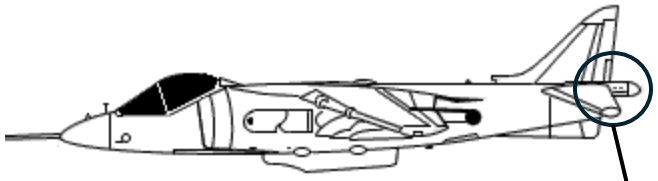


Multi-Fuel Combustion Engine

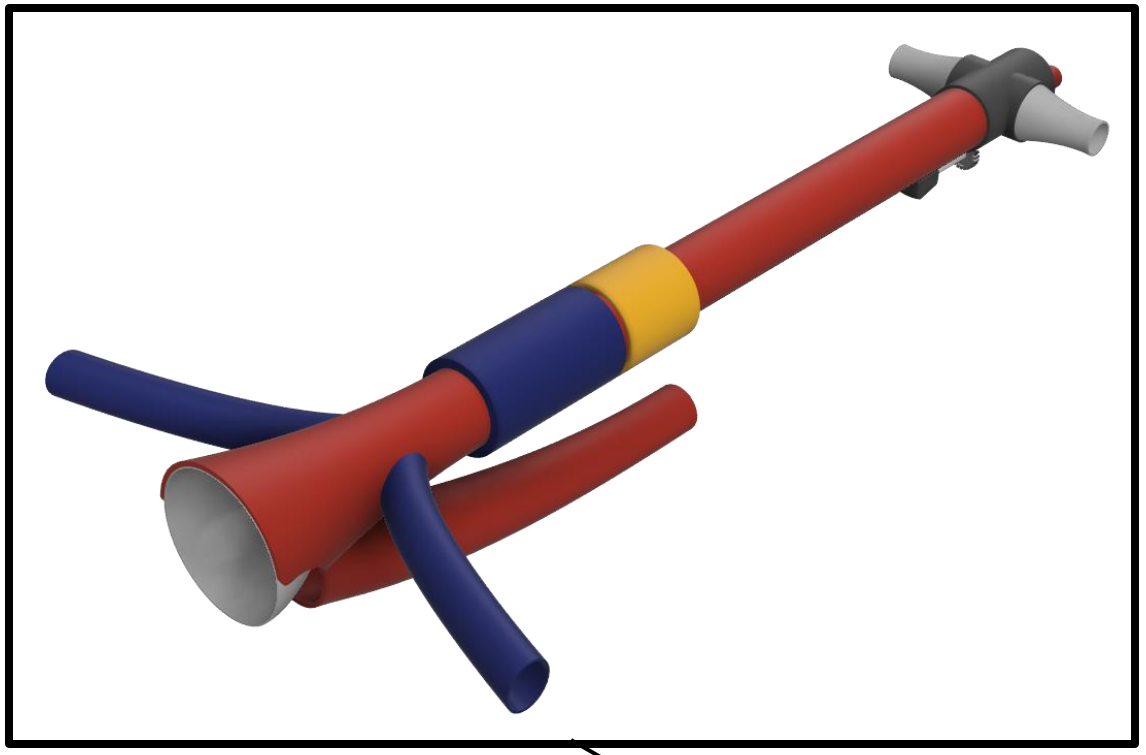


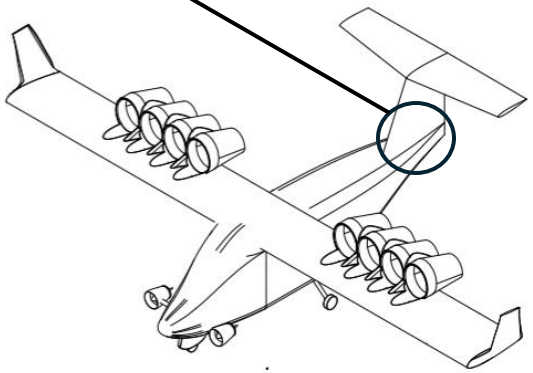


Hover Yaw Control System (HYCS)

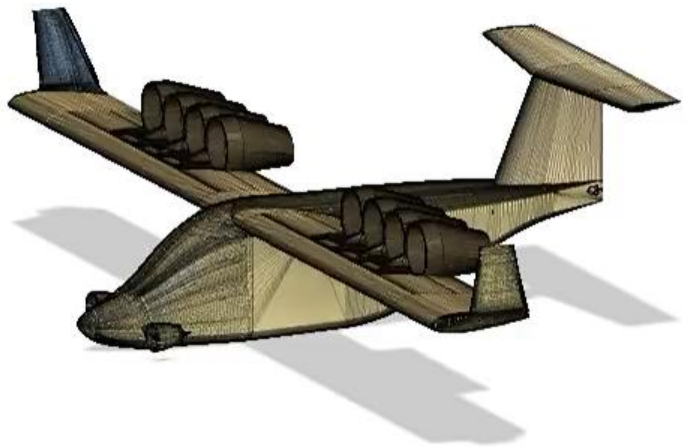


Puffer Jet System as seen on
The Harrier Jump Jet



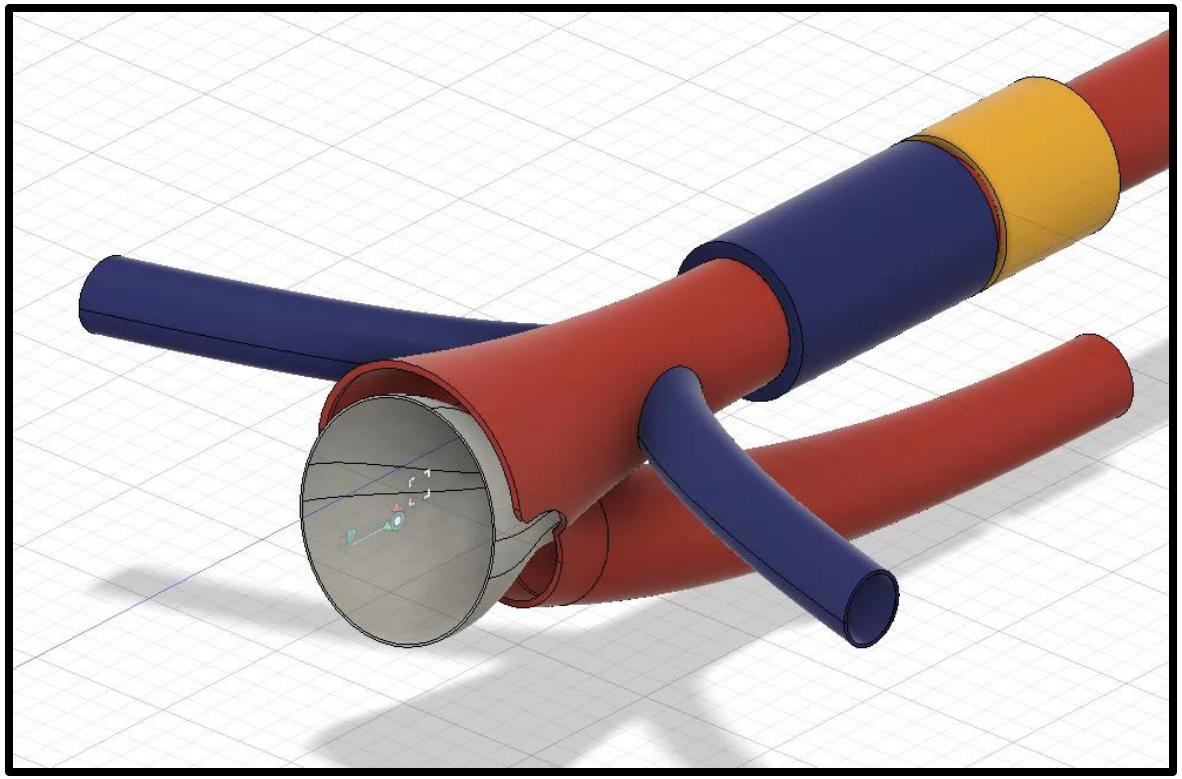


Hover Yaw Control System (HYCS)

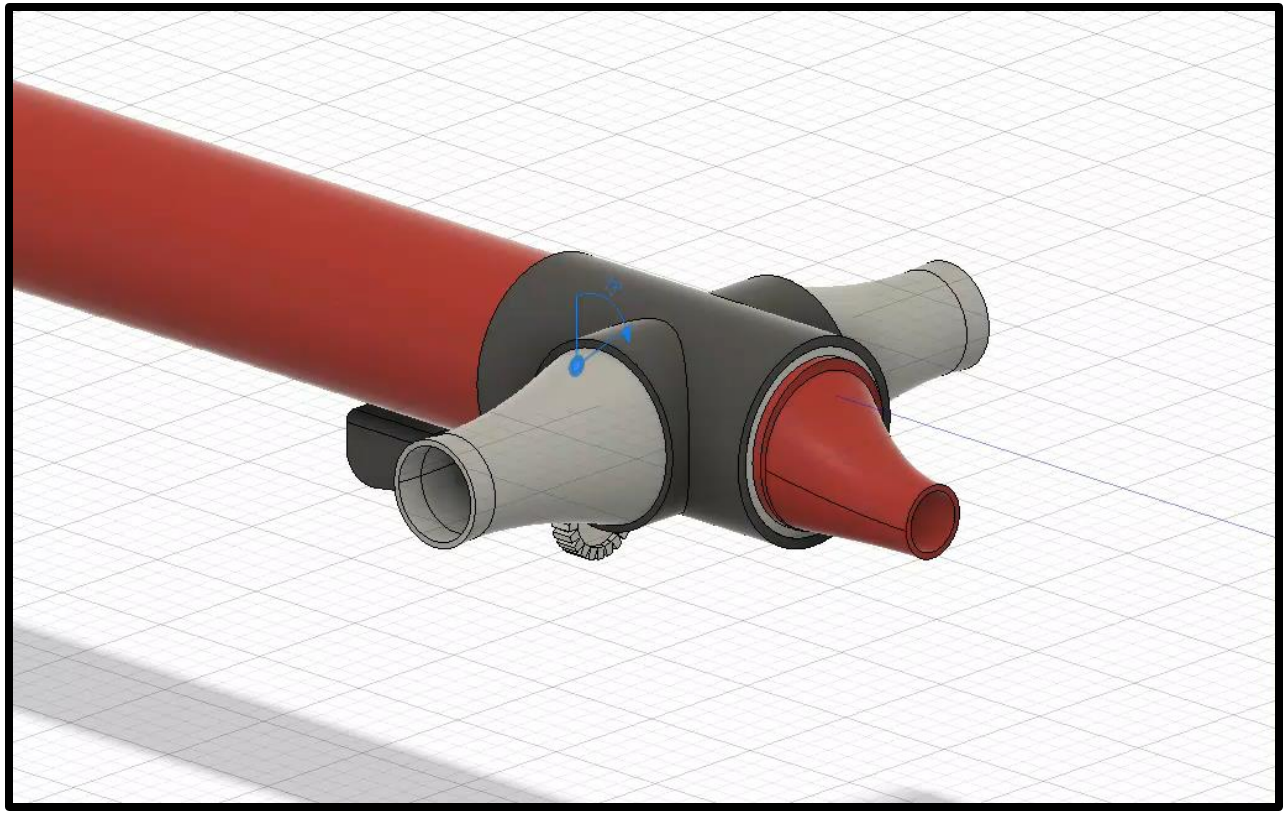


Hover Yaw Control System (HYCS)

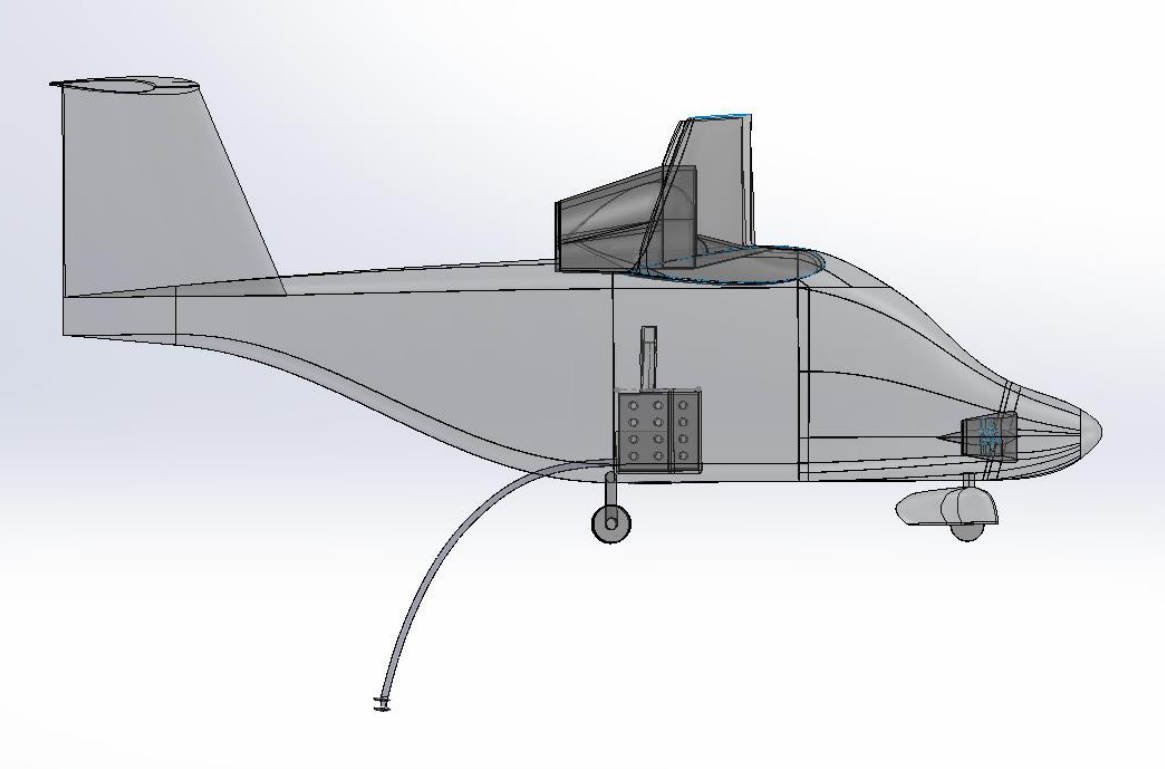
On/Off Control System

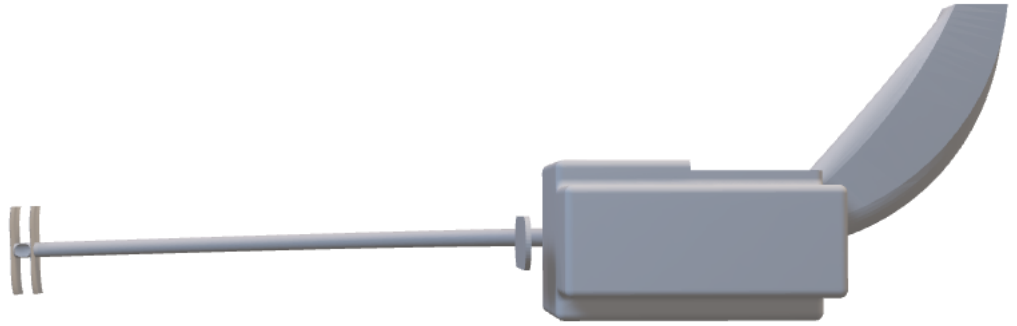


Nozzle Actuation System

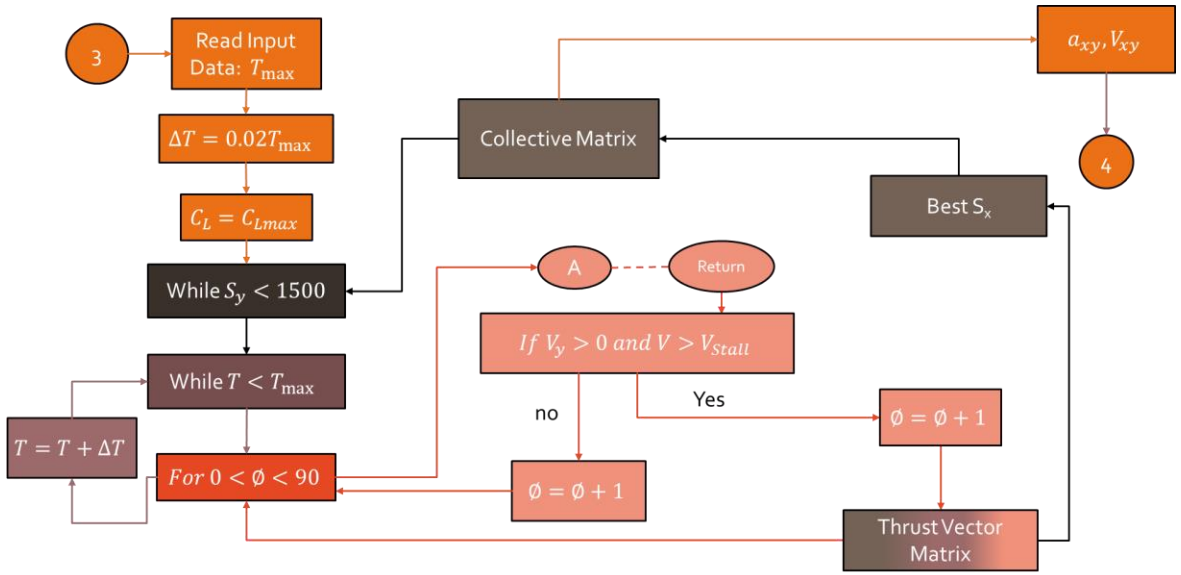


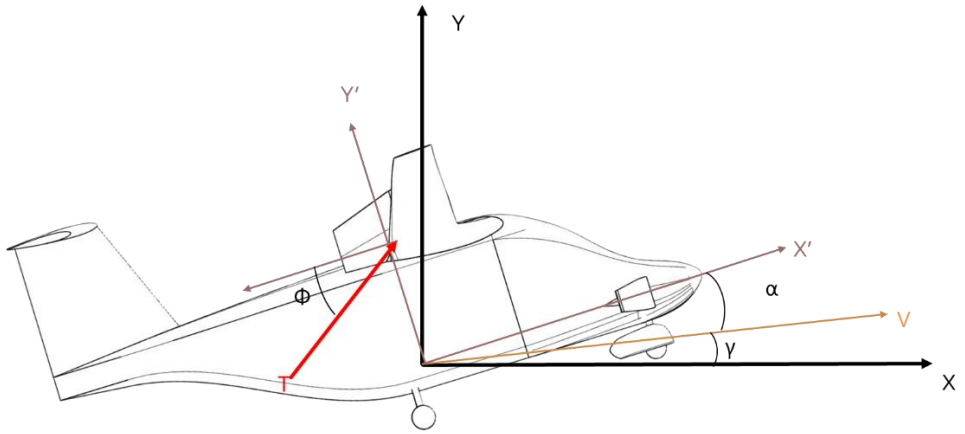
Firefighting Apparatus

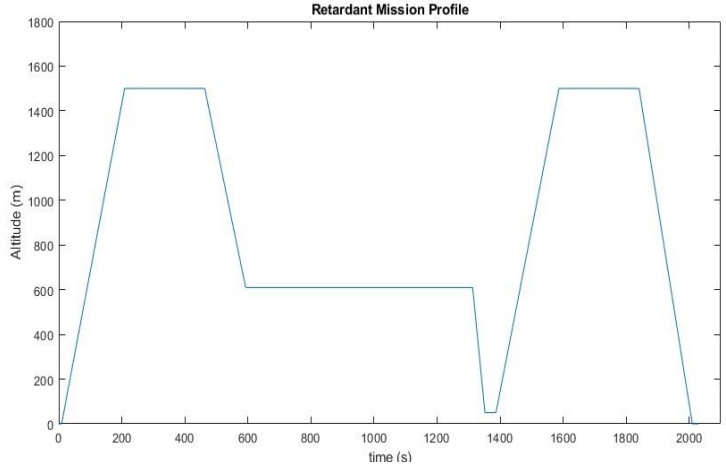


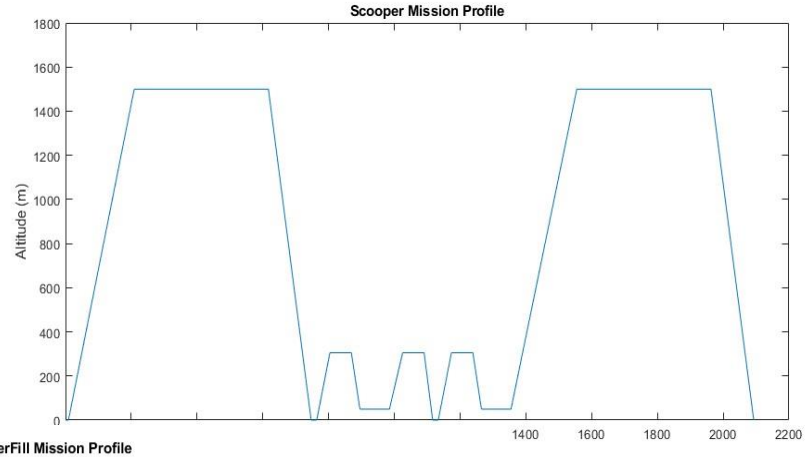


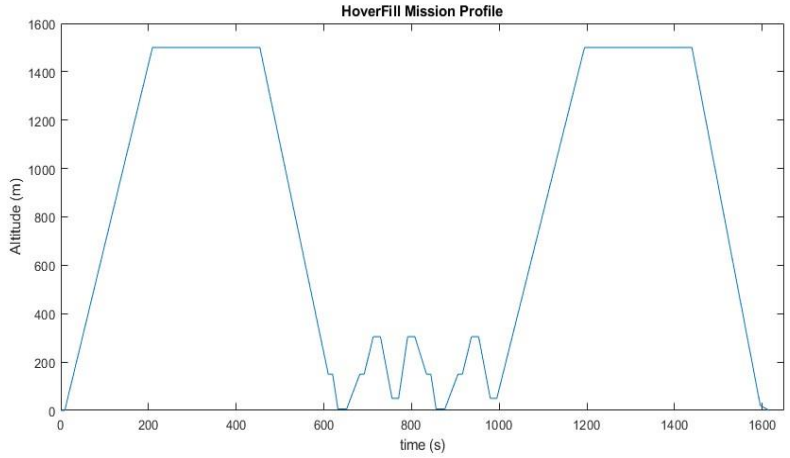
Misson Profiling and Trajectory Calculator











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Structures

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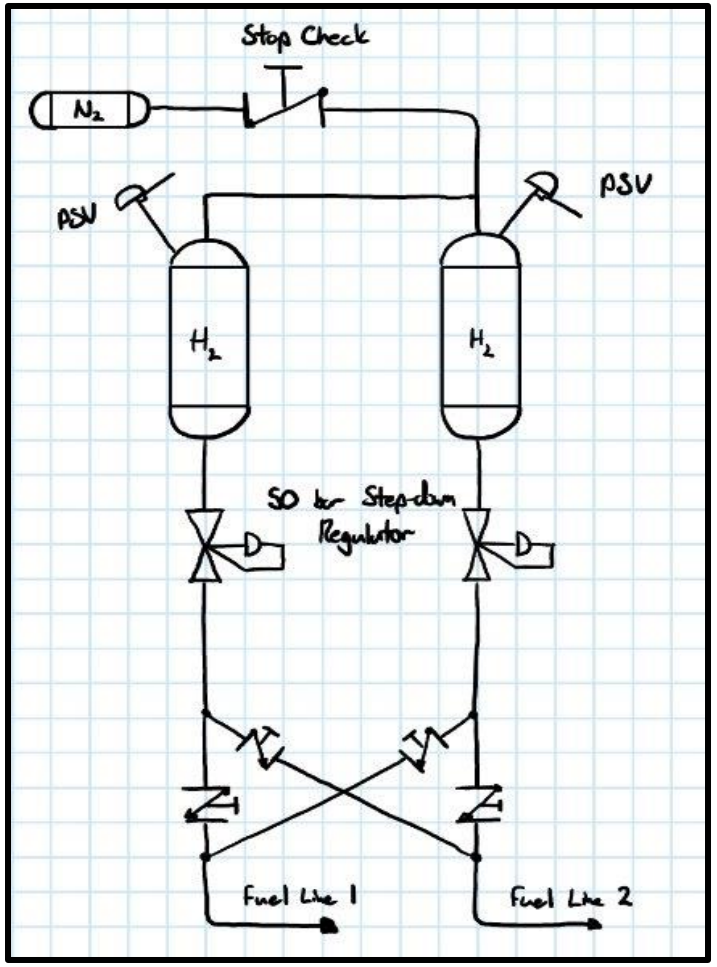
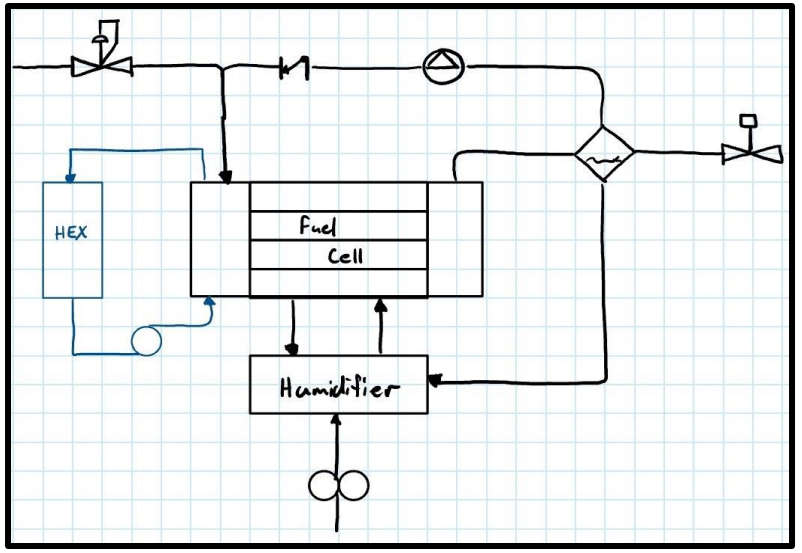
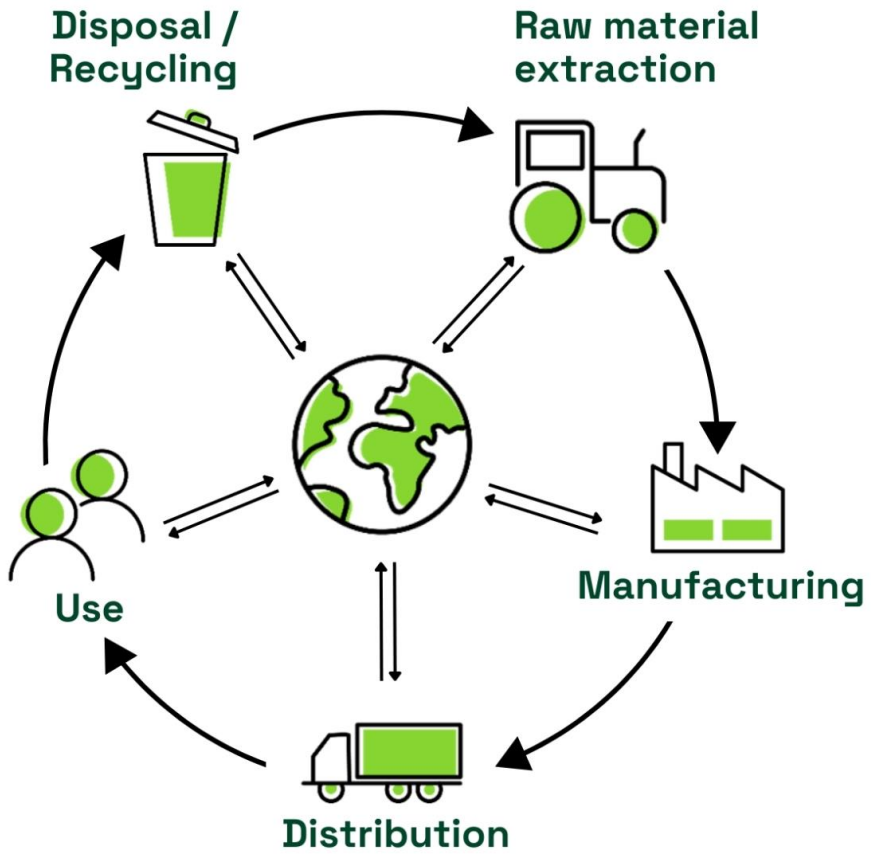
Internal Fuel System Configuration

Hydrogen Fuel System Component	Mass (kg)
Tanks (Wet Mass)	141kg
Distribution	11kg
Filters, Safety	5kg
Thermal Management	7kg
Fuel Cell & Turbine Interface	5kg
Optional Components	5kg
Total Mass	174kg





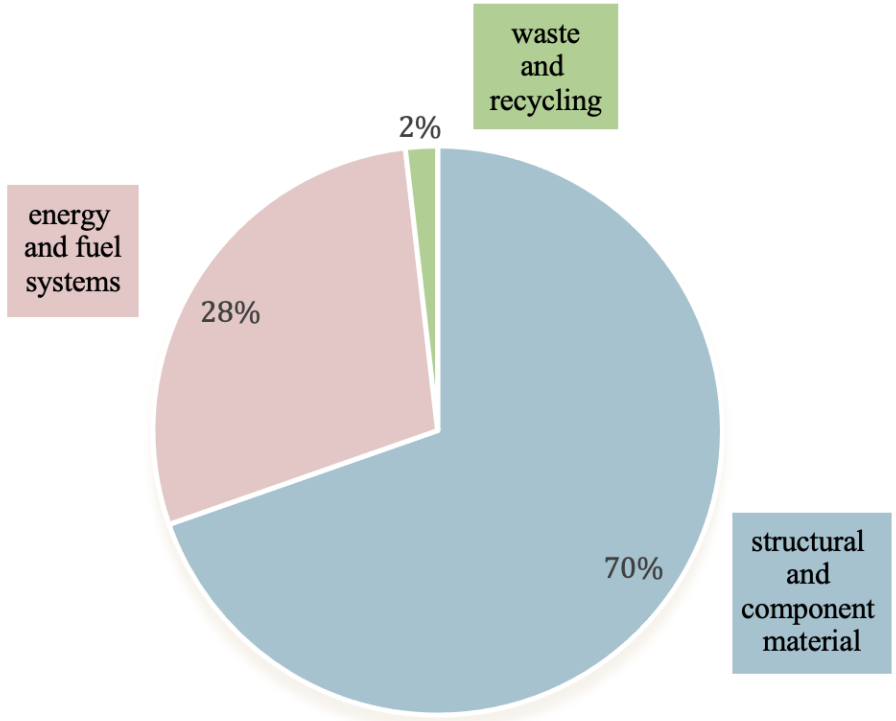
Life Cycle Analysis



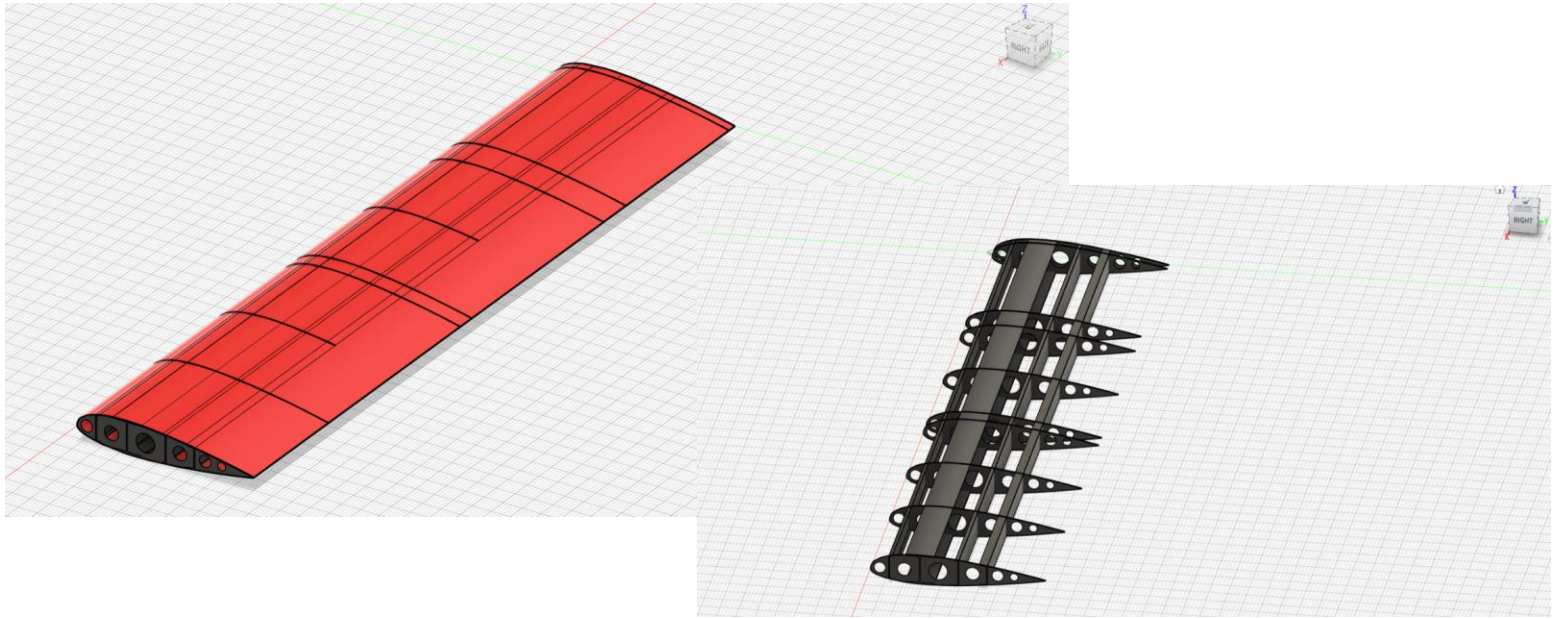
- LCA is used to evaluate the environmental impact of a product, process or activity from the raw material extraction to the end-of-life

Quantitative analysis of the LCA

- Demonstration of the environmental impact breakdown for each major consideration



Wings



Wing Component	Weight (kg)
Wing Skin	278.3
Full Rib (8 Total)	3.3 (Per Rib)
Cut Rib (2 Total)	2.69 (Per Rib)
Forward C-Spar	67.9
Center I-Spar	255.6
Center C-Spar	84
Trailing C-Spar	80.6

Parameter	
Winglet height	1.22m
Base cord	320mm
Tip cord	160mm
Spanwise extension	652mm

Empennage