

GT STORK

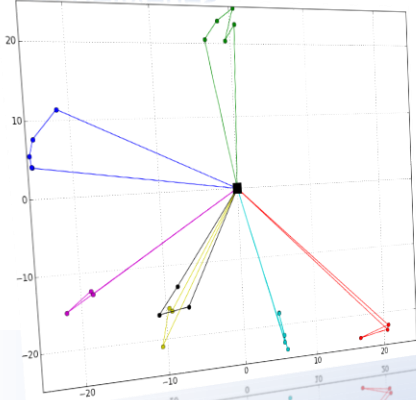


**Georgia
Tech** 

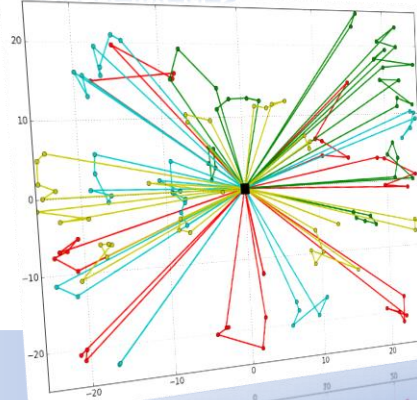


A Complete Logistical Solution

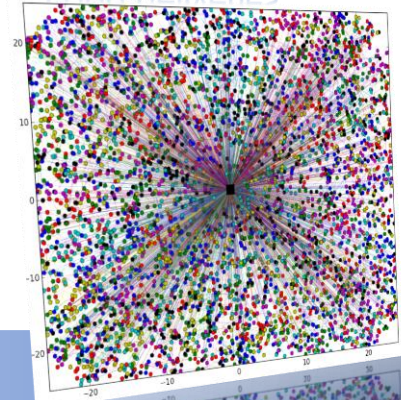
20 deliveries



200 deliveries

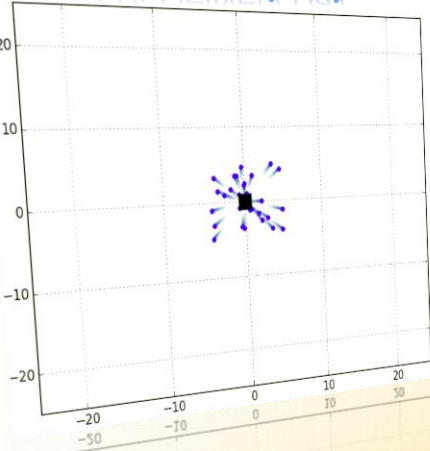


5,000 deliveries

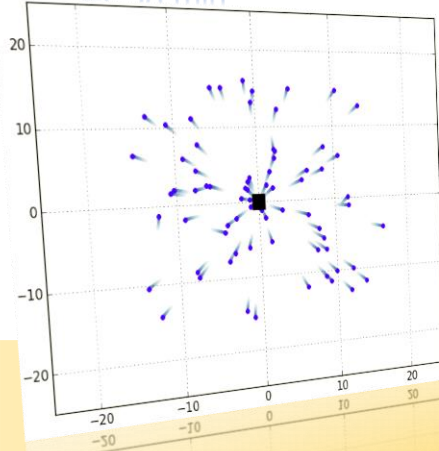


- **Detailed route planning** (based on Clarke-Wright Savings Algorithm)
- **Minimizes total distance at a system level** by grouping deliveries
- **Provides optimal logistical solution with maximum cost savings**

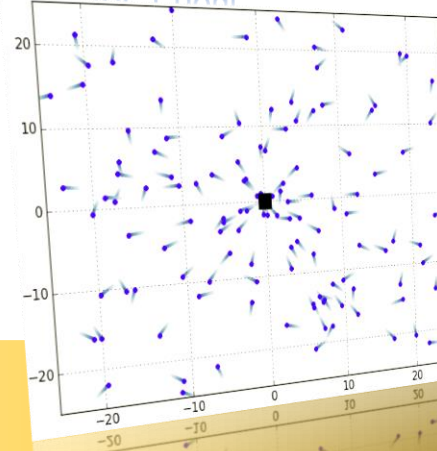
Start of Delivery Day



After 30 min



After 1 hour

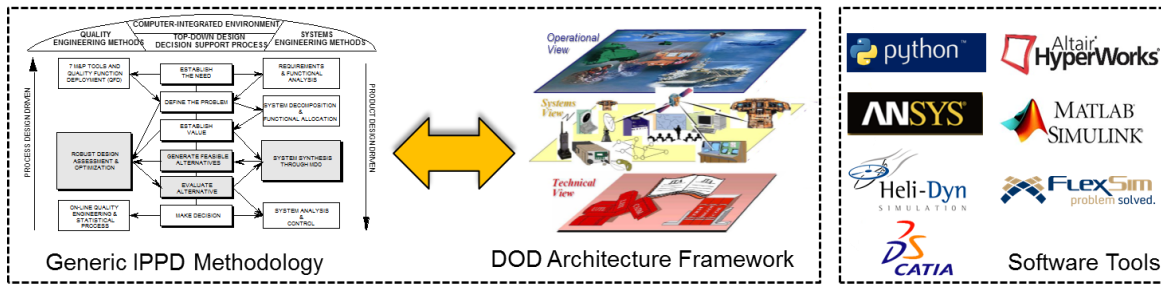


- **Scalable system-of-systems modeling** for entire work day (10 hours)
- **Integrated vehicle sizing** based on mission needs (payload size, range)
- **Adapts** to requirements of current mission day

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		

Detailed System Development

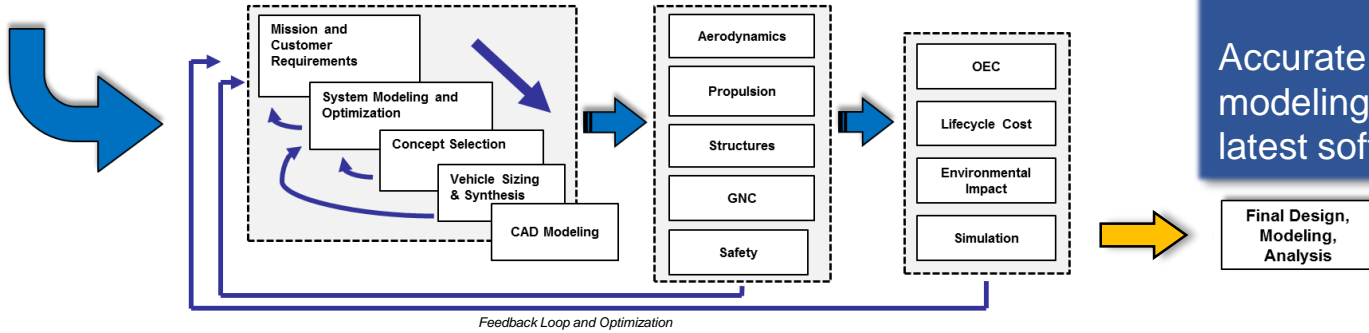


Design driven by requirements analysis

Iterative system design process

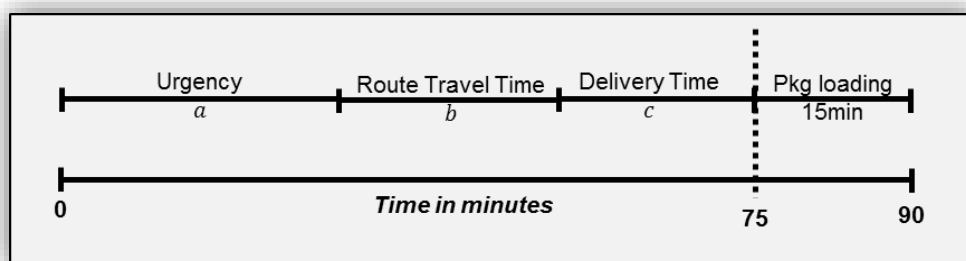
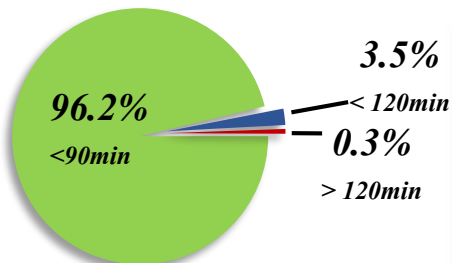
Accurate system modeling using the latest software tools

Final Design, Modeling, Analysis



- | | | |
|---|--|-----------------------------|
| Dedicated maintenance pads | Storage for 200 vehicles | Human-in-the-loop operation |
| Mechanical arms hold/rotate vehicle for easy inspection | Package sorting/staging by destination | Dispatch release authority |
| Drainage and ventilation | Real-time status tracking | Automated vehicle loading |

Average Delivery Time



- **99.7% delivery rate** within 2 hours
- Vehicle dispatch based on package “urgency”
- Improved system utilization rates; reduced vehicle departures with empty storage space

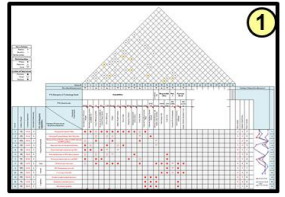
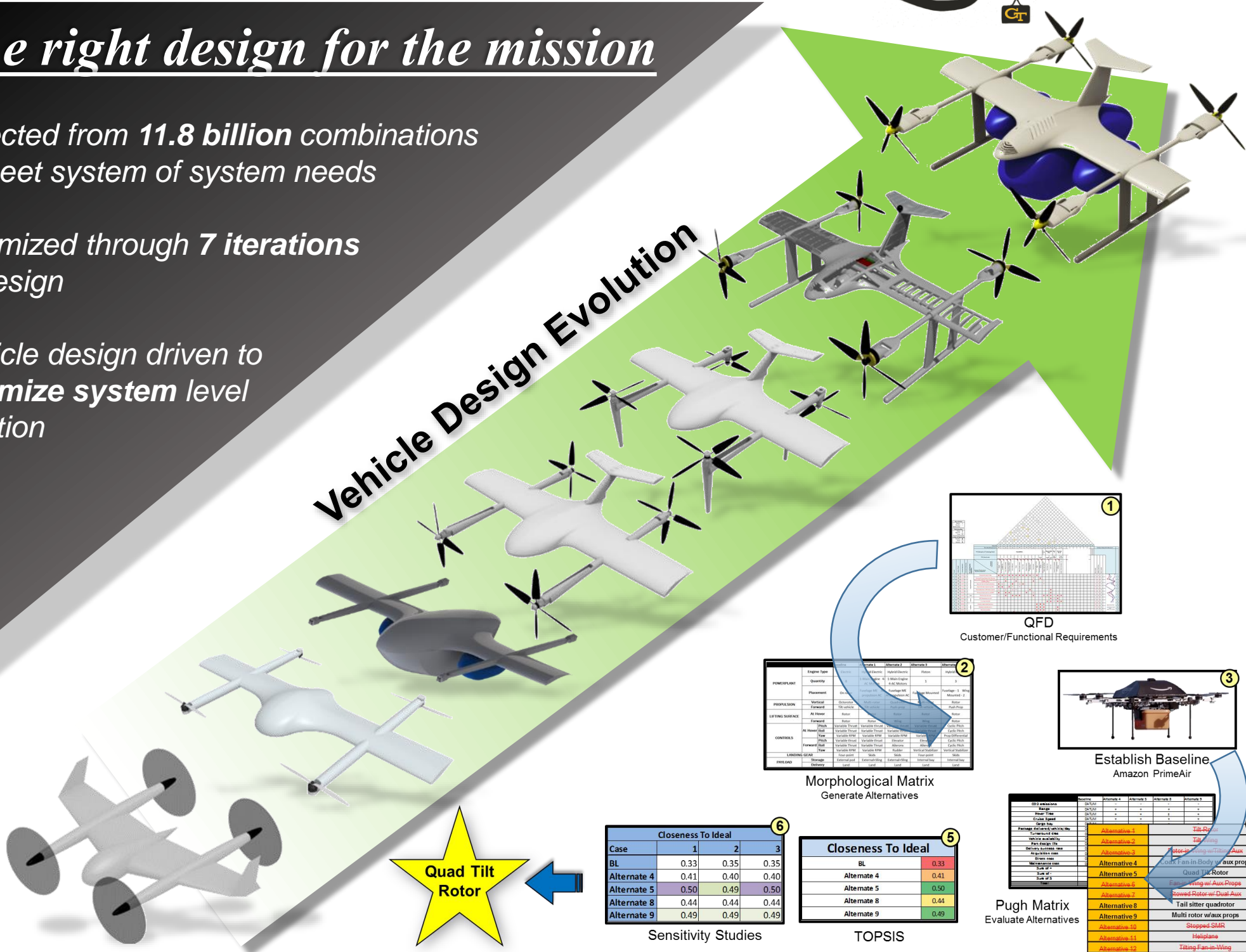
The right design for the mission

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 Design Evolution



QFD
Customer/Functional Requirements

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 8	Alternative 9
POWERPLANT							
Engine Type	Electric	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Quantity	4	1	1	1	1	1	1
Placement	Push	Push	Push	Push	Push	Push	Push
PROPULSION							
Vertical	Downward	Downward	Downward	Downward	Downward	Downward	Downward
Forward	10-vehicle	10-vehicle	10-vehicle	10-vehicle	10-vehicle	10-vehicle	10-vehicle
LIFTING SURFACE							
Wing	None	None	None	None	None	None	None
Forward	None	None	None	None	None	None	None
CONTROLS							
AI Heave	None	None	None	None	None	None	None
Roll	None	None	None	None	None	None	None
Yaw	None	None	None	None	None	None	None
Forward	None	None	None	None	None	None	None
Roll	None	None	None	None	None	None	None
Yaw	None	None	None	None	None	None	None
LANDING GEAR							
Storage	External and	External and	External and	External and	External and	External and	External and
Internal	None	None	None	None	None	None	None
PAYLOAD							
Storage	External and	External and	External and	External and	External and	External and	External and
Internal	None	None	None	None	None	None	None

Morphological Matrix
Generate Alternatives



Establish Baseline
Amazon PrimeAir

Case	1	2	3
BL	0.33	0.35	0.35
Alternate 4	0.41	0.40	0.40
Alternate 5	0.50	0.49	0.50
Alternate 8	0.44	0.44	0.44
Alternate 9	0.49	0.49	0.49

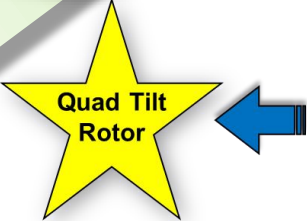
Sensitivity Studies

Case	Score
BL	0.33
Alternate 4	0.41
Alternate 5	0.50
Alternate 8	0.44
Alternate 9	0.49

TOPSIS

Case	Score	Notes
Alternative 1	0.33	Tilt-Rotor
Alternative 2	0.35	Tilt-Rotor
Alternative 3	0.35	Tilt-Rotor w/ Tilt-Aux
Alternative 4	0.41	Box Fan-in-Body w/ aux props
Alternative 5	0.49	Quad Tilt-Rotor
Alternative 6	0.40	Fanned Rotor w/ Aux Props
Alternative 7	0.40	Fanned Rotor w/ Dual Aux
Alternative 8	0.44	Tail slitter quadrotor
Alternative 9	0.49	Multi rotor w/aux props
Alternative 10	0.44	Stopped SMR
Alternative 11	0.44	Heliplane
Alternative 12	0.49	Tilting Fan-in-Wing

Pugh Matrix
Evaluate Alternatives



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

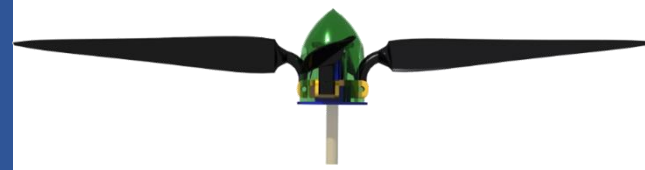
PRINCIPAL DIMENSIONS

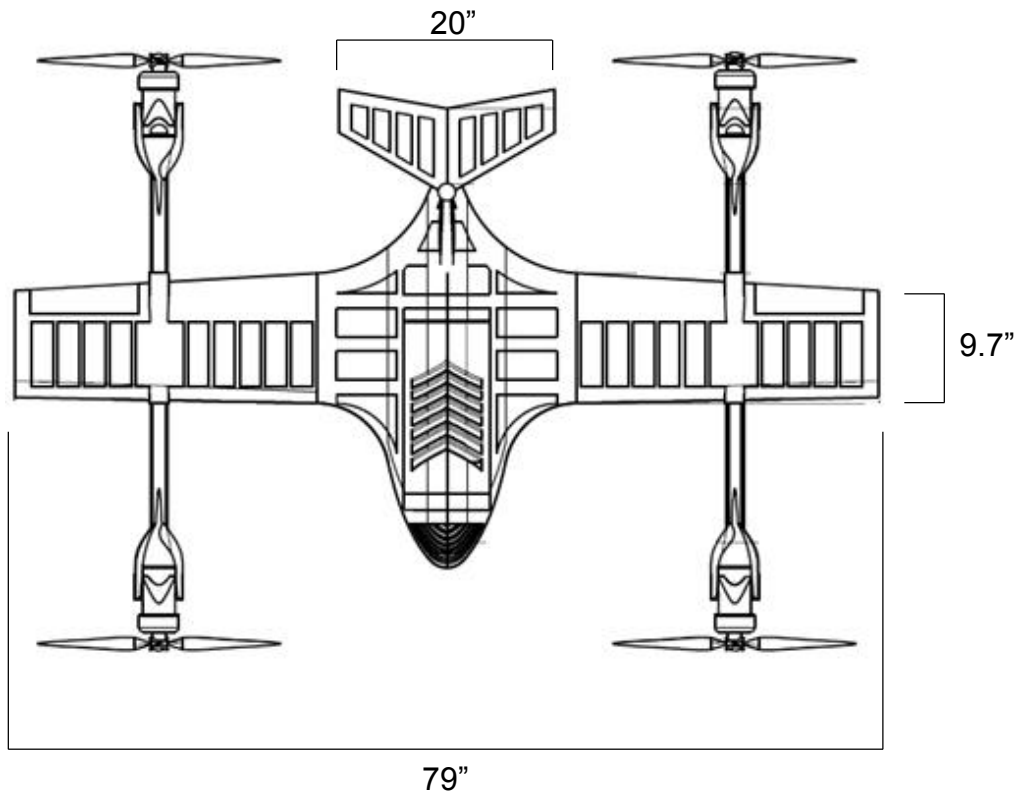
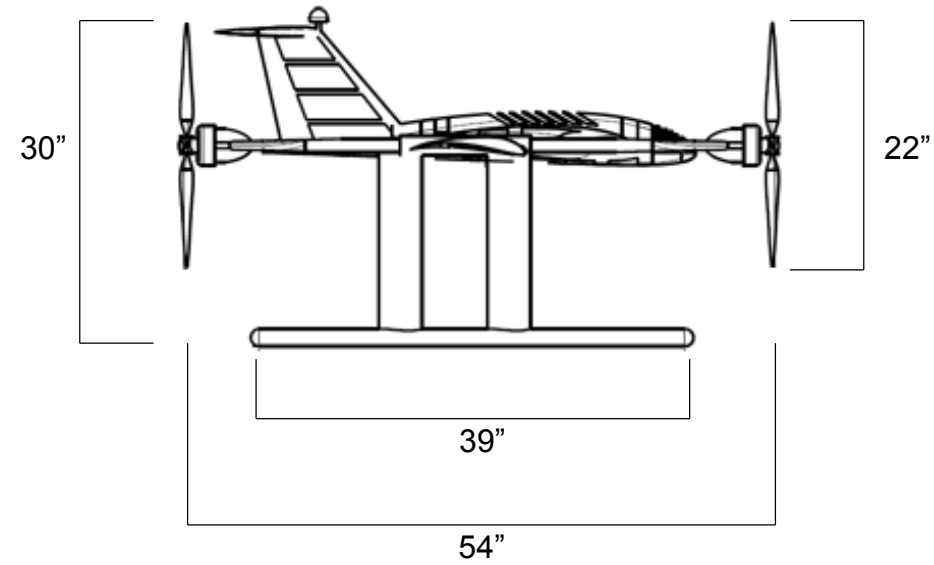
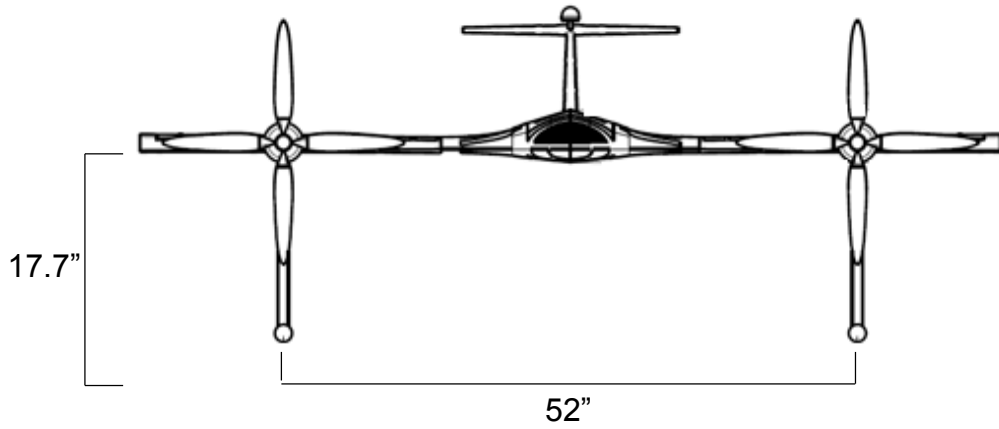
Height	2 ft 6 in	0.76 m
Length	4 ft 6 in	1.4 m
Wingspan / Width	6 ft 7 in	2.0 m
Ground clearance	1 ft 5 in	0.43 m
Maximum Gross Weight	105 lbs	48.1 kg
Design Gross Weight	99 lbs	44.9 kg
Useful Load	20 lbs	9.0 kg
Fuel Weight	16 lbs	7.2 kg
Empty Weight	63 lbs	28.5 kg



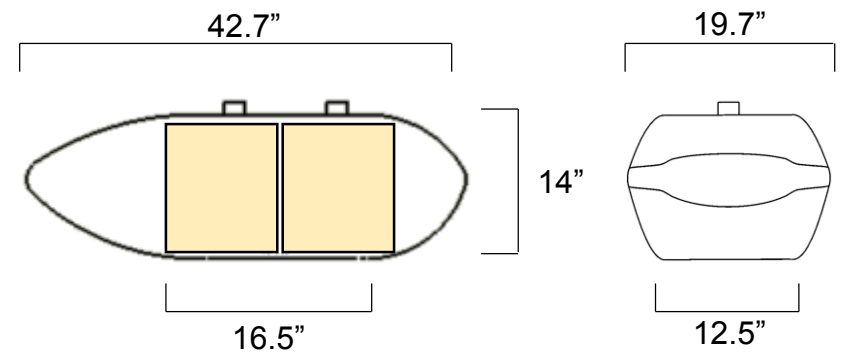
VEHICLE PERFORMANCE

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'	95°F
Hover Endurance (at 6000'/95°F)	2min	(at MTOGW)

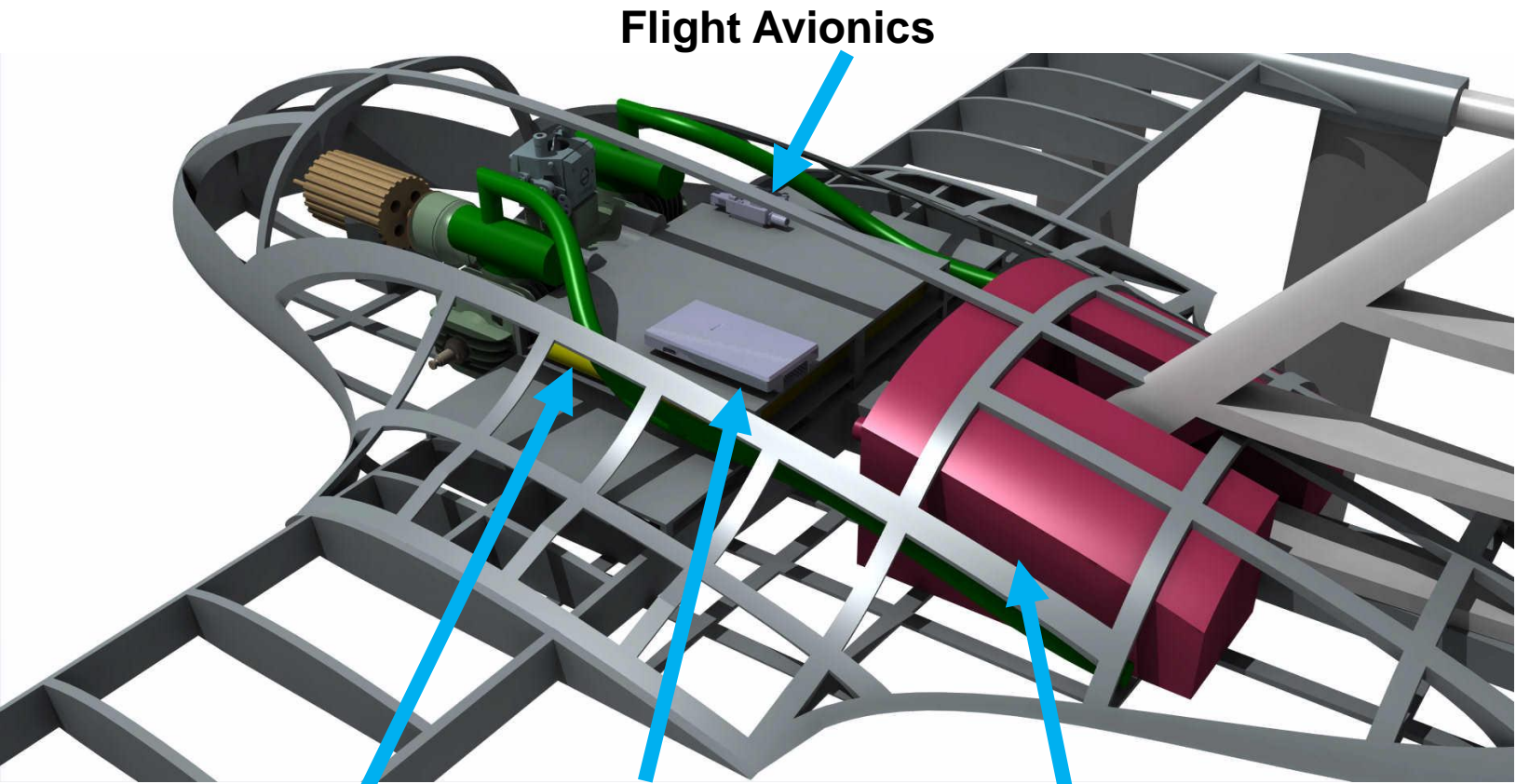




Payload Container



Major Component Layout

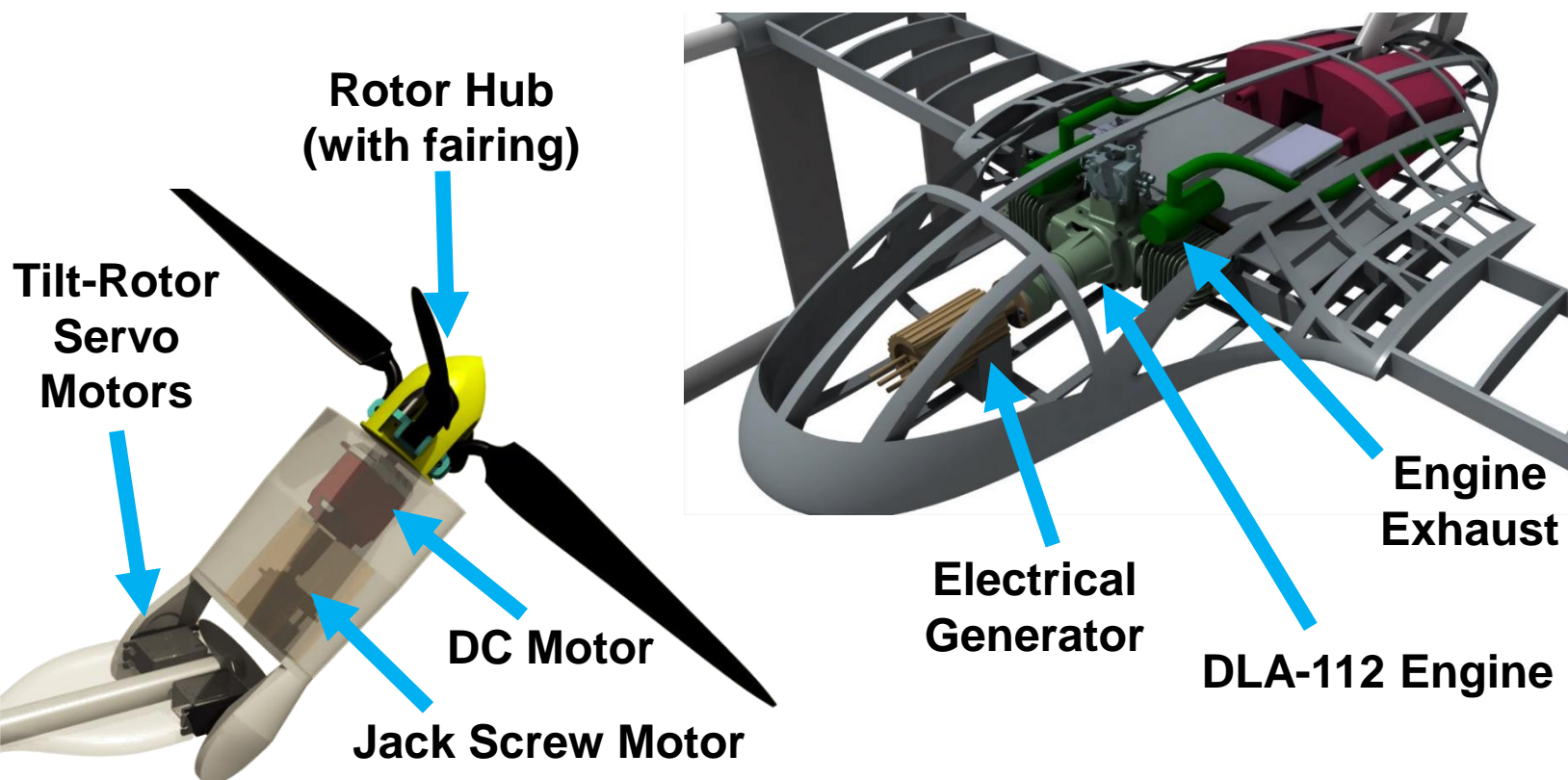


Flight Avionics

Lithium-Sulfur
Battery (2.0Ah)

Perception
Module

Fuel Tank (3 gal capacity)



Rotor Hub
(with fairing)

Tilt-Rotor
Servo
Motors

DC Motor

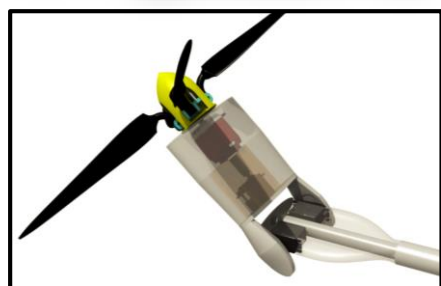
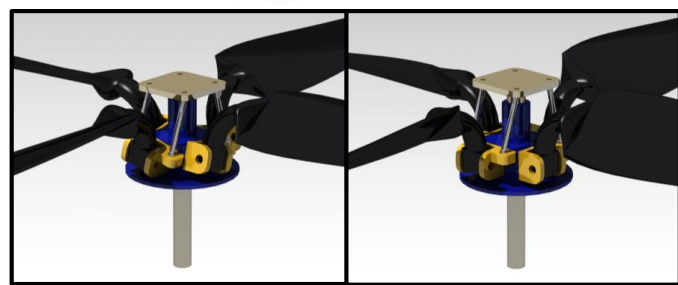
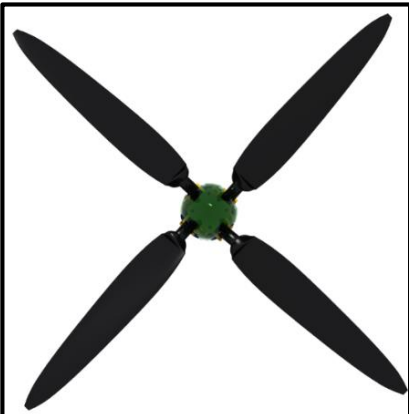
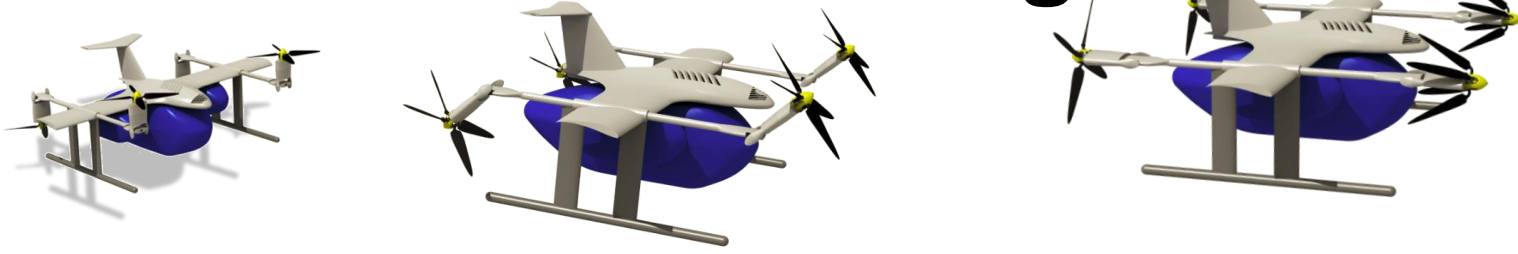
Jack Screw Motor

Electrical
Generator

Engine
Exhaust

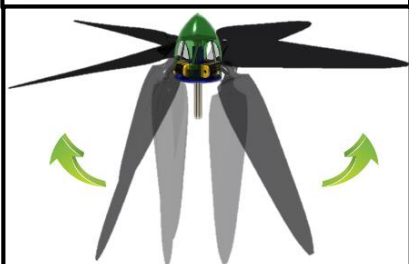
DLA-112 Engine

Innovative Vehicle Design

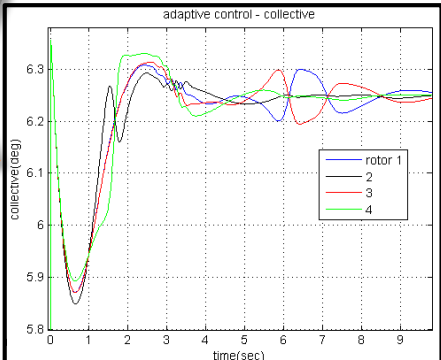


Variable Pitch Rotor Hub

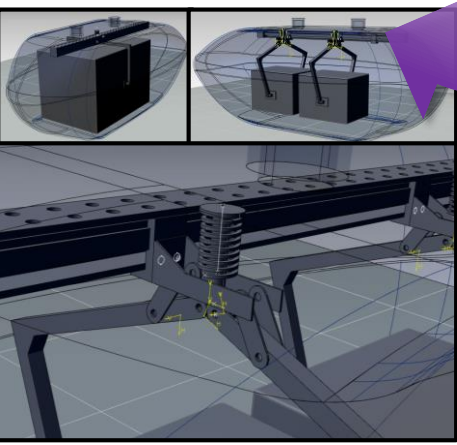
Tilt-Rotor Design



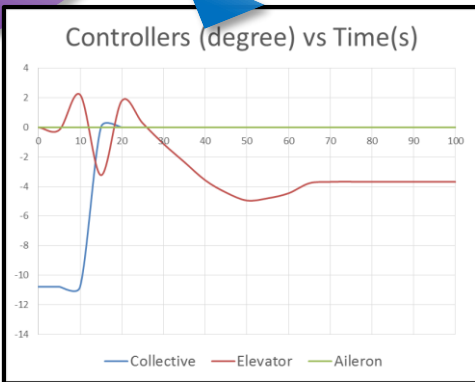
Folding Front Rotors Reduce Drag in Cruise



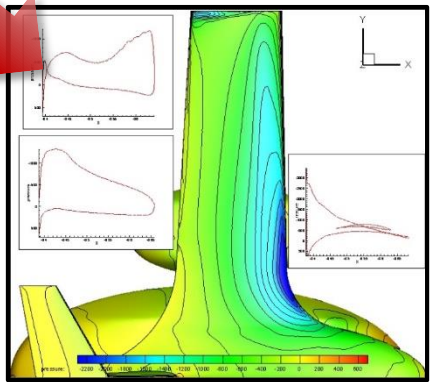
Adaptive Controls Robust to Disturbances



Automated Package Handling System



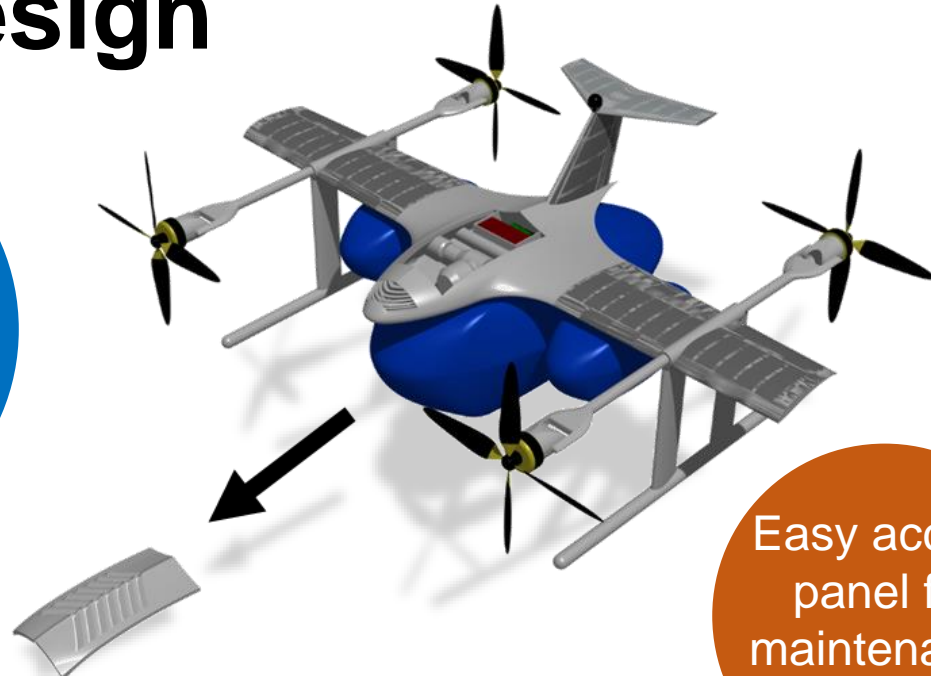
Smooth Hover-to-Cruise Transition



Wing Efficiency in Cruise Flight

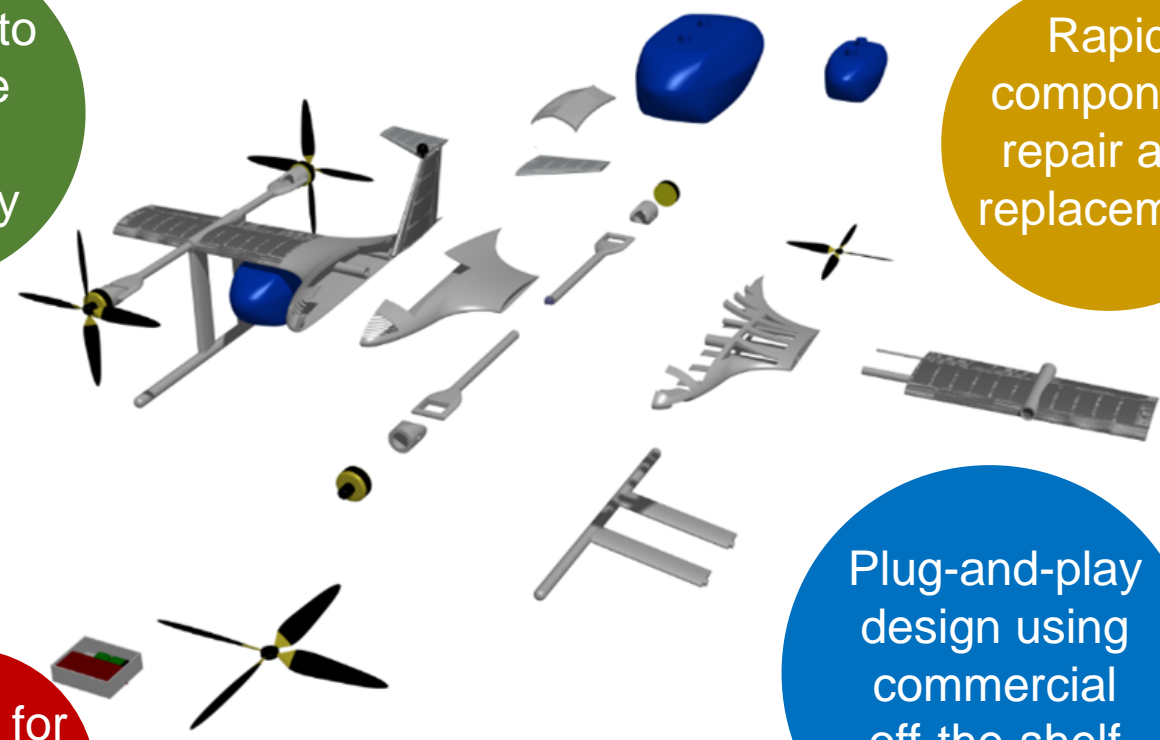
Modular Design

Decreased risk of damage during inspection and troubleshooting



Easy access panel for maintenance personnel

Designed to maximize vehicle availability



Rapid component repair and replacement

Ready for future upgrades

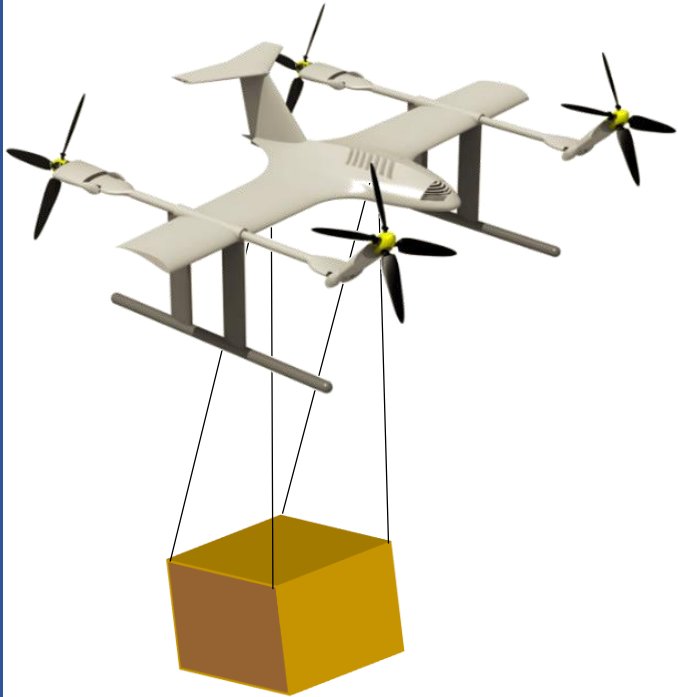
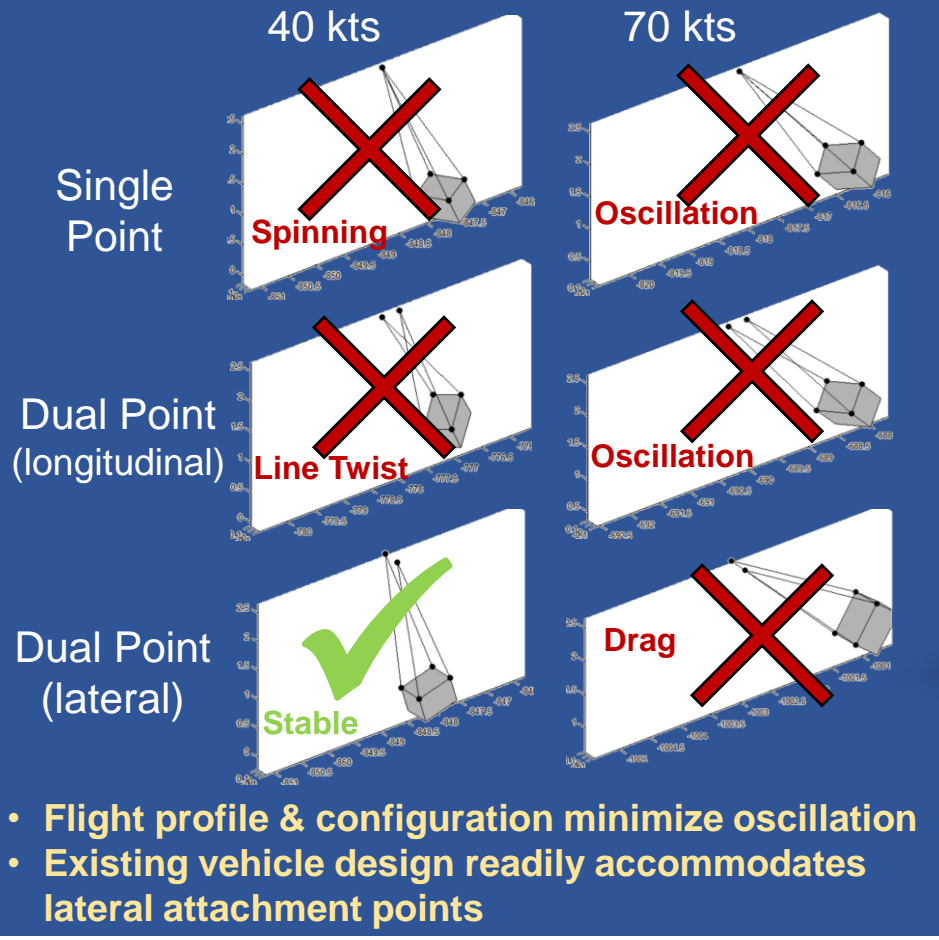
Plug-and-play design using commercial off-the-shelf parts

Fitting the Customer's Needs

DETAILED SLING LOAD MODELING

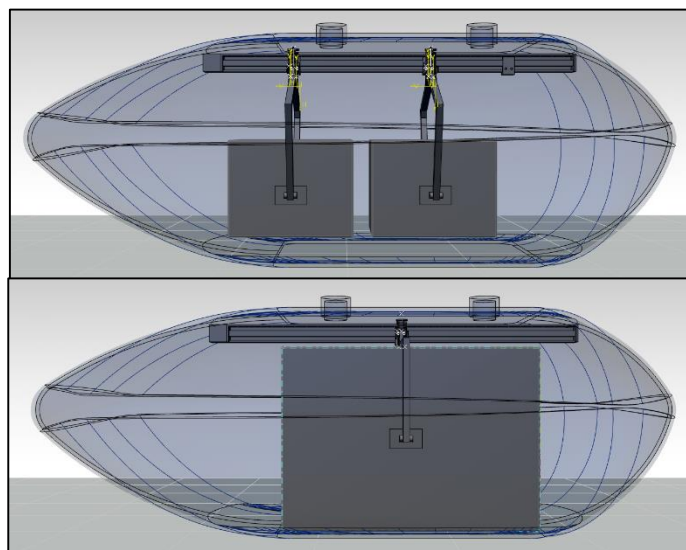
(24" x 24" package)

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

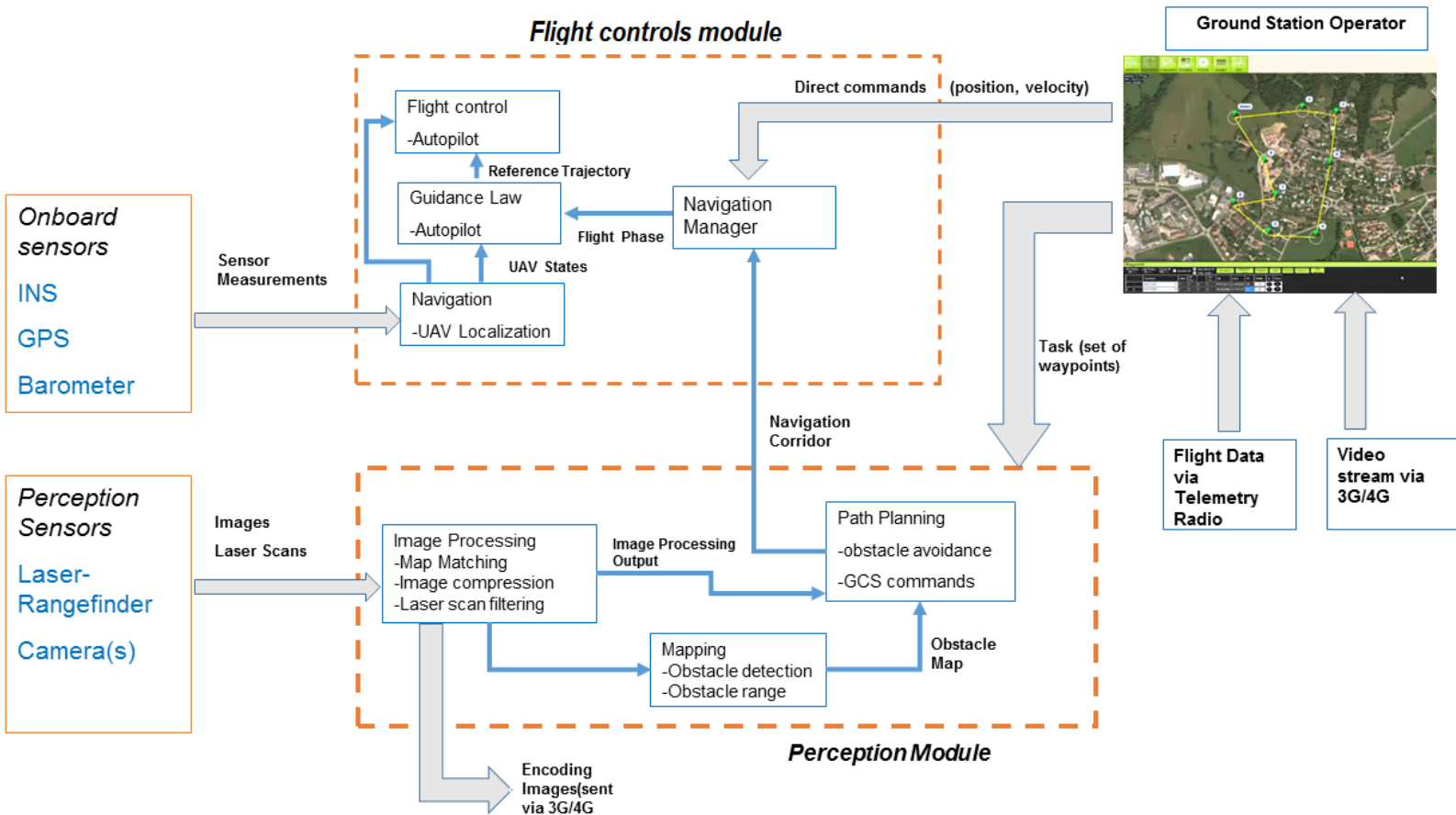


PAYLOAD VERSATILITY

- 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



Avionics for the Urban Environment



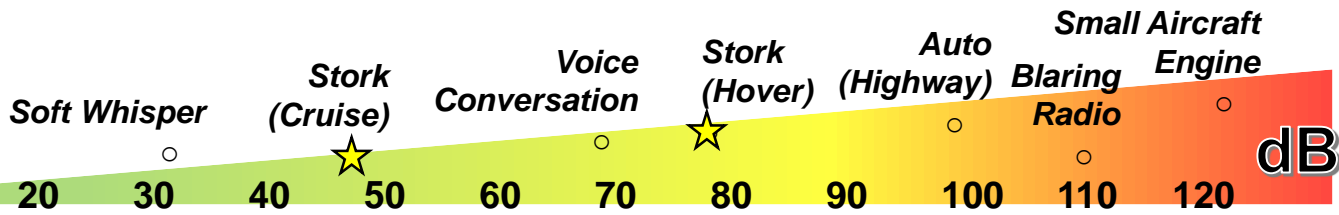
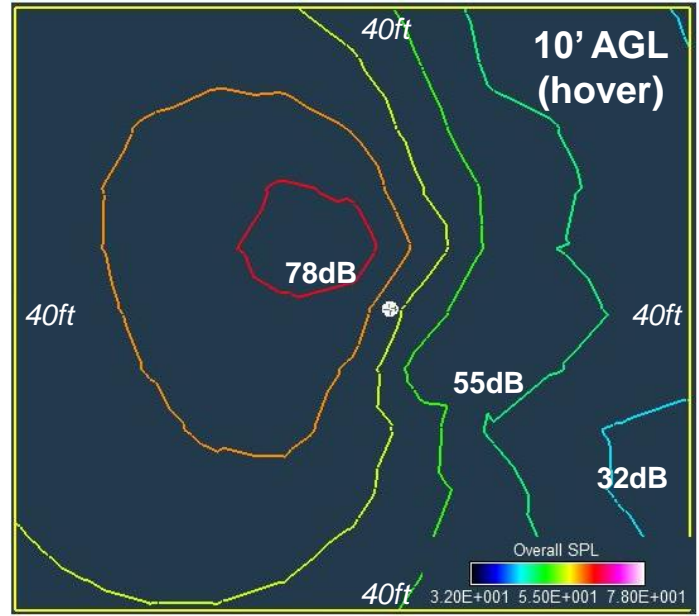
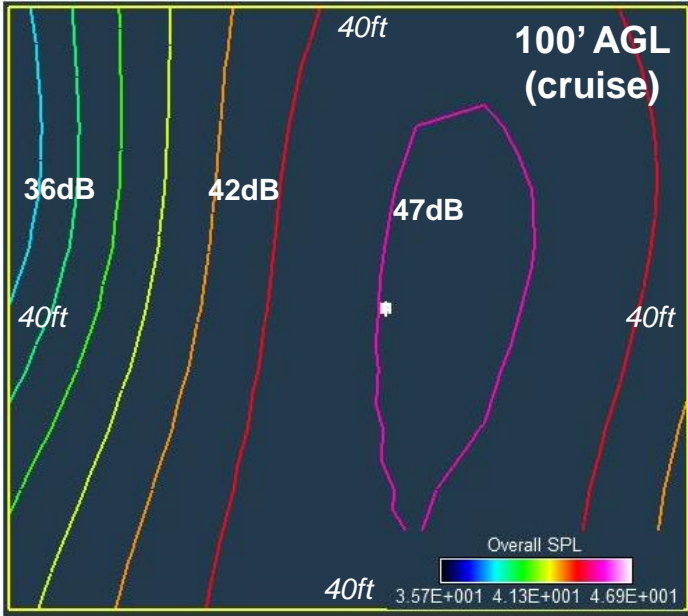
SENSORS

- 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

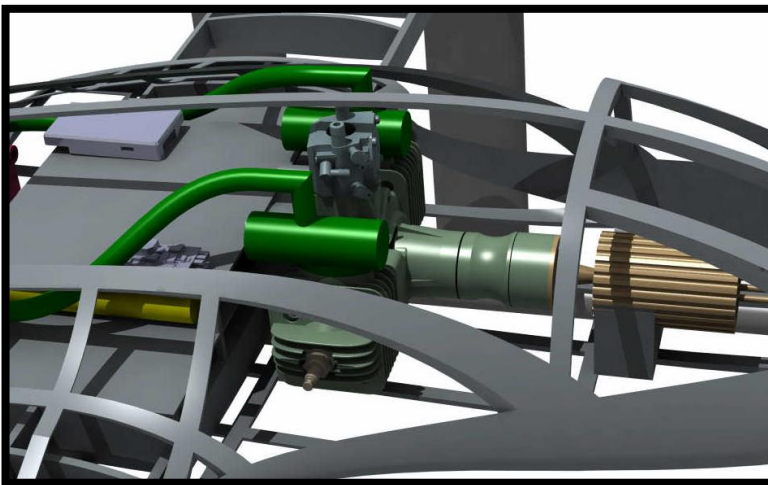
COMMUNICATION

- 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

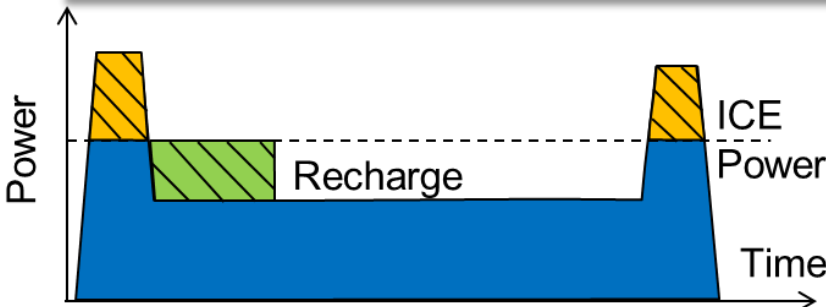
Use of internal combustion engine (ICE) plus battery power during peak power demand phases (hover)

Battery recharge during low power demand periods (cruise)

Reduction of emissions

Battery provides 2 min of flight power during engine failure

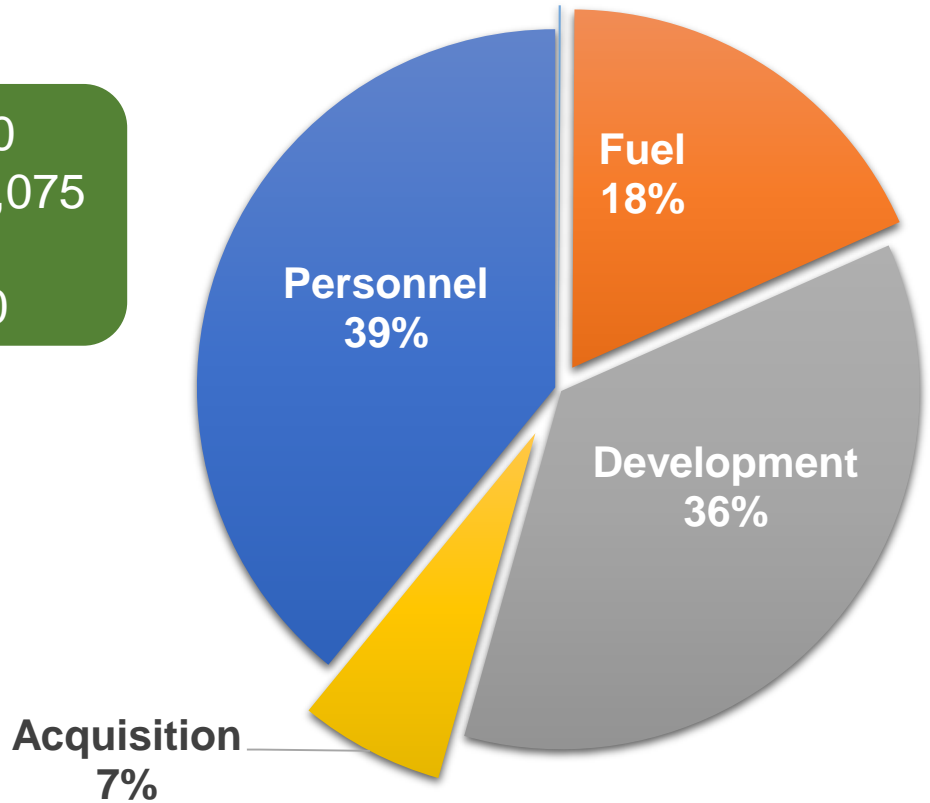
Battery power during ground operations; enables receipt of commands from operations center



Safe, Cost-Effective Solution

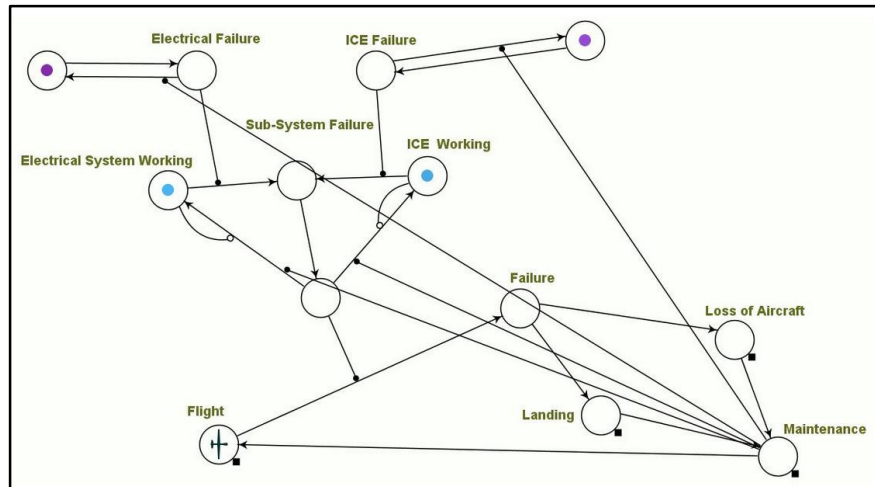
3-Year Life Cycle Cost: \$28,645,487

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

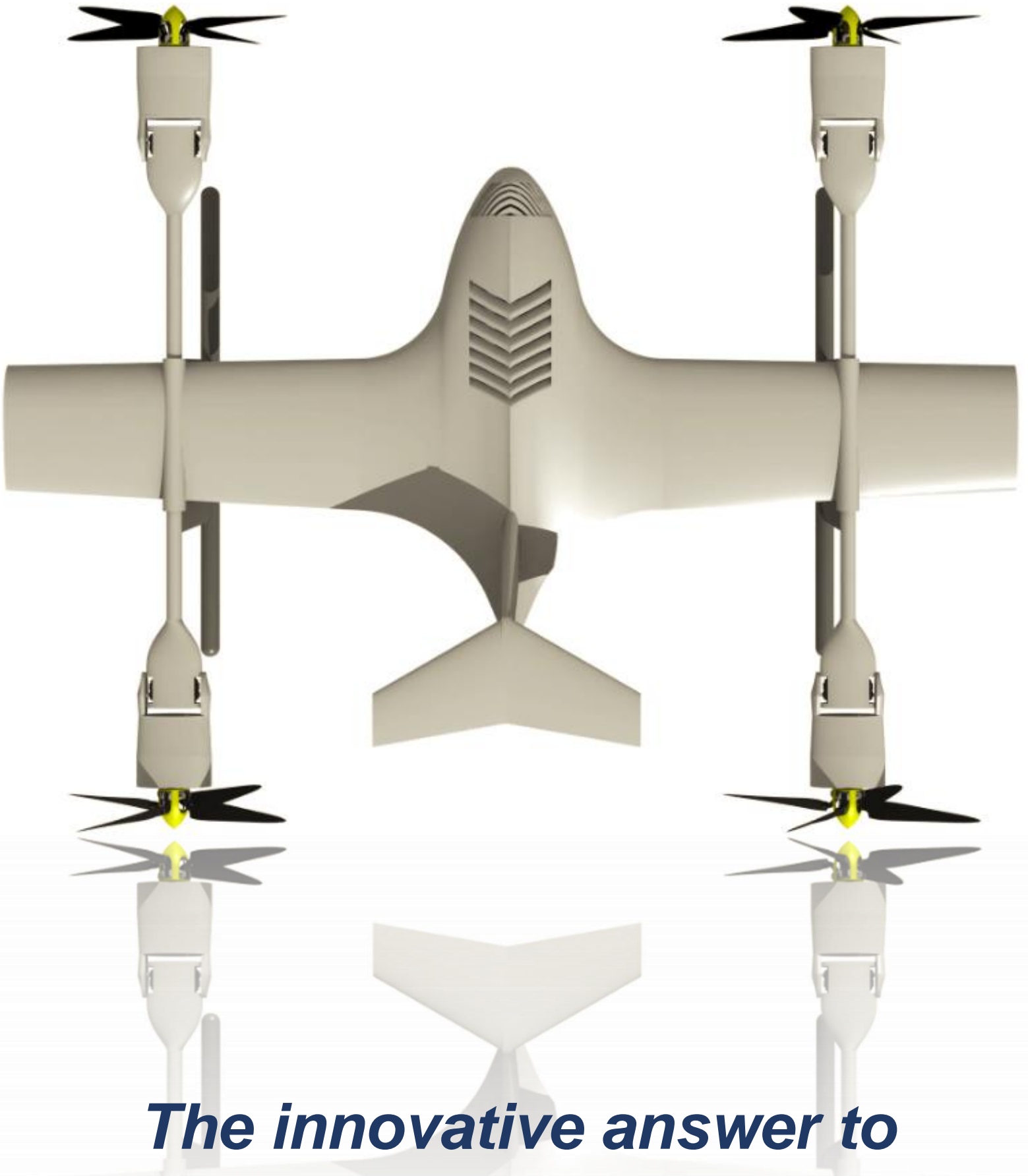


SAFETY FEATURES

- 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



The innovative answer to tomorrow's delivery needs