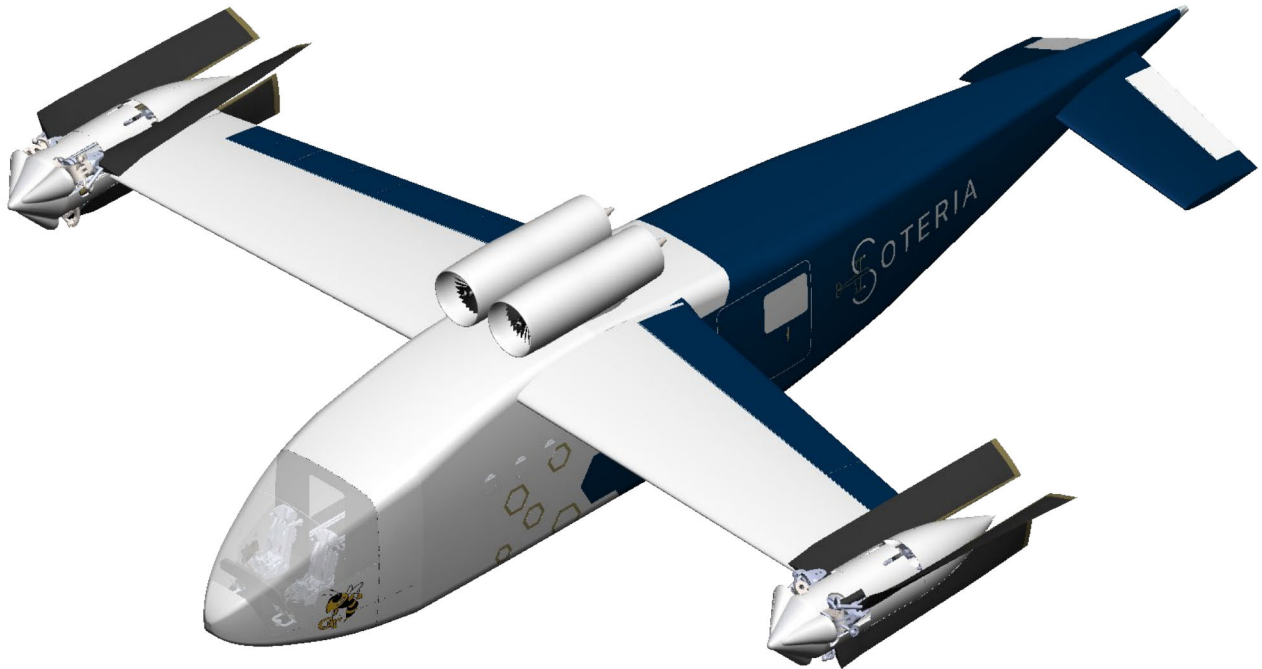




SOTERIA



Executive Summary

Graduate Design Team
Georgia Institute of Technology

40th Annual VFS Student Design Competition

High Speed Vertical Takeoff and Landing (HSVTOL) Aircraft

Sponsored by Sikorsky, a Lockheed Martin Co.



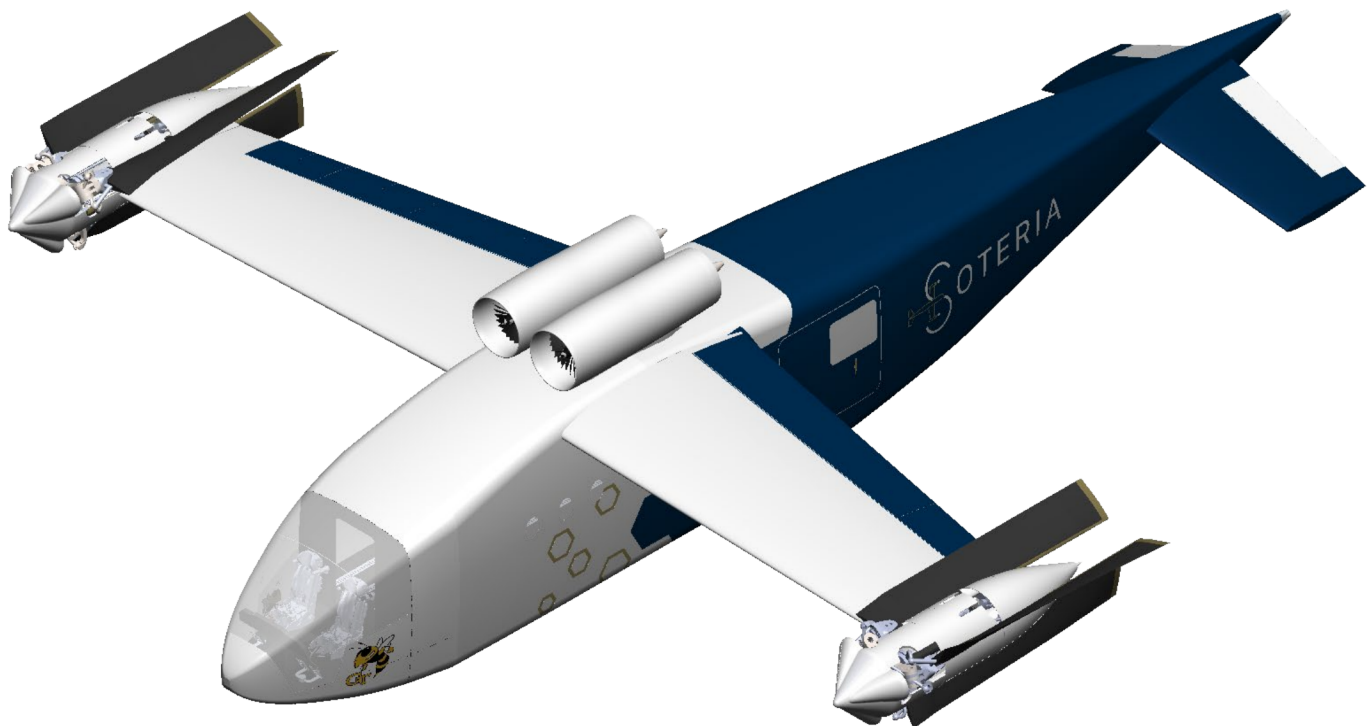
Introduction



- In response to the Vertical Flight Society's 40th annual student design competition Request for Proposal (RFP), the Georgia Tech graduate design team proposes *Soteria*. Named after the **Greek goddess of safety and rescue, Soteria** is a high-speed VTOL designed for combat search and rescue operations

Design Capabilities

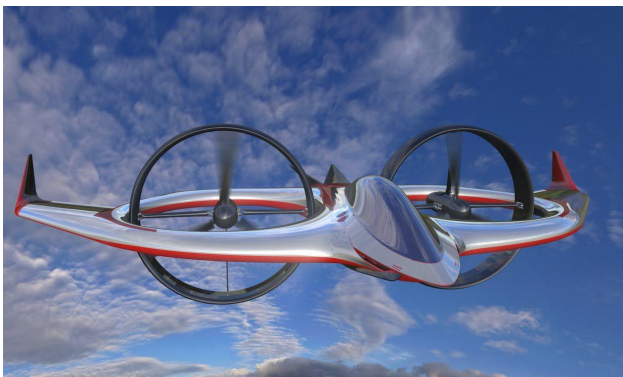
- *Soteria* is a **compound tiltrotor+fold configuration** designed to carry a large payload volume at a minimum 450 knots altitudes above 20,000 ft with a minimum radius of operation of 500 nmi, while being able to operate over unprepared surfaces





Tiltrotor

- Highest forward flight speed in rotorcraft mode
- More mechanical complexity/weight
- Control/recovery issues in emergency scenarios



Fan-in-wing

- Scalability issues with concept
- High forward flight speeds
- Large download in hover



Stopped Rotor

- Extensive literature available
- Aeroelastic coupling issues when in stopped configuration
- Large drag due to hub during high-speed cruise

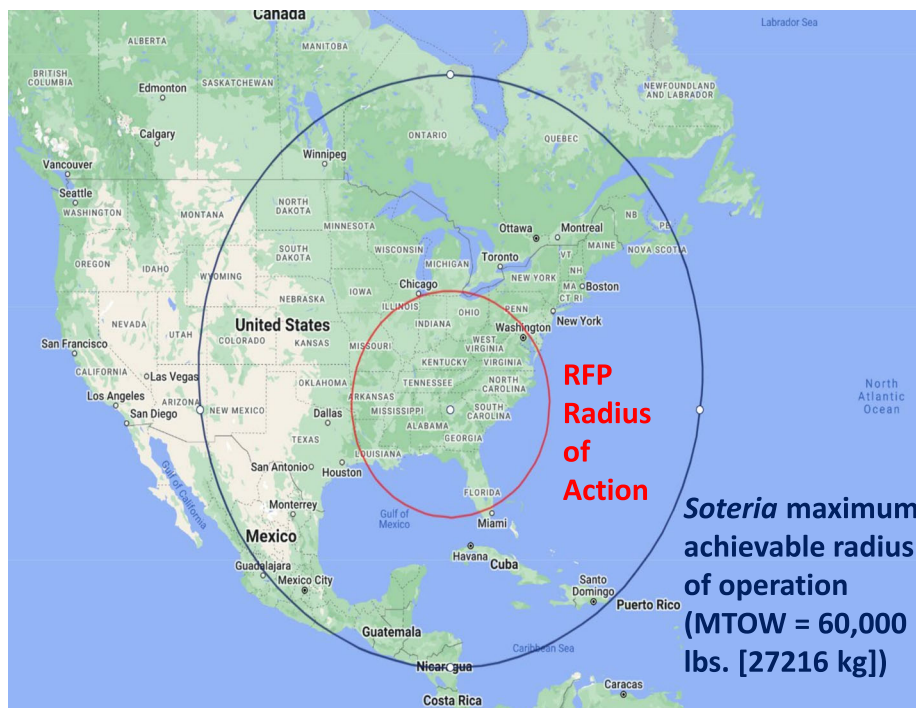
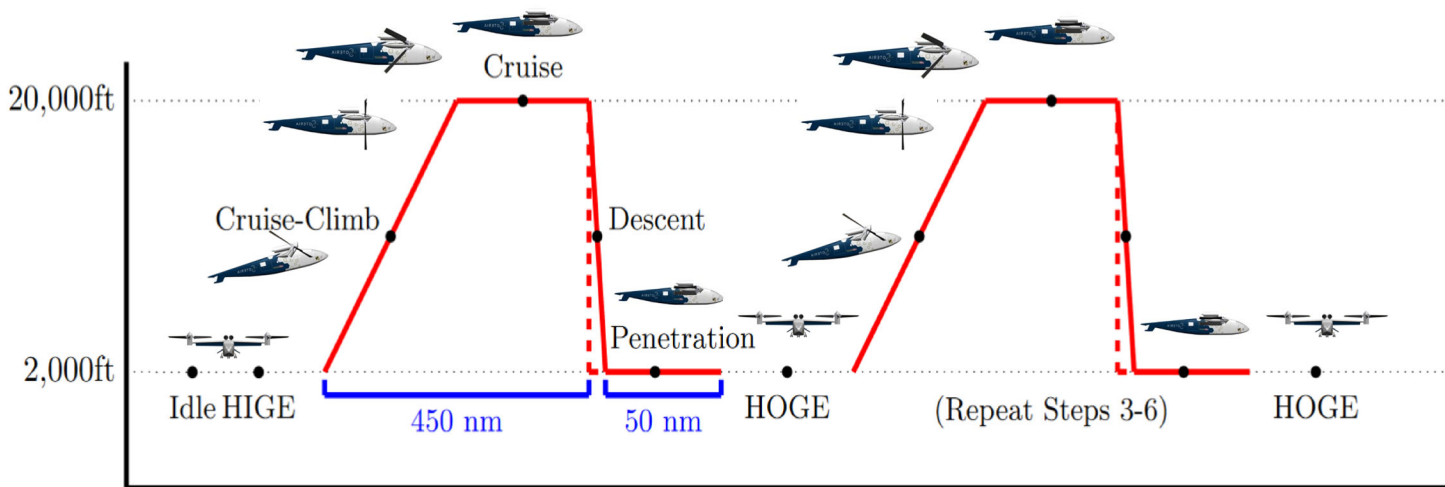
Selected Configuration: Tiltrotor + Fold Configuration

- Allows for the rotor to be stowed without requiring additional empennages
- Smoother transition between rotorcraft and fixed-wing modes

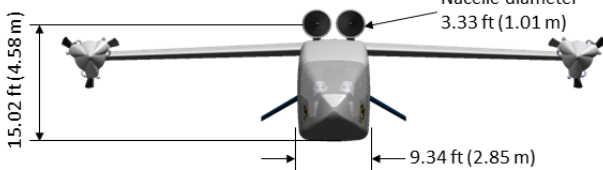
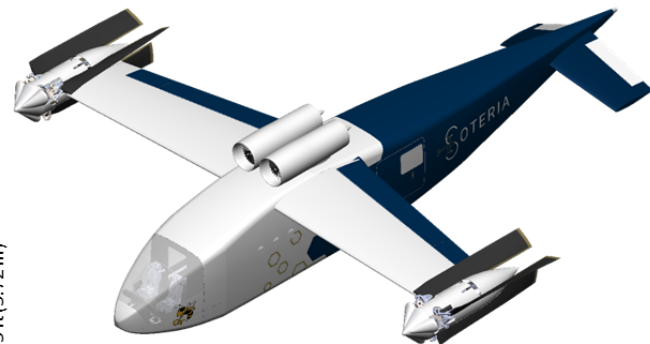
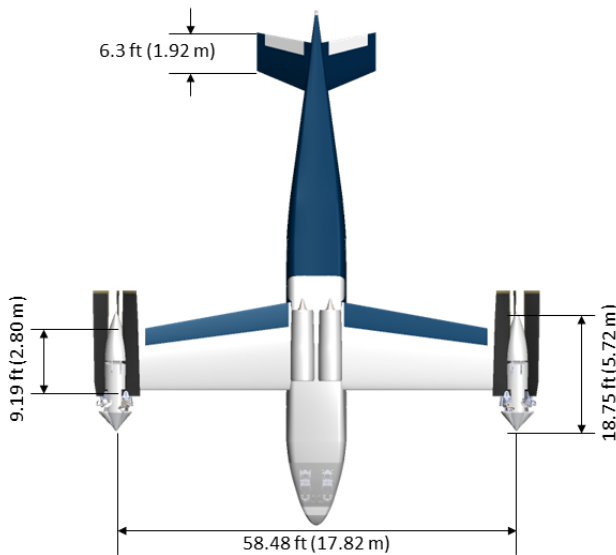
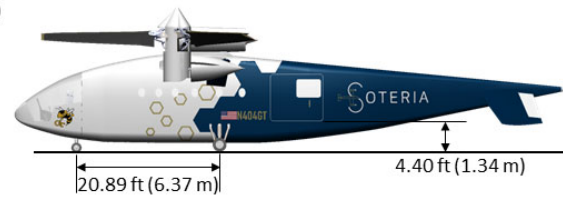
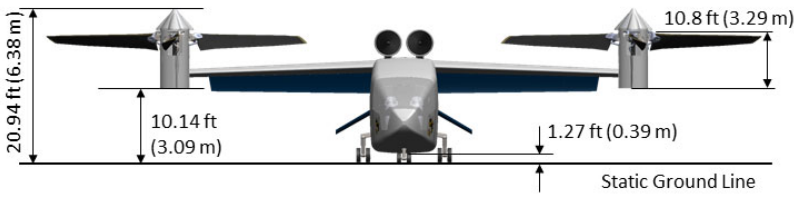
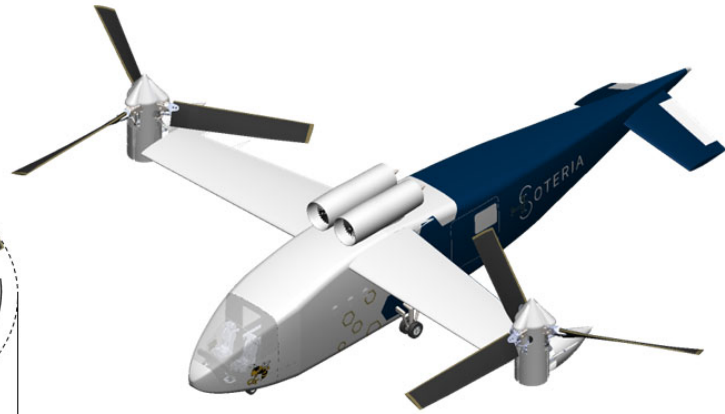
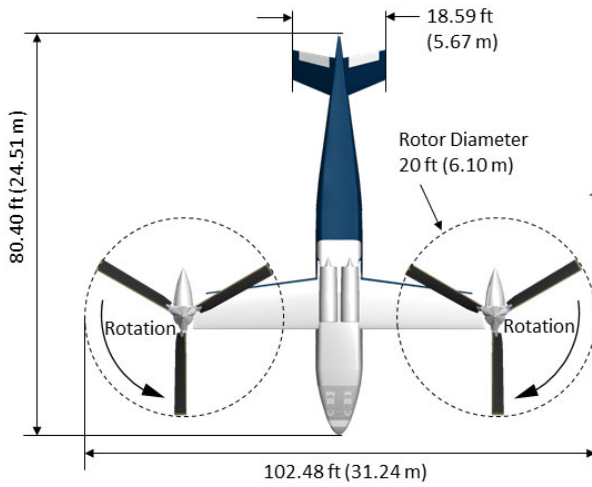


Mission Profile

- In a combat search and rescue scenario, an adaptable vehicle is crucial
 - Soteria's ability to cruise at high speed & perform VTOL operations makes it a crucial vehicle for such operations
 - Rated for 60,000 lbs MTOW, Soteria has a radius of operation of 1450 mi (2333 km)
 - Negates the need for forward operation bases → reduced operational cost

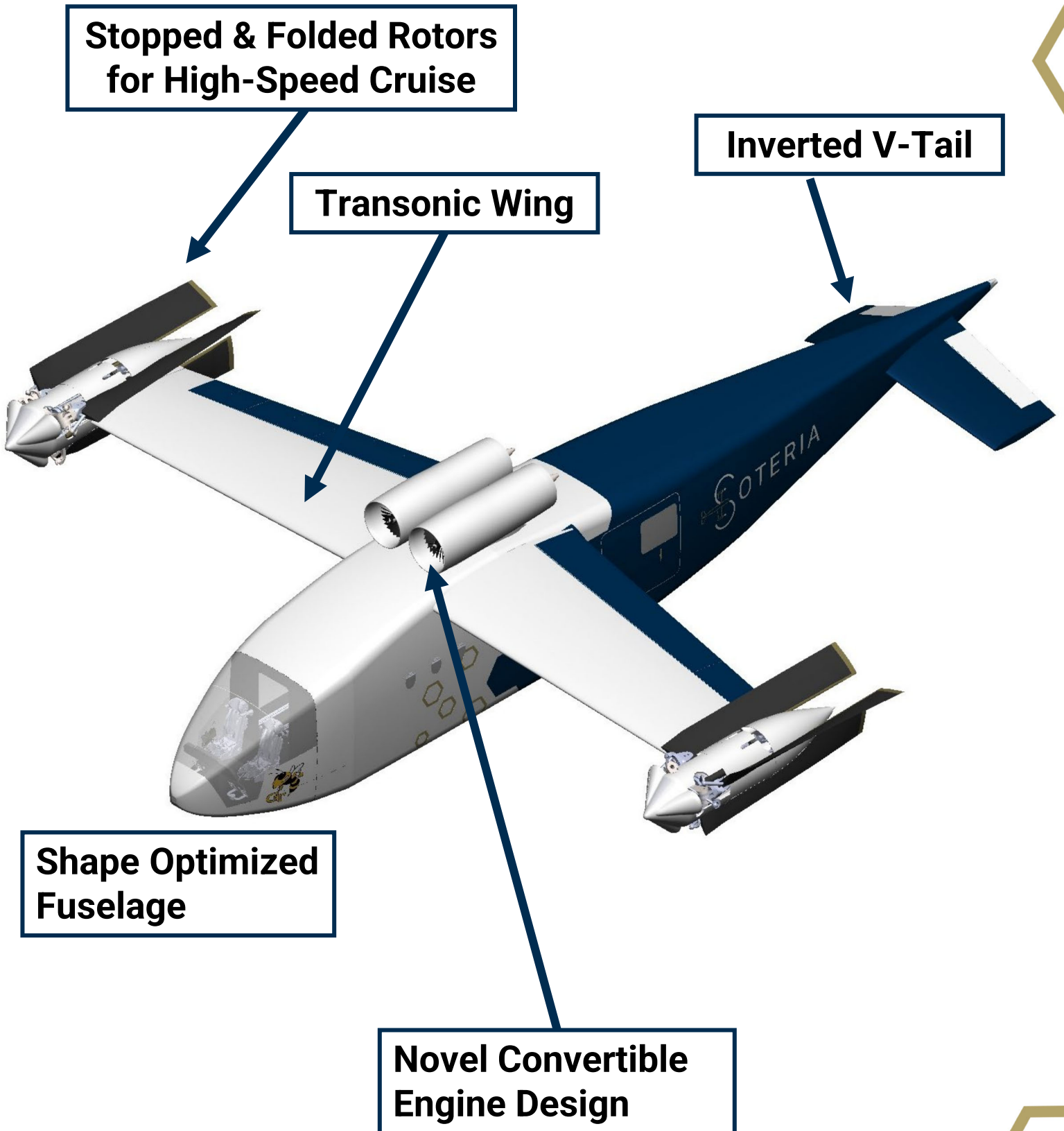


Design Overview





Fly beyond boundaries with *Soteria*



**Shape Optimized
Fuselage**

**Stopped & Folded Rotors
for High-Speed Cruise**

Transonic Wing

Inverted V-Tail

**Novel Convertible
Engine Design**



220+ kt
410+ kph



200 kt
370 kph



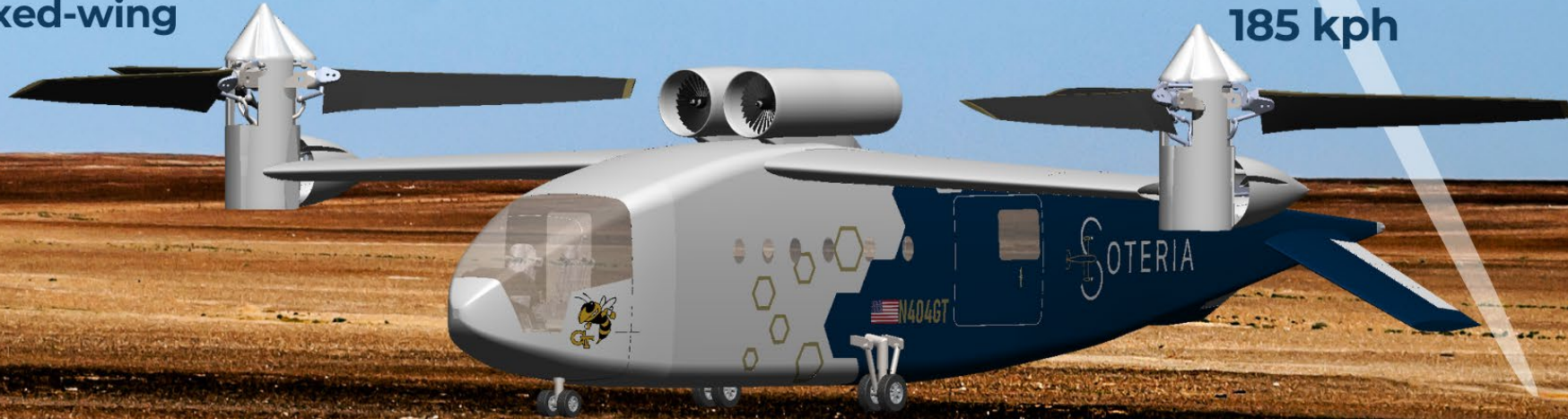
180 kt
335 kph



100 kt
185 kph



50 seconds
transition
helicopter to
fixed-wing



MAXIMUM RANGE
1450 nm
2330 km



CRUISE ALTITUDE
25,000 ft
7620 m



CRUISE SPEED
450 kt
830 kph



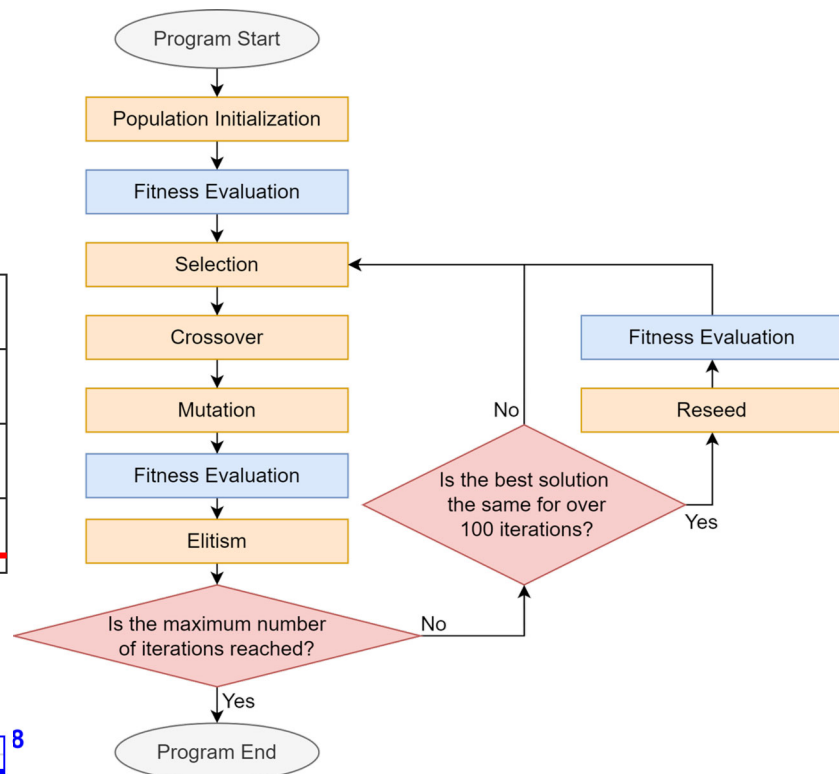
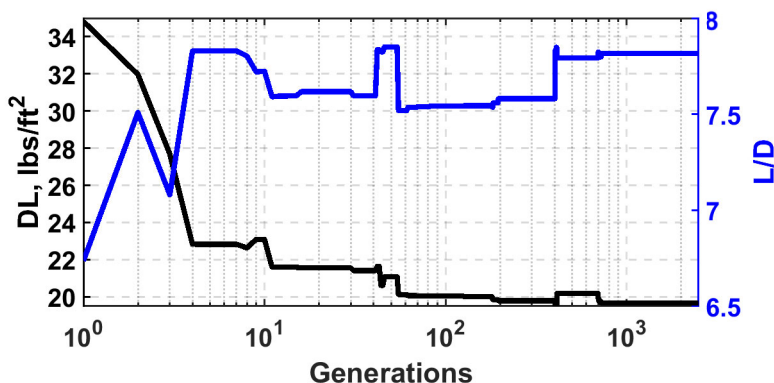
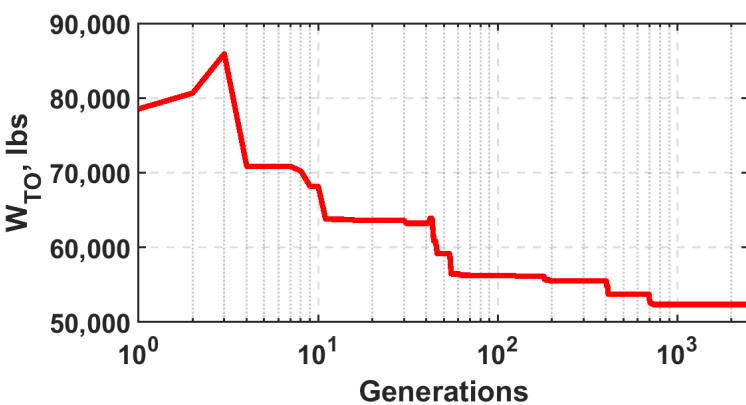
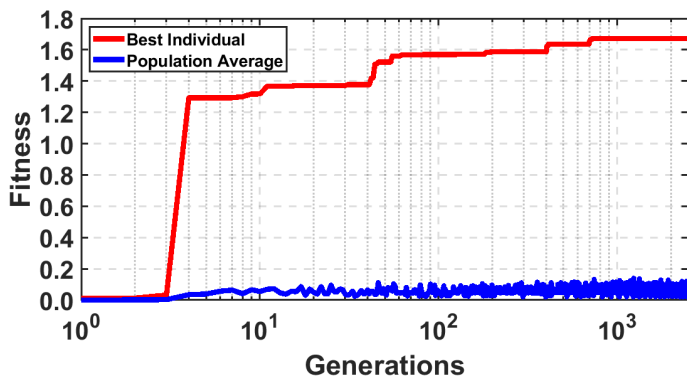
CABIN VOLUME
8x7x35 ft³
2.5x2.1x10.7 m³



Vehicle Development: Genetic Algorithm

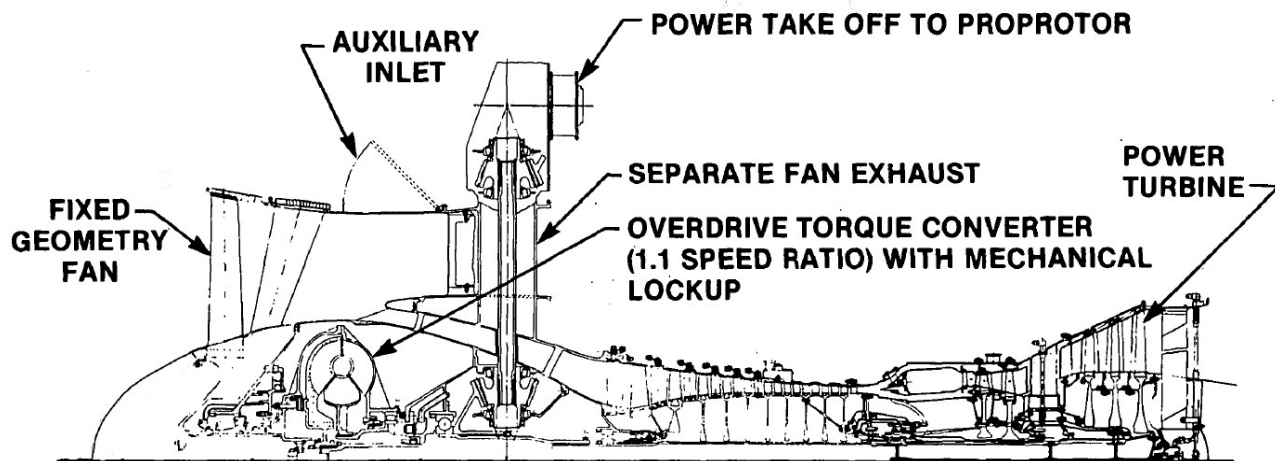


- A fully self-developed **genetic algorithm** optimization scheme was used for **preliminary vehicle sizing** and **rotor blade design**.
- **200,000** potential vehicle designs efficiently evaluated and optimized in 34 hours on a desktop computer.

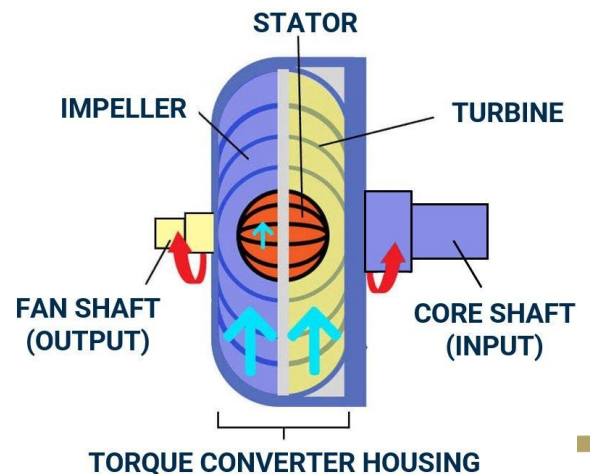
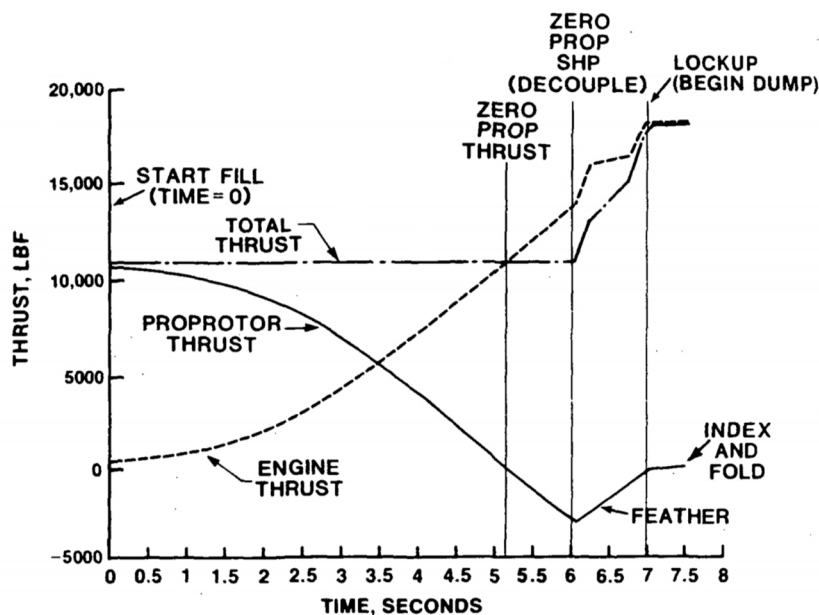


Novel Convertible Engine Technology

- One engine capable of operating both as a turboshaft during vertical flight operation and turbofan in the other phases of the mission.

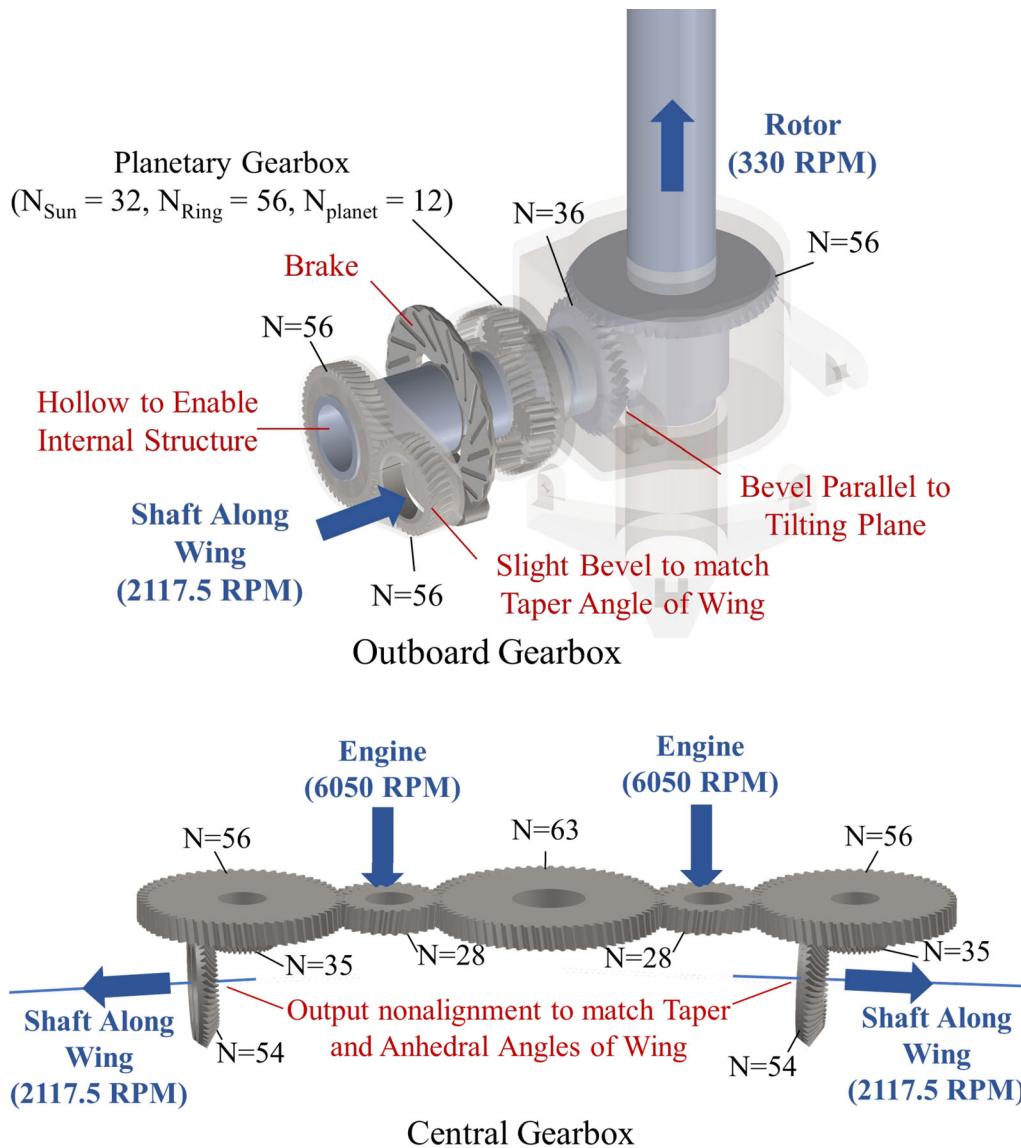


- A torque converter declutches the fan during helicopter-mode operations allowing power to be transmitted to the rotors. Output thrust during transition remains constant



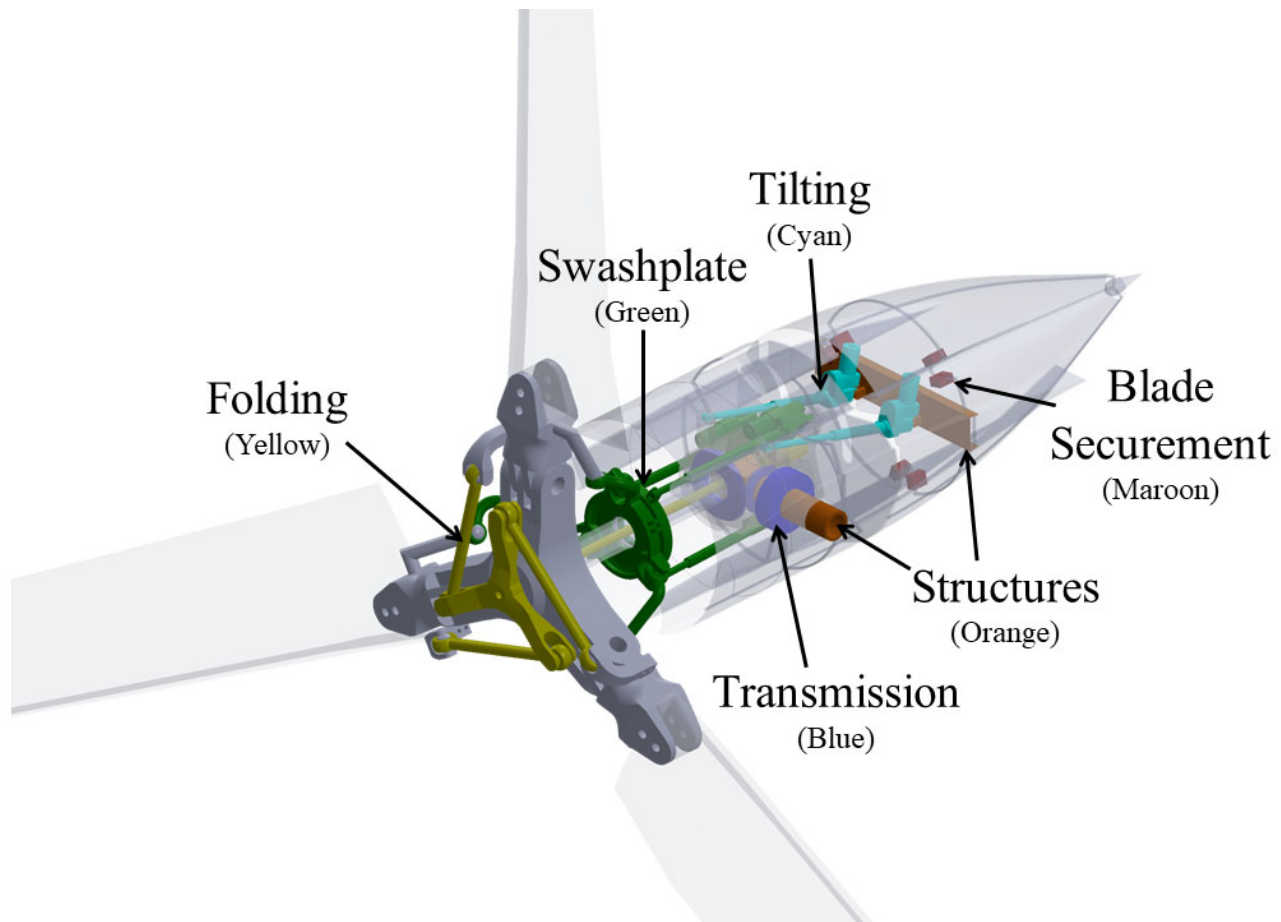
Transmission

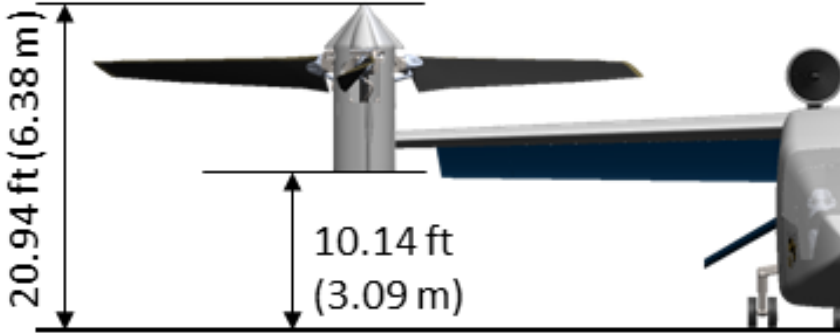
- Total Shafting Length of 82.15 ft (25.04m)
- Total Shafting Weight of 384.62 lbs (174.5 kg)
 - 55.5 ft (16.9 m) of composite shaft weighing 140.42 lbs (63.69 kg) capable of transmitting 287,800 in-lbs (32517 N-m)



Rotor Tilt & Blade Folding Mechanism

- Hingeless rotor for mechanical simplicity and reparability
- Co-axial folding mechanism (see yellow system)
- In folded configuration, blades are oriented leading edge down → allows greater contact area for blade and magnetic locking mechanism
- Tilting mechanism articulated using only two electrohydraulic linear actuator



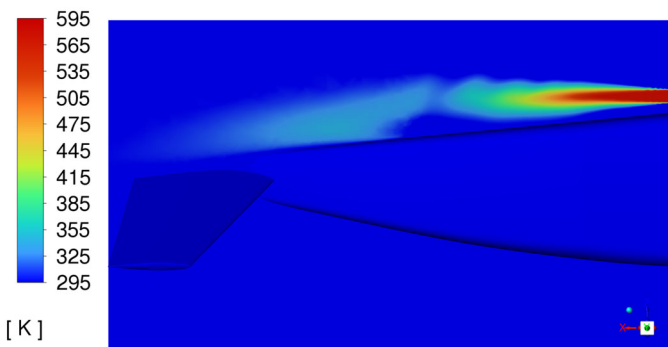


Rotor plane and jet exhaust centered over 15 ft from the ground to protect ground crew

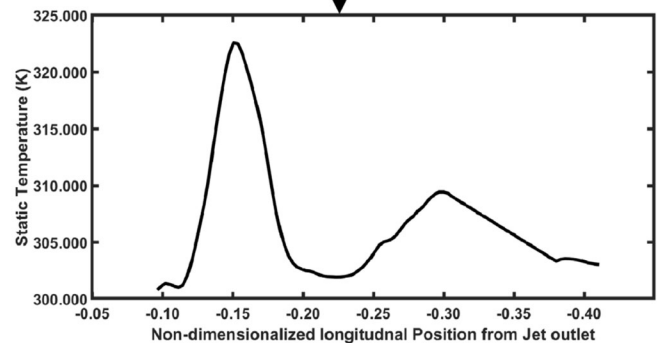
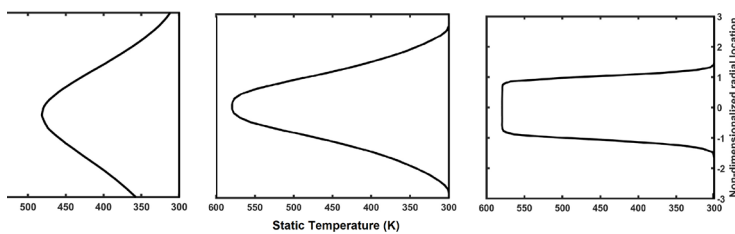
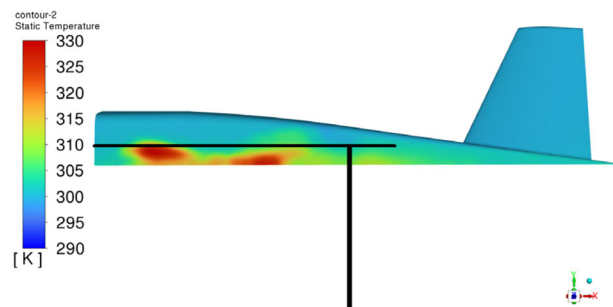
- Convertible engine can be operated without negative thermal effects
- All vehicle components safe from excess heating when in shaft power mode

contour-3
Static Temperature

Ansys
2021 R2



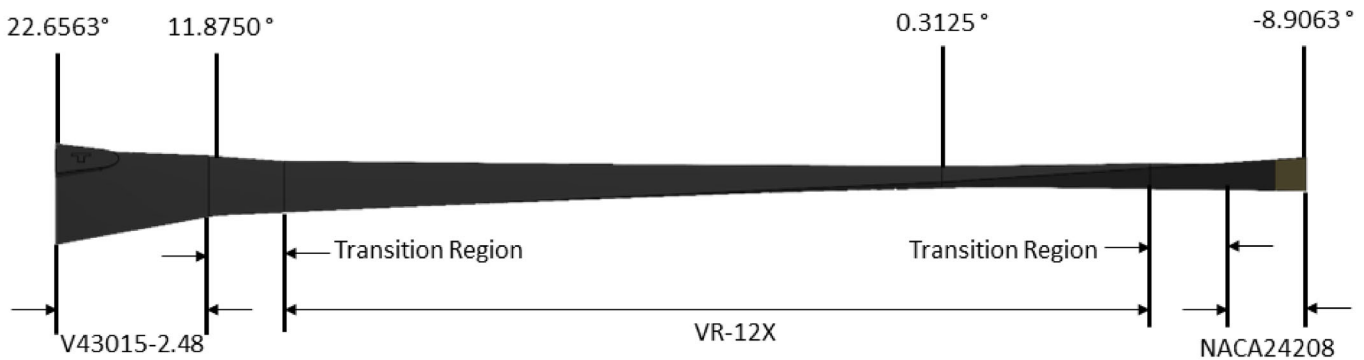
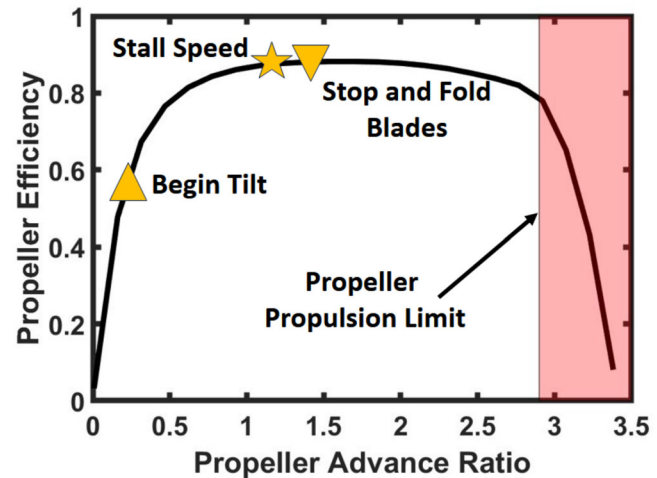
Ansys
2021 R2



Thermal profile at 20, 10, and 2 radii downstream of jet (left to right)

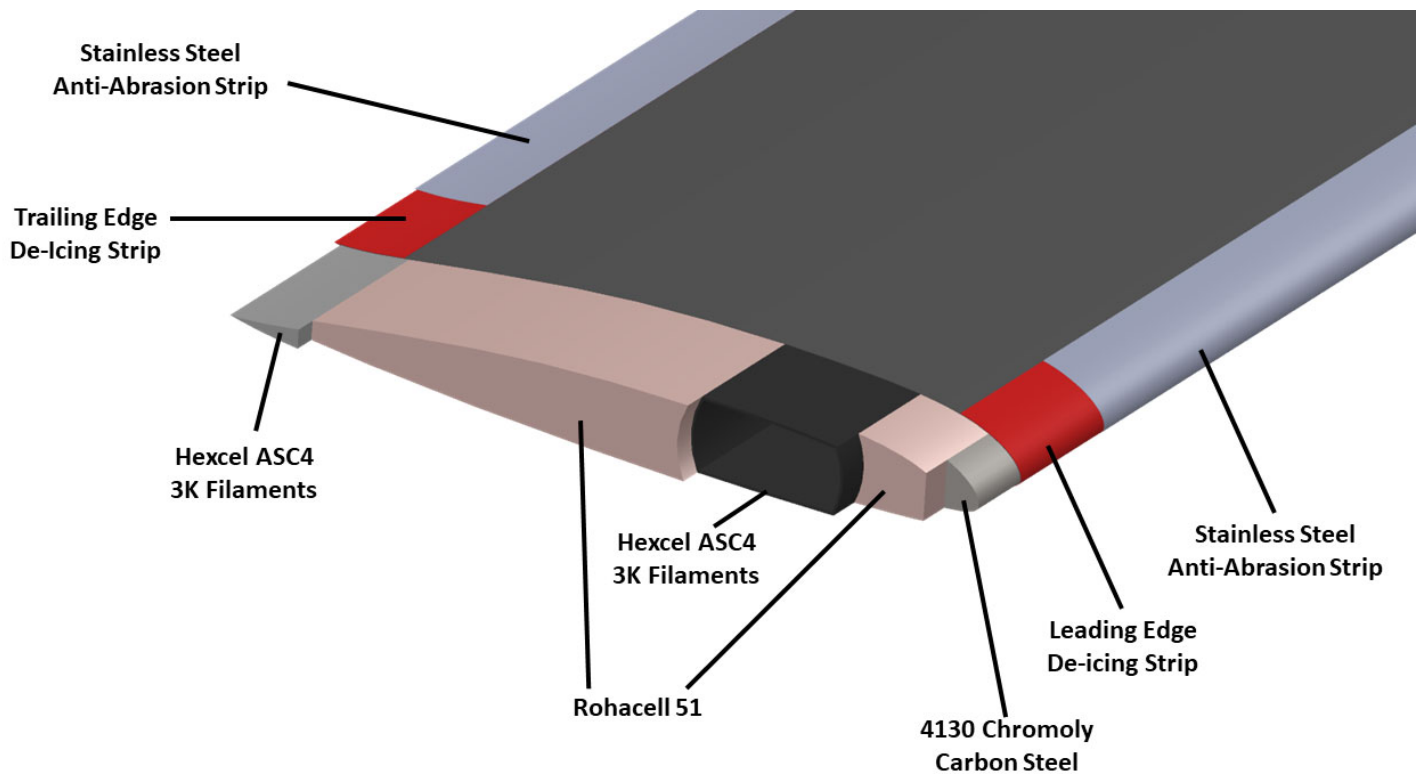
Rotor Blade Design

- A genetic algorithm was used to optimize the rotor blade
 - Blade split into three segments, with free variation in chord, twist, and airfoil parameters within each segment
- BET analysis performed for hover and propeller code modelled for forward flight
 - High propeller efficiency in forward flight (>0.825)
- Results from propeller design confirmed using CHARM



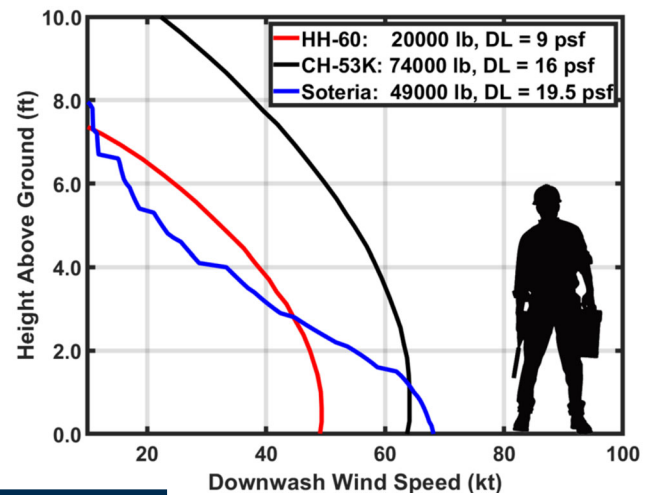
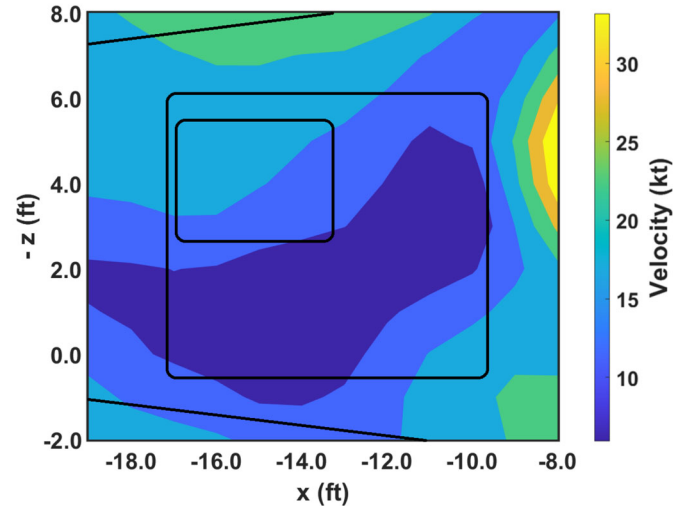
Rotor Blade Design

- Blade internal structure modelled using principles stated in composite blade modelling resource, iVABS

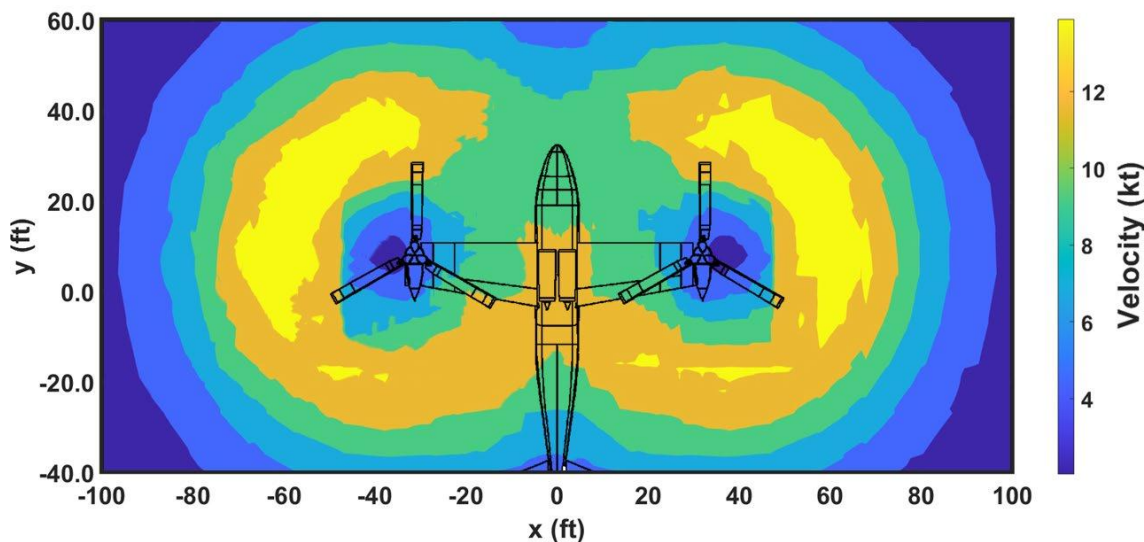


- Vibratory modes of the rotor blade were not within 20% of the /rev lines for rotorcraft or propeller configurations
- Rotor designed proved sufficiently stiff to sustain loads during the different mission segments

- Downwash/outwash velocity minimized near cargo door, allowing for easier ground operations
- Ground operation sweeps shows downwash wind speeds comparable to similarly sized SMR vehicles
- Flowfield analysis indicates low outwash velocities on ground during air rescue operations

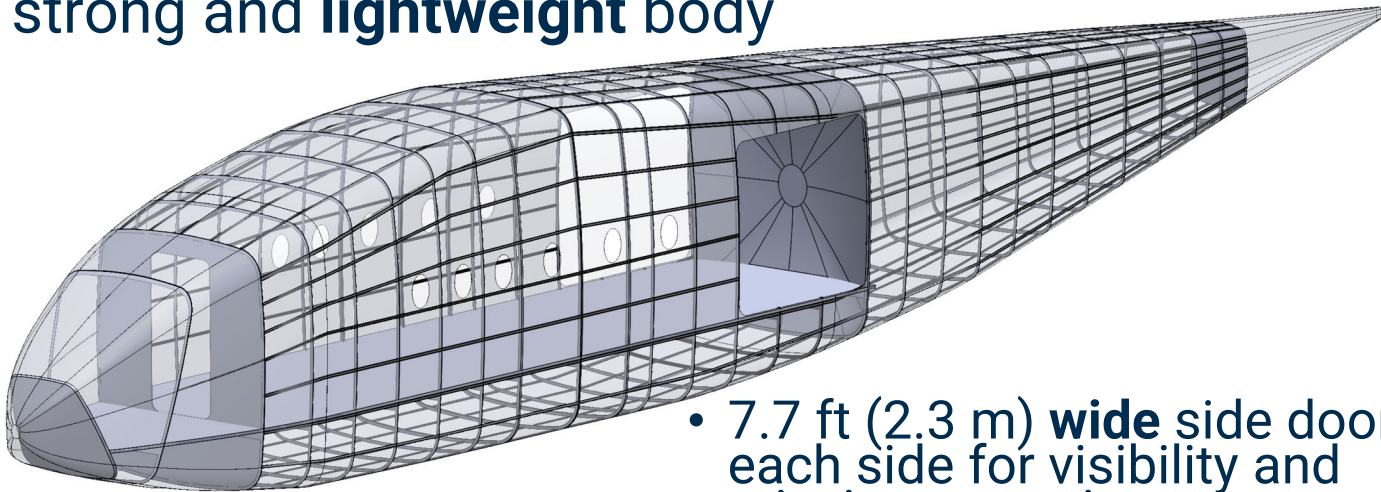


Airflow speed on the ground during a 50 ft height simulated rescue operation



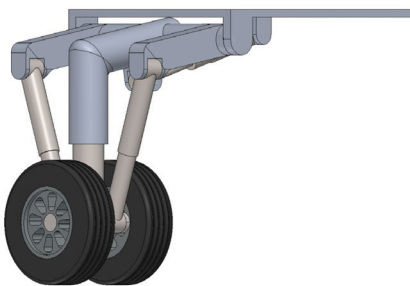
Fuselage Structure Highlights

- **Semi-monocoque** design and advanced **thermoplastic carbon fiber** composites for a strong and **lightweight** body

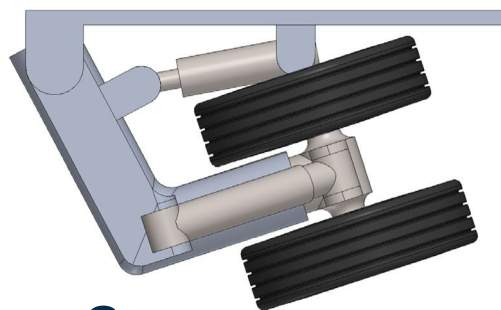


- **7.7 ft (2.3 m) wide** side door on each side for visibility and mission operations

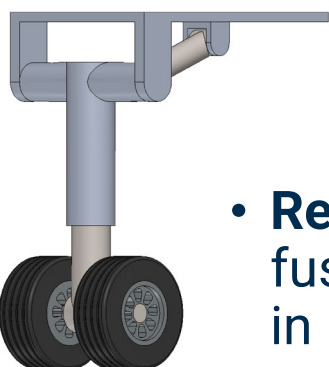
Landing Gear



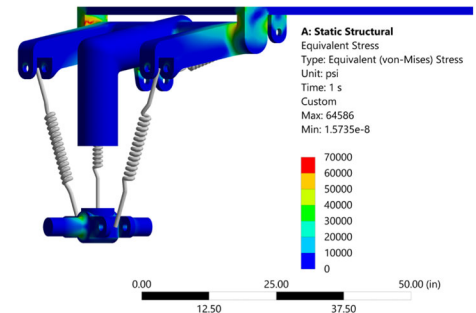
Main Landing Gear



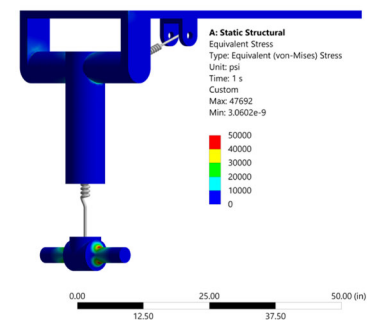
Nose Landing Gear



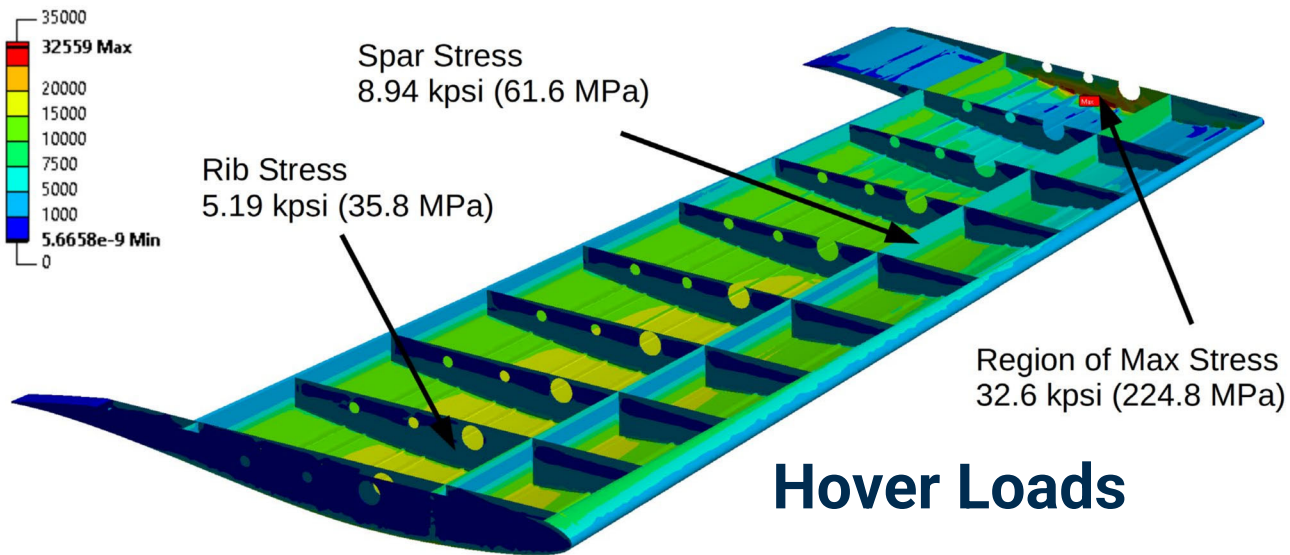
- **Retracts** within the fuselage to minimize drag in high speed cruise



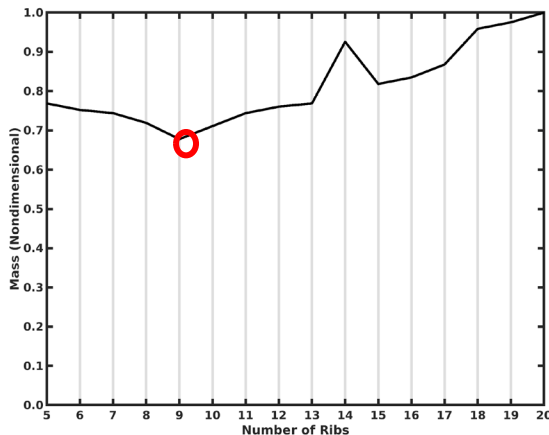
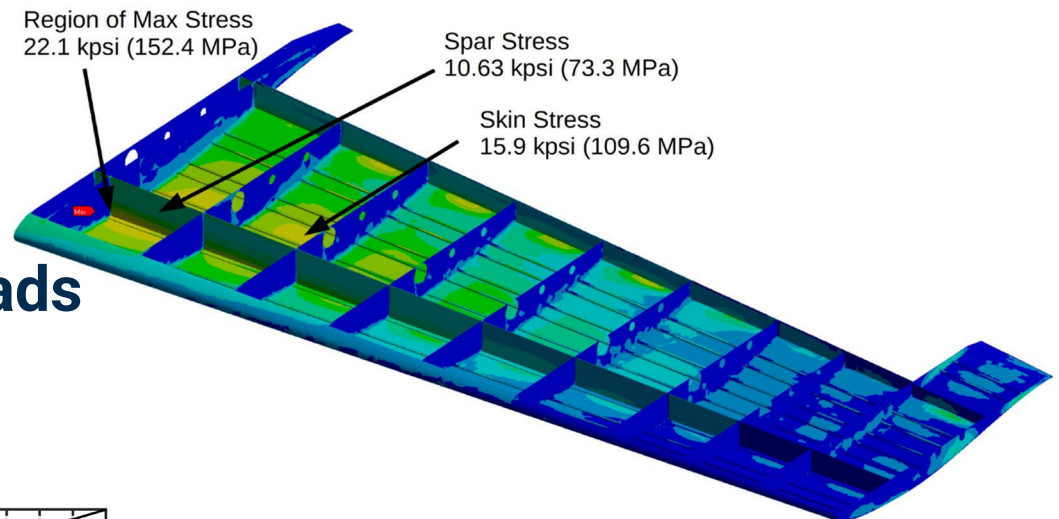
- Designed to withstand **10 ft/s (3.05 m/s)** touchdown speed



Wing Structure Highlights



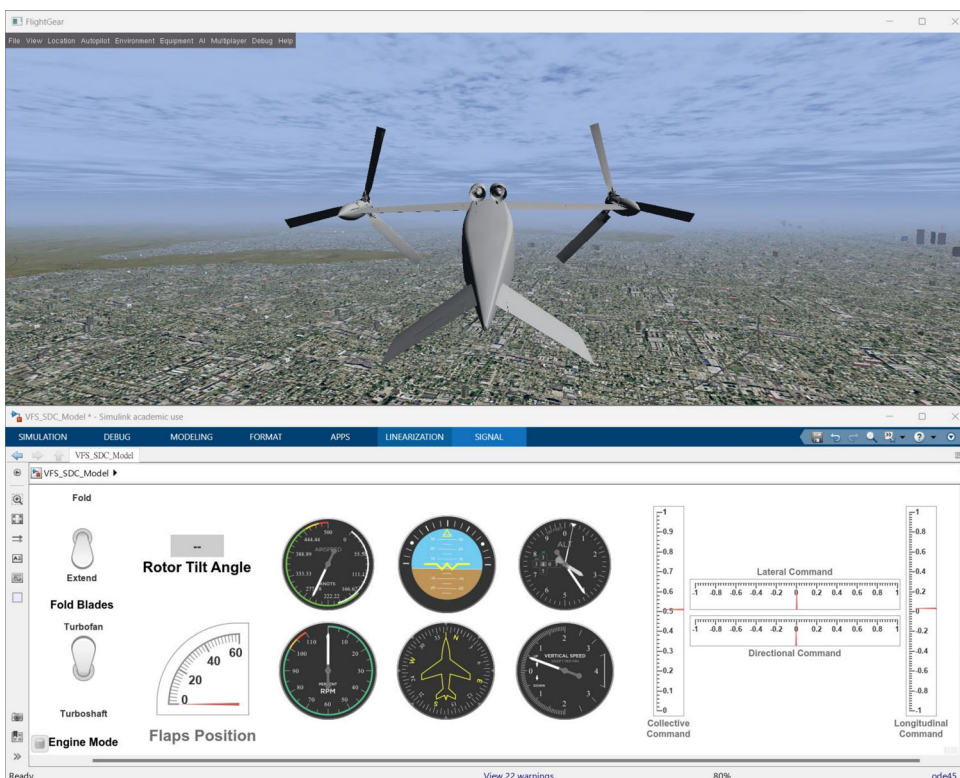
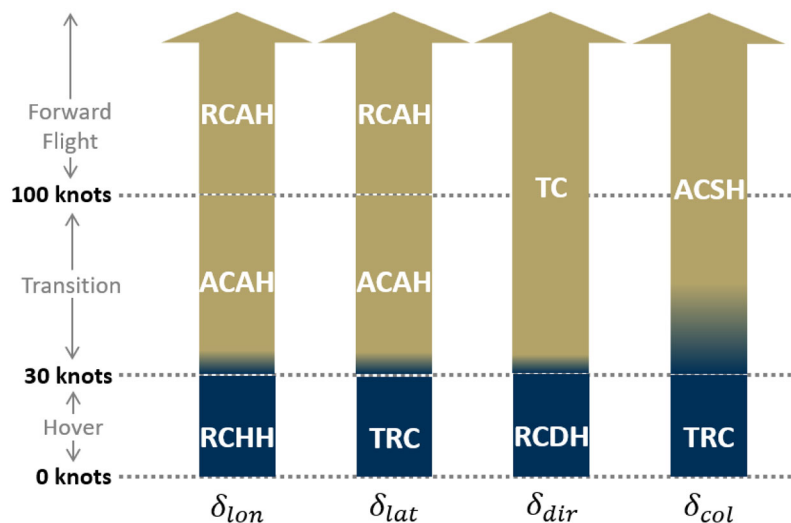
- Main wing analyzed for both flight modes



- Adjoint-method **optimized** wing structure to achieve a mass of 1,608 lb (729 kg) per wing.

Controls & Flight Simulation

- **Full vehicle flight dynamics** modeled in Simulink.
- **Fly-by-Wire** control system with **Unified control framework**.
- **Real-time piloted flight simulation environment** with vehicle visualization in **Flight Gear** capable of simulating flight conditions that covers the normal operation envelope of the vehicle from **hover, transition to forward flight**.



Flight Simulation User Interface





Thank You for Reading

