VORTEX

Vertically Optimized Research, Testing, & EXploration

Manufacturing Status Review

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Team

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IRISS
INTEGRATED REMOTE & IN SITU SENSING

Project Overview

Mission Statement

In order to expand the capabilities of the IRISS center and TORUS project in gathering meteorological data and understanding the formation of supercell thunderstorms, the VORTEX team will bring Vertical Takeoff and Landing (VTOL) functionality and extended endurance to the RiteWing Drak airframe.

Mission CONOPS

Levels of Success

	Level 1	Level 2	Level 3
Flight	Show on a static test stand that the propulsion system is capable of producing enough thrust to provide a TWR greater than 1	Maintain tethered hover at 2m altitude for 30 seconds as well as demonstrate capability to transition to horizontal flight while aircraft is mounted to a test stand	Aircraft shall demonstrate takeoff ability via RAP Cat launch system as well as demonstrate full transition from vertical to horizontal flight modes.
Budget	The aircraft shall cost no more than $1250, not including IRISS avionics package.	The aircraft shall cost no more than $1000, not including IRISS avionics package.	The aircraft shall cost no more than $900, not including IRISS avionics package.
Endurance	The propulsion system shall maintain required thrust output for the equivalent of 1 hour cruise and 2 takeoffs and landings (approximately 1 hr 16 minutes) on a static test stand in simulated freestream conditions of 18 m/s with >15% battery remaining	-	Demonstrate 1 hour of flight cruise as well as 2 takeoffs and landings
Airframe	A finite element analysis of the modified airframe will be performed to demonstrate that it can withstand the required forces with a FOS of 1.7	The aircraft will have full integration capabilities with RAPCat launch system, and show that it can withstand the forces due to acceleration.	The airframe shall with stand axial and lateral forces up to 10G.
Avionics & Electronics	All motors and actuators shall be successfully inte grated with the flight con troller. The telemetry link shall be maintained with less than 25% packet loss within 1 km of the ground station.	All external (non-native) sensors are successfully integrated with the avionics system.	-

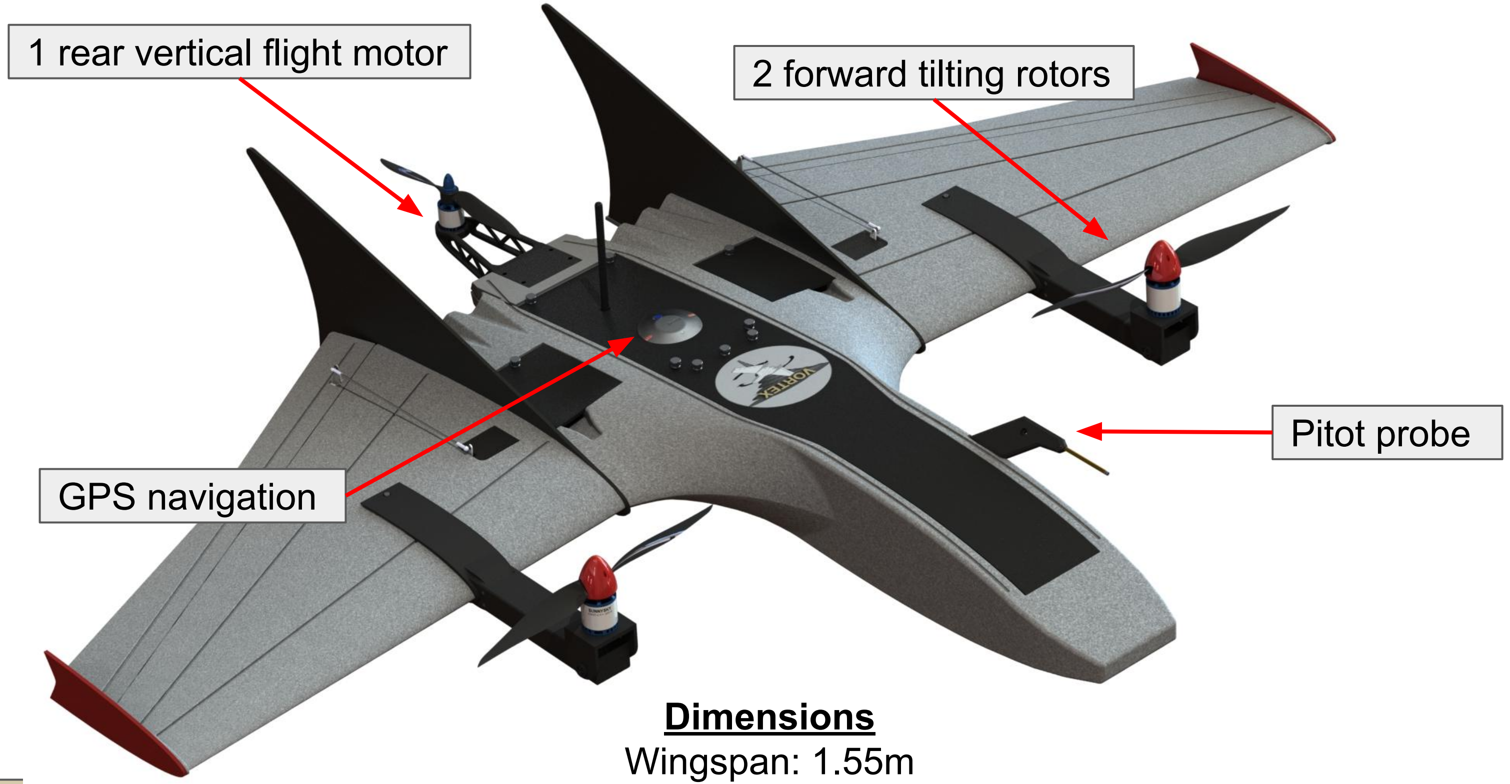
Critical Project Elements

Element	Justification
Vertical Takeoff and Landing **(VTOL)**	Primary deliverable of project.
Structure **(STR)**	Structure must withstand forces of takeoff, flight, and landing.
Endurance **(END)**	Aircraft must be able to maintain flight for the required duration of 1 hour plus takeoffs and landings.
Automation **(AUT)**	Aircraft must autonomously perform mission flight profile as well as controlling takeoff, landing, and transitions.

Functional Requirements

FR1	**VTOL**	The aircraft shall be a VTOL conversion of the COTS Ritewing RC “Drak” airplane kit
FR2	**END**	The aircraft shall have an endurance of 1 hour with 2 takeoffs and landings
FR3	**AUT**	The aircraft shall be able to autonomously execute all aspects of its mission from first takeoff through final landing
FR4	**AUT**	The aircraft shall maintain communication with the ground station up to a distance of 2km
FR5	**STR**	The aircraft shall be capable of carrying a 0.5kg payload
FR6	**STR**	The aircraft shall be capable of taking off from existing RAPCat launch system
FR7	**VTOL**	The airframe, propulsion system, and required mounting hardware shall cost no more than $1000 per aircraft

Baseline Design (CDR)

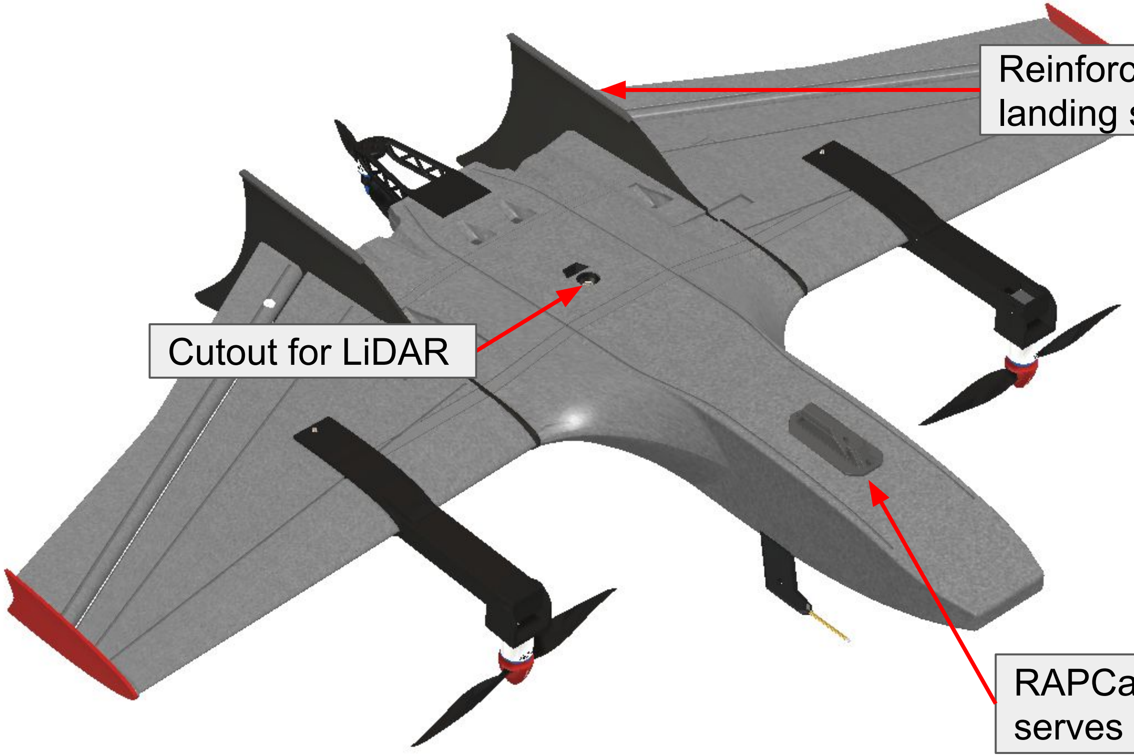


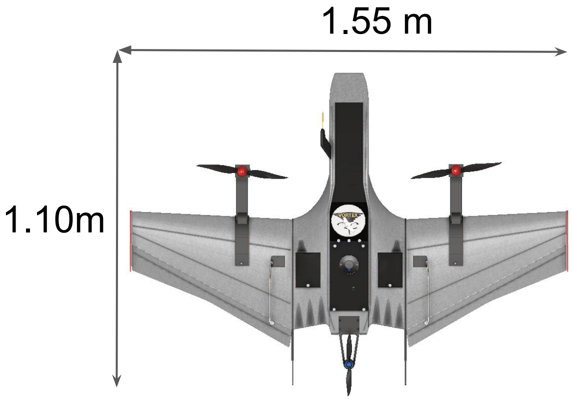
Dimensions

Wingspan: 1.55m

Nose-to-tail: 1.10m

Baseline Design (CDR)





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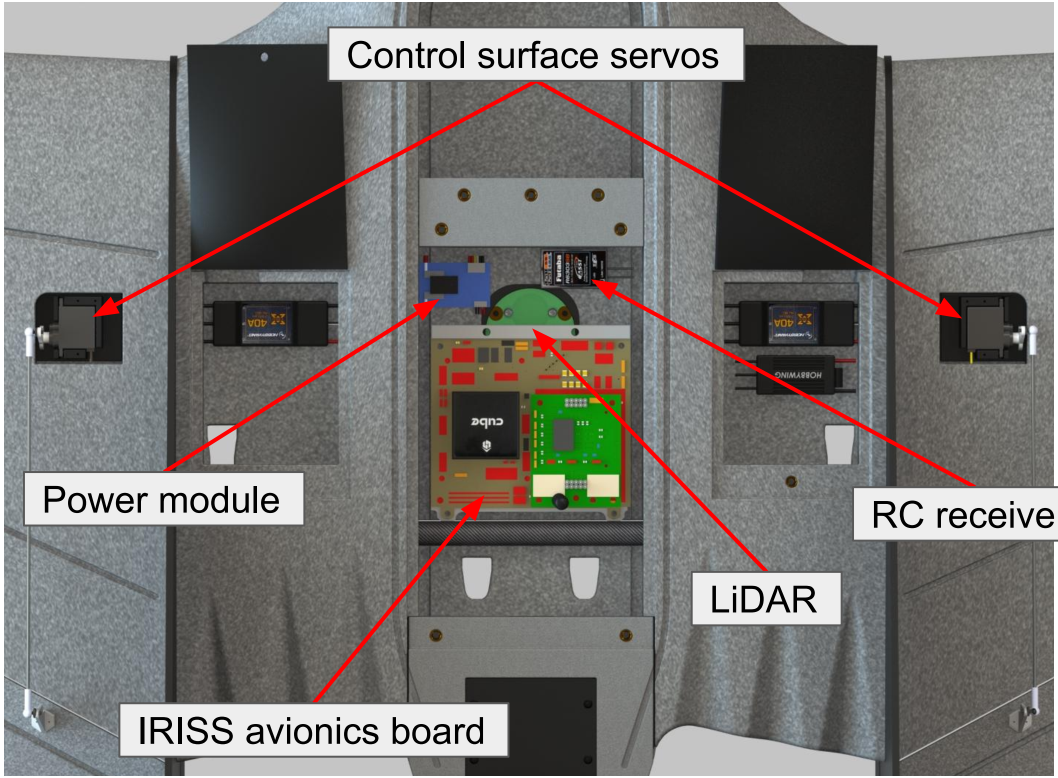
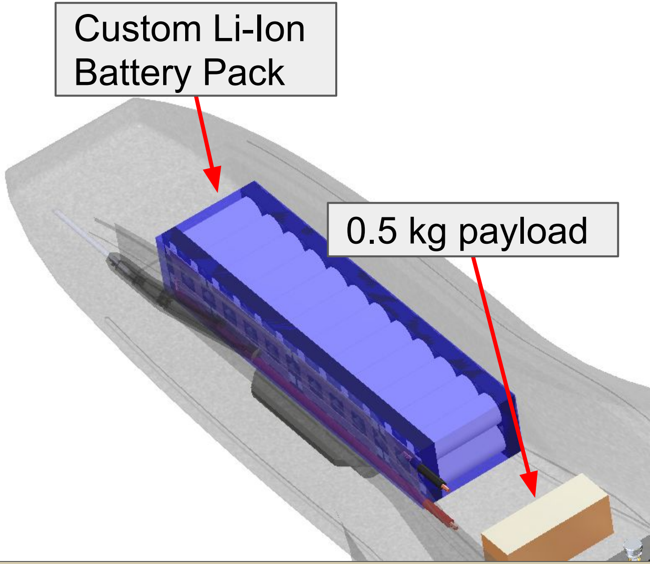
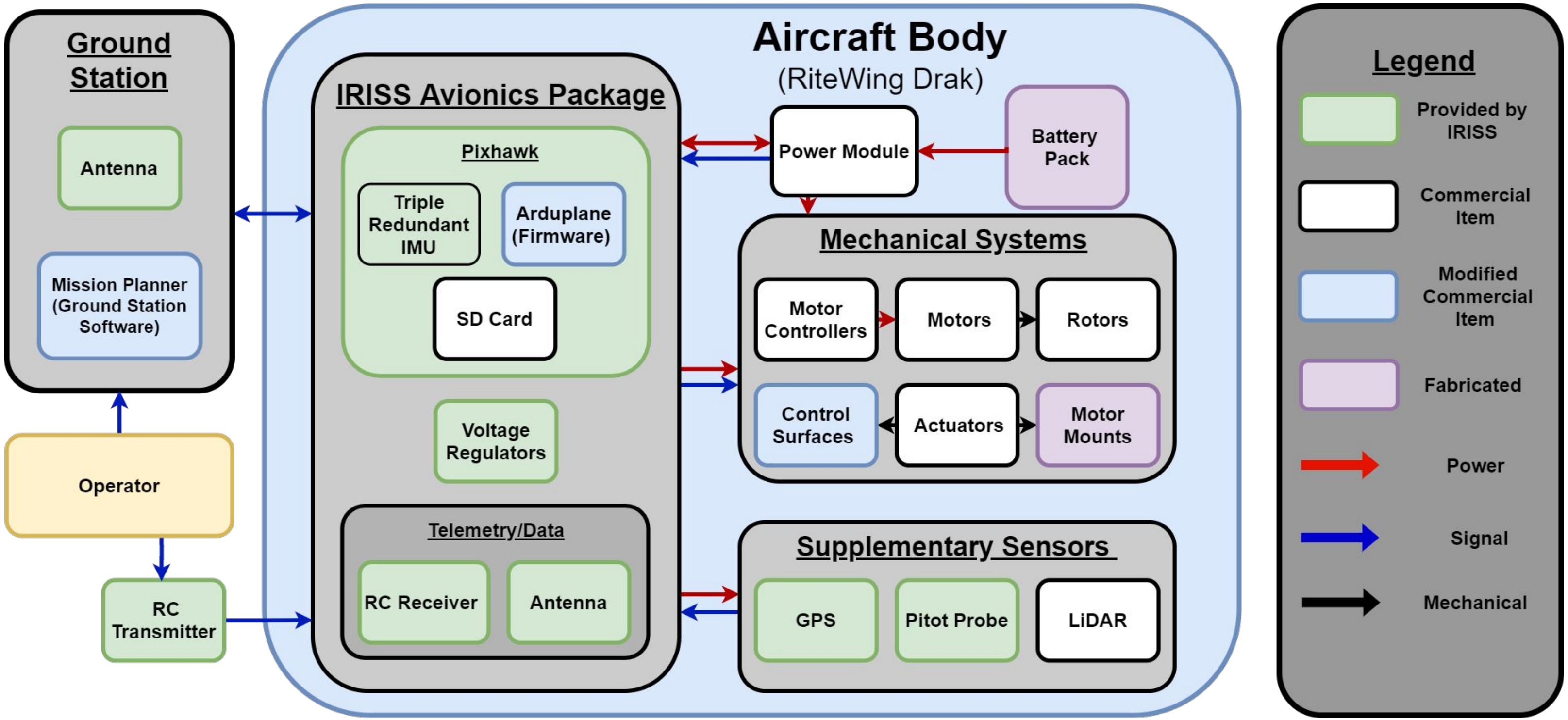
Baseline Design (CDR)

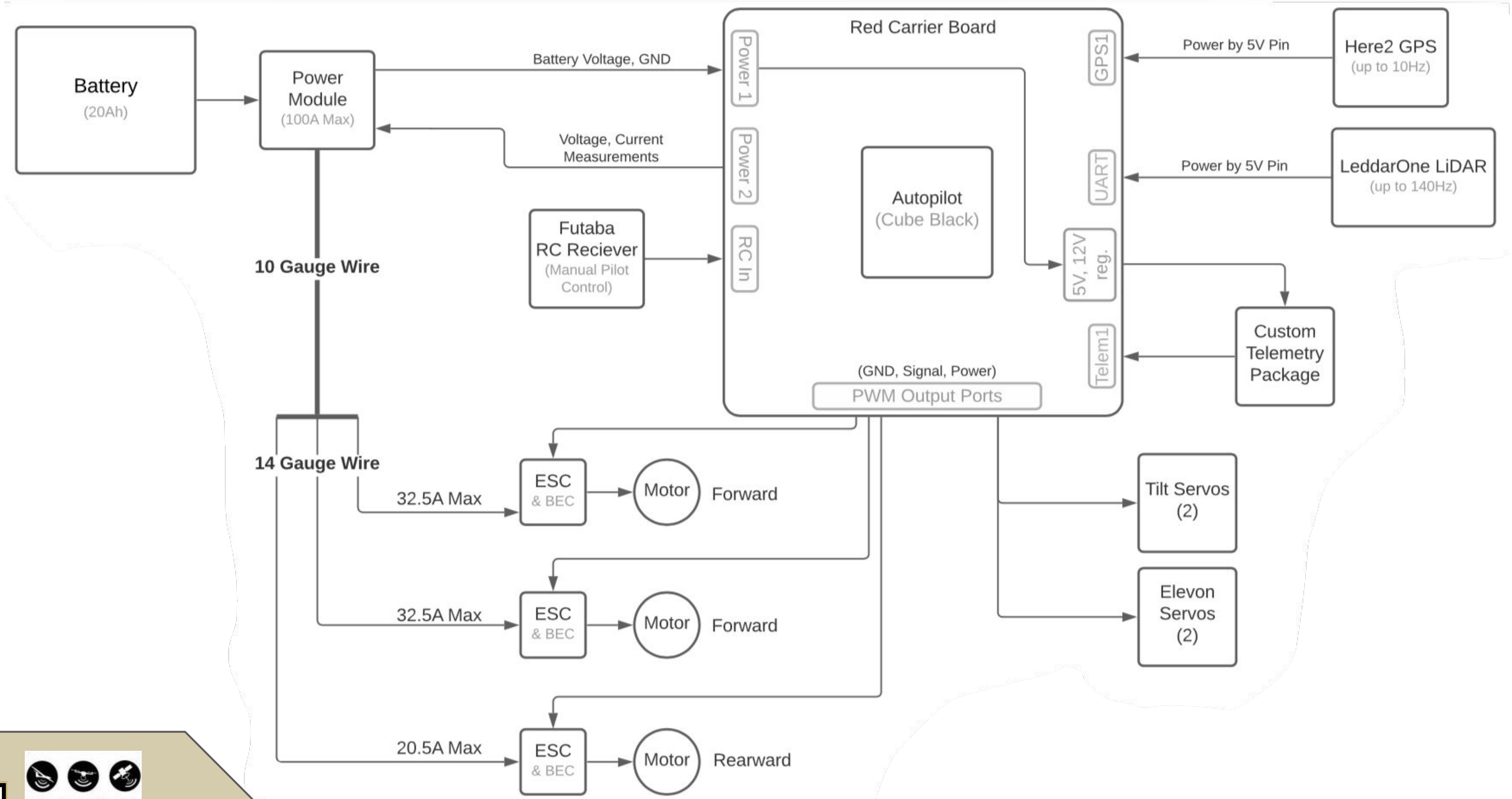




System Functional Block Diagram



Avionics Functional Block Diagram



Changes Since CDR

Changes Since CDR

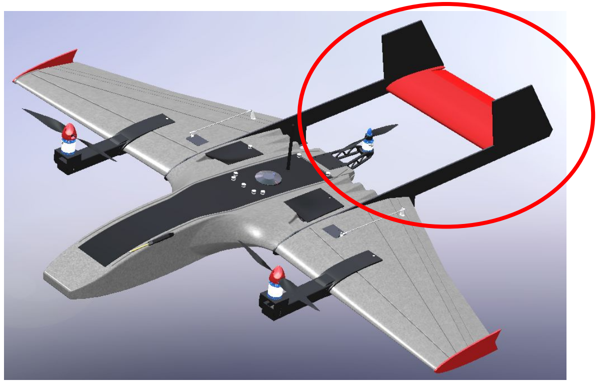
Wing Motor Mount Testing

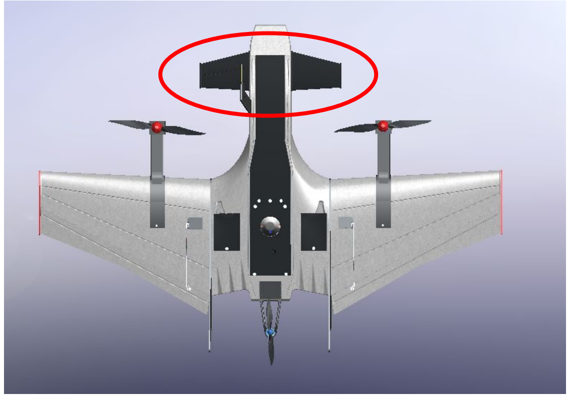
- Structural integrity concern due to custom wing motor mount
- Minor modifications to mounting bracket
- Additional testing to compare against FEM data
  - Assemble the component with a wing, load arm to 10G requirement, then load until failure

Changes Since CDR

Canard or Vertical Tail Addition

- Cruise conditions too close to stall
- Little room for maneuverability in operational flight
- New CFD iterations are too time consuming and have concerns with validation
    - Vehicle mounted test stand for obtaining aerodynamic data





Empennage Sizing Model and Equations

Static Equilibrium of Forces

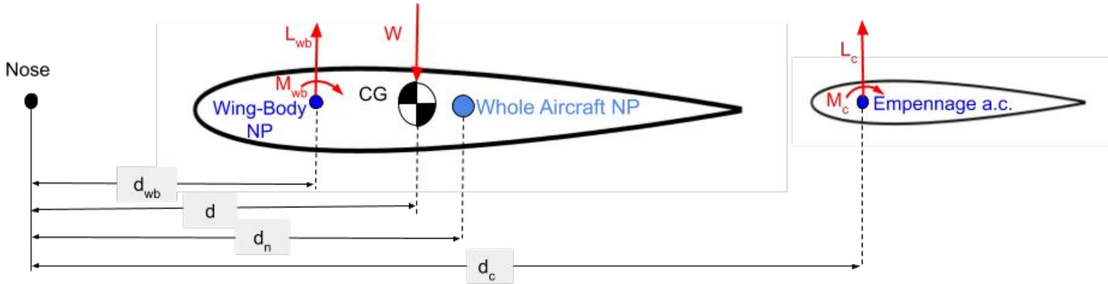
$$\sum F = C_{L_c} q_\infty S_c + C_{L_{wb}} q_\infty S - W$$

Static Equilibrium of Moments
(about wing/body neutral point)

$$\sum M = C_{m_c} q_\infty S_c \bar{c}_c + C_{L_c} q_\infty S_c (d_{wb} - d_c) + C_{m_{wbac}} q_\infty S \bar{c} - W(d_{wb} - d)$$

Static Stability

$$K = \frac{1}{\bar{c}} \left[\frac{C_{L_{c\alpha}} \frac{S_c}{S} d_c + C_{L_{wb\alpha}} d_{wb}}{C_{L_{c\alpha}} \frac{S_c}{S} + C_{L_{wb\alpha}}} \right]$$

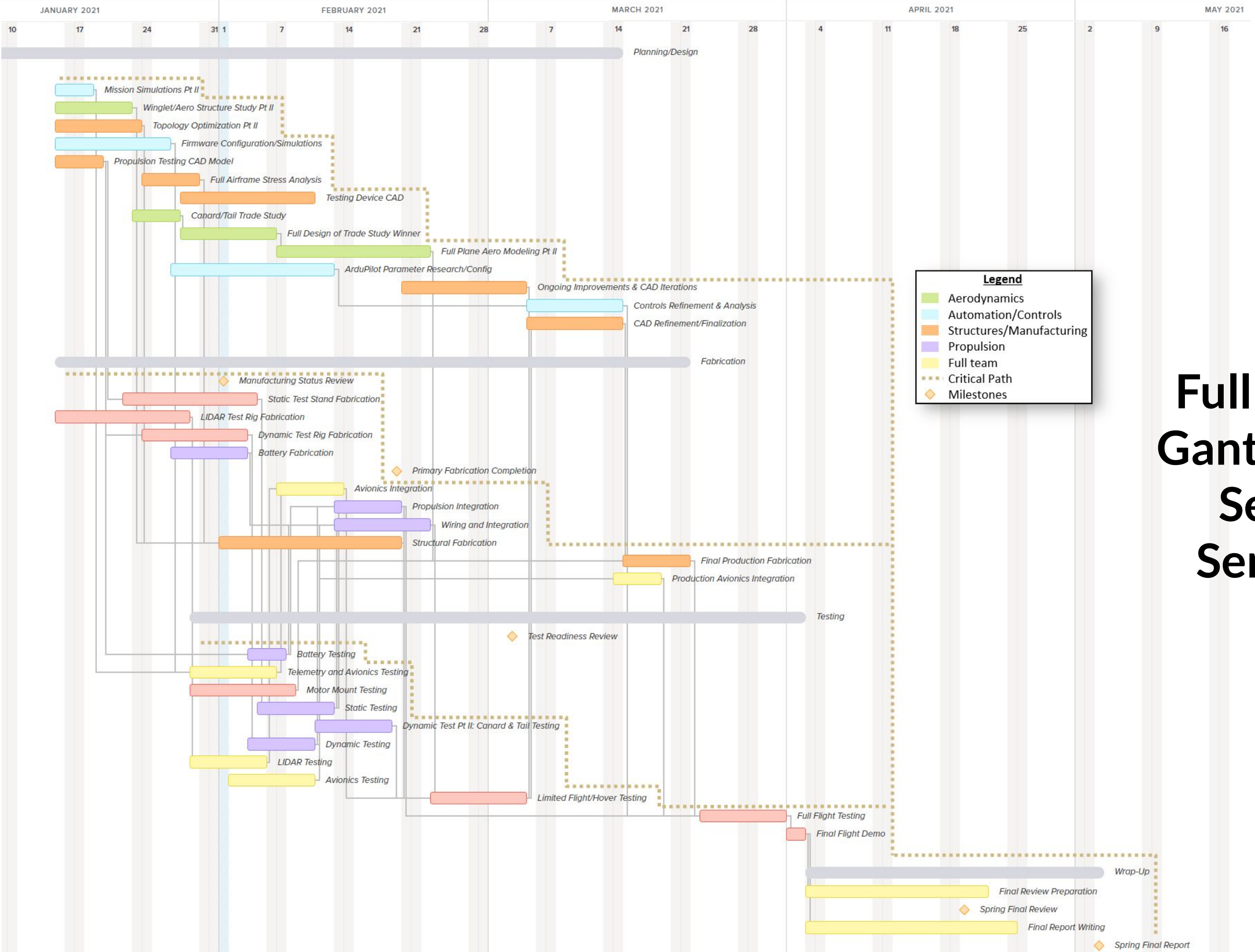


Update: Test Descriptions - Why are we building?

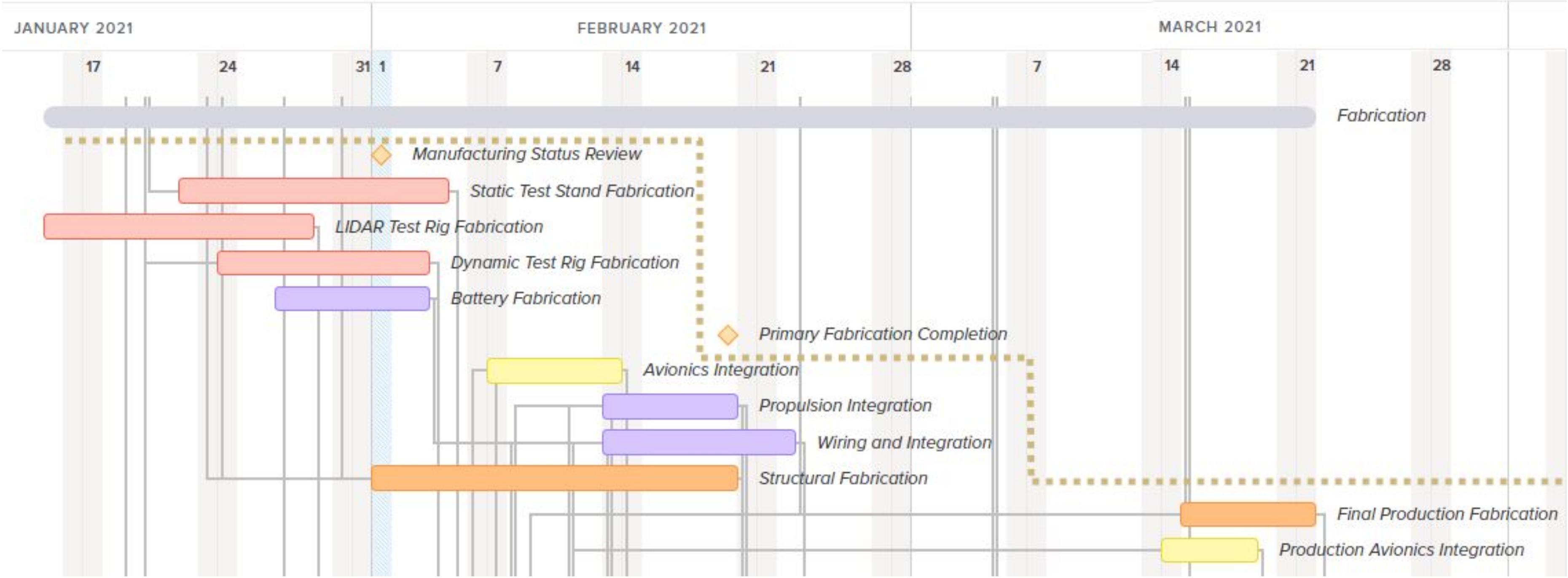
- **LiDAR Verification**
  - For verifying the accuracy of the LiDAR
  - Tested by comparing the known heights of the stand to the height measured by the LiDAR
- **Static Test**
  - For verifying manufacturer specifications of motor and propeller combinations
  - DBF already has a stand but it requires safety improvements, entire test stand will be donated to DBF after project
- **Dynamic Test**
  - For measuring Lift, Drag, and Moment of the Aircraft
  - Necessary because the Drak is too large for any wind tunnels we have access to
  - Attach aircraft to test stand and drive at flight speed (~40 mph)
    - Test location approved at Colorado Air and Space Port - 10,000 ft of straight, private road
- **Motor Mount Testing**
  - Verify SolidWorks FEM
  - Print and mount motor arm
  - Apply expected maximum flight loading and measure deflection with calibrated camera
  - Check foam for deformation or damage
  - Apply loading to failure, record maximum loading values and behavior

Schedule

Full Project Gantt Chart - Second Semester



Fabrication and Testing Gantt Chart



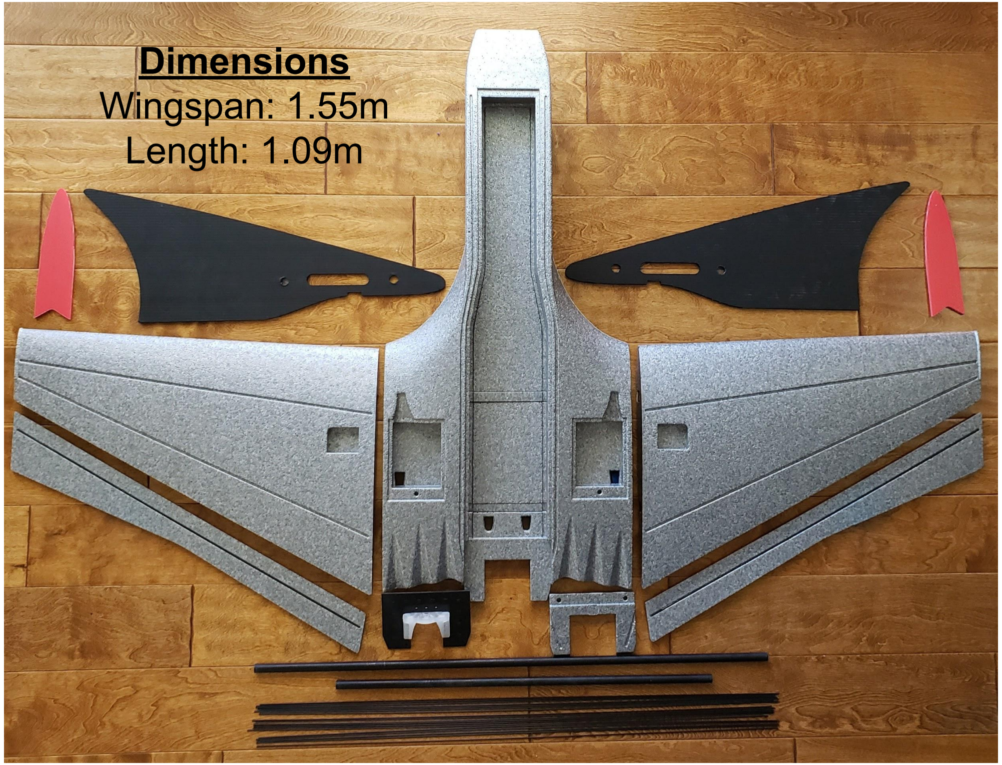
Manufacturing

Overview and Scope

Component	Purchased or Manufactured	Manufacture Time	Completion Date	Status
Drak Wing Kit	Purchased/Assembled	~ 3 days	Feb 5th-8th	Waiting on Adhesive
Wing & Motor Mounts	Manufactured/Printed	12 hours	Jan 30th	Printed
Lidar Test Stand	Purchased/Printed	1 hour	Feb 5th	Printed, Waiting on Delivery
Custom Battery	Manufactured	6 hours	Feb 3rd	Waiting on R2R
Static Test Stand	Manufactured	3 hours	Feb 4th	Waiting on R2R
Dynamic Test Stand	Manufactured	4 hours	Feb 3rd	Waiting on Delivery

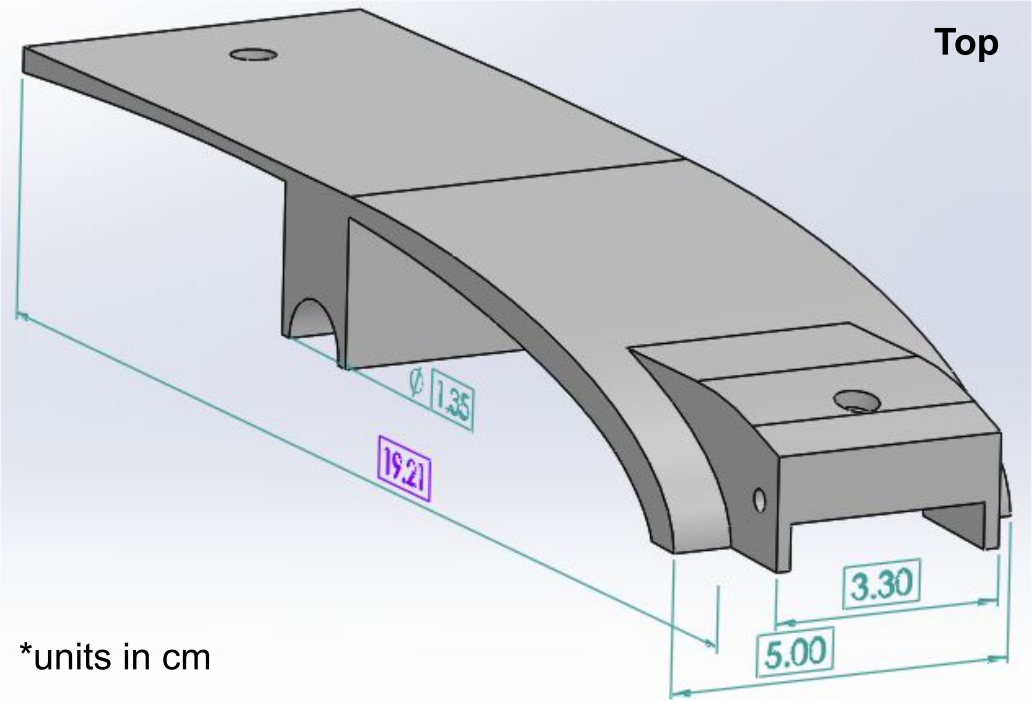
Drak

- Three Drak kits purchased and in our possession
  - Backups in case of damage during testing
- Extra wing set
  - Test wing mount loading
- Kit includes EPP foam body, coro-plast stabilizers, carbon fiber rods and spars
- Additional assembly tools
  - Adhesive
  - Tape for control surfaces



All Drak kits procured, waiting on adhesive to be delivered
To be assembled by Feb 5th-8th

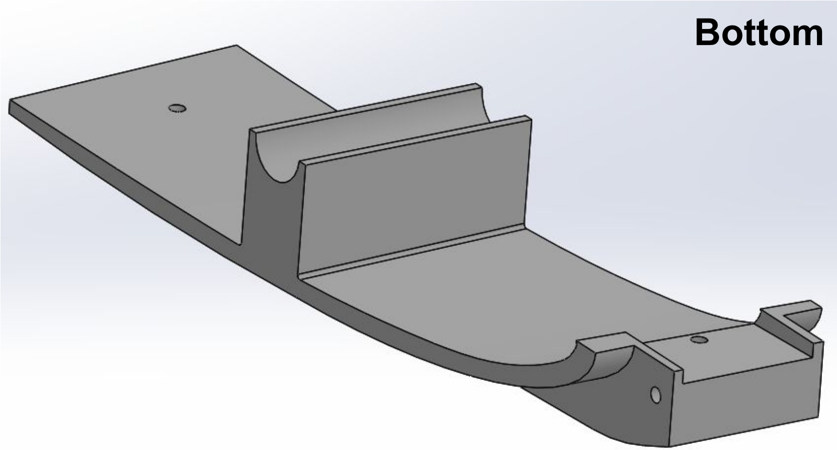
Wing Mounting



*units in cm

- Wing mounts printed out of PETG
  - ~12 hours total
- Wing mounts held together by glue and forward & rear 3mm bolts in the wing

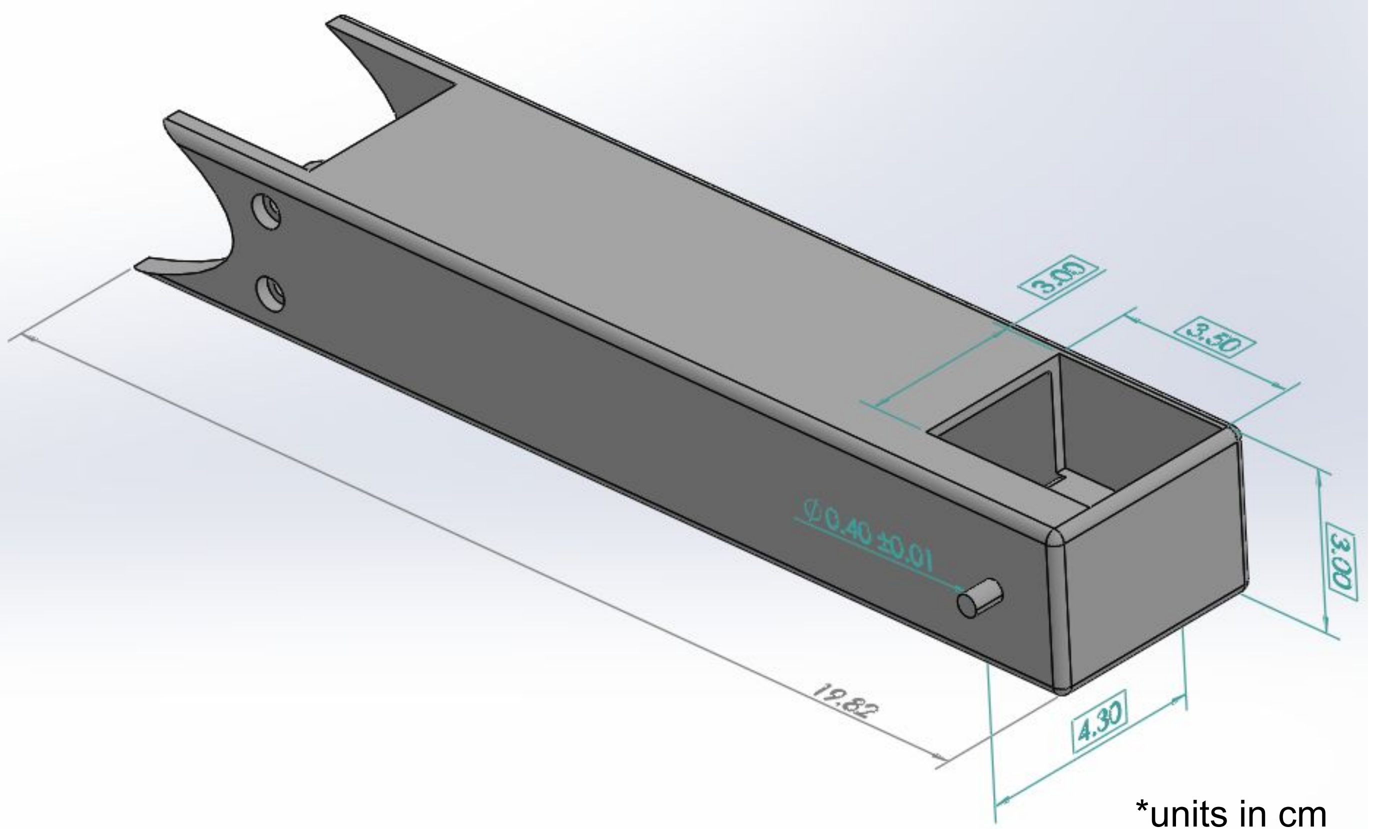
One set is printed and ready to begin wing load testing



Motor Arm

- Arm mounts printed out of PETG
  - ~10 hours each
  - Hollow to allow for wire channeling
- Motor arm attaches to wing mount by two horizontal 3mm bolts

To be 3D printed by Feb 5th

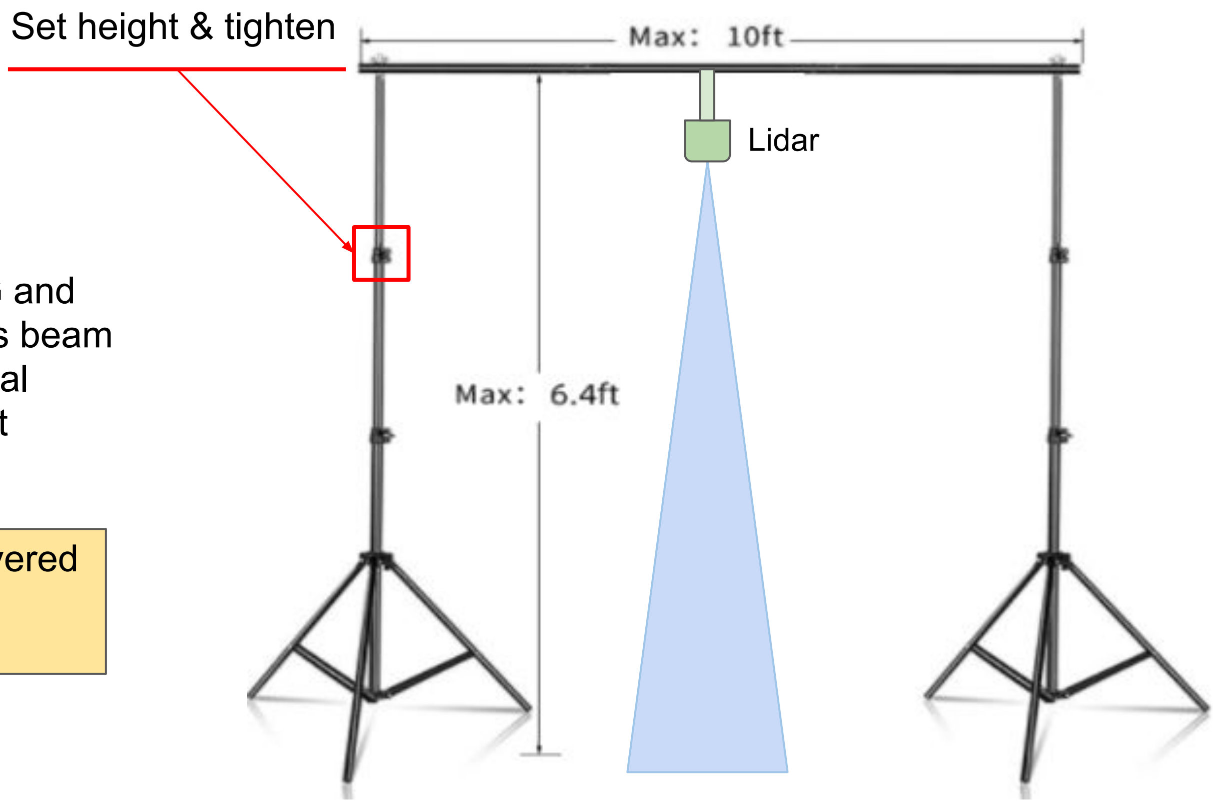


*units in cm

LiDAR Test Stand

- Test stand has been purchased
  - Waiting on delivery
- Lidar Mount printed out of PETG and mounts to the center of the cross beam
  - Holds lidar sensor in vertical orientation at known height

Waiting on Test stand to be delivered
LiDAR mount printed
Assembled by Feb 5th



*Dimensions in mm

Custom Battery Progress

Inventory

Still waiting for procurement on 1 major part

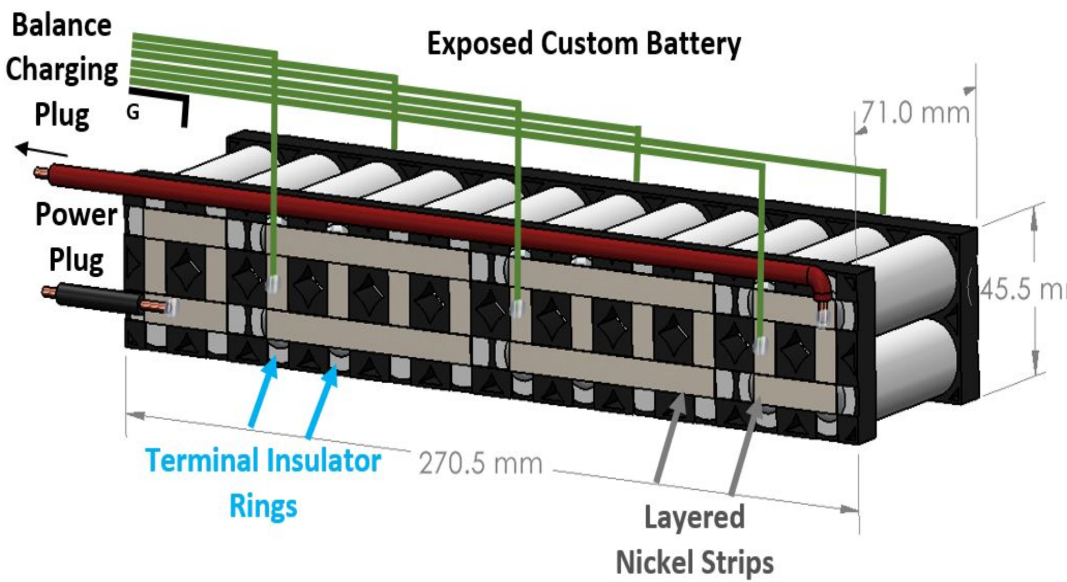
- Charging pin (delivery eta: **unknown**)

Deliverables

1. Single simple parallel cell testing (4 cells)
   Estimated time (1 hour)
2. 1st iteration full battery pack (24 cells)
   Estimated time (1 day)

Progress

Waiting on R2R approval to begin manufacturing



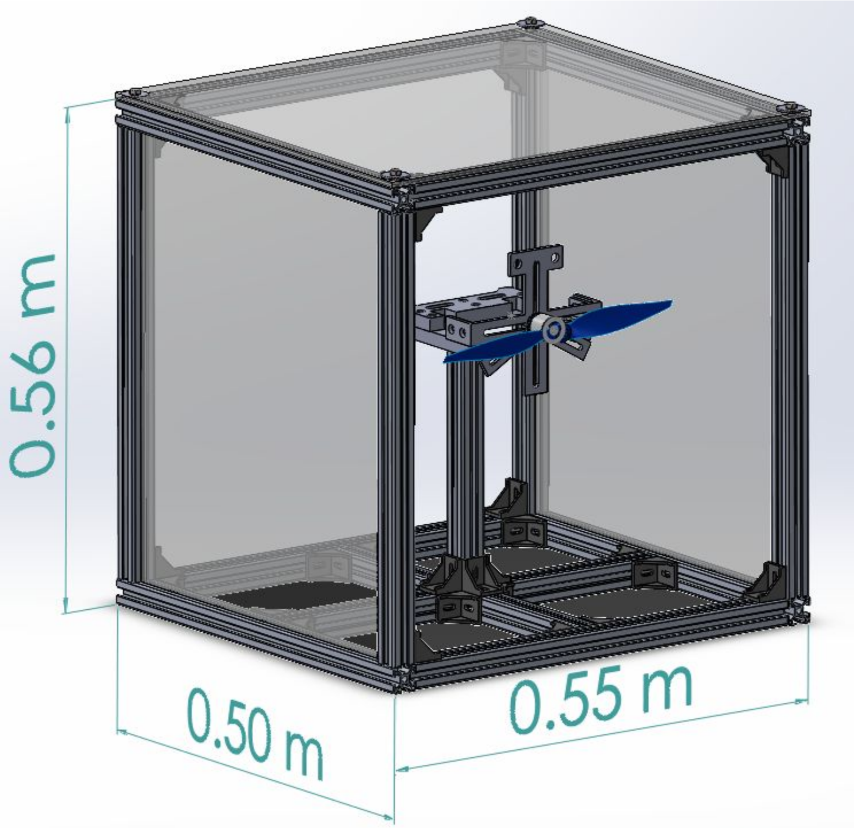
Custom Battery Progress

- On Hand:
  - Insulator rings
  - XT90 connectors
  - XT60 connectors
  - MT60 connectors
  - 10 AWG Wire
  - Wire Kapton tape
  - 100x LiPo battery cells
- Barriers to Progress
  - Balancing cable not delivered
  - Waiting on R2R
  - Spot welding to connect cells
  - Spot welder supplied by IRISS

Waiting on R2R approval and balancing cable to begin manufacturing

Static Propulsion Test Stand

- Will be assembled by us
- Main Parts
  - Aluminum Extrusion
    - Cut to length/thread ourselves
  - 3 ¼" Acrylic Panels on sides
    - Cut to size ourselves
  - 1" wire screen for front/rear
  - Load Cell/Motor Mount Assembly
    - Lent by DBF

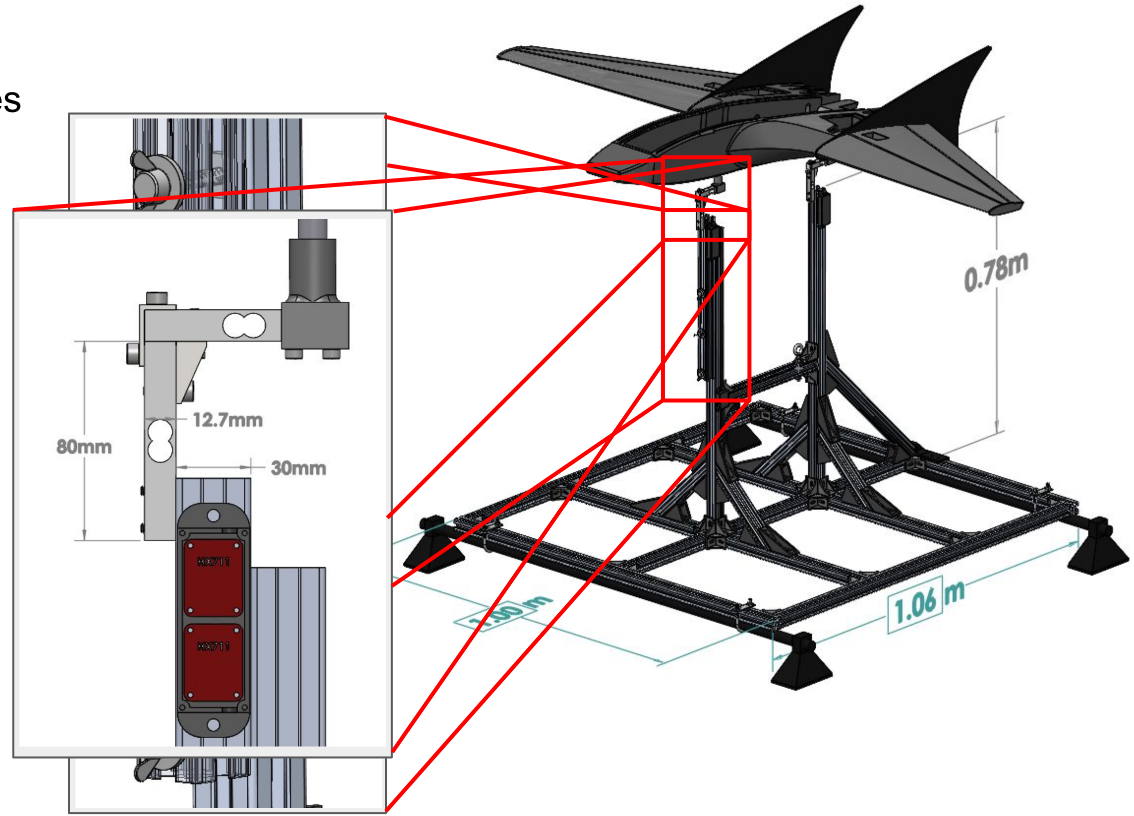


Cutting aluminum extrusion and assembling this week

Aerodynamic Test Stand

- Main Parts
  - Aluminum Extrusion
    - Cut/assemble ourselves
  - Mounting Brackets
    - 90° aluminum
    - 45° 3D Print
    - 135° 3D Print

Cutting aluminum extrusion and assembling this week

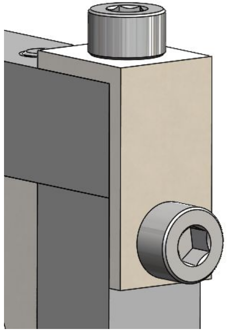


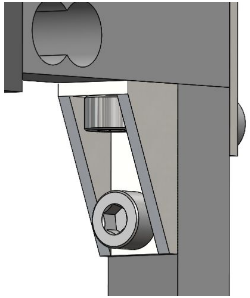
Aerodynamic Test Stand: Load Cells

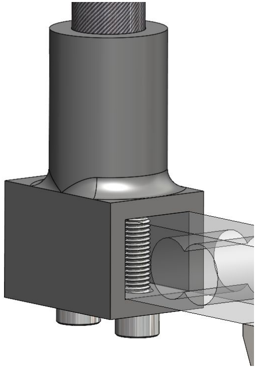
Manufacturing Sufficient Brackets

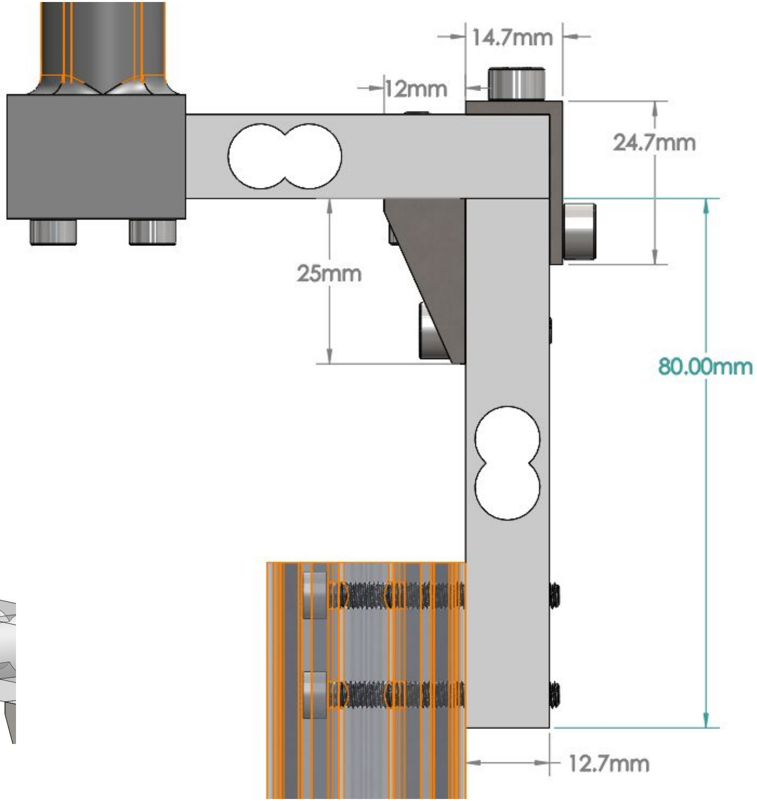
Solution:

- Nylon Alloy 3D print bracket for cell to carbon fiber rod
- 90° inner and outer brackets milled from a low carbon steel block







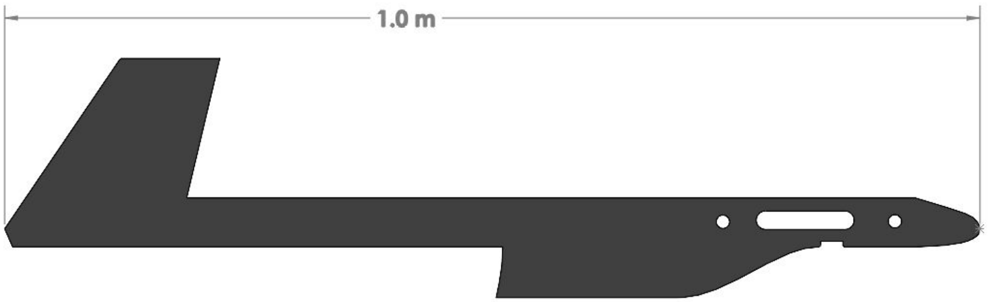


Aerodynamic Test Stand

Manufacturing the Tail

- Cut Foam Horizontal Tail
  - CNC Hot Wire Foam Cutter
  - XPS foam

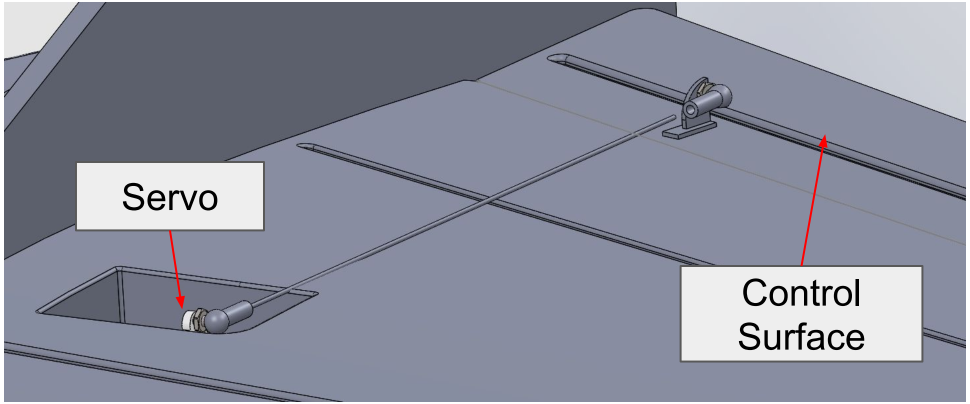
- Tail Booms
  - Laser Cut Coroplast
  - 8 mm thick



- Preliminary Dimensions (Subject to Change)
  - 1 m length
  - V_h= 0.6
  - S = 0.089 m^2
  - c = 0.22 m

Manufacturing Extra Control Surfaces

- Control Surface
  - Same material and manufacturing method as horizontal tail
  - Mounted using Z-Tape
- Servo
  - Mounted inset into the horizontal tail
  - Connected to control surface same as wing
- Foam and servo still need to be purchased



Mounting example from the wing

Manufacturing of horizontal tail and control surfaces is scheduled to be completed by Feb 11th

Manufacturing/Testing Concerns

Category	Concern	Notes
Dynamic Test Stand	High	Primarily safety, Milling and cutting metal, Organizing testing space, Intense data processing
Static Test Stand	Medium	Safety, Experience with DBF propulsion testing, Shop work
Custom Battery Packs	Medium	Shipping parts. Battery pack performance after manufacturing. Safety
Motor Mounts, and Loading Test	Low	Uncertainty in FEM causing failure before the required loading.
Extra Control Surface	Low	Tail booms approx. 40 in, Hot wire foam cutting, Optimization Sizing, Ardupilot parameters

Budget

Parts/Material Procurement

Important Parts	Application	Status
LiDAR Sensor	Avionics, Testing	Received
Servos	Controls	Received
Batteries	Endurance, Testing	Received
Front and Rear Motors	Propulsion	Received
Front and Rear Propellers	Propulsion, Testing	Received
Front and Rear ESCs	Endurance/ Propulsion	Received
Ritewing Drak Kit	Structures, Testing	Received

Important Parts	Application	Status
Ritewing Drak - Extra Wings	Testing	Received
Nuts/Screws/Bolts etc.	Manufacturing	Received
Aluminum Extrusion	Testing, Manufacturing	Received
LiDAR Test Stand	Testing	Ordered
Load Cells	Testing	Ordered
Adhesives	Manufacturing	Ordered
Misc Battery Fabrication Materials*	Testing	Received

*Battery brackets for fabrication are about a month or more delayed

Financial Status/ Budget

VORTEX Budget Breakdown:

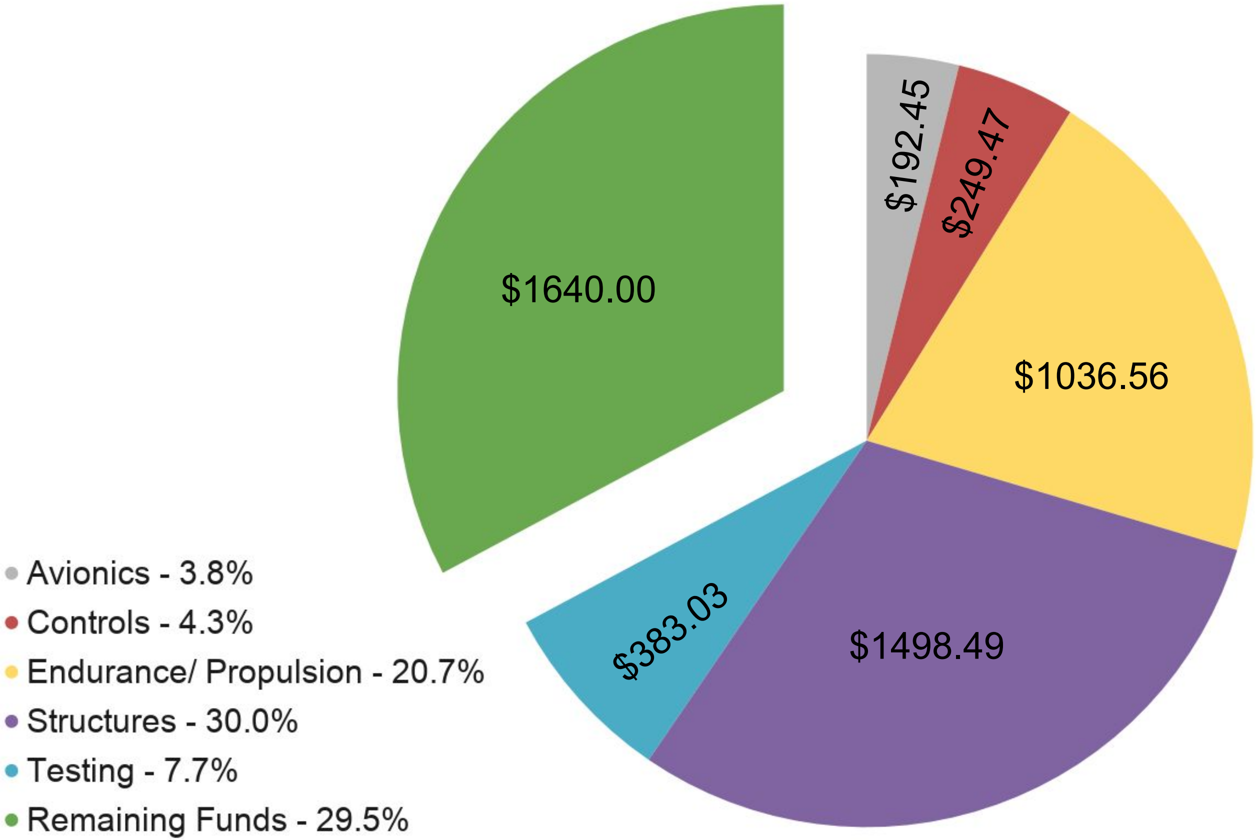
Total Budget: $5,000.00

Confirmed Purchases: $3,560.00
Pilot Lab Deposit: -$200.00 (assuming is returned)
Estimated Future Costs: $400.00
Contingency Budget: $1000.00 *

Total Expenses: $4,760.00

Estimated Final Balance: $240.00

***Note:** Estimated final balance assumes entire contingency/complication budget is used.



Thank You!

Questions?

Backup Slides

Canard vs Tail Trade Study

Options Considered
- Static Canard
- Static Tail
- Tail with Elevator

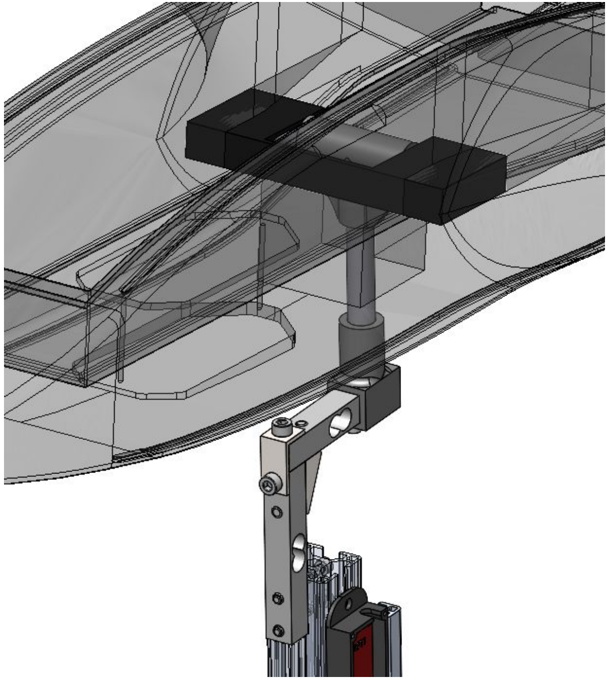
Tail with Elevator won out
- Reduces elevon deflection
- Used by IRISS
- Heavier than Canard though
- Easy to manufacture

Criteria	Things to Consider	Criteria Weight
LIft and Drag Performance	• Trim Lift Deficit Calculations • Estimate Drag, NACA airfoil, Parasite, Induced, etc. • Effect on Elevon deflection at trim	25%
Stability	• Static Margin Calculations • Trim Moment Deficit Calculations • Stall performance • Static, dynamic stability	30%
Weight	• Weight of supplementary components ○ Servos, Spars, Foam • Shift in center of gravity	15%

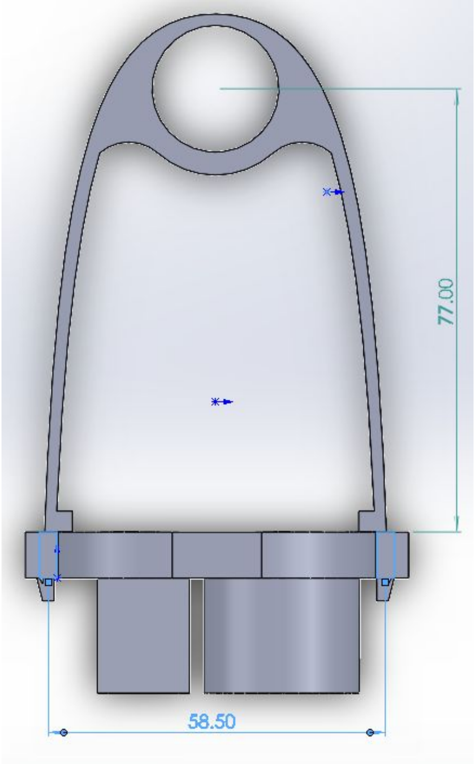
Complexity	• Supplementary Components
	• Electronics
	• Structure required
	• Manufacturability
	  ○ Materials and Methods
	• Design Optimization
	  ○ Expected effort to optimize the design
		30%

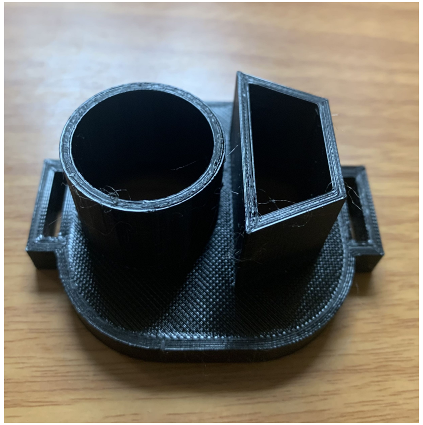
Aerodynamic Test Stand Adjustable Angle Bracket

- Internal bracket allows spar to slide forwards and backwards to change angle
- Horizontal carbon fiber rod slides inside internal bracket
- Internal bracket will be 3D printed out of PETG



LiDAR Test Stand





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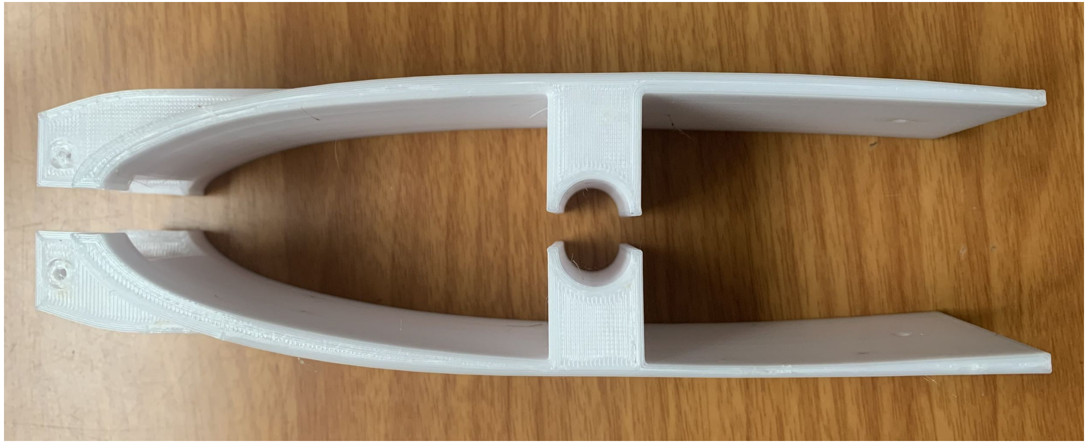

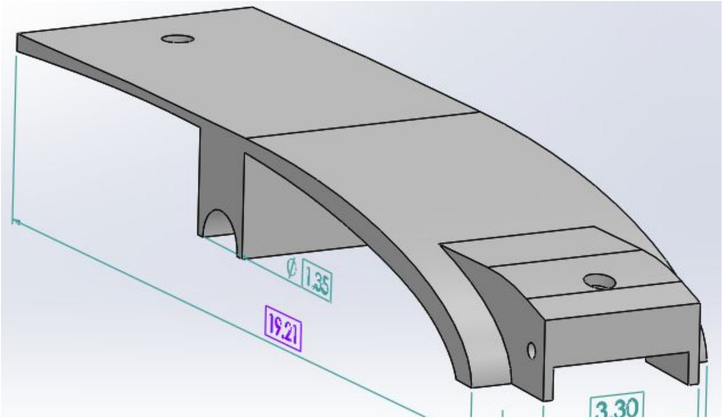

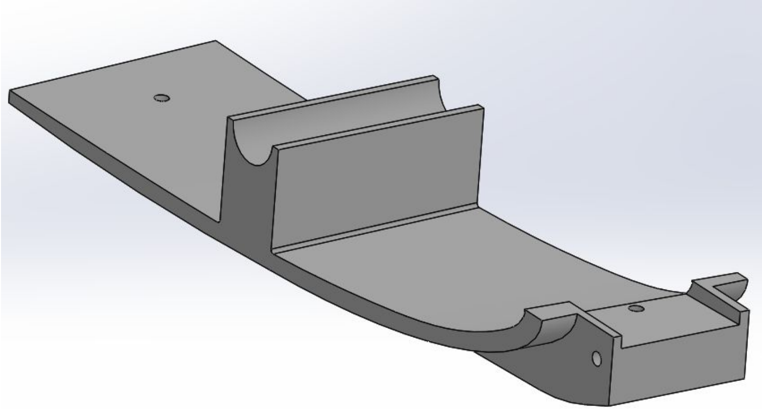

Aerodynamic Test Stand - 3D Printed

Full Project Budget

Current Balance

$1,640.00

WBS	Task	Purchase Status	Shipping Status	Link	Per Unit: Materials Units	Per Unit: Materials $/Unit	Per Unit: Actual	Per Unit: Budget	Per Unit: Margin	Per Unit: Under/(Over)	Total: Materials Units	Total: Materials $/Unit	Total: Shipping	Total: Actual	Total: Budget	Total: Margin	Total: Under/(Over)
							$ 844.98	$ 1,000.00	-15.50%	$155.02				$ 3,360.00	$ 5,000.00	-32.80%	$1,640.0
1	**Avionics**						**$ 149.60**	**$ 170.00**	**-12.00%**	**-$20.40**				**$ 192.45**	**$ 374.00**	**-48.54%**	**$181.5**
1.1	LIDAR Sensor	Received		https://www.robotshop.c	1.0	$125.00	125.00	135.00	-7.41%	-10.00	1.0	$125.00	$11.98	136.98	280.00	-51.08%	143.0
1.2	Current Measurement Board	Ordered	EST 2/6?	https://www.mauch-elect	1.0	$24.60	24.60	35.00		-10.40	1.0	$24.60	$6.90	31.50	64.00	-50.78%	32.5
1.3	9V battery clip	Ordered		https://www.amazon.con	0.0	$5.99	-	-		0.00	1.0	$5.99	$0.00	5.99	12.00	-50.08%	6.0
1.4	Micro SD card adapter	Ordered		https://www.amazon.con	0.0	$6.99	-	-		0.00	1.0	$6.99	$0.00	6.99	7.00	-0.14%	0.0
1.5	Micro SD Card - 64GB	Ordered		https://www.amazon.con	0.0	$10.99	-	-		0.00	1.0	$10.99	$0.00	10.99	11.00	-0.09%	0.0
2	**Controls**						**$ 150.92**	**$ 190.00**	**-20.57%**	**-$39.08**				**$ 249.47**	**$ 315.00**	**-20.80%**	**$65.5**
2.1	Control Horn	Received		https://www.dubro.com/c	1.0	$2.10	2.10	5.00	-58.00%	-2.90	4.0	$2.10	$8.99	17.39	29.00	-40.03%	11.6
2.2	Elevon Servos	Received		https://www.servocity.co	2.0	$22.99	45.98	60.00	-23.37%	-14.02	2.0	$22.99	$6.99	52.97	76.00	-30.30%	23.0
2.3	Front Servos	Received		https://www.servocity.co	2.0	$44.99	89.98	100.00	-10.02%	-10.02	2.0	$44.99	$0.00	89.98	135.00	-33.35%	45.0
2.4	Servo Connector	Received		https://www.amazon.con	0.2	$10.99	1.84	5.00	-63.29%	-3.16	1.0	$10.99	$0.00	10.99	15.00	-26.73%	4.0
2.5	Servo Wire	Received		https://www.amazon.con	0.1	$17.22	1.72	5.00	-65.56%	-3.28	1.0	$17.22	$0.00	17.22	20.00	-13.90%	2.7
2.6	Swivel Ball Link	Received		https://www.dubro.com/p	0.3	$22.95	7.64	10.00	-23.58%	-2.36	1.0	$22.95	$0.00	22.95	30.00	-23.50%	7.0
2.7	4-40 Threaded Rod	Received		https://www.dubro.com/c	0.3	$5.00	1.67	5.00	-66.70%	-3.34	1.0	$5.00	$0.00	5.00	10.00	-50.00%	5.0
2.8	Pitot Tubes	Ordered		https://www.amazon.con	0.0	$10.99	-				3.0	$10.99		32.97			
3	**Endurance/Propulsion**						**$ 154.48**	**$ 230.00**	**-32.84%**	**-$75.52**				**$ 1,036.56**	**$ 1,304.00**	**-20.51%**	**$267.4**
3.1	Li-ion battery cells	Received		https://www.18650batter	0.0	$485.00	-	-		0.00	100.0	$4.85	$12.93	497.93	500.00	-0.41%	2.0
3.2	Test Battery	Received		https://www.getfpv.com/l	0.0	$39.99	-	-		0.00	1.0	$39.99	$1.99	41.98	84.00	-50.02%	42.0
3.3	Front Motor (860Kv) test	Backorder		https://sunnyskyusa.com			-							-			
3.4	Front Motor (570Kv) test PRIORITY	Received		https://sunnyskyusa.com	2.0	$35.00	70.00	100.00			2.0	$35.00	$10.70	80.70	106.00	-23.87%	25.3
3.5	Front Motor (500Kv) test	Backorder		https://sunnyskyusa.com			-							-	-		
3.6	Rear Motor (880Kv) test PRIORITY	Received		https://sunnyskyusa.com	1.0	$22.80	22.80	40.00	-43.00%	-17.20	1.0	$22.80	$0.00	22.80	46.00	-50.43%	23.2
3.7	Front Propeller (13x6) test	Received		https://www.espritmodel.	0.0	$12.00	-			0.00	2.0	$12.00	$0.00	24.00	36.00	-33.33%	12.0
3.8	Front Propeller (13x8) test	Received		"	0.0	$12.00	-				2.0	$12.00	$0.00	24.00	36.00	-33.33%	12.0
3.9	Front Propeller (14x6) test	Received		"	0.0	$13.00	-				2.0	$13.00	$0.00	26.00	39.00	-33.33%	13.0
3.10	Front Propeller (14x8) test	Received		"	0.0	$13.00	-				2.0	$13.00	$0.00	26.00	39.00	-33.33%	13.0
3.11	Rear Propeller (9x5) test	Received		"	0.0	$7.00	-			0.00	2.0	$7.00	$0.00	14.00	21.00	-33.33%	7.0
3.12	Rear Propeller (9x6) test	Received		"	0.0	$7.00	-				2.0	$7.00	$0.00	14.00	21.00	-33.33%	7.0
3.13	Rear Propeller (9x7) test	Received		"	0.0	$7.00	-				2.0	$7.00	$0.00	14.00	21.00	-33.33%	7.0
3.14	Rear Propeller (10x6) test	Received		"	0.0	$8.00	-				2.0	$8.00	$0.00	16.00	24.00	-33.33%	8.0
3.15	Spinner	Received		https://www.dubro.com/p	0.0	$5.15	-			0.00	4.0	$5.15	$0.00	20.60	26.00	-20.77%	5.4
3.16	ESCs Front (test) Xrotor	Received		https://www.hobbywingd	1.0	$15.99	15.99	25.00	-36.04%	-9.01	1.0	$15.99	$5.42	21.41	44.00	-51.34%	22.5
3.17	ESCs Rear (test)	Received		https://www.hobbywingd	1.0	$29.99	29.99	40.00	-25.03%	-10.01	1.0	$26.32	$0.00	26.32	53.00	-50.34%	26.6
3.18	XT90 Connector	Received		https://www.amazon.con	0.1	$15.86	1.59	4.00	-60.35%	-2.41	1.0	$15.86	$0.00	15.86	18.00	-11.89%	2.1
3.19	XT60 Connector	Received		https://www.amazon.con	0.3	$8.99	2.70	4.00	-32.58%	-1.30	1.0	$8.99	$0.00	8.99	9.00	-0.11%	0.0
3.20	MT60	Received		https://www.amazon.con	0.4	$15.99	6.40	8.00	-20.05%	-1.60	1.0	$15.99	$0.00	15.99	16.00	-0.06%	0.0
3.21	JST XH wired charging pin	Ordered		https://www.amazon.con	0.0	$8.99	-			0.00	2.0	$8.99	$0.00	17.98	36.00	-50.06%	18.0
3.22	Kapton Tape	Received		https://www.amazon.con	0.0	$14.24	-			0.00	1.0	$14.24	$0.00	14.24	29.00	-50.90%	14.7
3.23	Insulator Rings	Received		https://www.amazon.con	0.0	$6.99	-			0.00	1.0	$6.99	$0.00	6.99	7.00	-0.14%	0.0
3.24	Battery Bracket	Ordered	EST 2/26-3/19	https://www.amazon.con	0.0	$4.38	-	-		0.00	1.0	$4.38	$0.00	4.38	10.00	-56.20%	5.6
3.25	Shrink Wrap	Received		https://www.amazon.con	0.0	$12.98	-	-		0.00	1.0	$12.98	$0.00	12.98	13.00	-0.15%	0.0
3.26	Nickel Strips (0.2x8mm)	Received		https://www.amazon.con	0.0	$17.99	-	-		0.00	1.0	$17.99	$0.00	17.99	18.00	-0.06%	0.0
3.27	Wire 10 AWG	Received		https://www.amazon.con	0.2	$15.48	2.32	4.00	-41.95%	-1.68	1.0	$15.48	$0.00	15.48	16.00	-3.25%	0.5
3.28	Wire 14 AWG	Received		https://www.amazon.con	0.1	$17.98	0.90	1.50	-40.07%	-0.60	1.0	$17.98	$0.00	17.98	18.00	-0.11%	0.0
3.29	Wire 16 AWG	Received		https://www.amazon.con	0.1	$7.98	0.80	1.50	-46.80%	-0.70	1.0	$7.98	$0.00	7.98	8.00	-0.25%	0.0
3.30	Wire 20 AWG	Received		https://www.amazon.con	0.1	$9.98	1.00	2.00	-50.10%	-1.00	1.0	$9.98	$0.00	9.98	10.00	-0.20%	0.0
4	**Structures**						**$ 389.98**	**$ 410.00**	**-4.88%**	**-$20.03**				**$ 1,498.49**	**$ 1,507.00**	**-0.56%**	**$8.5**
4.1	Ritewing Drak Kit	Received		http://ritewingrc.com/pro	1.0	$350.00	350.00	350.00	0.00%	0.00	3.0	$350.00	$85.00	1,135.00	1,135.00	0.00%	0.0
4.2	Ritewing Drak - Extra Wings (3)	Received		http://ritewingrc.com/pro	0.0	$200.00	-	-			1.0	$200.00	$0.00	200.00	200.00	0.00%	0.0
4.3	3D printing filament	Received		https://www.amazon.con	0.5	$59.99	30.00	40.00	-25.01%	-10.01	1.0	$59.99	$0.00	59.99	60.00	-0.02%	0.0
4.4	Amazing Goop	Ordered	EST 2/2-2/5	https://www.amazon.con	1.0	$9.98	9.98	20.00	-50.10%	-10.02	1.0	$9.98	$0.00	9.98	20.00	-50.10%	10.0
4.5	Pitch Wing Bolt - M5 x 40mm (10 pcs)	Ordered		https://www.amazon.con	0.0	$8.88	-	-		0.00	1.0	$8.88	$0.00	8.88	18.00	-50.67%	9.1
4.6	Spring Ball Loaded Nuts - 3030 series M5 (12 pcs)	Ordered		https://www.amazon.con	0.0	$7.59	-	-		0.00	1.0	$7.59	$0.00	7.59	16.00	-52.56%	8.4
4.7	TiteBond	Ordered		https://www.amazon.con	0.0	$8.98	-	-		0.00	1.0	$8.98	$0.00	8.98	18.00	-50.11%	9.0
4.8	Gorilla Glue	Ordered		https://www.amazon.con	0.0	$9.94	-	-		0.00	1.0	$9.94	$0.00	9.94	20.00	-50.30%	10.0
4.9	Misc Bolts/Nuts/Washers/Screws	Received		https://www.boltdepot.cc	0.0	$14.81	-	-		0.00	1.0	$14.81	$4.95	19.76	20.00	-1.20%	0.2
4.10	Carbon Fiber Rods	Ordered	EST 2/1	https://www.rockwestcor	0.0	$26.99	-	-		0.00	1.0	$26.99	$11.38	38.37	20.00	91.85%	-18.3
5	**Testing**						**$ -**	**$ -**		**$0.00**				**$ 383.03**	**$ 500.00**	**-23.39%**	**$116.9**
5.1	Misc Testing						-			0.00	0.0	$400.00		-	500.00		
5.2	Aluminum Extrusion	Received		http://www.zyltech.com/t							2.0	$110.45	$21.42	242.32			
5.3	LIDAR Test Stand	Ordered	EST 2/2 - 2/9	https://www.amazon.con							1.0	$29.99	$0.00	29.99			
5.4	Fish Scale	Received		https://www.amazon.con							1.0	$9.99	$0.00	9.99			
5.5	Load Cell Weight Sensor	Ordered		https://www.amazon.con			-	-		0.00	1.0	$8.48	$0.00	8.48			
5.6	Load Cell - 10kg	Ordered		https://www.sparkfun.co			-	-		0.00	5.0	$8.50	$0.00	42.50			
5.7	Load Cell Amplifier	Ordered		https://www.sparkfun.co			-	-		0.00	5.0	$9.95	$0.00	49.75			
6	**Miscellaneous**						**$ -**	**$ -**		**$0.00**				**$ -**	**$ 1,000.00**	**-100.00%**	**$1,000.0**
6.1	Contingencies and Complications				0.0	$0.00	-	-		0.00	0.0	$800.00		-	800.00	-100.00%	800.0
6.2	Pilot Lab Deposit				0.0	$0.00	-	-		0.00	0.0	$200.00		-	200.00	-100.00%	200.0

IRISS

INTEGRATED REMOTE & IN SITU SENSING

Overview and Scope

The purpose of the early manufacturing stages with regards to the VORTEX project is to both build and test individual subsystems.

1. Assemble basic functioning subsystems
2. Assemble testing apparatuses
3. Test and simulate realistic performance against modeled performance

Moving forward, each subsystem will be iteratively improved to meet desired performance. Full system testing can begin.

Subsystem	Testing Equipment
Autonomy	• Ardupilot • Pixhawk • LIDAR Test Stand
Structures	• Dynamic Test Stand
Propulsion	• Static Test Stand • Construction Battery • Dynamic Test Stand

Key
Software (in-house)
Custom Hardware (in-house)
Borrowed Hardware

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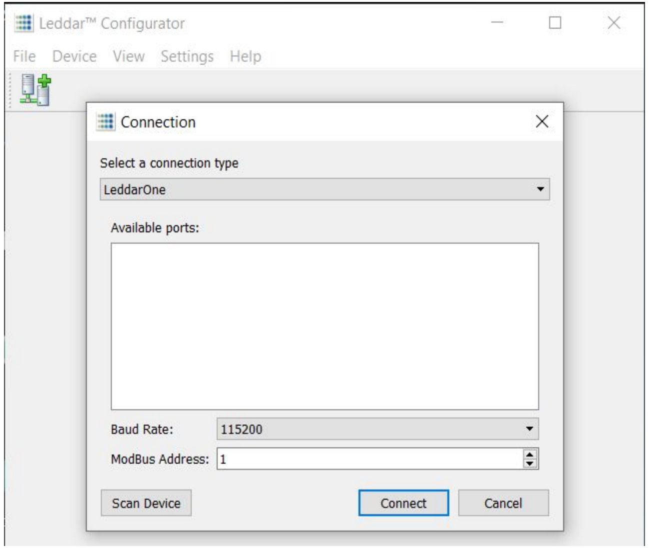
Testing the purchased LiDAR sensor to verify 10cm accuracy

LeddarTech Configurator
- Exports data to .txt file
- USB to UART cable to laptop

LeddarTech Configurator



LeddarOne Sensor