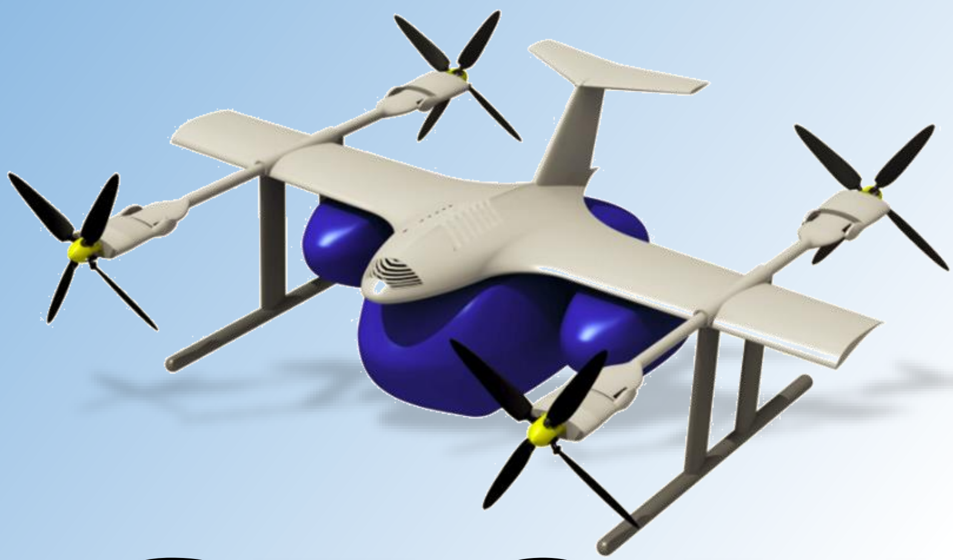
32nd Annual American Helicopter Society International Student Design Competition



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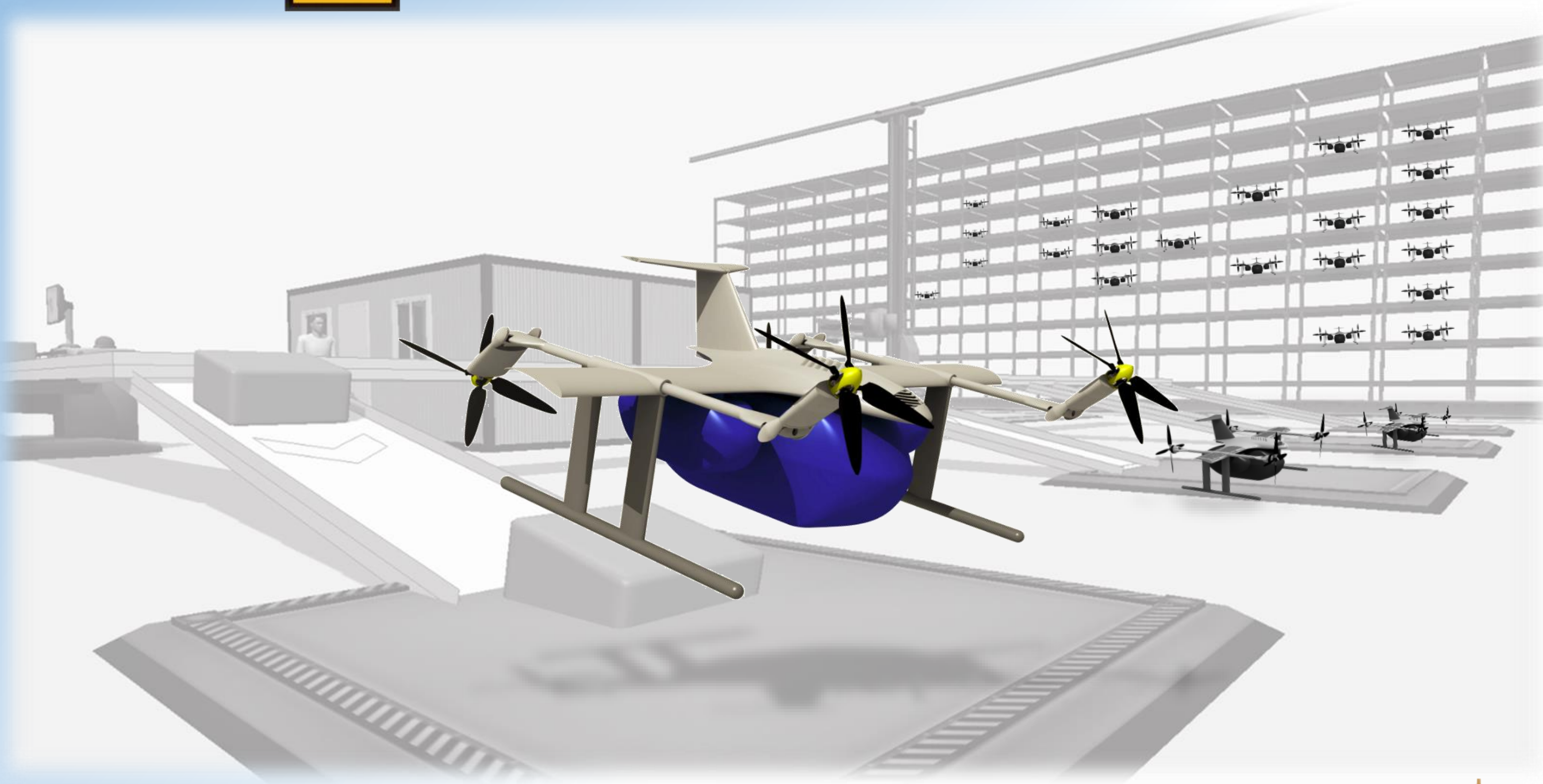
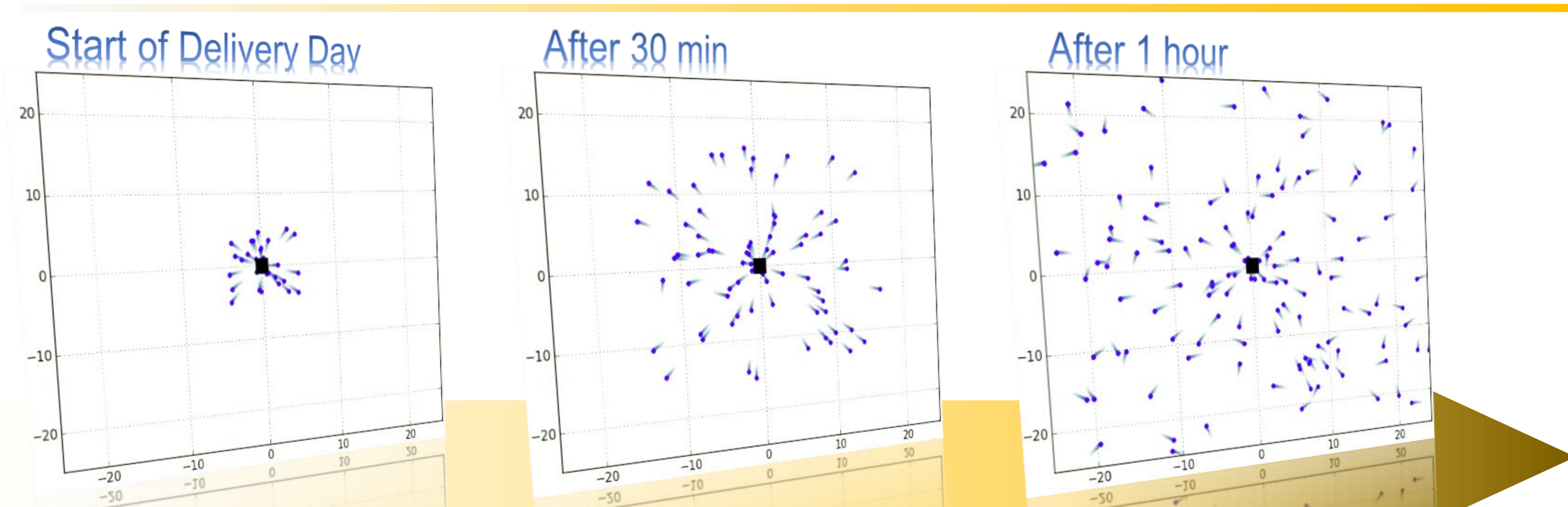


A Complete Logistical Solution

- ***Detailed route planning*** (based on Clarke-Wright Savings Algorithm)
- **Minimizes total distance at a *system level* by grouping deliveries**
- **Provides optimal logistical solution with *maximum cost savings***



- ***Scalable*** **system-of-systems modeling for entire work day (10 hours)**
- ***Integrated vehicle sizing*** **based on mission needs (payload size, range)**
- ***Adapts*** **to requirements of current mission day**

SYSTEM PERFORMANCE METRICS

Capacity	5,000 pkgs/day	Flight Time	850 hrs/day
Aerial Vehicles	140	Daily Fuel Consumption	1,373 gal (8,239 lbs)
Operators	8	Packages/Vehicle/Day (avg)	35
Maintainers	5		

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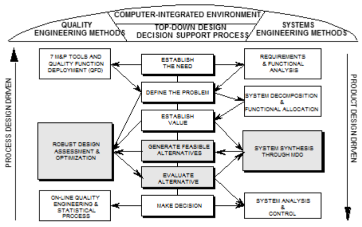
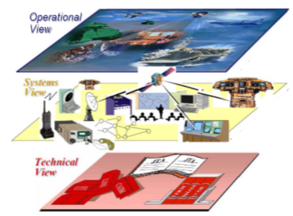
Detailed System Development



Generic IPPD Methodology



DOD Architecture Framework

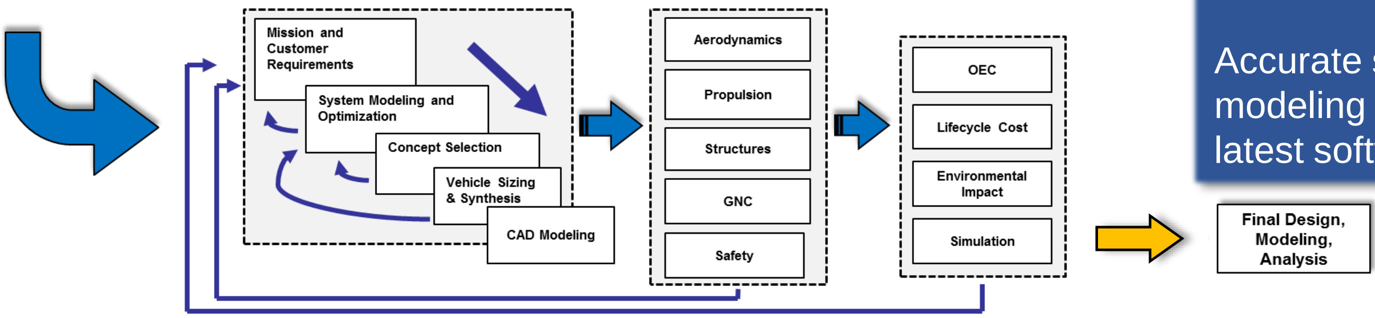
python
Altair HyperWorks
ANSYS
MATLAB SIMULINK
Heli-Dyn SIMULATION
FlexSim problem solved.
CATIA

Software Tools

Design driven by requirements analysis

Iterative system design process

Accurate system modeling using the latest software tools



Feedback Loop and Optimization

Dedicated maintenance pads

Mechanical arms hold/rotate vehicle for easy inspection

Drainage and ventilation

Storage for 200 vehicles

Package sorting/staging by destination

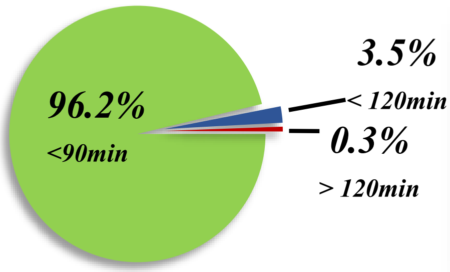
Real-time status tracking

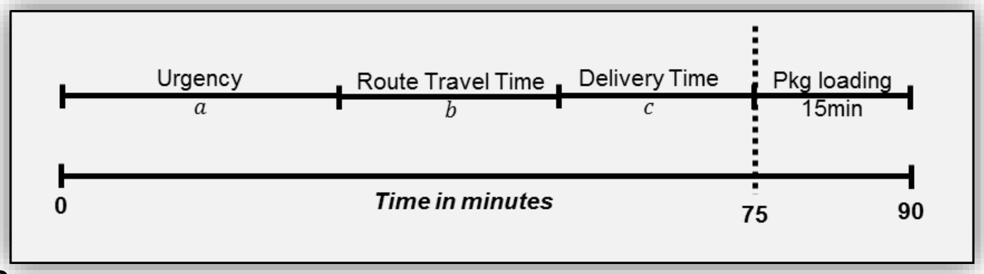
Human-in-the-loop operation

Dispatch release authority

Automated vehicle loading

Average Delivery Time





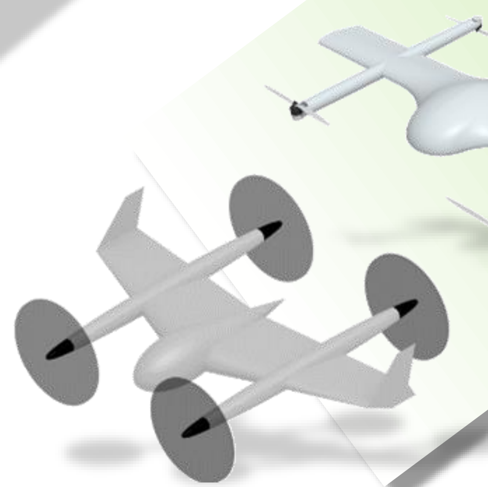
- ***<u>99.7% delivery rate</u>*** **within 2 hours**
- **Vehicle dispatch based on package "urgency"**
- **Improved system utilization rates; reduced vehicle departures with empty storage space**

The right design for the mission

*Selected from **11.8 billion** combinations to meet system of system needs*

*Optimized through **7 iterations** of design*

*Vehicle design driven to **optimize system** level solution*



Vehicle Performance

ROTOR DIMENSIONS

Airfoil Shape	NACA 0012	
Radius	10.8 in	.27 m
Solidity	0.15	

ROTOR PERFORMANCE

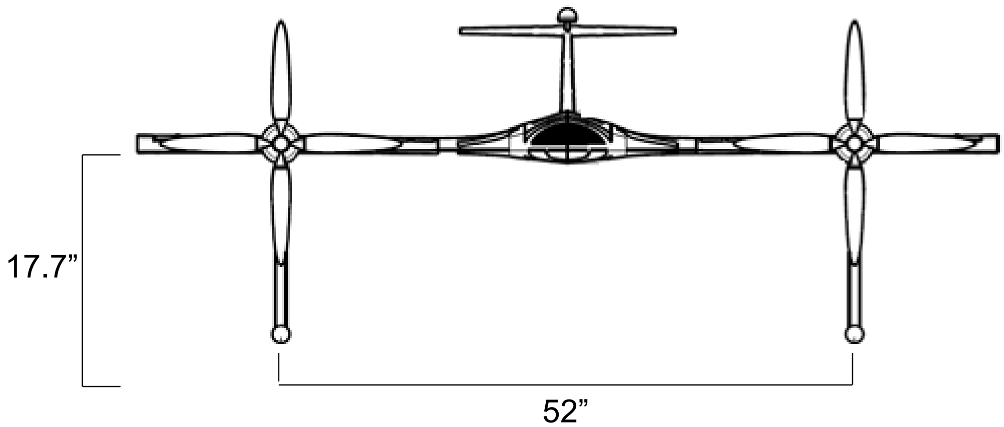
RPM (Hover)	6100
Figure of Merit	0.78
RPM (Cruise)	4745
Prop Efficiency	0.83

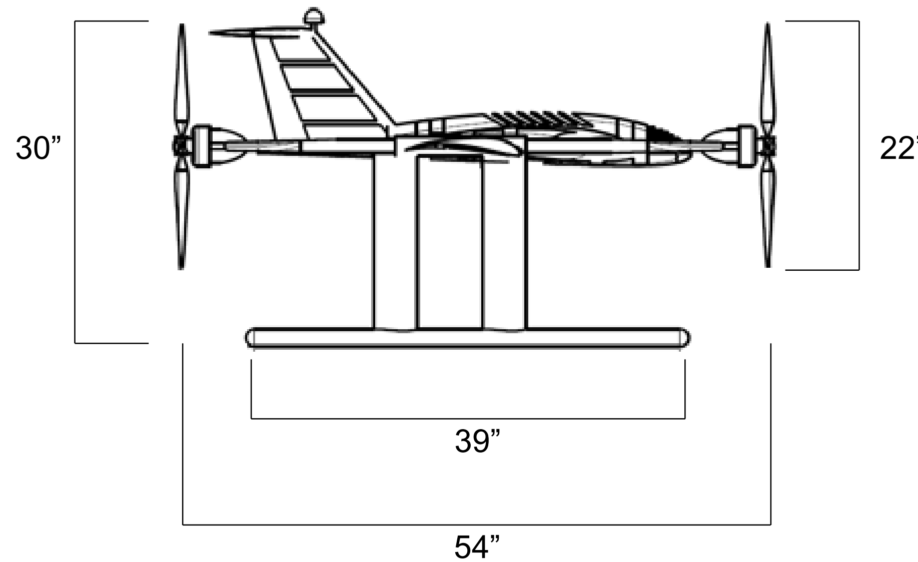
PRINCIPAL DIMENSIONS

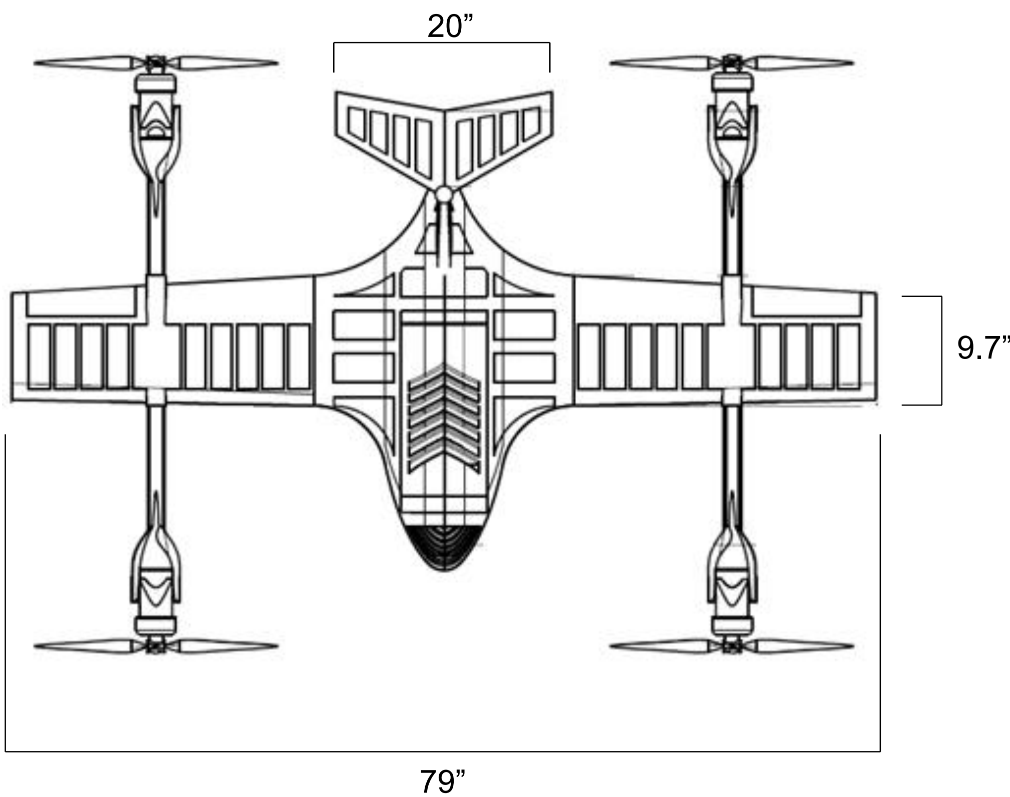
Height	2 ft 6 in	0.76 m
Length	4 ft 6 in	1.4 m
Wingspan / Width	6 ft 7 in	2.0 m
Ground clearance	1 ft 5 in	0.43 m
Maximum Gross Weight	105 lbs	48.1 kg
Design Gross Weight	99 lbs	44.9 kg
Useful Load	20 lbs	9.0 kg
Fuel Weight	16 lbs	7.2 kg
Empty Weight	63 lbs	28.5 kg

VEHICLE PERFORMANCE

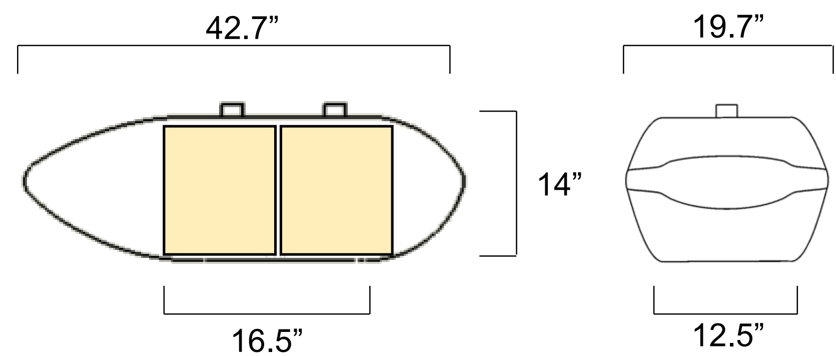
Installed Power	17 hp	
DLA-112 Engine (7500 rpm)	11.5 hp	8.6 kW
Lithium Sulfur Battery	2.0 Ah (at 37V)	
Cruise Speed	75 kts	138.9 kph
Maximum Range	70 sm	112 km
Hover Ceiling (at design GW)	7200'/95ºF	
Hover Endurance (at 6000'/95ºF)	2min (at MTOGW)	



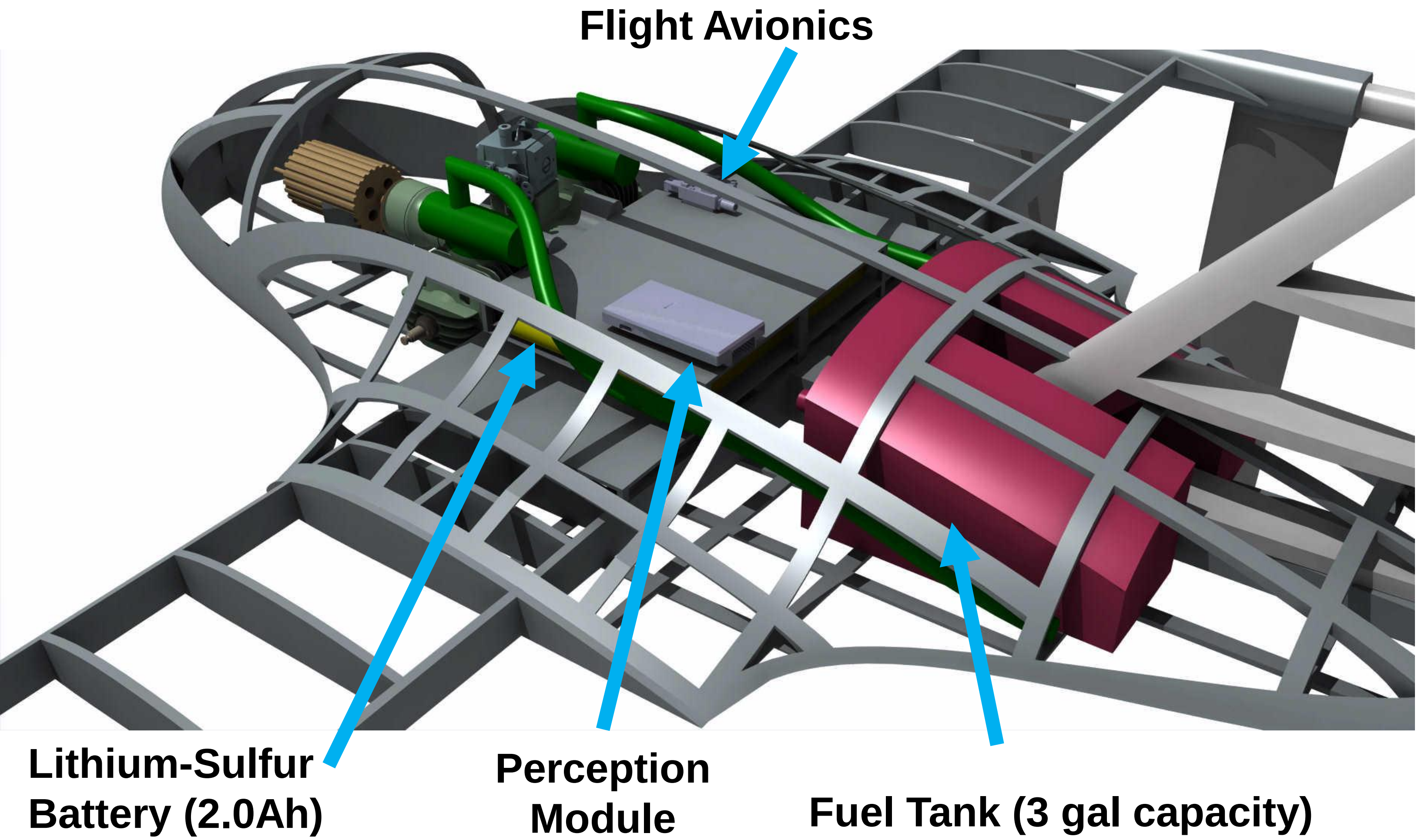


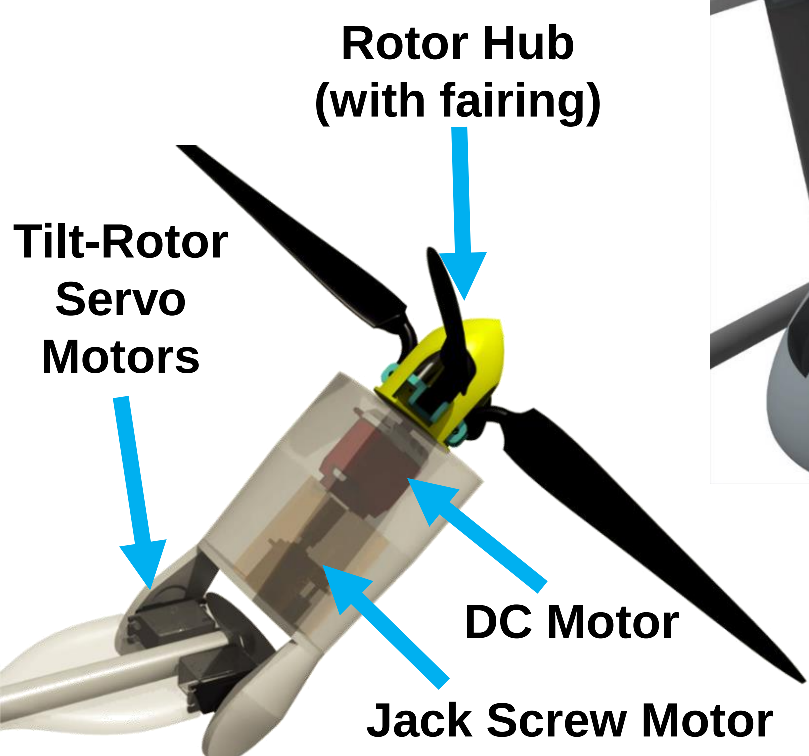


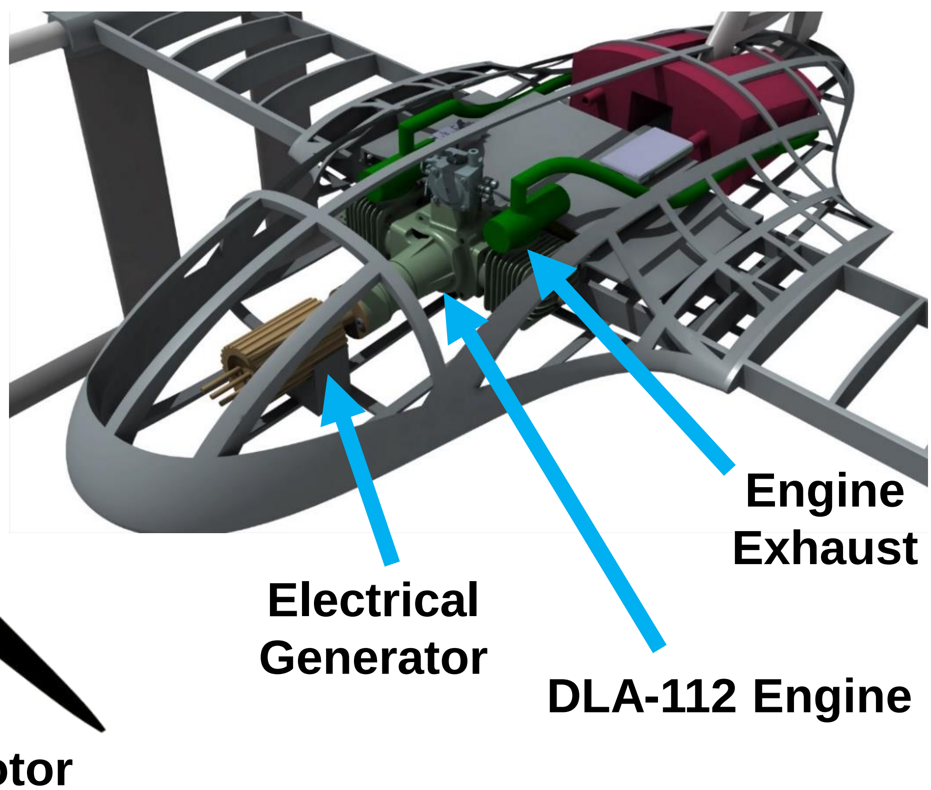
Payload Container



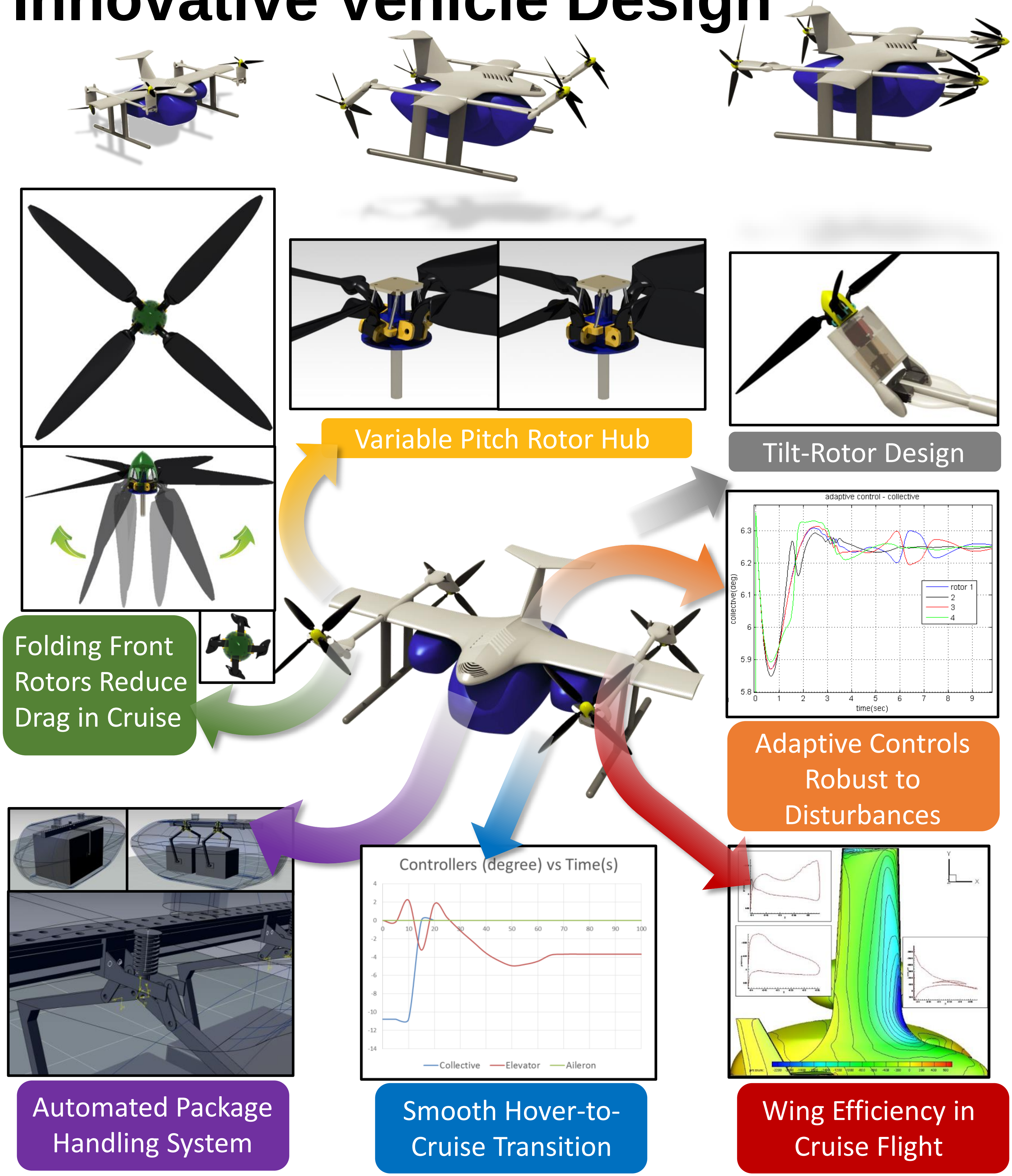
Major Component Layout





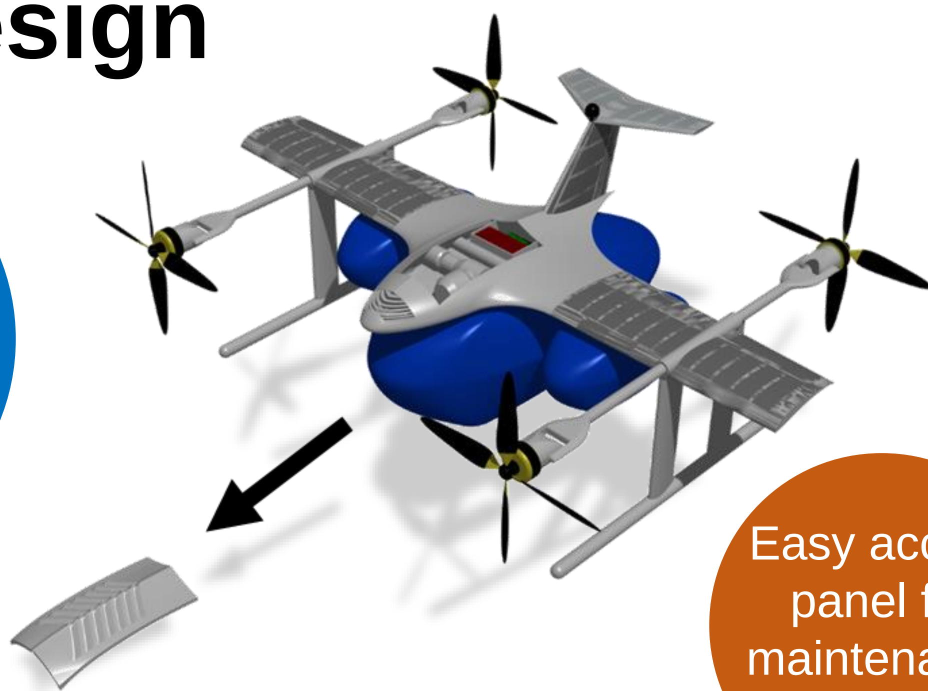


Innovative Vehicle Design



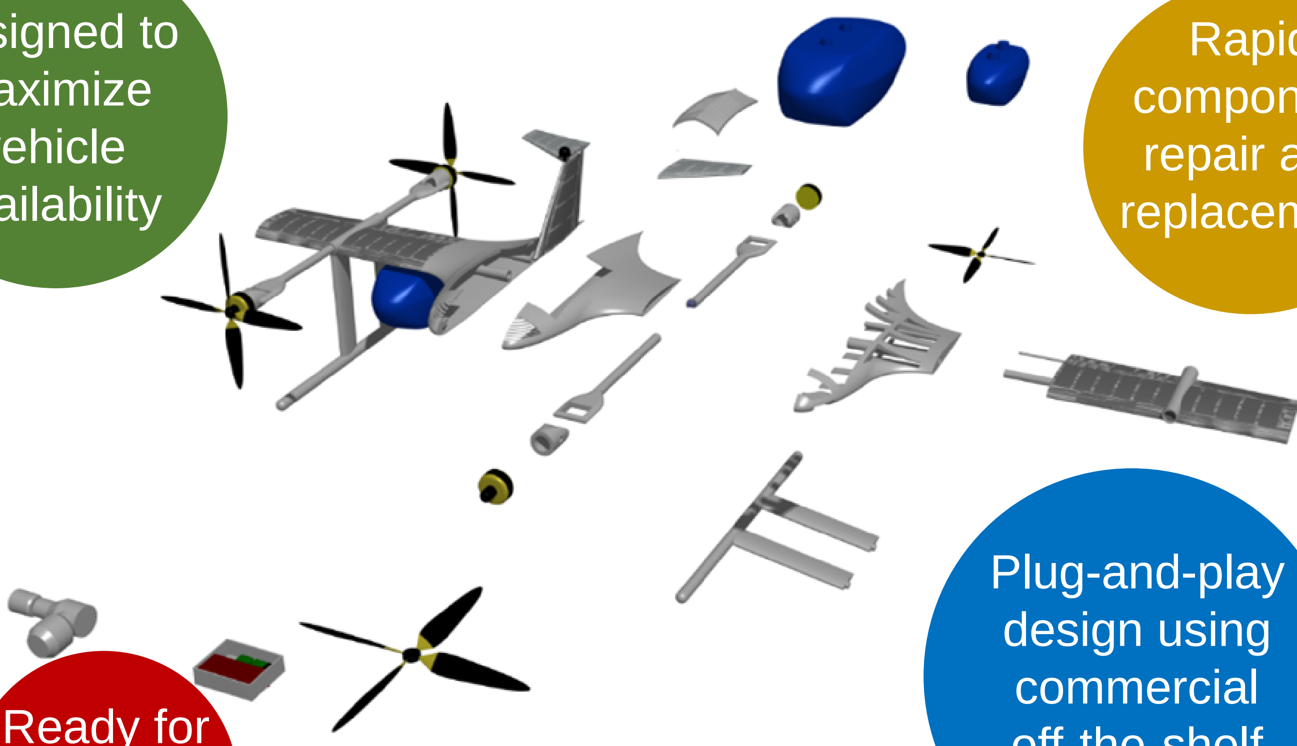
Modular Design

Decreased risk of damage during inspection and troubleshooting



Easy access panel for maintenance personnel

Designed to maximize vehicle availability



Rapid component repair and replacement

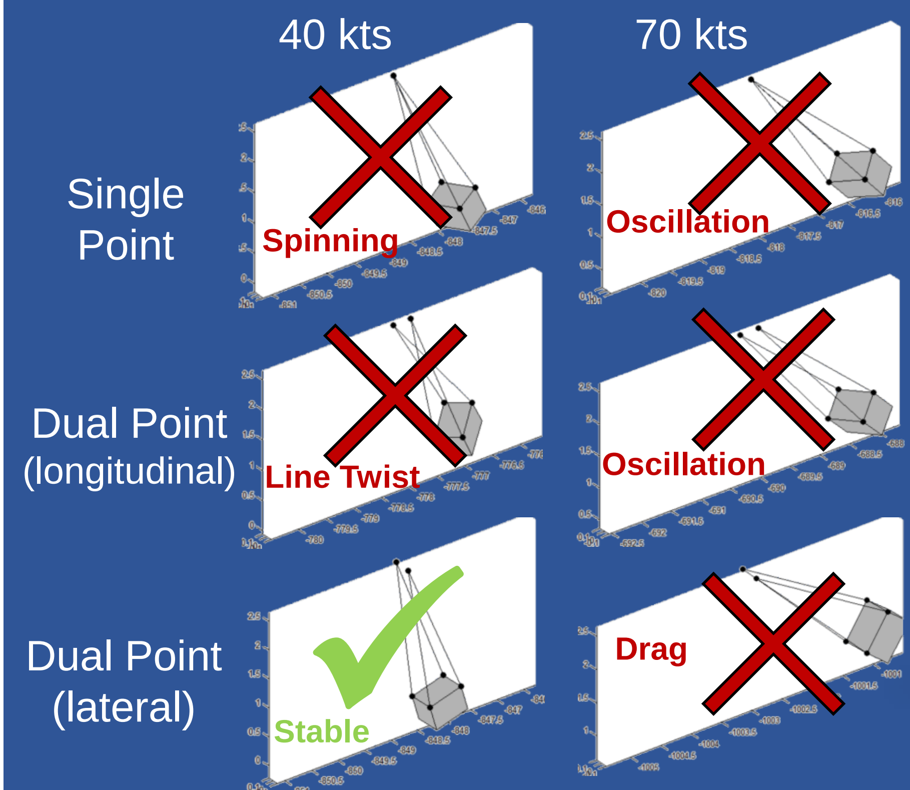
Plug-and-play design using commercial off-the-shelf parts

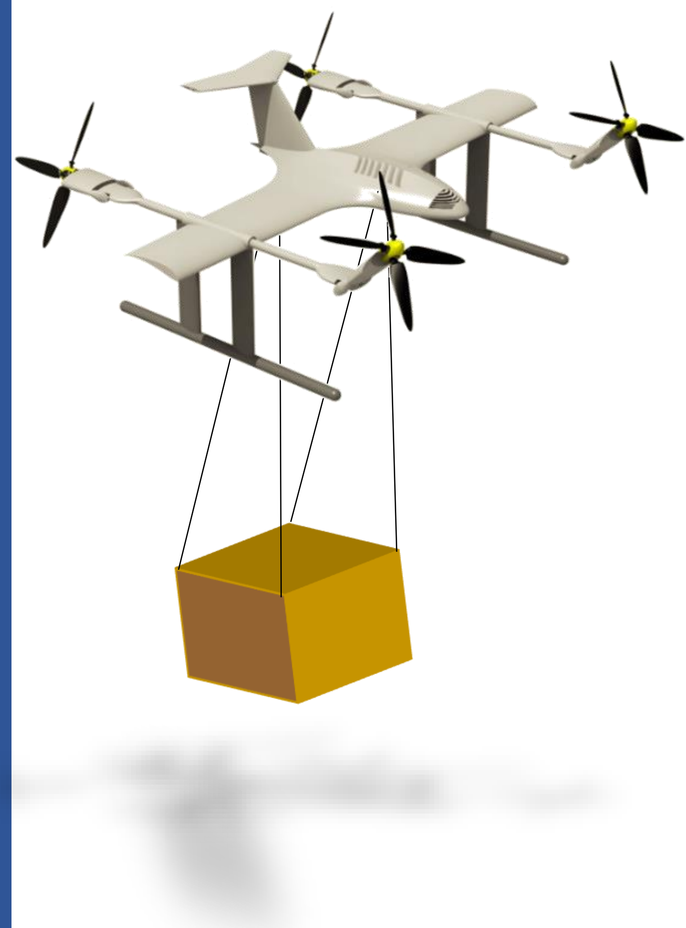
Ready for future upgrades

Fitting the Customer’s Needs

DETAILED SLING LOAD MODELING (24” x 24” package)

Generated using Georgia Tech Aerodynamic Bluff Body Model, v1.2





- **Flight profile & configuration minimize oscillation**
- **Existing vehicle design readily accommodates lateral attachment points**

PAYLOAD VERSATILITY

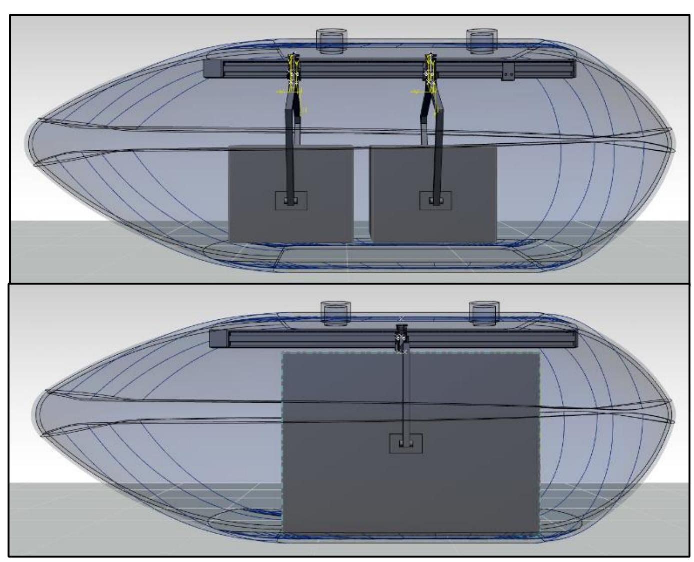
Weather proof payload container

Automated package delivery

Accommodate various package sizes

Maintain aircraft CG by shifting package positions

Slingload ready; meets the needs of nonstandard package dimensions



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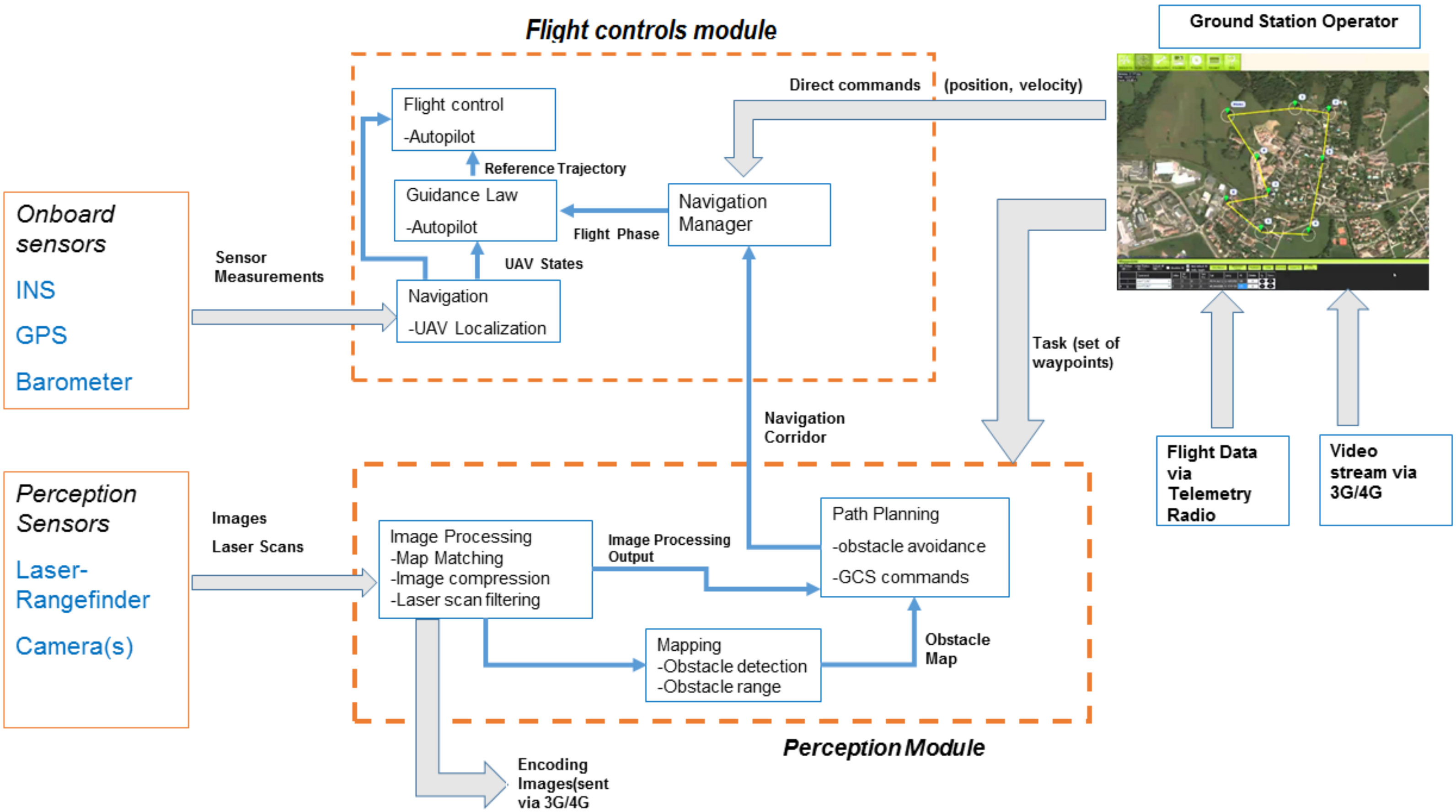
Avionics for the Urban Environment



SENSORS

GPS for primary navigation

Stereo cameras provide see-and-avoid obstacle detection

Image map-matching provides navigation during degraded GPS operation

Laser rangefinder for approach/departure obstacle clearance

On-board mapping of local area terrain and static obstacles

COMMUNICATION

3G/4G antenna utilizes existing urban infrastructure

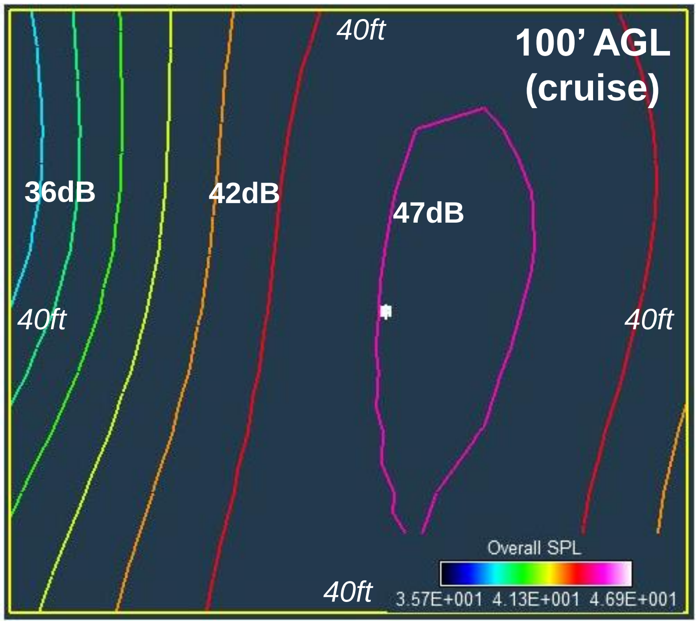
Continuous status tracking

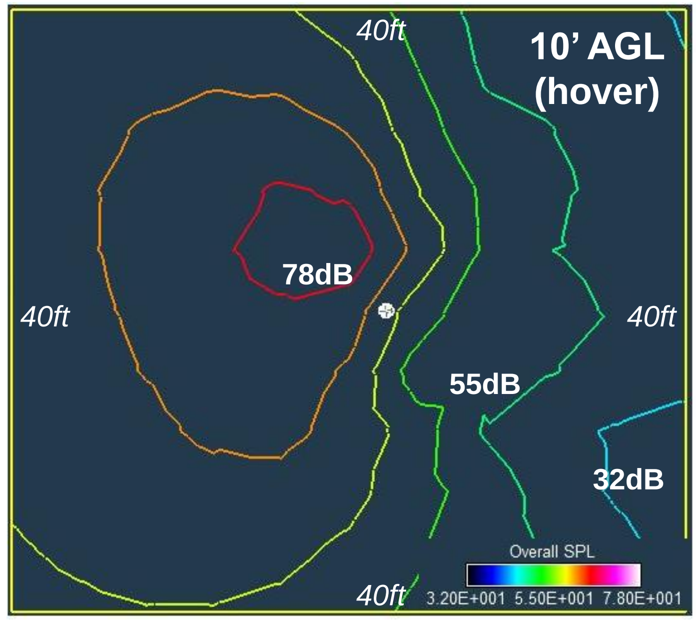
Dynamic retasking capability

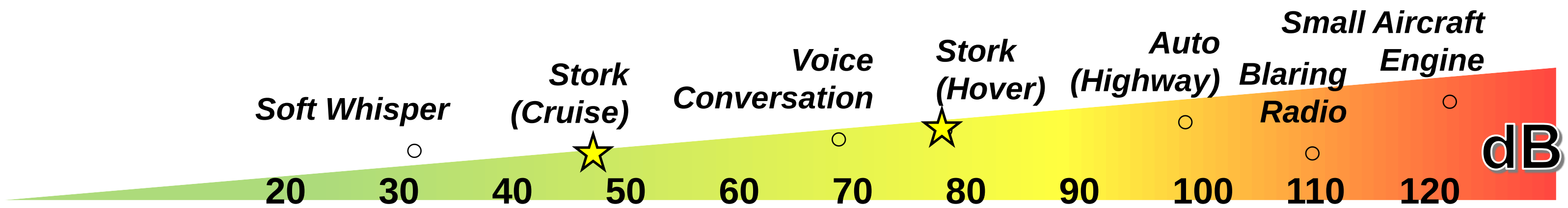
Health monitoring and emergency conditions relayed to operations center

Human-in-the-loop provides operator override of hazardous conditions

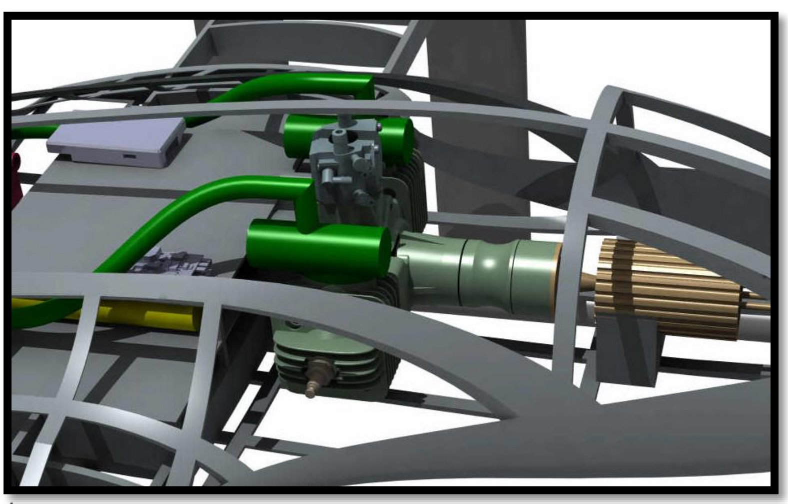
Environmentally Friendly

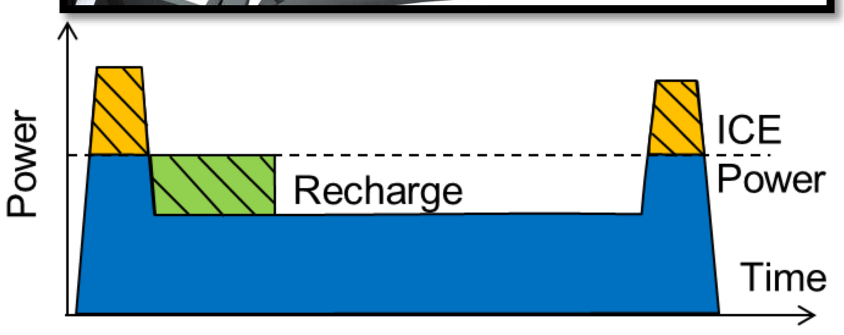






- **Low acoustic signature in all modes of flight**
- **Design supports initiatives for "friendly flying" near populated areas**
- **Minimal noise pollution relative to typical urban environment**





HYBRID-ELECTRIC POWER

Use of internal combustion engine (ICE) plus battery power during peak power demand phases (hover)

Battery recharge during low power demand periods (cruise)

Reduction of emissions

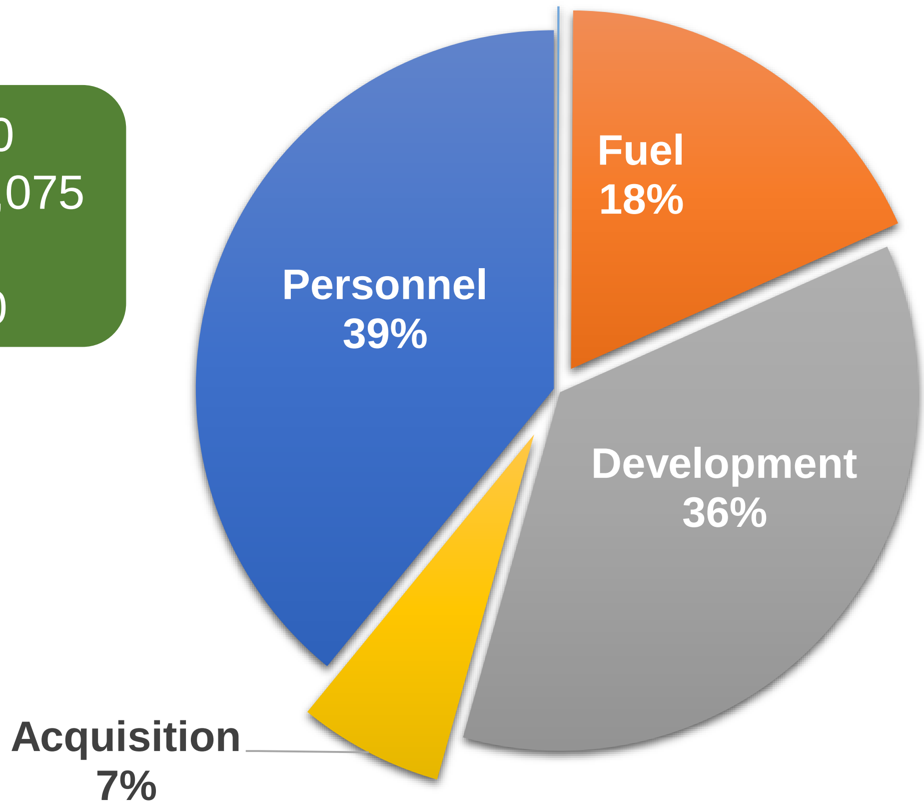
Battery provides 2 min of flight power during engine failure

Battery power during ground operations; enables receipt of commands from operations center

Safe, Cost-Effective Solution

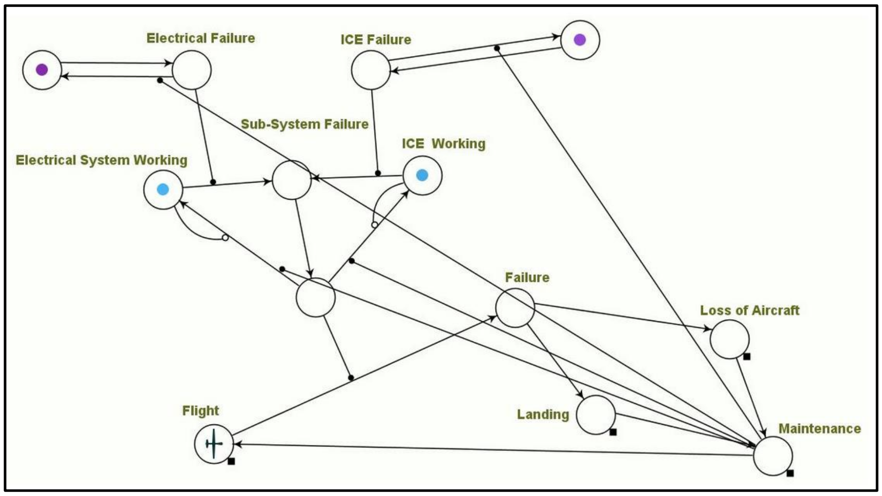
3-Year Life Cycle Cost: $28,645,487

Personnel - $11,700,000
Development - $10,785,075
Fuel - $5,460,412
Acquisition - $1,960,000



SAFETY FEATURES

- Redundant power sources (internal combustion and battery)
- Excess power provides safe landing during emergency
- Tilt-rotor reduces delivery time while retaining hover capability
- Variable pitch hub for responsive control input and optimal settings during hover/cruise
- Variable RPM provides control during fixed pitch condition
- Onboard database of nearest safe landing areas



Failure Rate Modeling Using Abridged Petri Nets

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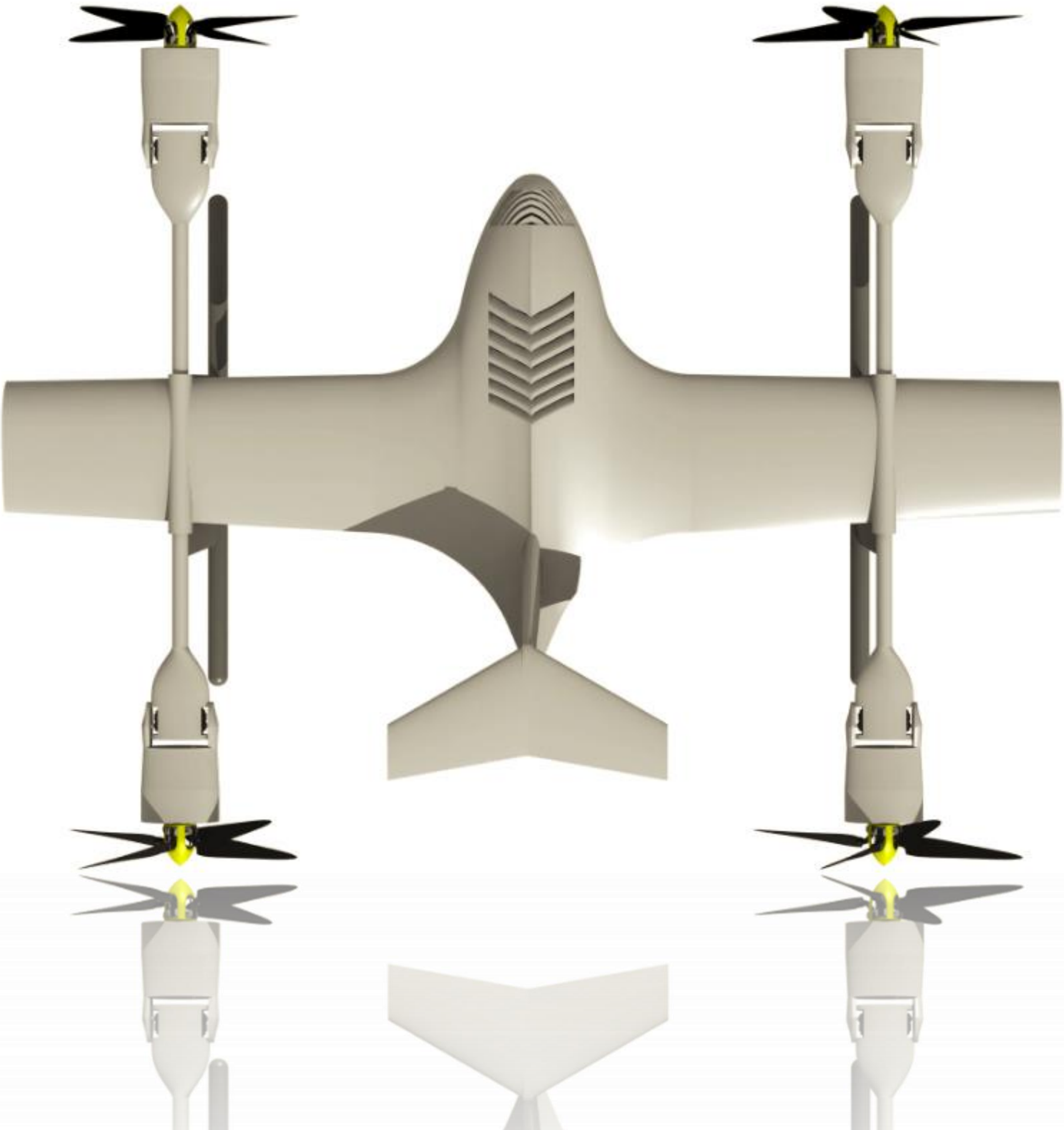

The innovative answer to tomorrow's delivery needs