UF Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Attack of the Gators A-11 Rooster

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This design is based off the AIAA Request for Proposal to build a light attack aircraft with the following mission requirements:

- Austere Field Performance
- Survivability Considerations
- 3,000 lbs of Armament
- Weapon Deployment Capabilities
- Integrated Gun
- 15,000-hour service life over 25 years
- ≥ 30,000 ft Service Ceiling
- Two Crew Members with Ejection Seats
- Critical Technology at TRL 8 or Above
- Certifiable for Military Standard Air Worthiness (MIL-STD-516C)

Initial Weight Estimate

$$W_{TO} = W_P + W_C + \left(\frac{W_F}{W_{TO}}\right) W_{TO} + \left(\frac{W_E}{W_{TO}}\right) W_{TO}$$

$$\left(\frac{W_F}{W_{TO}}\right) = 1.06\left(1 - \frac{W_X}{W_{TO}}\right)$$

$$\left(\frac{W_E}{W_{TO}}\right) = A\left(W_{TO}{}^{C}\right) K_{VS}$$

$$\left(\frac{W_X}{W_{TO}}\right) = \left(\frac{W_1}{W_{TO}}\right)\left(\frac{W_2}{W_1}\right)\ldots\left(\frac{W_{X-1}}{W_{X-2}}\right)\left(\frac{W_X}{W_{X-1}}\right)$$

Fuel Weight Ratio Estimation

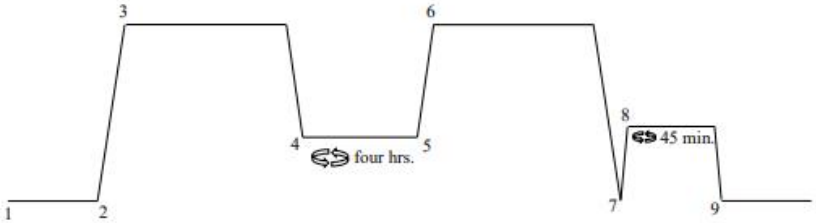
Mission Segment	(W_i/W_{i-1})
Warmup and takeoff	0.970
Climb	0.985
Landing	0.995

Loiter

$$\left(\frac{W_{i+1}}{W_i}\right) = exp\left[\frac{-EC_{Loiter}}{\left(\frac{L}{D}\right)_L}\right]$$

Range

$$\left(\frac{W_{i+1}}{W_i}\right) = exp\left[\frac{-RC_c}{V_c\left(\frac{L}{D}\right)_c}\right]$$



Design Mission (3,000 lbs. Payload)

1: Taxi/Takeoff (Austere Field, 50 ft Obstacle, ≤ 4,000 ft)
2: Climb (To Cruise, ≥ 10,000 ft)
3: Cruise 100 n mi
4: Loiter Four Hours (3,000 ft)
5: Climb (To Cruise, ≥ 10,000 ft)
6: Cruise 100 n mi
7: Climb (To Loiter, 3,000 ft)
8: Loiter 45 Minutes
9: Land/Taxi (Austere Field, 50 ft Obstacle, ≤ 4,000 ft)

Ferry Mission (Full Crew, 1,800 lbs. Payload)

1: Taxi/Takeoff (Austere Field, 50 ft Obstacle, ≤ 4,000 ft)
2: Climb (To Cruise, ≥ 18,000 ft)
3: Cruise 900 n mi
4: Climb (To Loiter, 3,000 ft)
5: Loiter 45 minutes
6: Land/Taxi (Austere Field, 50 ft Obstacle, ≤ 4,000 ft)

Initial Weights

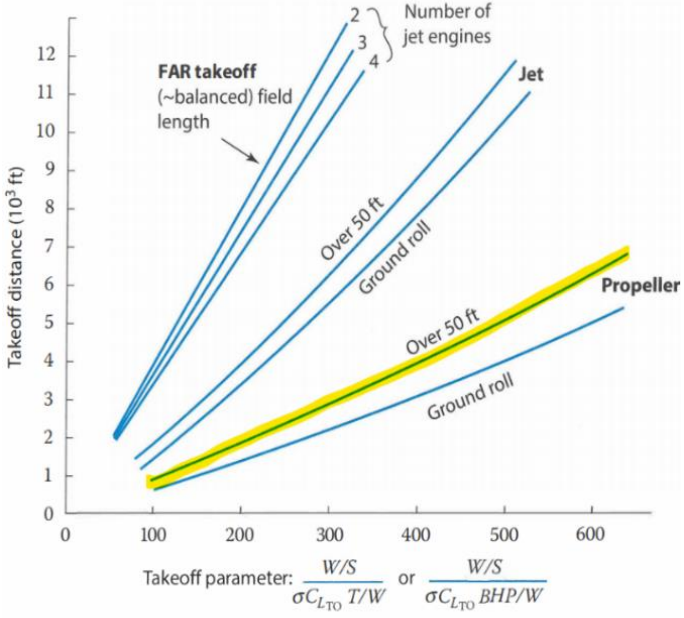
$$W_{TO} = \frac{W_{crew} + W_{payload}}{1 - \left(\frac{W_F}{W_{TO}}\right) - \left(\frac{W_E}{W_{TO}}\right)}$$

- Design Mission: 17,400 lbs
- Ferry Mission: 11,700 lbs

Initial P/W Ratio

$$\left(\frac{P}{W_{TO}}\right) = aV_{max}{}^{C} = 0.22\ hp/lbf$$

Initial Wing Loading



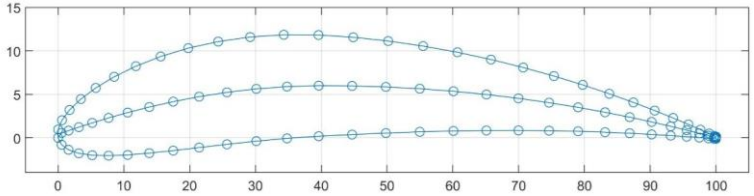
Takeoff Parameter: ~450

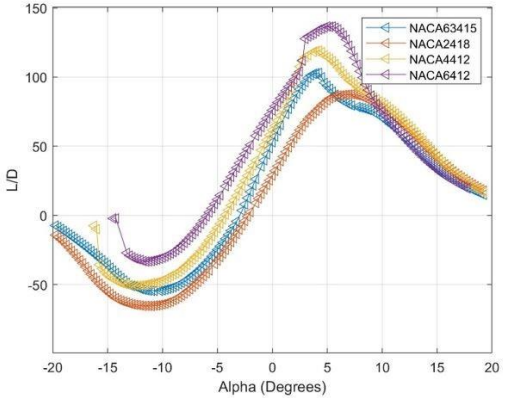
Wing Loading: 44.3 lb/ft^2

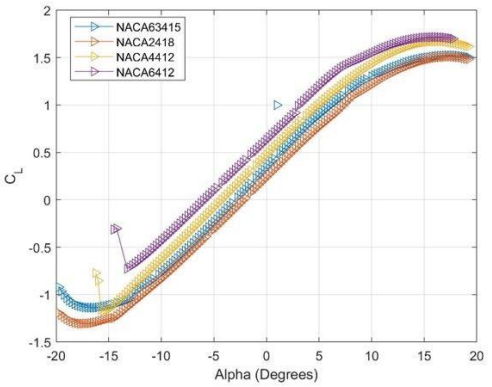
Wing Design

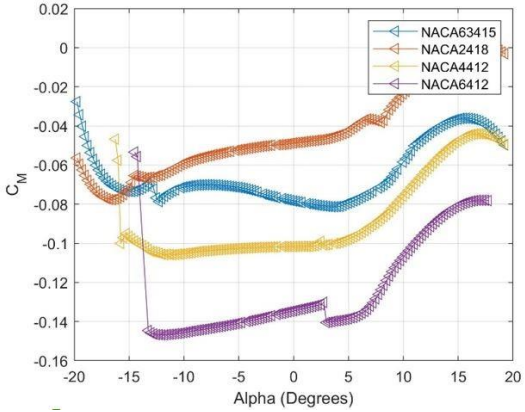
Airfoil Selection

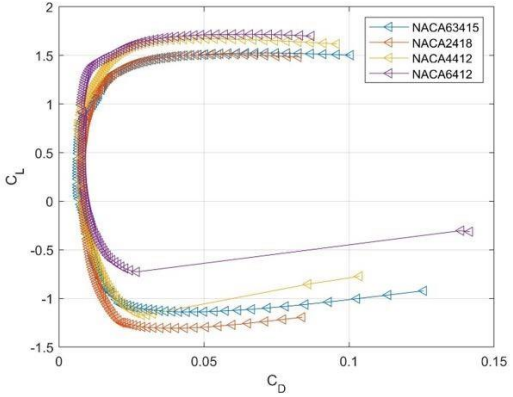
- Analyzed four various airfoils found in similar light attack aircraft
- NACA6412 airfoil was chosen



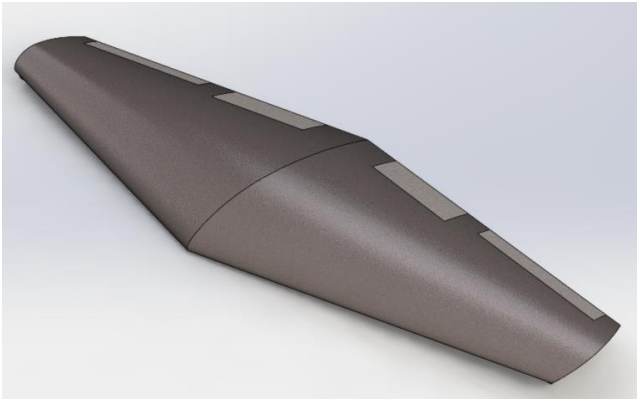








Wing Design

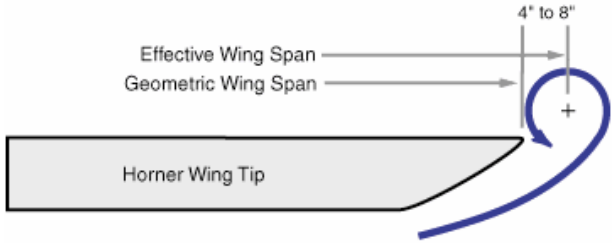


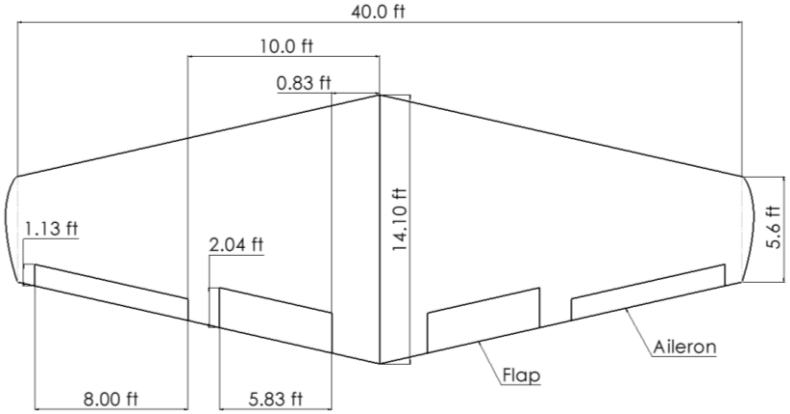
Wing Geometry

- Mid-Mounted wing
- Dihedral: 2° Dihedral
- Sweep Angle: 0°
- Taper Ratio: 0.4
- Reference Area: 397 ft^2
- Wing-Span:40 ft
- Root Chord Length: 14 ft
- Tip Chord Length: 5.6 ft
- Incidence Angle: 0°
- Twist: -3° Geometric
- Horner Wing Tip

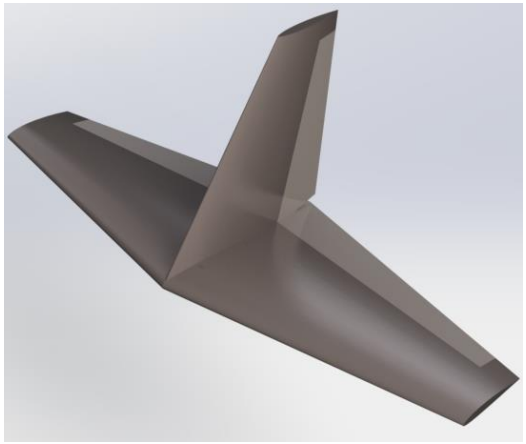
Control Surfaces and High Lift Devices

- Aileron Span: 8 ft
- Aileron Chord Length: 1.13 ft
- Flap Span: 5.83 ft
- Flap Chord Length: 2.04 ft

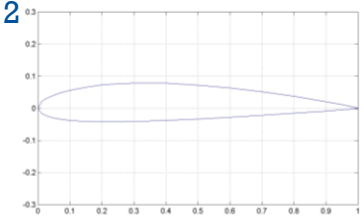




Tail Design

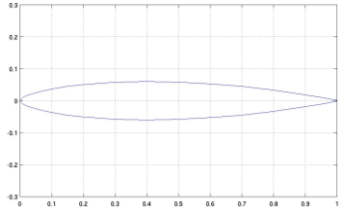


Horizontal Stabilizer

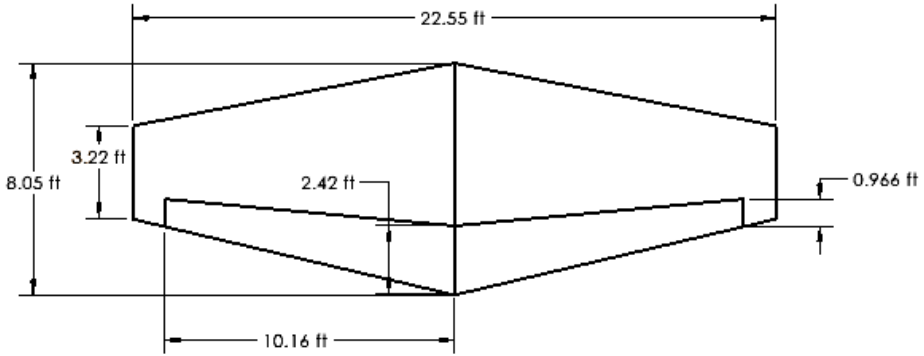


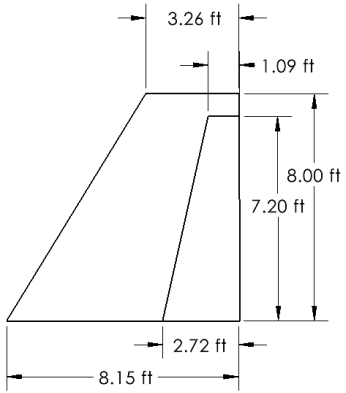
- Airfoil: NACA2412
- Area: 127.1 ft^2
- Aspect ratio: 1.4
- Taper ratio: 0.4
- Sweep angle: 5°
- Span: 22.55 ft
- Root chord length: 8.05 ft
- Tip chord length: 3.22 ft
- Elevator span: 10.16 ft
- Elevator root chord length: 2.42 ft
- Elevator tip chord length: 0.966 ft

Vertical Stabilizer



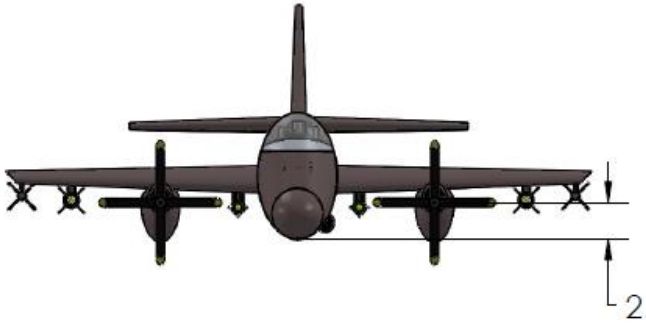
- Airfoil: NACA0012-34
- Area: 45.66 ft^2
- Aspect ratio: 1.4
- Taper ratio: 0.4
- Sweep angle: 5°
- Span: 8 ft
- Root chord length: 8.15 ft
- Tip chord length: 3.26 ft
- Rudder span: 7.20 ft
- Rudder root chord length: 2.72 ft
- Rudder tip chord length: 1.09 ft

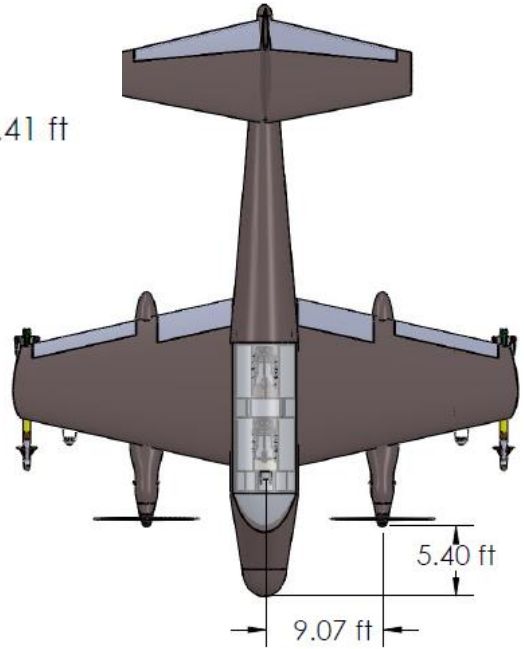




Propulsion

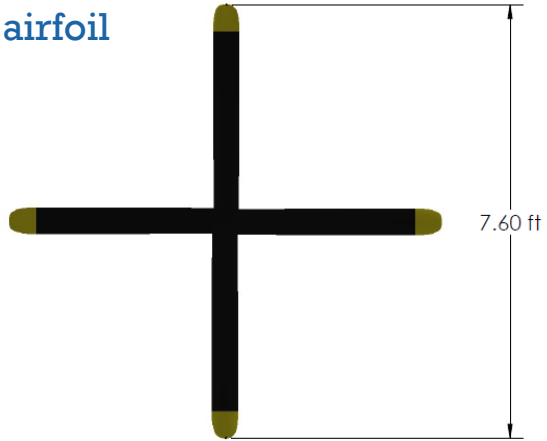
- Turbo prop engines
- Wing Mounted
- 2x Pratt & Whitney Canada PT6A-68B
- Total Power: 3200 HP (2400 HP required at takeoff)
- Total Thrust: 8000 lbf (6500 lbf required at takeoff)
- P/W = 0.15 HP/lbf

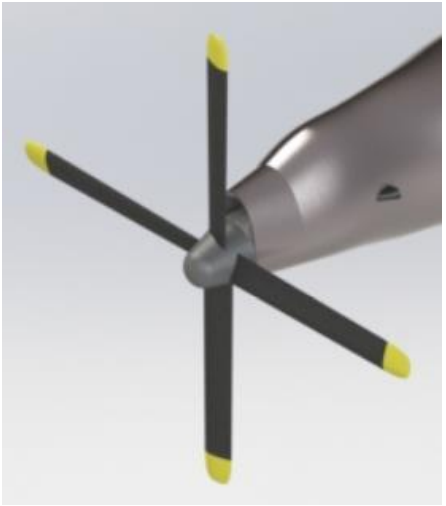




Propulsion

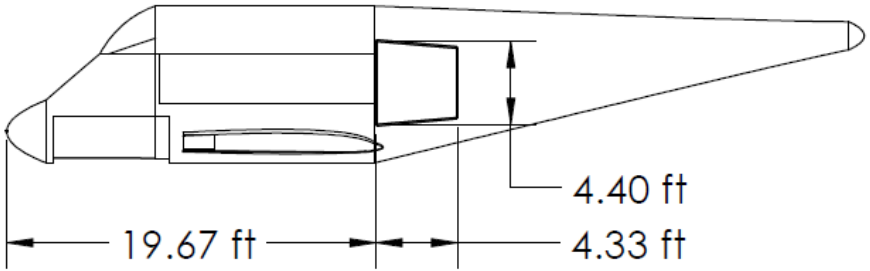
- Propeller: 4 blades
- Diameter: 7.6’
- Blades Airfoil: EPPLER-E856 airfoil
- Operate at 2000 RPM





Propulsion

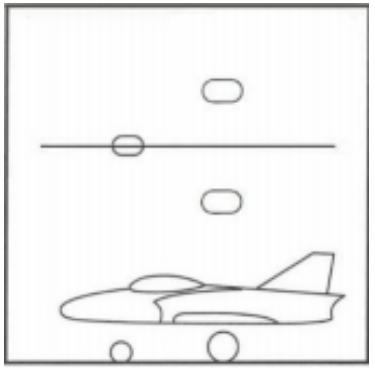
- Fuel: JP-5
- Storage: self-sealing bladder located behind the cockpit
- Capacity: 495 gallons
- Weight: 3350 lbs



Landing Gear

- Stable while on the ground
- Must withstand impact during landing and be large enough so brakes can absorb the kinetic energy
- Worst landing conditions considered

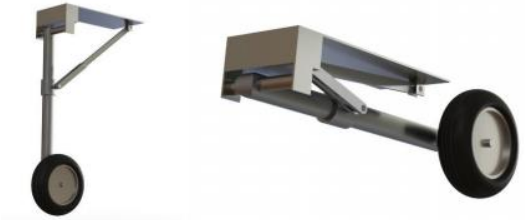
- Type III Tires
- Retractable
- 45 PSI


Tricycle

Main Wheels:
Diameter – 33.7 in.
Width – 9.6 in.

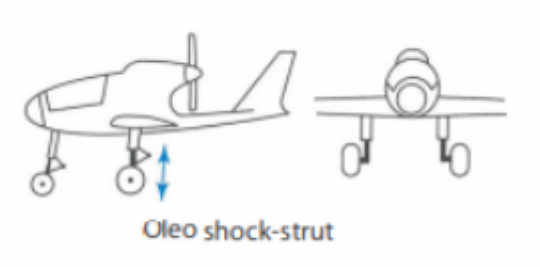

Main gear in deployed and stowed positions

Nose Wheel:
Diameter – 27 in.
Width – 7.7 in.


Nose gear in deployed and stowed positions

Shock-Absorption

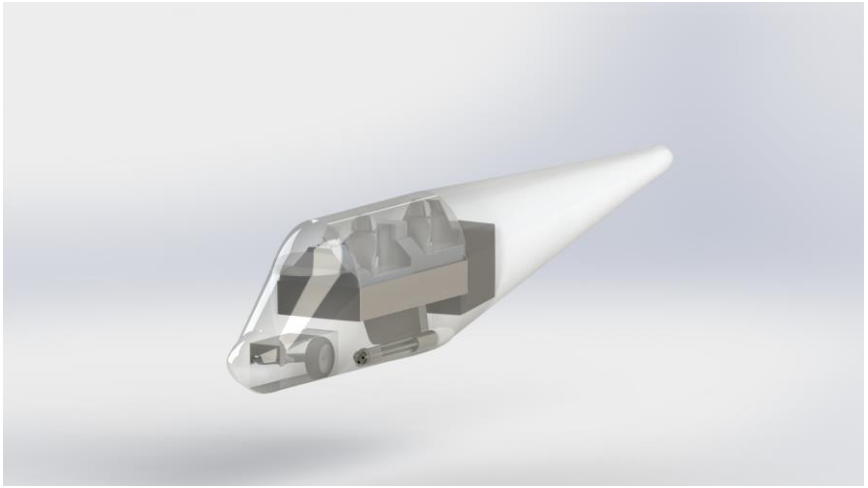
- Oleopneumatic (oleo) Shock-Strut
- Light in weight
- The Oleo provides the entire amount of the wheel deflection therefore, a minimum landing gear height of double the stroke is needed.
- Strong enough to take the concentrated lateral and braking loads of the wheel that are applied to the point of attachment on the aircraft



Side and front views of an Oleo-shock strut

Weapons

- AIM-9X: Multi-function missile which uses infrared technology to track down enemy operators
- GAU-22/A: Four barreled gatling gun capable of damaging both armored and un-armored enemy forces



Weapons

- AGM-65E: Highly accurate air-to-ground missile used to destroy enemy fortifications, armored vehicles, and surface combatants

- MK-82: 500 lb. bomb that will be used in conjunction with a GBU-38 joint direct attack munition (JDAM)

Countermeasures

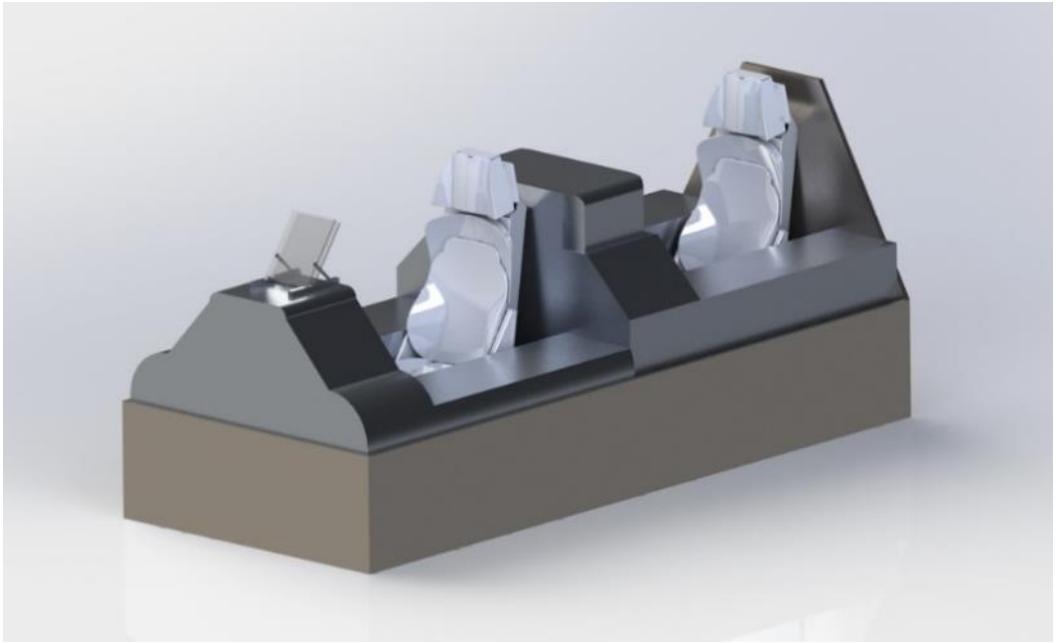
- MJU-66/B Pyrophoric Flares
- RR-188 Chaff Cartridges

Stealth Consideration

- Radar Absorbing Materials (RAM)
- Conductive Metal Coatings
- Solar Reflective Paint
- Horizontal Tail parallel to Wing

Crew Station Design

2 crew members

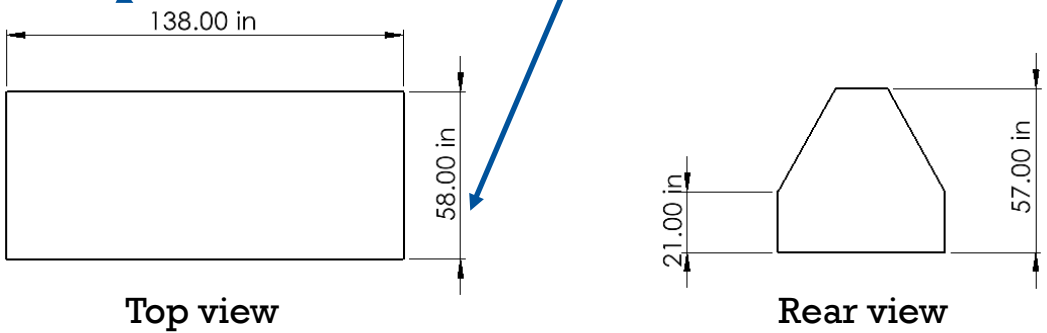


- Ejection seats
- Titanium shell
- Bullet proof canopy
- Oxygen system

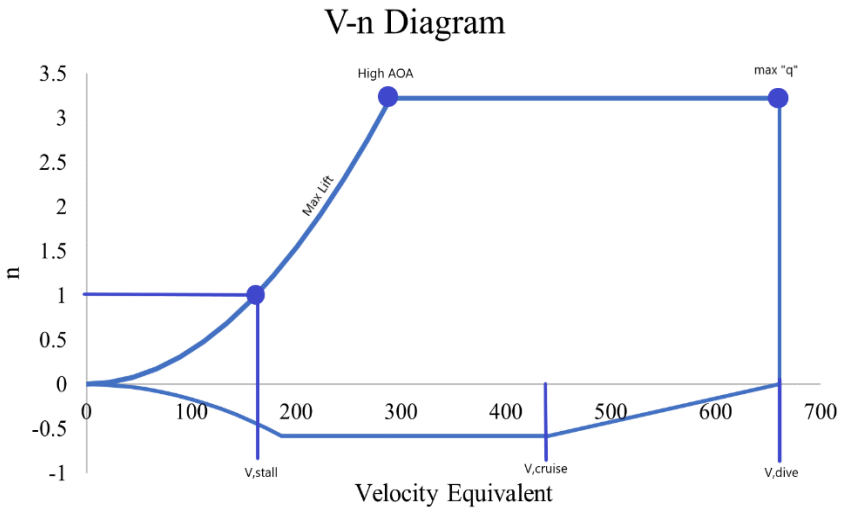
Crew Station Dimensions

26" shoulder width + Additional clearance of 30" + 1" aluminum shell

50" per pilot + 38" for computer systems

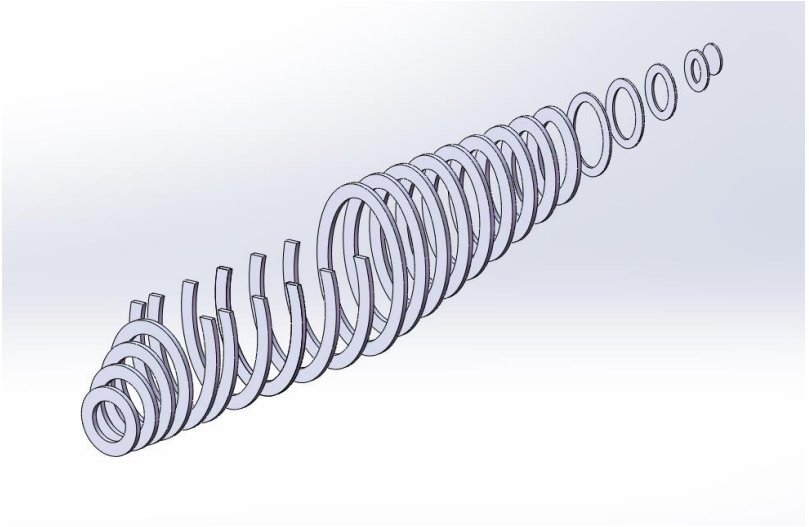


V-n Diagram

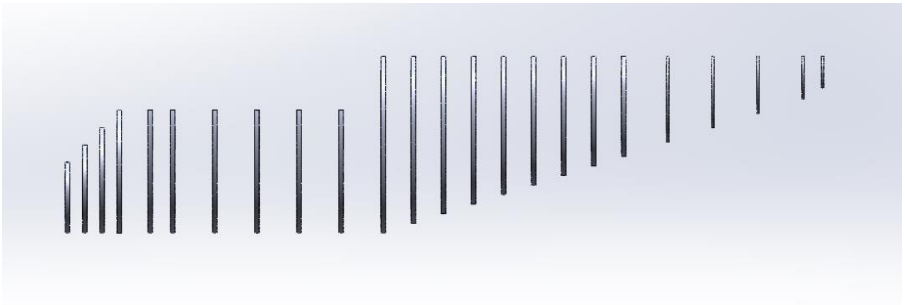


Velocity Variable	True Airspeed (mph)
$V_{Manuever}$	208
V_{Dive}	525
V_{Stall}	148
$V_{Takeoff}$	178
V_{Cruise}	350

Fuselage Structure



- Semi-Monocoque Design
  - Skin: AL 2024
  - Ribs: AL 7075
- Most utilized design in modern aviation



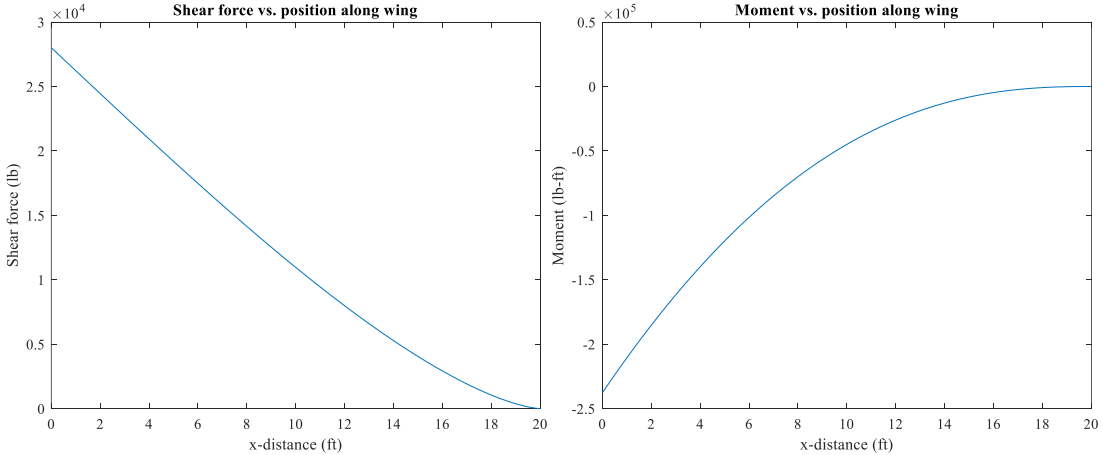
Structural Analysis

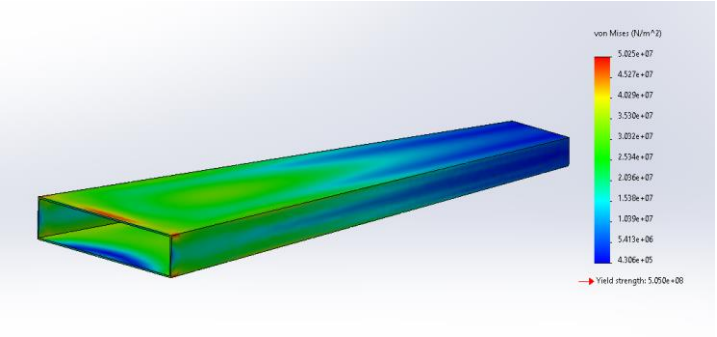
Loading Calculations

- Load factor = 3.22
  - Elliptical lift distribution of 56,028 lbs

FEA Analysis

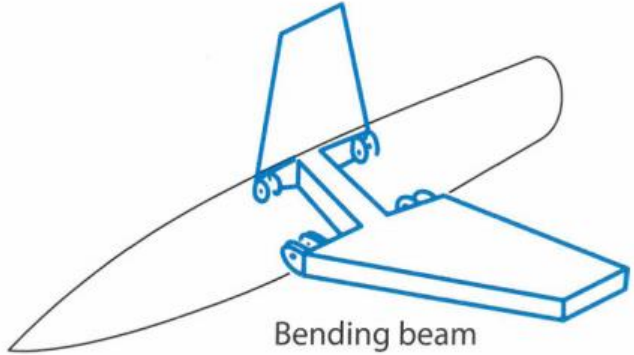
- Reaffirm hand calculations
- Factor of Safety > 1.5
- Tip Deflection = 14.4 mm

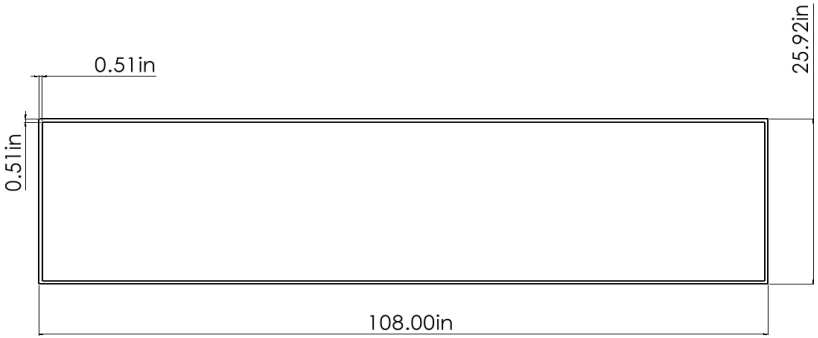


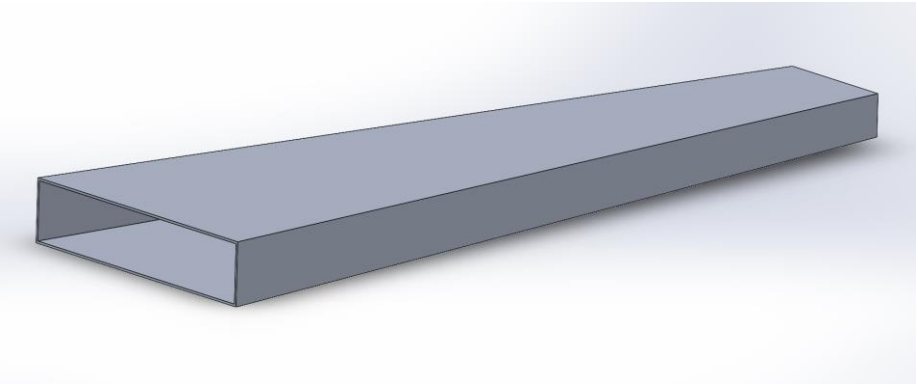


Wing Structure

- Tapered design extending 90% of wing
  - Skin: AL 2024
  - Ribs/Box: AL 7075







Updated Takeoff Weight

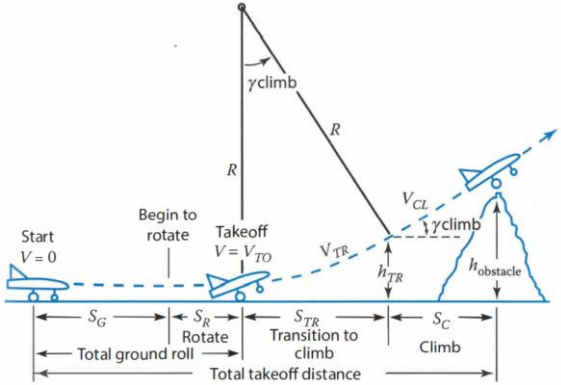
Weight Analysis		
System	Sub System	Weight (lb)
Propulsion	Engine	1,180
	Propeller	441
	Nacelle	376
Aircraft Structure	Wing	4,755
	Empennage	376
	Landing Gear	1,347
	Fuselage	2,501
	Vertical Stabilizer	479
	Horizontal Stabilizer	560
Control System	Fly-By-Wire	100
Crew	2 Crew	300
	2 Seats	300
	Titanium Shell	1,800
Payloads/Weapons	AGM-65E	1,260
	MK 92 Fitted With GBU-38 JDAM	1,000
	AIM9	376
	GAU-22/A 25mm	250
Systems	Instruments	300
	Fuel	3,357
	TOTAL	21,058

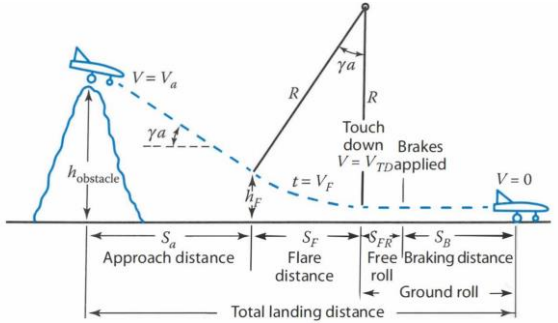
Performance Metrics – Range and Endurance

- Range of 1435 nmi (1651 miles)
- Endurance of 5.86 hours
- Stall speed of 147 ft/s
- L/D ratio of 12.5
- Max speed of 400 mph or 587 ft/s
- Cruise velocity of 350 mph or 507 ft/s.

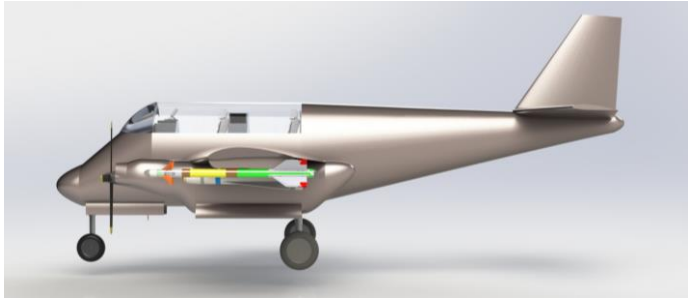
Performance Metrics – Takeoff and Landing

- Total takeoff distance of 2979 ft.
- Composed of 563 ft for ground roll and 2416 ft of transition.
- Clears 50-foot obstacle by end of transition.
- Total landing distance of 3548 ft.
- Composed of 1546 ft of approach, 286 ft of flare, and 1716 ft of ground roll
- Landing and takeoff calculated same way, in reverse, and with slightly different weights.

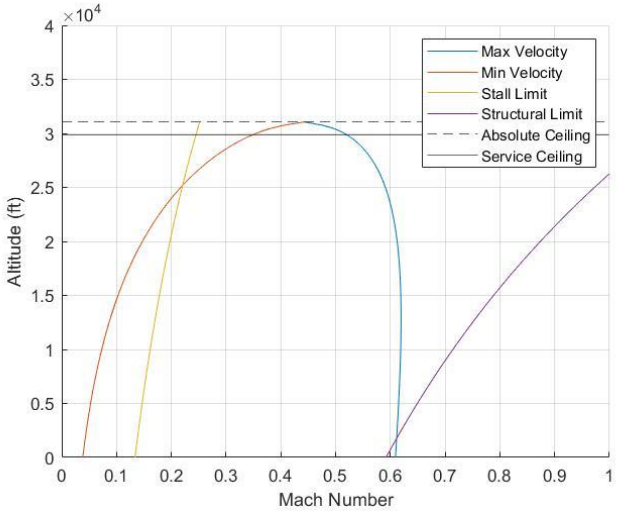




Stability



- Laterally, longitudinally, and directionally statically stable.
- Roll moment slightly negative to allow for adequate maneuverability.
- Use of the wing flaps to improve longitudinal stability and vertical tail to help with directional stability.
- Flight envelope shows our service ceiling is above 30,000 ft with a max speed is roughly 587 ft/s based on Mach speed.



Cost Estimation

Overview

- The RAND DAPCA IV model was used to estimate the cost for 50 aircrafts
- The two types of costs to consider are production costs and recurring costs

Cost Estimation

Production Cost

Acquisition Cost for 50 Aircraft

Cost	Hours	Cost (US $)
Engineering	5.17E+06	680,720,000
Tooling	2.74E+06	371,045,000
Manufacturing	6.68E+06	749,945,000
Quality Control	0.133	20
Development Support	-	150,530,000
Flight Test	-	55,291,000
Materials	-	214,220,000
Engine	-	2,000,000
Avionics	-	600,000
	Total	2,224,350,000

Cost Estimation

Recurring Costs

Operational Costs

- Fuel will cost us $301,514 per year
- Crew salaries will cost us $202,304 per year

Maintenance Costs

- The cost of manual labor is $409,560 per year
- The cost of parts is also $409,560 per year

Cost Estimation

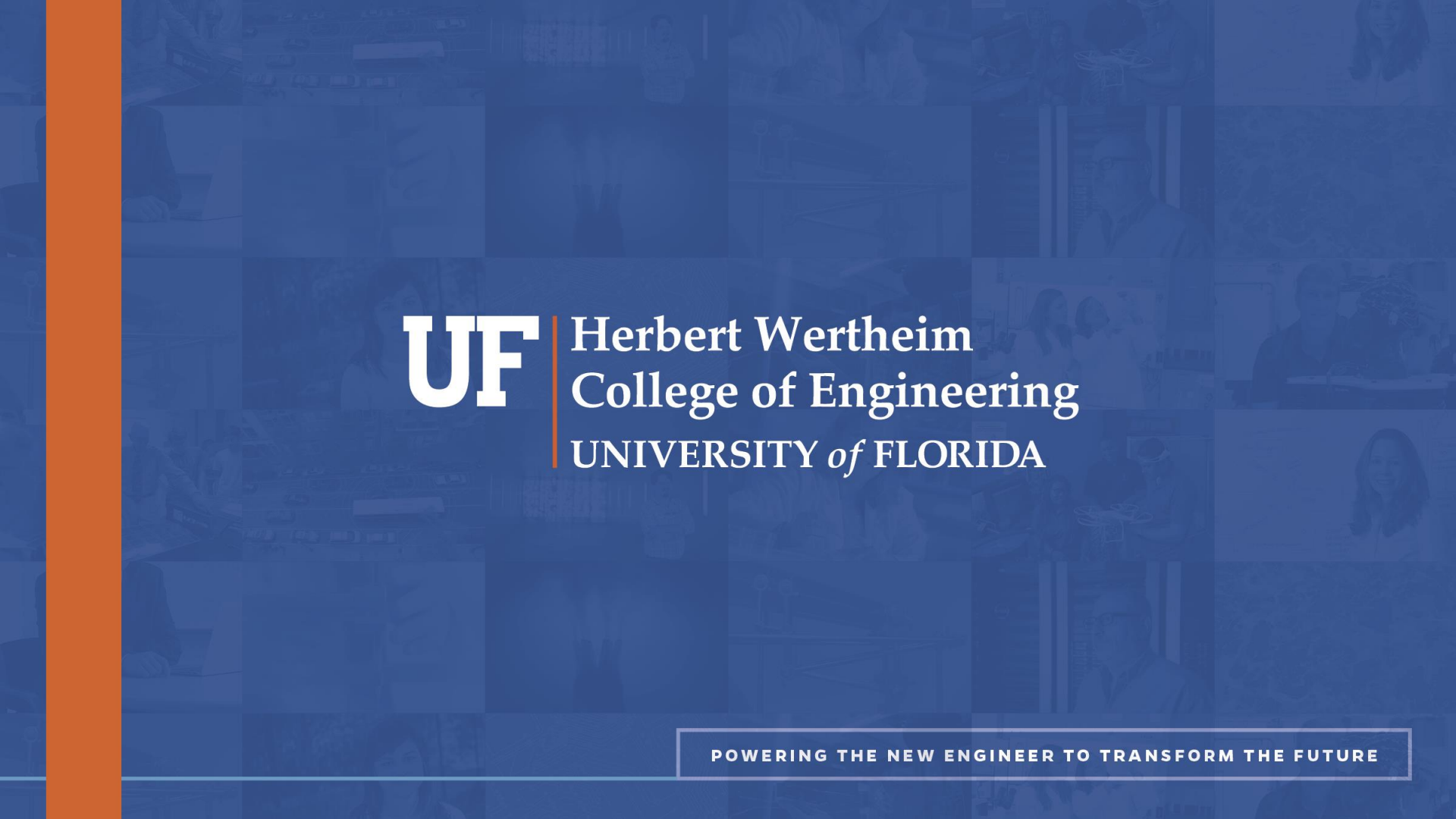
Total Cost for 50 Aircrafts

Part	Cost
RDT&E + Flyaway	$2,224,350,000
Fuel Costs	$301,514 / Year
Crew Salary	$202,304 / Year
Maintenance Cost	$819,120 / Year
Total	**$2,224,350,000 + $1,322,938 /Year**

Cost Estimation

Cost per Aircraft

- Our unit cost is $26,000,000 per aircraft
- This is the cost of the aircraft if we were to sell it to companies
- The cost per flight is $683 per hour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