Argonia Cup 2022

Final Presentation

Hill Jordan, Patrick Williams, Ethan Riffell, Evan Nicholas, Isela Ortiz, Nick Hymel, Taylor Bostick, Trevor Marshall, Zach Montebon

May 6th, 2022

Advisors: Dr. Jamey Jacob,
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School of Aerospace & Mechanical Engineering
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OKLAHOMA STATE UNIVERSITY
MECHANICAL & AEROSPACE ENGINEERING

ARGONIA CUP
EST. 2017

Space Cowboys

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Mission Criteria and Requirements

Design, Develop, and Launch

Competition April 9th-10th, 2021

A High-Powered Rocket capable of delivering a golf-ball to 8000' AGL

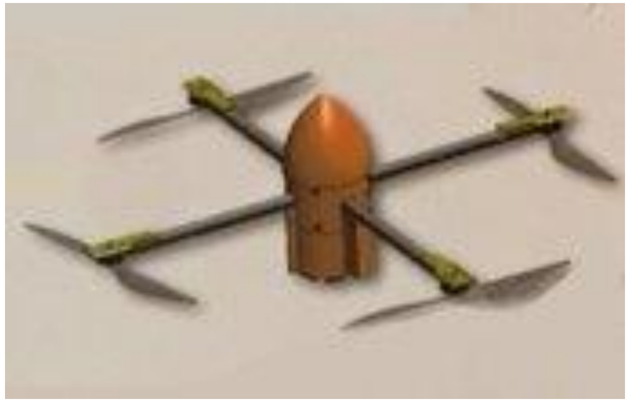
- Return golf-ball to designated target on the ground

- Budget - ~$2000
- Motor Impulse < 5120 Ns (L-class)
- 5:1 T-W Ratio at Liftoff
- Minimum Stability factor of 1 during flight
- Recovery Vehicle must fly below 30 fps below 300' AGL
- One Level 2 TRA member
- All components must be "Re-flyable"

Design Down Select

- Glider

- Multi-Rotor Aircraft

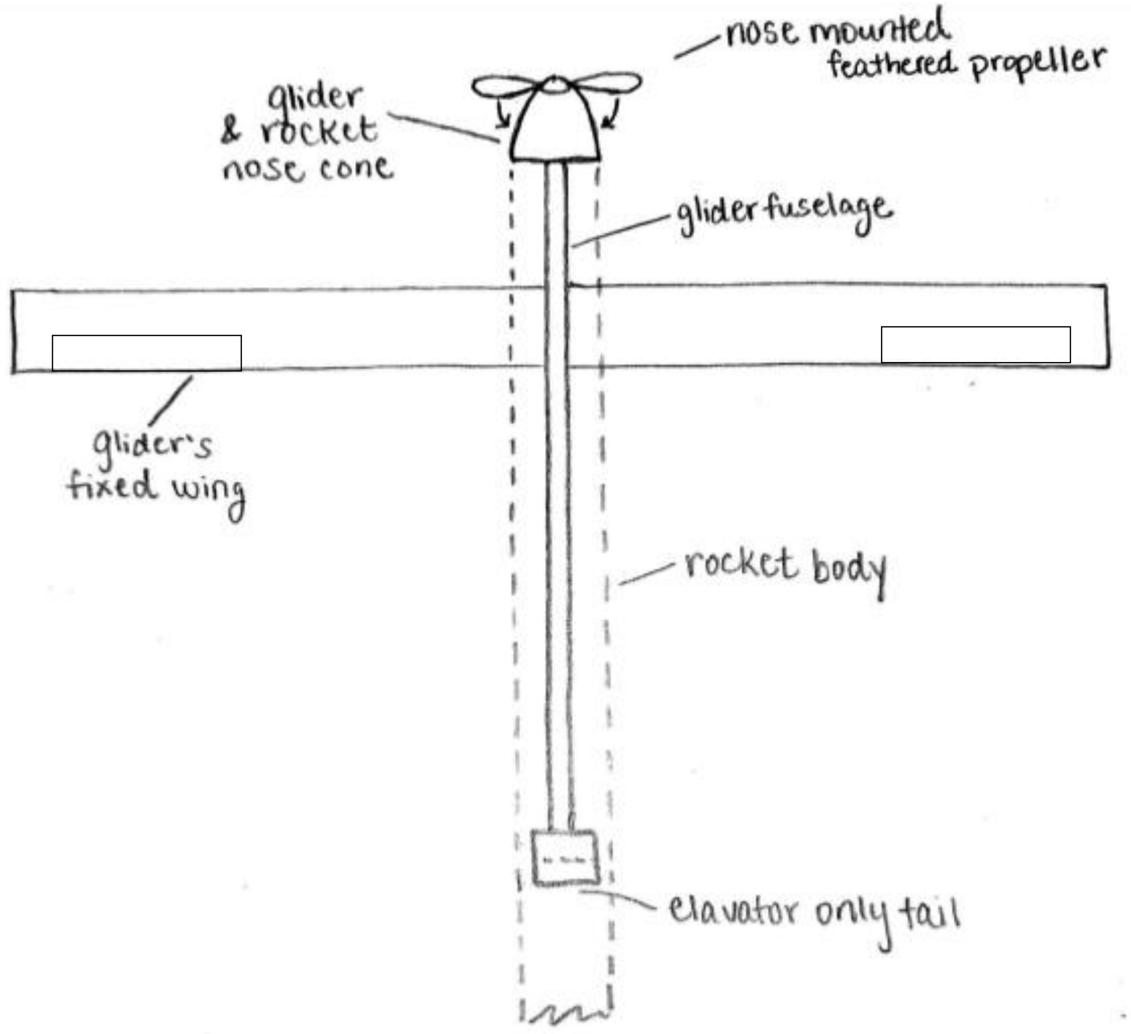


- Parasail/Parachute

Initial Full System Design

Nose-Propelled Fixed-Wing

- Propeller Springs out at Apogee
  - 1 Propeller – battery powered
  - Rest on, or nested in Nosecone for launch
  - Spin-up at deployment
- Cambered Carbon-Fiber Wings
  - Higher L/D than flat plate
  - w/ Alerions
- Tail
  - Elevator
  - No Rudder



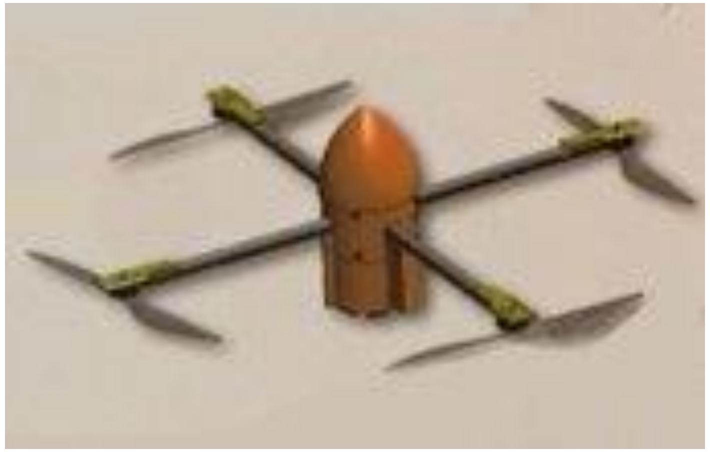
Quadcopter Design Choices

- Microscale

Pros
- Easy Fit
- Deployment

Cons
- Battery Life
- Wind Resistance

- Nose Cone



Pros
- Rocket Integration
- Previous Designs

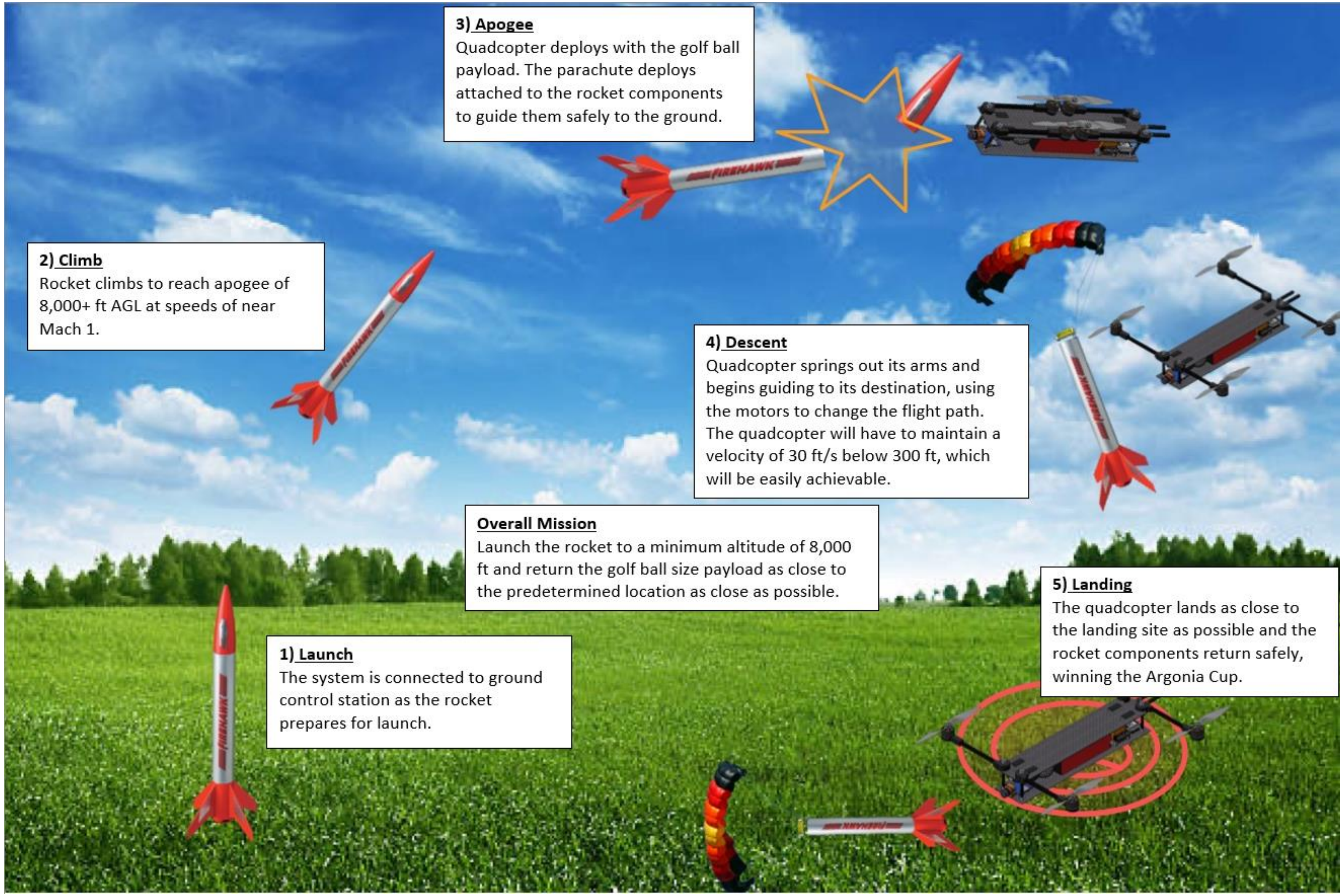
Cons
- Manufacturability
- Avionics Layout

- H-Frame

Pros
- Battery Life
- Wind Resistance

Cons
- Rocket integration
- Arm Deployment

CONOPS

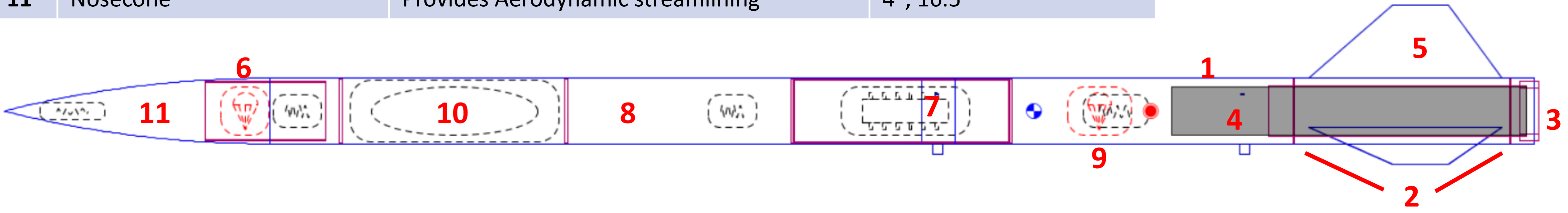

3) Apogee
Quadcopter deploys with the golf ball payload. The parachute deploys attached to the rocket components to guide them safely to the ground.
2) Climb
Rocket climbs to reach apogee of 8,000+ ft AGL at speeds of near Mach 1.
4) Descent
Quadcopter springs out its arms and begins guiding to its destination, using the motors to change the flight path. The quadcopter will have to maintain a velocity of 30 ft/s below 300 ft, which will be easily achievable.
Overall Mission
Launch the rocket to a minimum altitude of 8,000 ft and return the golf ball size payload as close to the predetermined location as close as possible.
5) Landing
The quadcopter lands as close to the landing site as possible and the rocket components return safely, winning the Argonia Cup.
1) Launch
The system is connected to ground control station as the rocket prepares for launch.

Rocket Design & Layout

#	Component	Description	Size (Diam, len.)
1	Sustainer	Bottom Stage of the Rocket, contains motor	4", 36"
2	Centering Rings	Centers Motor Mount in Sustainer	3.9-3.1", .08"
3	Motor Mount/Retainer	Holds 75 mm Motor in rocket	3.1", 16"
4	Aerotech L1940X	Propels the rocket forwards	75mm, varies
5	Fins	Provides Aerodynamic Stability	
6	Drogue Parachute	Slows rocket during ascent	36", N/A
7	Avionics & Slip band	Holds two halves together, controls separation	3.9", 13.5"
8	Payload Section	Contains Drone & Main Parachute	40.5"
9	Main Parachute	Slows Rocket for Drone & Ground Hit	48", N/A
10	Drone Sled	Stores the drone for flight	3.8", 18"
11	Nosecone	Provides Aerodynamic streamlining	4", 16.5"

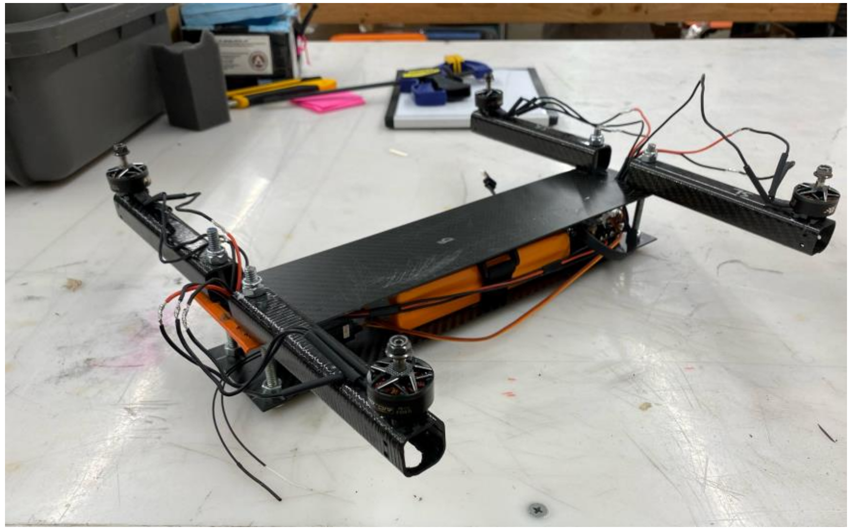
Total Length: 95.3"
Pad Weight: 25.6 lb.
CG: 63.96"
CP: 71.21"
Stability: 1.79 cal.
Estimated CD ~ 0.72

Competition Motor
Aerotech L1940X
Total Impulse: 4330 N-s (973 lbf-s)
Max Thrust: 2340 N (526 lbf)
Burn time: 2.2 s

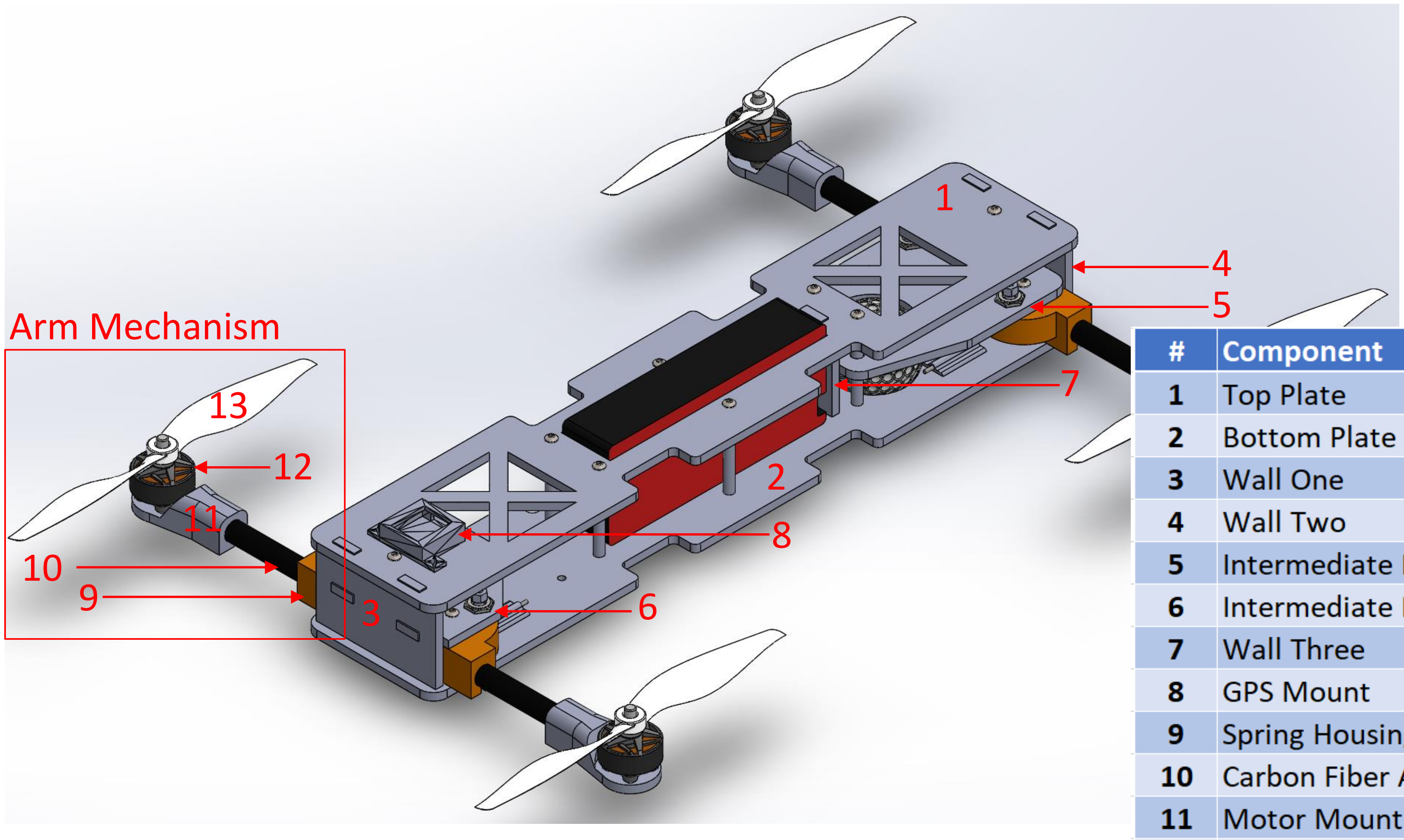


First Quad Prototype

- H-Style quadcopter with carbon fiber Plates, carbon fiber arms and steel bolts
  - Significantly heavier
  - Did not fit into the rocket
  - No functional arm folding system
  - Allowed for quadcopter flight testing
  - Gave insight as to what components needed to be optimized



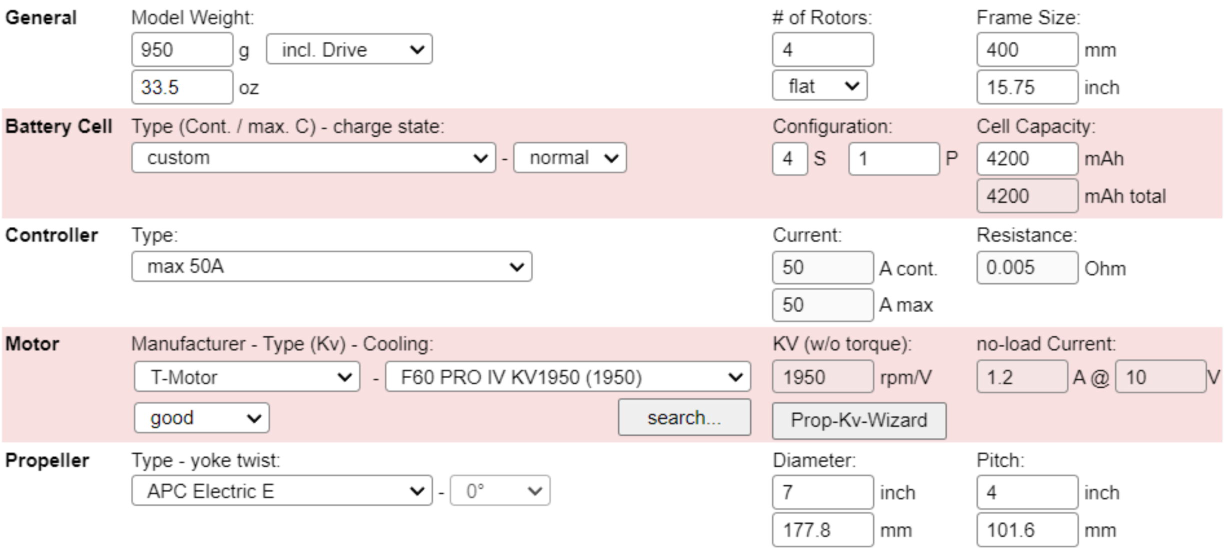
Quadcopter Design



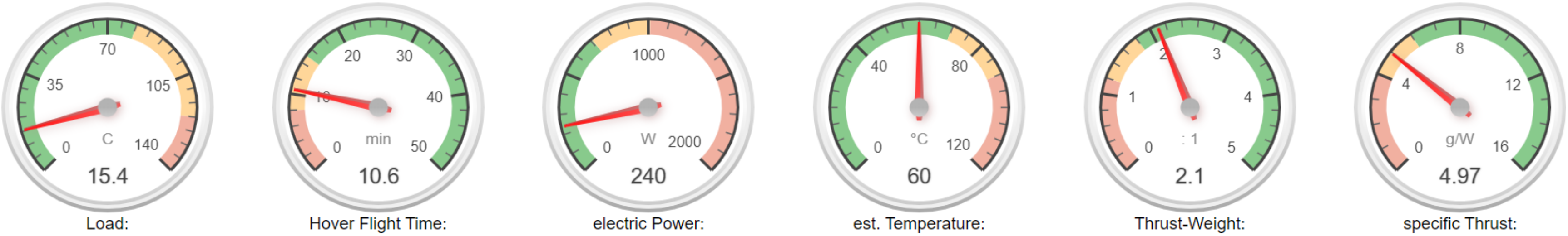
#	Component	Description
1	Top Plate	Balsa-Wood Core Carbon Fiber Layup
2	Bottom Plate	Balsa-Wood Core Carbon Fiber Layup
3	Wall One	Stock Carbon Fiber Rigid Plate
4	Wall Two	Stock Carbon Fiber Rigid Plate
5	Intermediate Plate One	Golf Ball Retention Plate
6	Intermediate Plate Two	Retention Plate
7	Wall Three	Internal Support
8	GPS Mount	Stock Carbon Fiber Mount
9	Spring Housing	Onyx Print
10	Carbon Fiber Arm	Stock Carbon Fiber 3/16" Rod
11	Motor Mount	Onyx Print
12	Motor	-
13	Propellor	-

Quad Sims

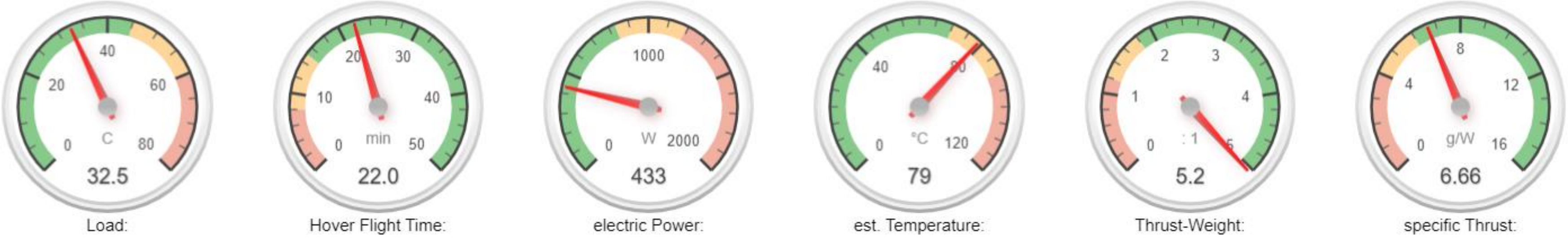
- Lowering Weight Overall
  - More efficient structure
  - Smaller battery
  - More efficient propellers



CDR Sims ->

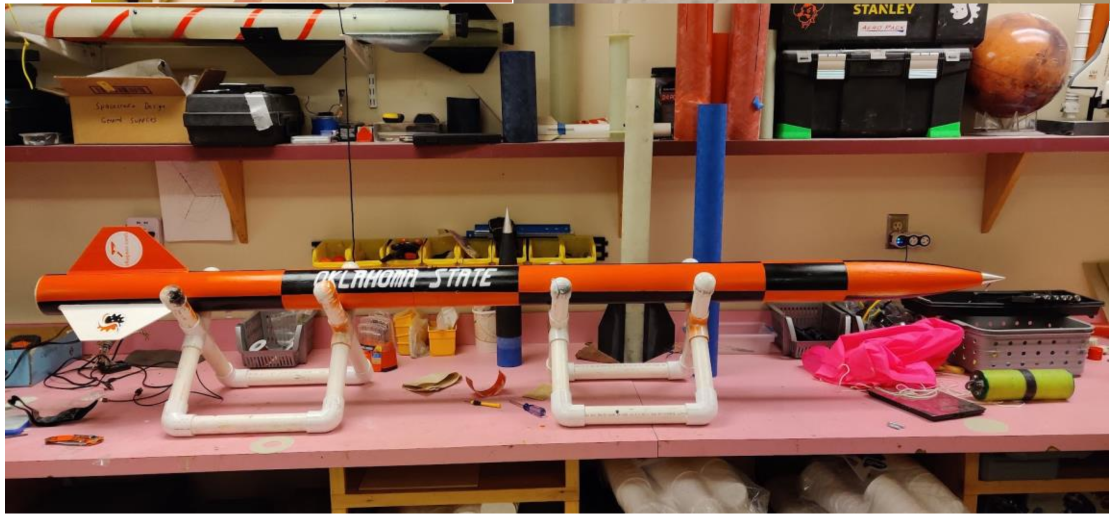


Final Sims ->



Rocket Build

- Was primarily Conducted over Spring Break
  - Fin slots cut w/ router
  - Fins & Bulkheads CNC'd
  - Body Tubes cut on chop saw
  - 2-56 Shear Pins for seperation
  - ¼" bolts used to keep the av-bay and payload
    bay connected
  - Y-loop harness epoxied to Motor mount tube



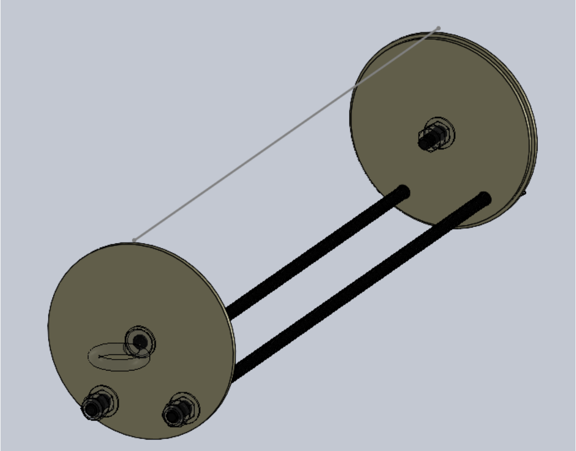
Quadcopter Testing

- Conducted 4-5 drop test from M600
- Multiple waypoint missions @ flight field
- Full scale w/rocket 2 times
  - Quad got tangled in shock cord after deployment on first launch
  - Second launch had successful deployment however had to be manually controlled back
- General flight tuning (PID)

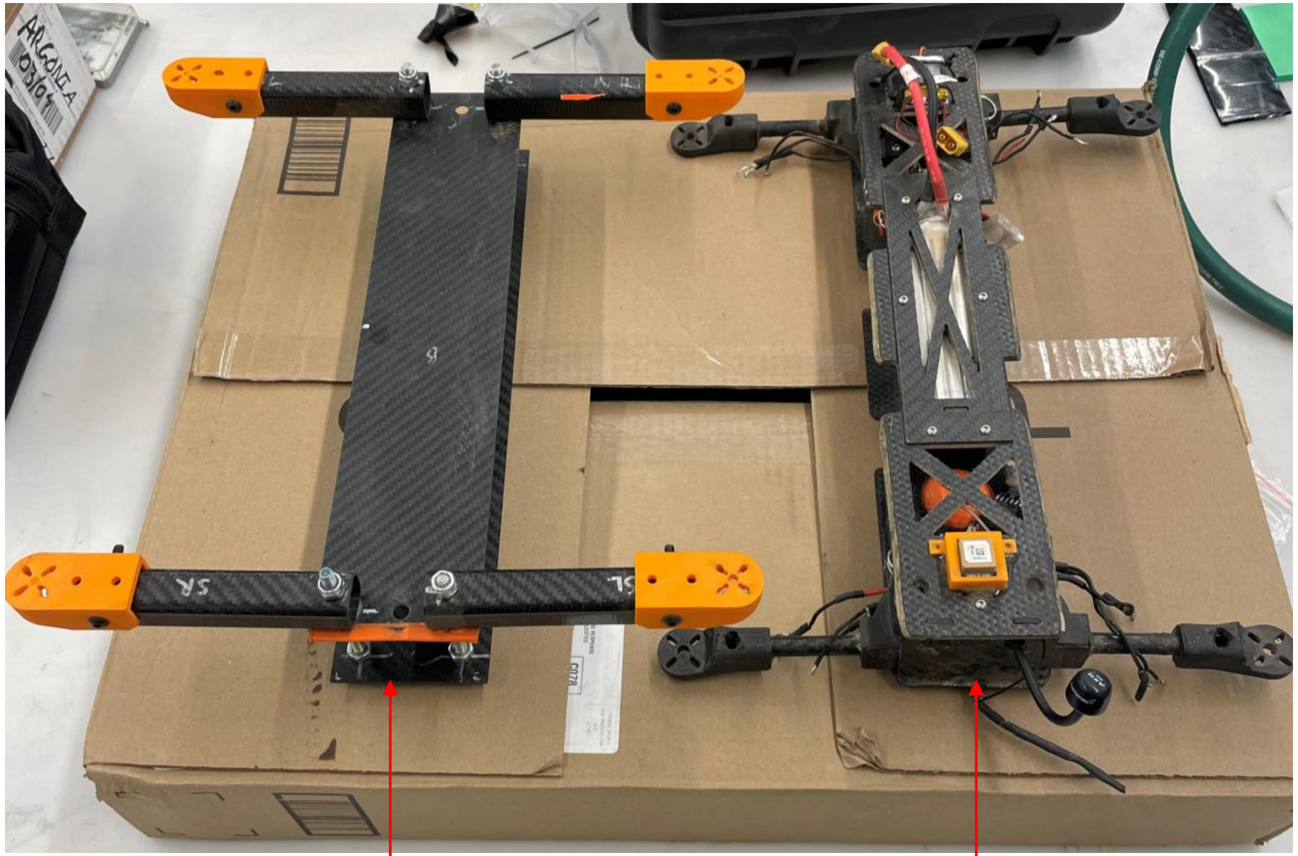
Name	Proportional	Integral	Derivative	Control Derivative
Basic/Acro				
Roll	50	60	23	60
Pitch	54	75	25	60
Yaw	45	80	0	60
Barometer & Sonar/Altitude				
Position Z	50	0	0	
Velocity Z	100	50	10	
Magnometer/Heading				
Heading Hold	60			
Nav Heading	0	0	0	
GPS Navigation				
Position XY	50			
Velocity XY	50	25	50	40
Surface	0	0	0	

Ejection Testing

- Material & Time limits forced a simple quad sled redesign
- Found we needed to shorten the sleds shock chord to prevent quad from tangling
- Final Black Powder configuration
  - Telemega: Main – 2.2 g, Apogee – 2.4 g
  - Easymini: Main – 2.4g, Apogee – 2.6 g



Final Quadcopter Build

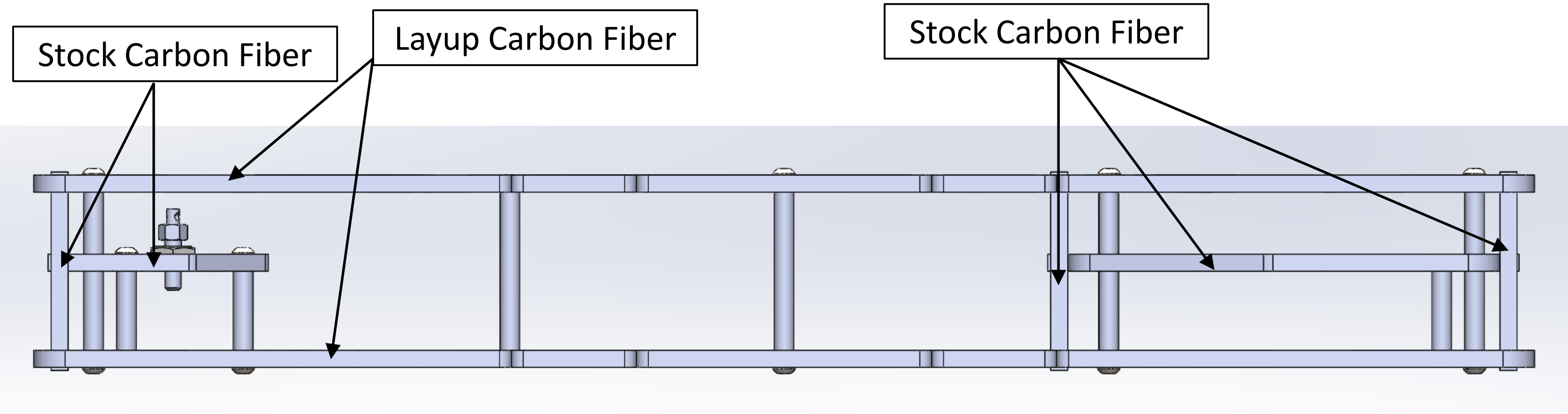


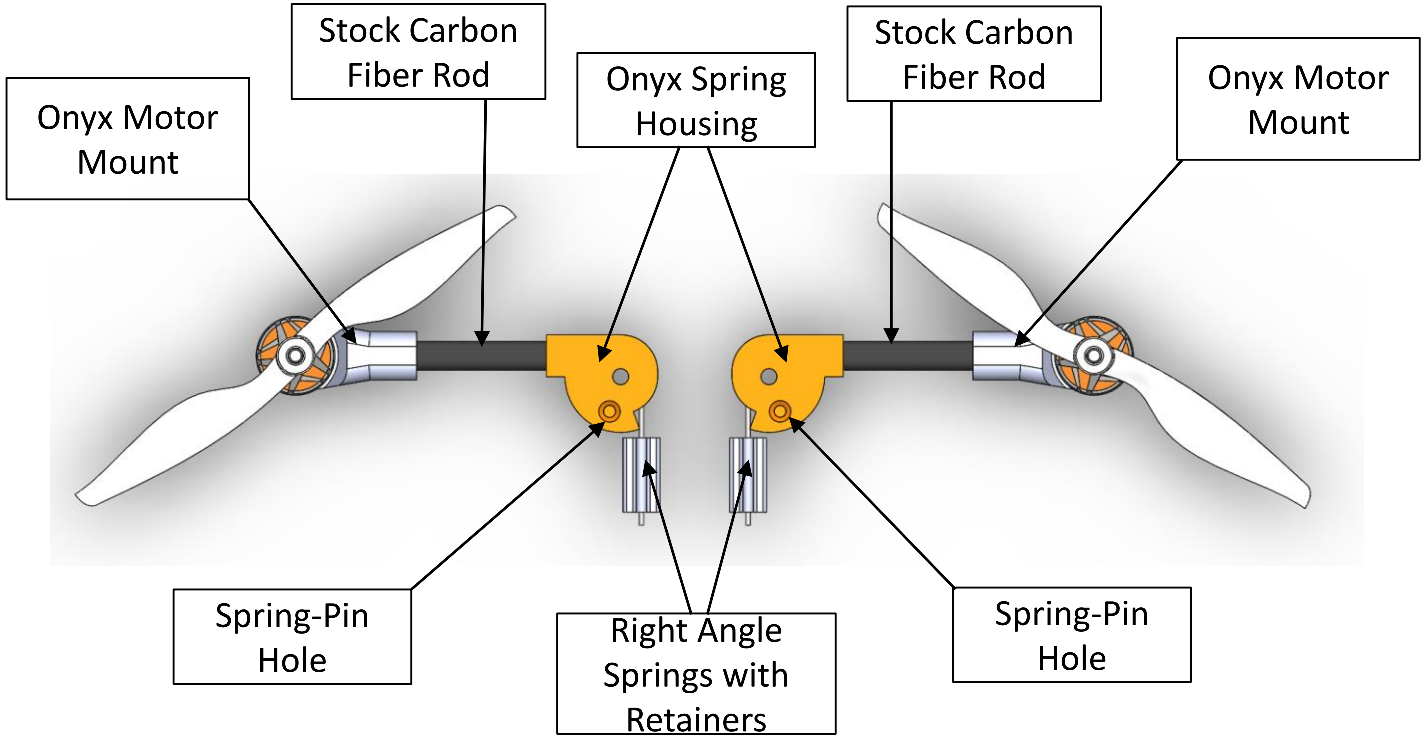
First Prototype → 8 iterations → Final Vehicle

Final Quadcopter Build Components

- Main Body
  - Layup outer shell (balsa wood core)
  - Stock carbon fiber intermediate plates
  - Cutouts for weight mitigation and wire security
- Arms
  - 14-lb right angle springs
  - Onyx print motor mounts and spring housings
  - Stock carbon fiber rod arm structure
  - Spring pin arm mechanism
- Retention
  - 25-mm/40-mm aluminum standoffs, 2-mm bolts
- Rigidity
  - Pin/Epoxy components to absorb spring shock

Final Quadcopter Build





Final Quadcopter Build Components

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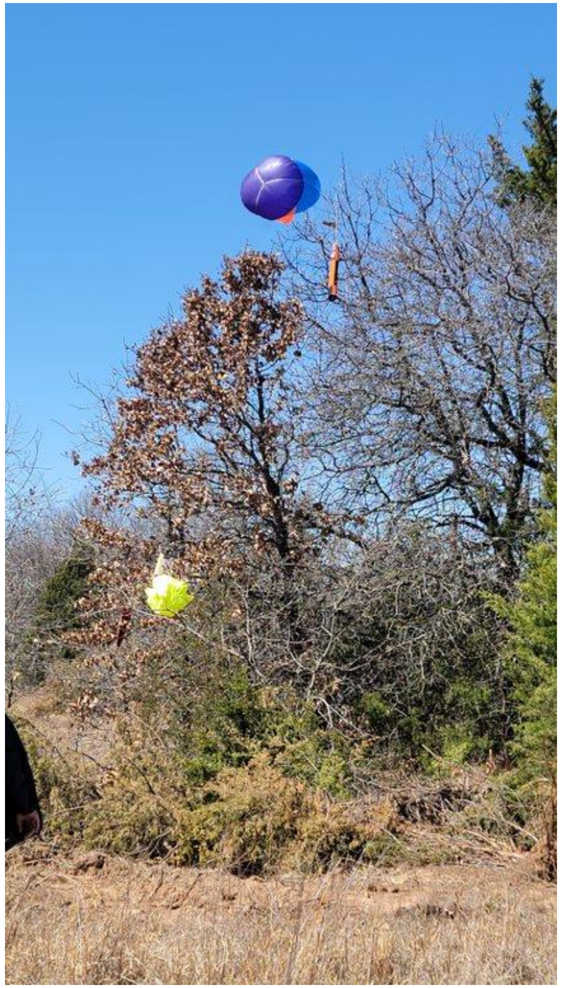
  - Spring-Pin arm mechanism
- Retention
  - 25-mm/40-mm aluminum standoffs, 2-mm bolts
- Rigidity
  - Pin/Epoxy components to absorb spring shock

Full System Test Launches

- 1st test flight – March 26th
  - No quad avionics (had parachute controlled by Jolly Logic – FAILED)
  - Main rocket parachute got tangled in deployment
- 2nd test flight – April 5th
  - With quad avionics but quad got tangled in shock cord around sled
- 3rd test flight – April 6th
  - Full working system
  - Quad had avionics issues, but pilot got it to land close by
  - Rocket got stuck in tree
- All Launches conducted with Aerotech J570



Argonia Cup Weekend

April 9th – 10th – Argonia, Kansas

Overview:

- Launched 2 times out of our 3 allowed attempts
  - Once Saturday at 1pm
  - Once Sunday at 2pm

Saturday Launch:

- 10,917 feet apogee
- Mach 1.1
- 22.75 G
- Quad/golf ball distance: 2.8 miles from target

Sunday Launch:

- 8,108 feet apogee
- Mach 1.0
- 18.75 G
- Quad/golf ball distance: 3,062 feet from target

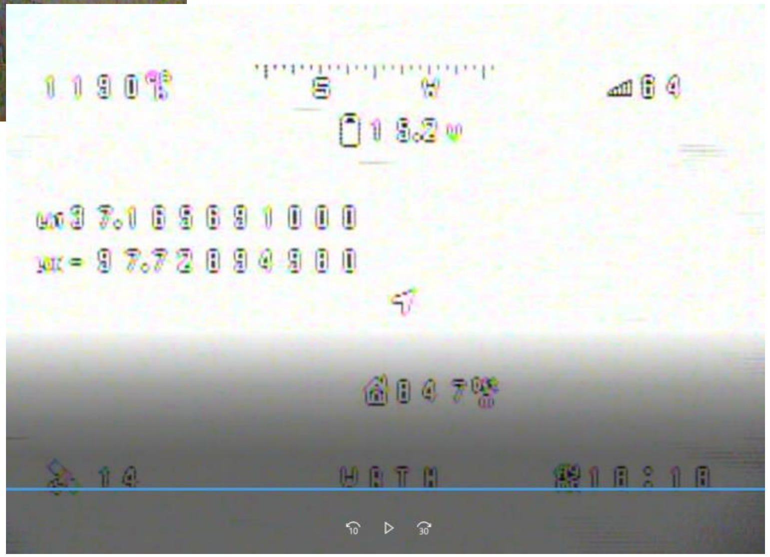
Overall, our team won 3rd place with our Sunday launch.

Argonia Cup Saturday Launch Video

Argonia Cup Sunday Launch Video

Argonia Cup Quad Performance

- Autonomous flight (iNav) incapable of fighting wind
- Clear 5.8 GHz video @800 mW
- Battery life was severely reduced due to windy conditions
  - 10-12 min flight time
- Made OSD adjustments
- Multiple broken parts leading to only 2 flights

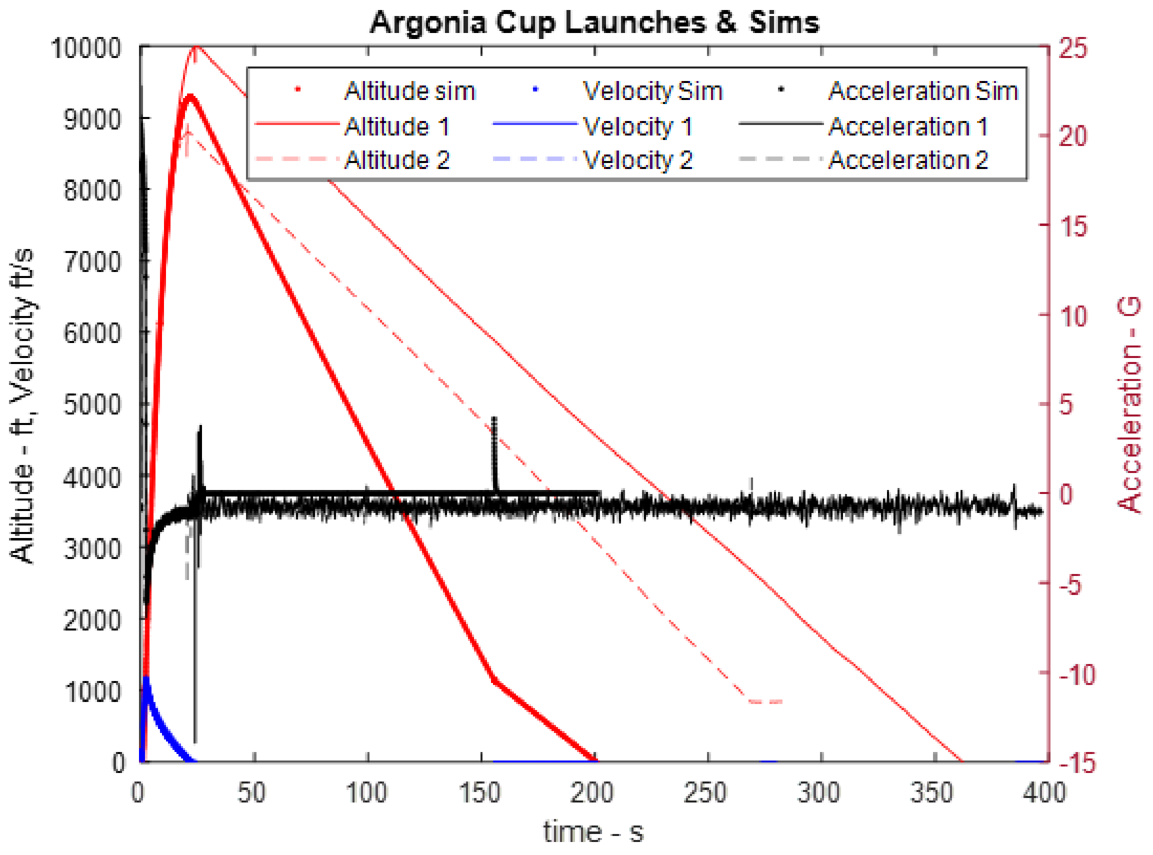


Argonia Cup Rocket Performance

Flight 1
Max Height: 10,926 ft
Max Velocity: Mach 1.1
Max Accel: 22.25 G

Flight 2
Max Height: 8,108 ft
Max Velocity: Mach 1.0
Max Accel: 18.25 G

Lost Ground Telemetry due to the antenna snapping off the TeleMega Board



SpeedFest


OKLAHOMA STATE


Space Cowboys – Argonia Cup Capstone 2022
Hill Jordan, Patrick Williams, Ethan Riffell, Evan Nicholas, Isela Ortiz, Nick Hymel, Taylor Bostick, Trevor Marshall, Zach Montebon
Dr. Jamey Jacob, Andrew Walsh, Bryce Randall
Mission Criteria:
Design, Develop, & Launch
A High-Powered Rocket System capable of reaching 8,000' and returning a golf ball payload to a designated target
Requirements:
Motor Impulse < 5120 N-s (L-class motor or lower)
5:1 Thrust-to-Weight ratio minimum at Takeoff
Minimum Stability Factor of 1 cal.
System must be re-flyable upon recovery
Design (Rocket):
93.3" Tall
4" Diameter
17" Quadcopter Sled
36" Drogue Parachute
48" Main Parachute
Stage separation via black powder charges
Apogee, Drogue, 2.2g
1000ft, Main Parachute, 2.4g
Flight Computers
Altus Metrum TeleMega
Altus Metrum Easy Mini
Competition Motor Aerotech L1940X
Total Impulse: 4330 N-s (973 lbf-s)
Max Thrust: 2340 N (526 lbf)
Burn time: 2.2 s
Design (Quadcopter):
Structures:
H-Style Racing Quadcopter Design
Optimized Mechanics to Allow Foldable Arms to Fit within Rocket Fuselage
Carbon Fiber Arms, Utilizing Onyx Prints for the Mechanical Component Housings and Motor Mounts
Balsawood – Carbon Fiber Layup Material as Outer Shell, Stock Carbon Fiber as Intermediate Structure
Spring-Pin Mechanism to Create a Rigid Relationship Between Foldable Arm and the Quadcopter
Avionics:
Fully Autonomous Capabilities (iNav firmware)
40 km Long Range Radio Communication (TBS Crossfire System)
Long Distance, Line-of-Sight First Person View (FPV) (TBS Unify Pro 5G8 HV running on 800mW)
F7 Flight Controller, 4-in-1 ESC, 4x 1950kv Motors w/ 6"-7" Propellers
Results:
Our team went to Argonia, Kansas for the competition April 9th-10th, 2022.
The team placed 3rd overall with our 2nd launch with an apogee of 8,108 ft and a quad/golf ball distance of 3,062 feet from the target.
Mach 1.0
18.75 G
Our first launch
10, 917 ft
Mach 1.1
22.75 G
Quad/golf ball distance: 2.8 miles from target


oklahoma state university

Parts Lists

- 9 different order lists from February to April
- Difficulties from ordering parts
  - Shipping times longer than expected
  - Stock went quickly
  - Bottlenecked from parts required

Part	Part Number	Quantity	Estimated Cost		Link	Additional Notes
Quad Copter						
Motors	11863	4	$	108.00	https://www.getfpv.com/t-motor-f60-pro-iv-motor.html	
Propellers (7040)	764613338355	2	$	6.00	https://www.getfpv.com/dalprop-cyclone-7040-7-2-blade-propeller.l	Best Prop option. Buying two sets of 4 to have backup
Propellers (6040)	652118489637	2	$	4.00	https://www.getfpv.com/lumenier-6x4-slow-flyer-propeller-set-of-4-(	Second set to test.
Propellers (7050)	686661070394	2	$	5.00	https://www.getfpv.com/apc-7x5ep-speed-propeller.html	Third set to test. CW props
Propellers (7050)	686661070295	2	$	5.00	https://www.getfpv.com/apc-7x5e-speed-propeller.html	Third set to test. CCW props
FC + ESC Stack	14010	1	$	129.00	https://www.getfpv.com/lumenier-lux-f7-ultimate-razor-led-55a-bun	Flight Controller and ESC bundle
Rocket						
Motor Retainer		1	$	51.00	https://wildmanrocketry.com/collections/assembly/products/ra75p	
Rail Guides		1	$	10.00	https://wildmanrocketry.com/collections/rail-guides/products/2052-lg-rail-guides	
Shear Pins	2626	1	$	6.00	https://csrocketry.com/recovery-supplies/shear-pins/shear-pin-4/4(	Shear Pin-4/40
Screw Switch		3	$	12.00	https://wildmanrocketry.com/products/screw-switch	
Low Voltage Cable	9697T1	1	$	5.00	https://www.mcmaster.com/9697T1/	25 Feet
XT30 Connectors	B08H1JP7NW	1	$	12.00	https://www.amazon.com/FLY-RC-Upgrade-Connectors-Battery/dp/B08H1JP7NW/ref=sr_1_2?crid=FQJKY919YH1G&keywords	
Shock Cord		1	$	79.00	https://wildmanrocketry.com/collections/onebadhawk-harnesses/products/4-inch-harness	
Quick Links	2123	4	$	9.00	https://csrocketry.com/recovery-supplies/hardware-and-shock-chor	1/8 Quick Link Stainless Steel
Misc						
Washers	90107A029	1	$	10.00	https://www.mcmaster.com/90107a029/	
Nuts	95462A029	1	$	6.00	https://www.mcmaster.com/95462A029/	
Nylock Nut	90630A110	1	$	5.00	https://www.mcmaster.com/90630A110/	
Threaded Rods	98790A054	4	$	4.00	https://www.mcmaster.com/98790a054/	
Wing Nuts	90866A029	1	$	19.00	https://www.mcmaster.com/nuts/thumb-nuts/steel-and-iron-wing-nuts-8/wing-nut-profile~standard/thread-size~1-4-20/	
RocketPoxy		1	$	65.00	https://wildmanrocketry.com/products/rocketpoxy-2-quart-set?_pos=2&_sid=79c805b2c&_ss=r	
Screwtap	2522A665	1	$	7.00	https://www.mcmaster.com/2522A665/	
Left-hand 4.5 lb spring	9271K585	1	$	6.00	https://www.mcmaster.com/torsion-springs/torsion-springs-5/deflection-angle~90-/	
Right-Hand 4.5 lb spring	9271K651	1	$	6.00	https://www.mcmaster.com/torsion-springs/torsion-springs-5/deflection-angle~90-/	
Left-hand 7.9 lb spring	9271K145	1	$	8.00	https://www.mcmaster.com/torsion-springs/torsion-springs-5/deflection-angle~90-/	
Right-hand 7.9 lb spring	9271K151	1	$	8.00	https://www.mcmaster.com/torsion-springs/torsion-springs-5/deflection-angle~90-/	
		Subtotal	$	585.00		
		Est. Tax	$	46.80		
		Total	$	631.80		

Final Budget

- Simplified Final Budget
  - Backfilling USRI materials included
- Specific Order Lists included in Argonia Archive zip folder

Order List	Amount
11-Feb	$ 585.00
16-Feb	$ 521.00
28-Feb	$ 54.00
4-Mar	$ 322.00
5-Mar	$ 841.00
9-Mar	$ 915.00
28-Mar	$ 156.00
Total	**$ 3,394.00**

Questions

THANK YOU

OKLAHOMA STATE UNIVERSITY MECHANICAL & AEROSPACE ENGINEERING

ARGONIA CUP EST. 2017

Capstone Retroactives

Rocket Retroactives:

- Do not thread inner couplers
- Have 2-3 altimeter Wands
- Fix bending in the sled (minor)
- Triple check Telemega antenna
- Use Wildman ignitors (Aerotech suck)
- Close forward closure on motor before aft
- Use Epoxy nuts for payload section

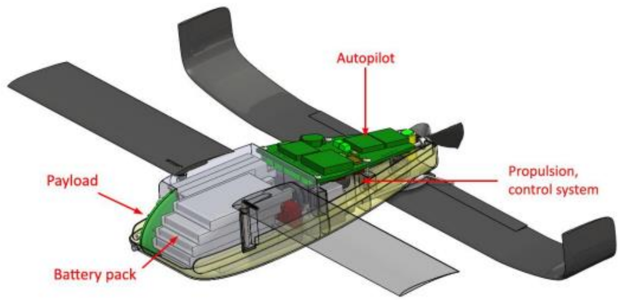
Quad Retroactives:

- Deploy quad around 2000’ to limit lateral distance from target (quad can catch itself quickly which negates the main concern with a low altitude deployment)
- Have live telemetry using RFD’s to ensure connection isn’t lost as easily / have another redundancy
- Tune quad autopilot better to work in high winds, winds aloft much stronger than ground winds.
- Add another camera looking downward to ensure closest landing to the X as possible
- Bring 4 fully functional quads in case something breaks outside of a competition launch (like during testing at the competition)
- Plan on losing a full quad during each launch (worst case scenario)

Project Importance

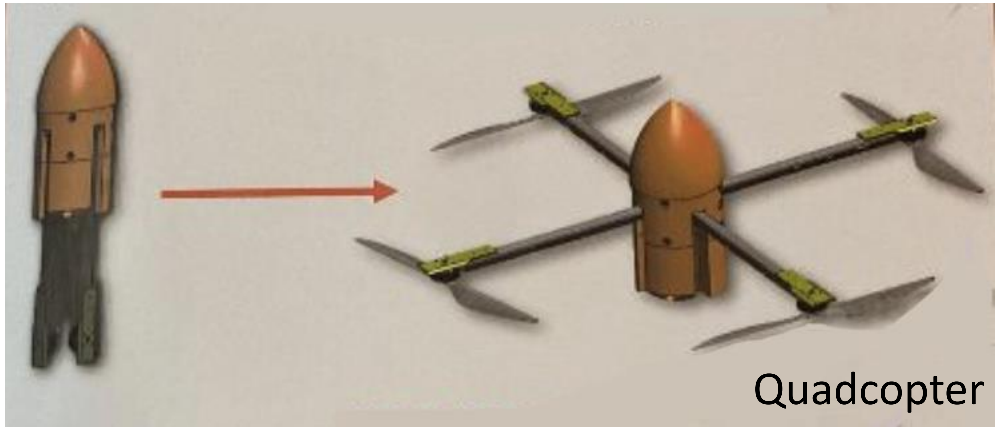
- High Powered Rockets with the capability to launch complex payloads are an area of growing interest
- Optimize High Altitude Rocket
  - Reduce mass, increase aerodynamics to increase apogee
  - Increase control and navigation
- High-Altitude Payloads with the ability to autonomously navigate can
  - Be used to conduct atmospheric research
  - Quickly deploy payloads to high altitudes
  - Deliver payloads to hard-to-reach locations
  - Provide local surveillance

Summary of Trade Study Designs



Glider

vs.



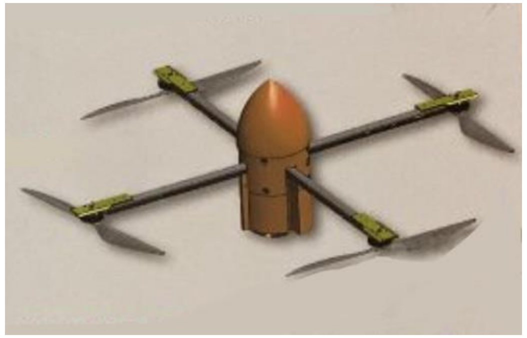
Pros:
- Previous class experience
- Deploy at highest altitude if wanted
- Adjustable Design Characteristics
- Range/Endurance

Cons:
- Less Landing Control
- Larger/Longer Design
- Compartmentalization/Deployment

Pros:
- Maneuverability
- Higher end goal accuracy
- Low weight

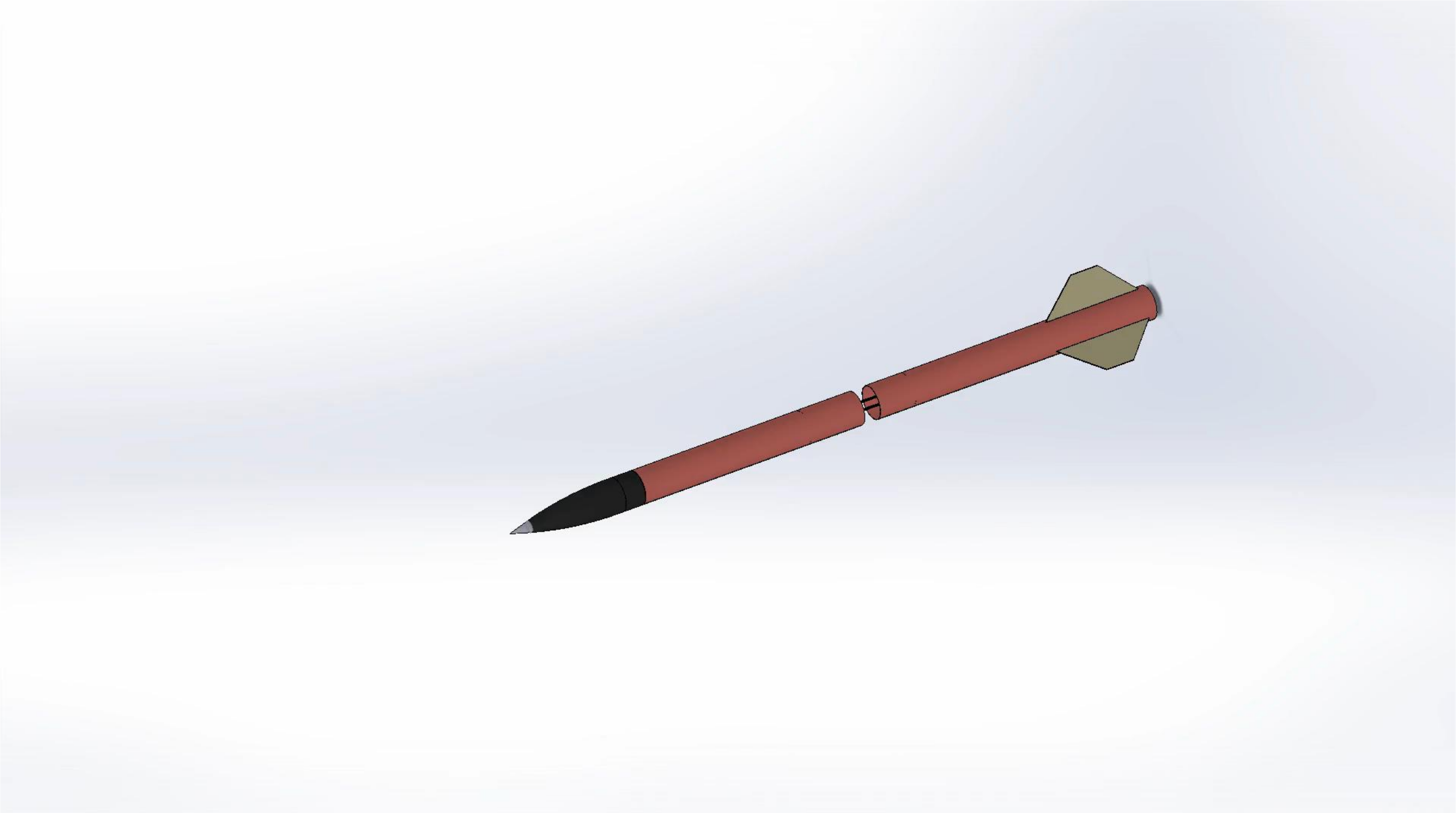
Cons:
- Reliability with differing wind resistances
- Landing durability
- Max flight time/distance concerns

Quadcopter Trade Study

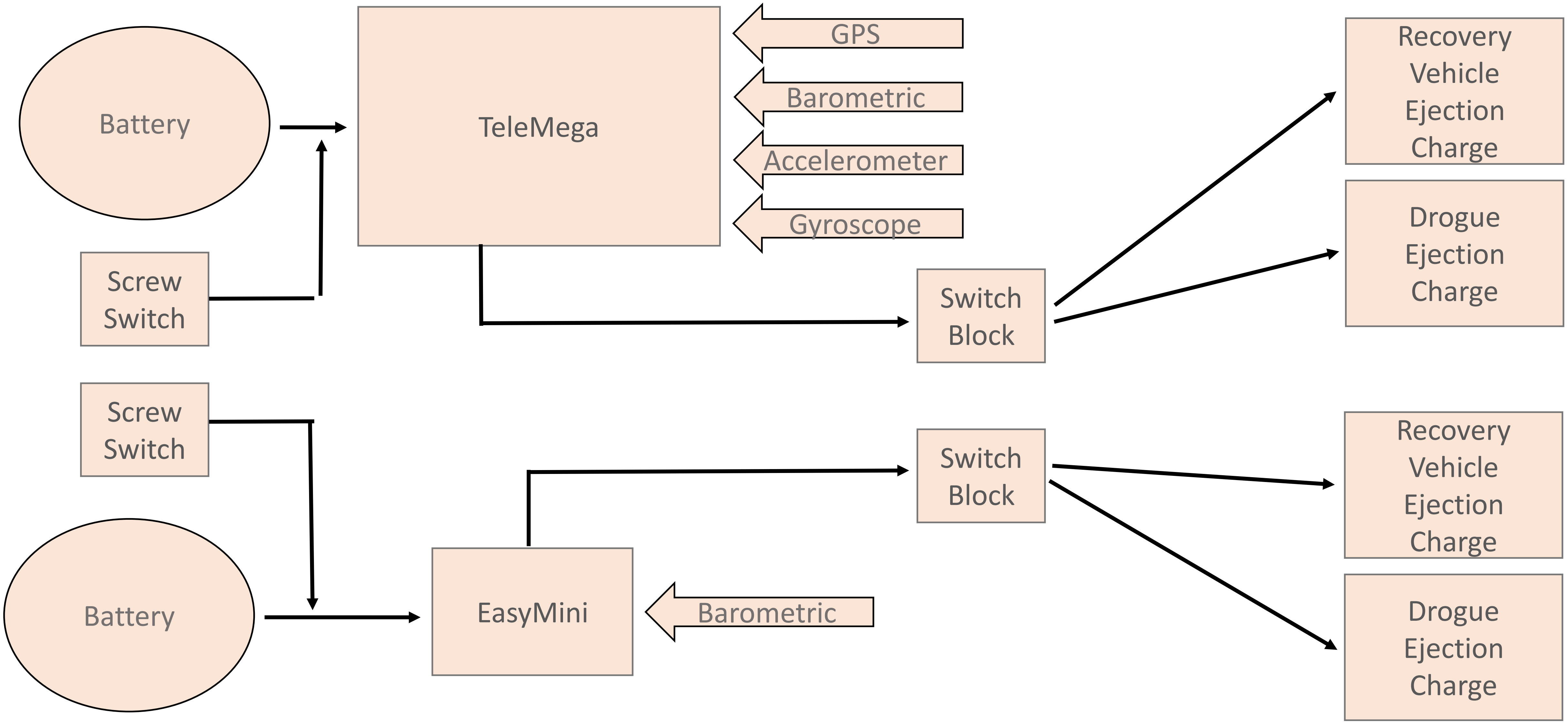


Microscale	Nose cone	H, racing
Pros • Fits in body • Lightweight • Simple (no springs)	**Pros** • Nice integration • Aesthetically pleasing • More space for payload/avionics	**Pros** • Basic • Manufacturability • Fits in body
Cons • Battery life • Limited room for avionics • Low wind resistance	**Cons** • Manufacturability • Stability • Has been done before (2018)	**Cons** • Integration • Deployment • Takes up most room

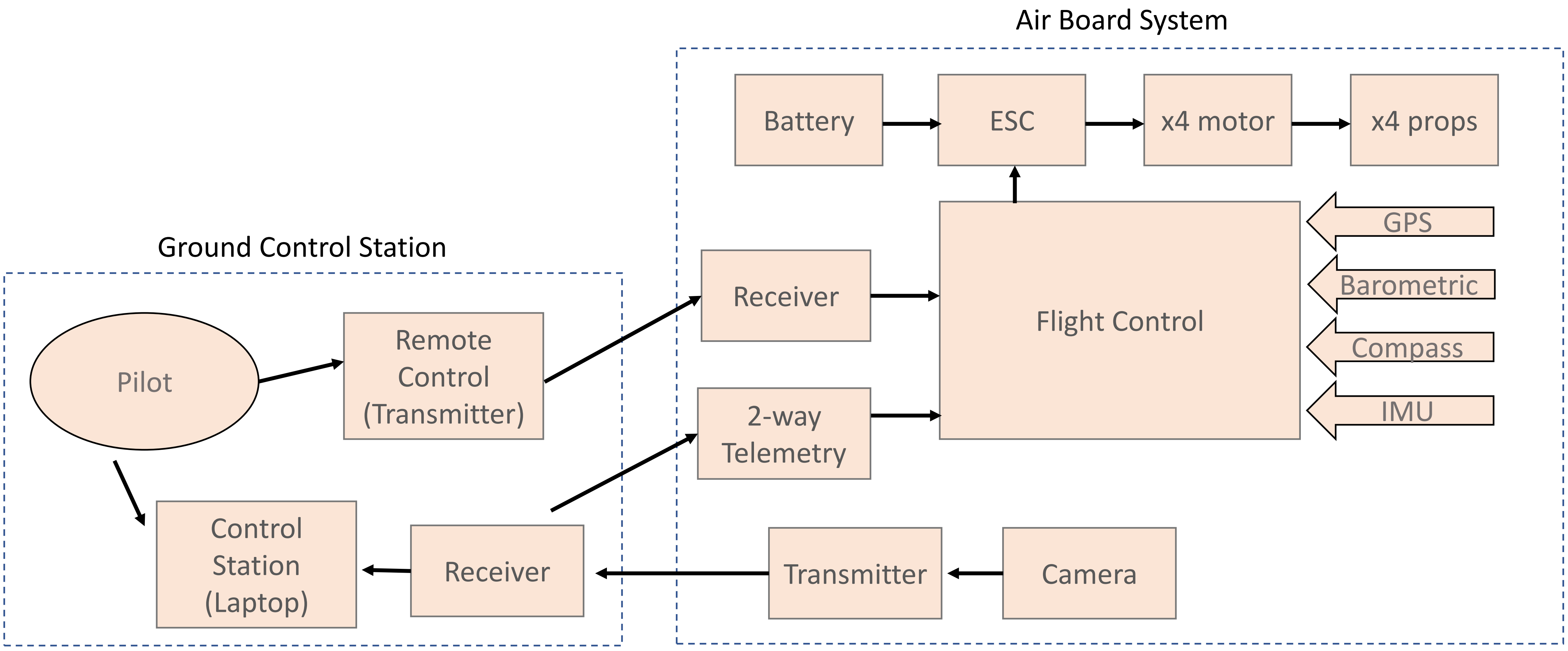
Point of Departure Design



Block Diagram of System – Rocket + Quad



Block Diagram of Recovery Vehicle



Design Details - Initial Rocket Layout

#	Component	Description	Size (Diam, len.)
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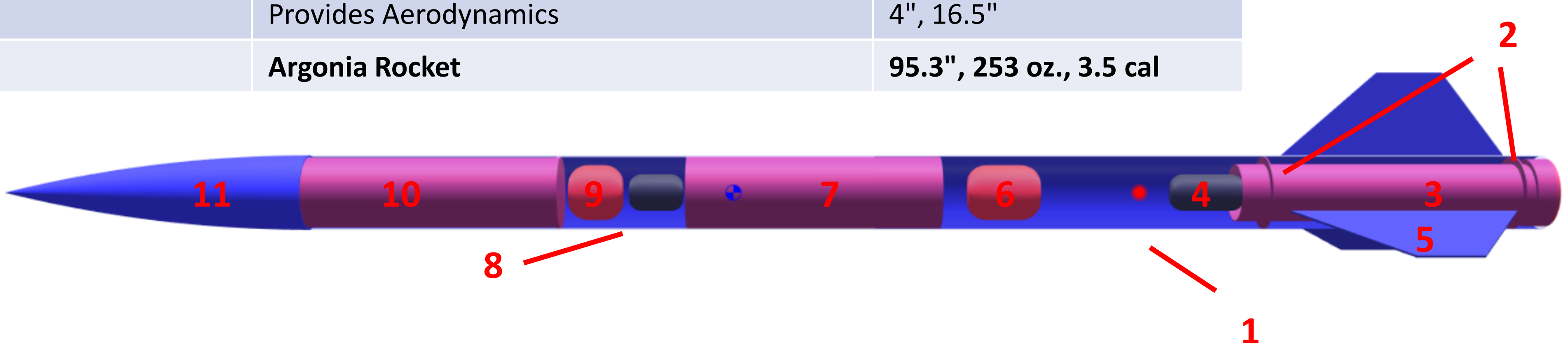
2	Centering Rings	Centers Motor Mount in Sustainer	3.9-3.1", .08"
3	Motor Mount/Retainer	Holds 75 mm Motor in rocket	3.1", 16"
4	Solid Rocket Motor	Propels the rocket forwards	75mm, varies
5	Fins	Provides Aerodynamic Stability	
6	Drogue Parachute	Slows rocket during ascent	36", N/A
7	Avionics & Slip band	Holds two halves together, controls separation	3.9", 13.5"
8	Payload Section	Contains Drone & Main Parachute	40.5"
9	Main Parachute	Slows Rocket for Drone & Ground Hit	60", N/A
10	Drone Sled / Nosecone Coupler	Holds nosecone on rocket, holds drone	3.8", 16"
11	Nosecone	Provides Aerodynamics	4", 16.5"
	Total	**Argonia Rocket**	**95.3", 253 oz., 3.5 cal**



Rocket Motor

default windspeed: 8mph		Motors											
default launch angle: 0 deg		1365			1420			4263-L1350			L851		
	Mass	Apogee (ft	Max G	Max V (ft/s)	Apogee (ft)	Max G	Max V (ft/s)	Apogee (ft)	Max G	Max V (ft/s)	Apogee (ft)	Max G	Max V (ft/s)
-15	13.43	11206	14.3	1270	10917	15.5	1287	9980	15.7	1271	9273	9.4	1030
-10	14.22	11096	13.8	1235	10810	15	1249	9908	15.1	1233	9122	9.06	999
-5	15.01	10983	13.4	1201	10703	14.5	1214	9784	14.6	1197	8956	8.73	969
0	15.8	10867	12.9	1170	10593	14.1	1181	9651	14.1	1162	8777	8.42	940
+5	16.59	10744	12.5	1139	10472	13.7	1149	9559	13.6	1130	8598	8.13	912
+10	17.38	10604	12.1	1110	10339	13.3	1119	9390	13.2	1098	8403	7.87	885
+15	18.17	10445	11.8	1081	10188	12.9	1089	9250	12.7	1067	8211	7.61	859
+20	18.96	10280	11.4	1054	10024	12.5	1060	9081	12.3	1038	7998	7.37	834
+25	19.75	10110	11.1	1027	9858	12.1	1033	8900	12	1009	7778	7.14	810

The Rocket Motor was selected by:

- Limited to Aerotech & Cesaroni
- Varying the total Mass & CG: +- 25%
- Limited to L-class motors
- Preferred Apogee of 9000 ft or greater to account for simulation errors/losses
- Selected the **Aerotech L1365** for Modeling Purposes

System Simulation - OpenRocket

- Simulation Data varying wind speed, launch angle, and vehicle deployment altitude

Wind Speed: 16mph	Deployment Altitude (ft)			
Launch angle: 6° upwind	**3500**	**4000**	**4500**	**5000**
Lateral Distance from target (ft)	1020	1265	1380	1525
Deployment Vehicle Velocity (fps)	59.7	59.8	59.9	59.9

Wind Speed: 8mph	Deployment Altitude (ft)			
Launch angle: 6° upwind	**3500**	**4000**	**4500**	**5000**
Lateral Distance from target (ft)	1770	1820	1840	2000
Deployment Vehicle Velocity (fps)	59.7	60.2	60.7	61.1

Wind Speed: 16mph	Deployment Altitude (ft)			
Launch angle: 6° downwind	**3500**	**4000**	**4500**	**5000**
Lateral Distance from target (ft)	3510	3350	3100	2970
Deployment Vehicle Velocity (fps)	59.9	60.3	60.7	61.1

Wind Speed: 8mph	Deployment Altitude (ft)			
Launch angle: 6° downwind	**3500**	**4000**	**4500**	**5000**
Lateral Distance from target (ft)	2760	2820	2660	2460
Deployment Vehicle Velocity (fps)	59.8	60.2	60.6	61.1

Wind Speed: 16mph	Deployment Altitude (ft)			
Launch angle: 0° vertical	**3500**	**4000**	**4500**	**5000**
Lateral Distance from target (ft)	1100	1130	850	560
Deployment Vehicle Velocity (fps)	59.7	60.1	60.6	61.1

Wind Speed: 8mph	Deployment Altitude (ft)			
Launch angle: 0° vertical	**3500**	**4000**	**4500**	**5000**
Lateral Distance from target (ft)	550	480	230	200
Deployment Vehicle Velocity (fps)	58.6	59	59.2	59.5

Design Details - Rocket Deployment

The Rocket will utilize the Telemega, EasyMini, and black-powder for deployment

- At Apogee – deploy sled & 36" Drogue
- At 5000 ft. – deploy 60" main
- Deployment Altitude was chosen at apogee
  - Minimize distance to the target
  - Deploy the drone <= 40 ft/s
  - Ensure Ground Hit <= 32 ft/s

Design Details - Quadcopter Structure

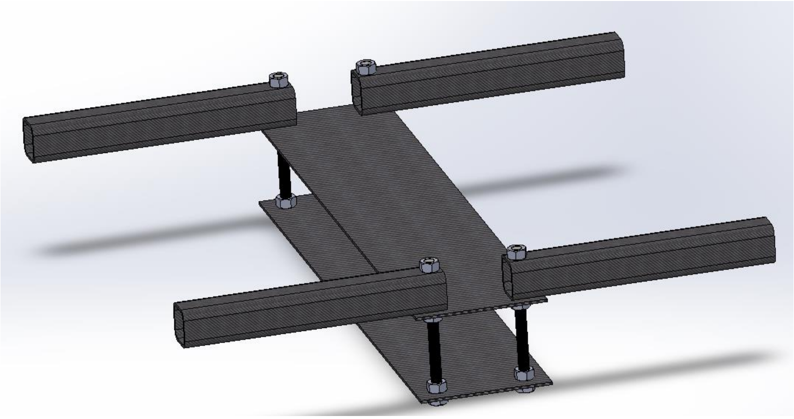
- Structural Objective
  - Fitted payload integration
  - Deployment after launch
  - Avionics placement
  - Recovery capability
- Compartment Limitation
  - Golf ball payload allocation
  - Antenna apart from GPS
  - Extensive battery height
  - Bolt spacing efficiency
- Deployment Obstacle
  - Motor/Propeller security
  - Arm extension

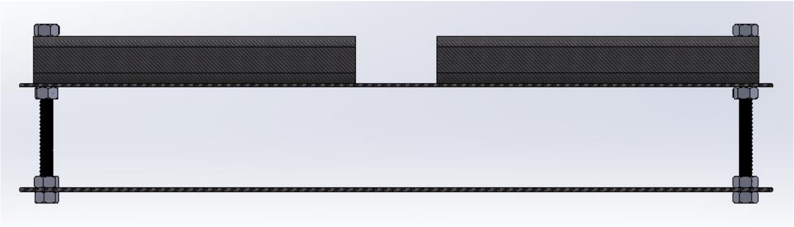
Weight Estimation

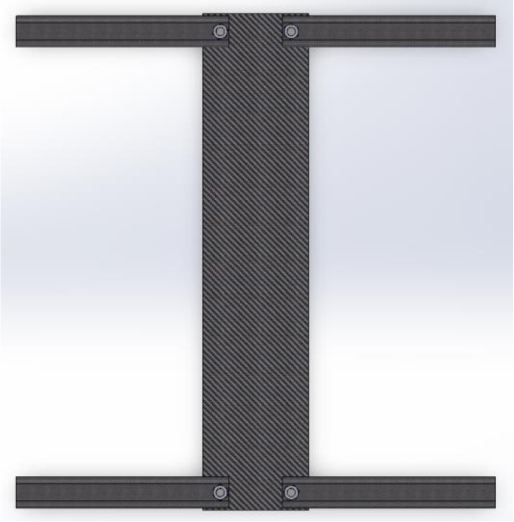
Empty Weight	0.75 lbs
Avionics Weight	0.5 lbs
Drive Weight	2.5 lbs
Target Weight	**3.75 lbs**

Initial Structural Design Iteration

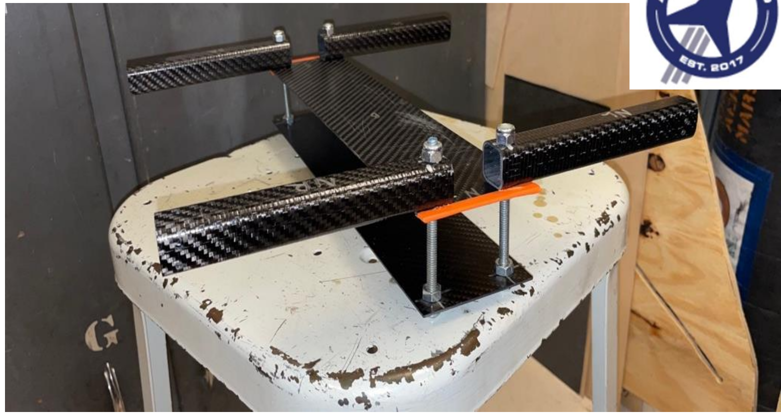
- Design Aspects
  - Compact Avionics
  - Topside Arms/Propellers
  - Secured Payload
- Potential Issues
  - Arm Sizing - Height
  - Bottom Platform - Width
- Potential Solutions
  - Redesign Arms
    - Flat Plate
  - Redesign Bottom
    - Taper Body
    - Shave/Round Edges







Quadcopter Prototype



Loaded

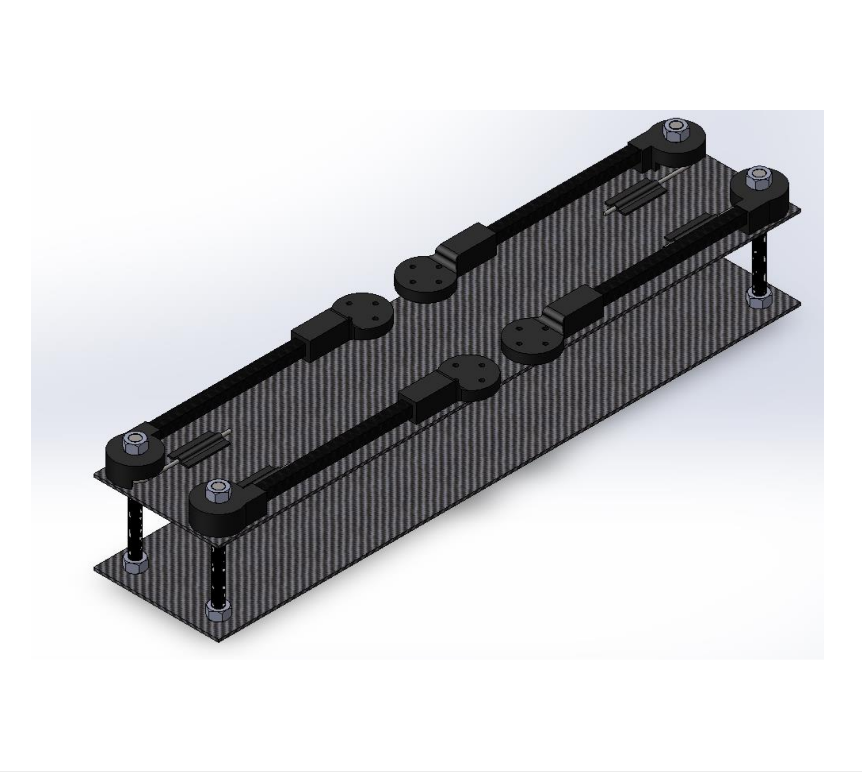
Unloaded

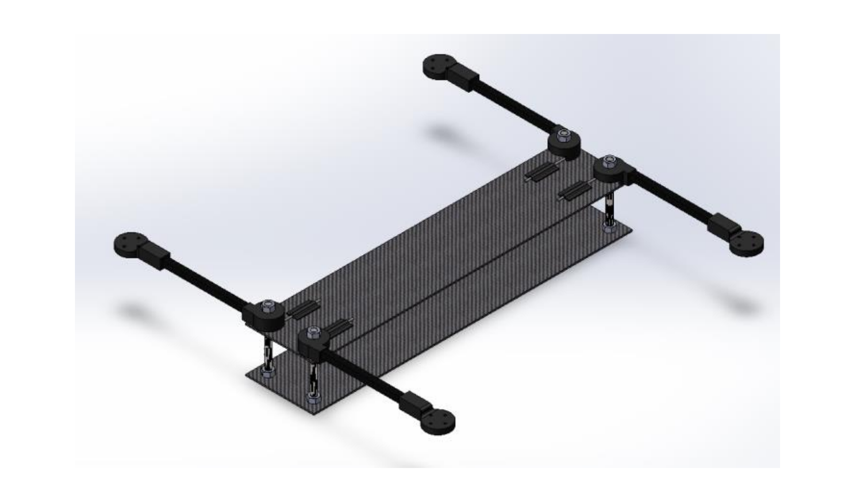
- ➢ Prototype Mission Objective
  - Flight capability assessment
  - Determine vehicle sizing with drive and avionics
- ➢ Prototype Neglection
  - Precise rocket integration sizing
  - Propeller arm deployment

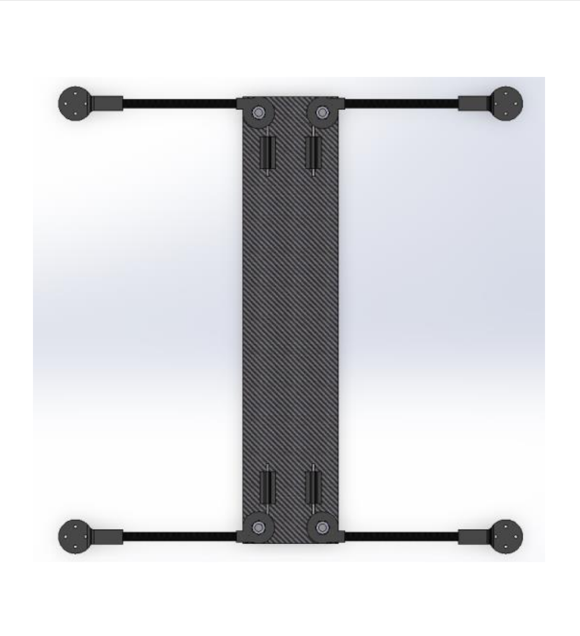
← Arm Fold/Extension Mechanism

Innovative Design Iteration

- Updated Characteristics
  - 0.25”x0.25” Arms
  - ~8 lb. 90 degree Torsion Springs
  - Fixed Bracket Mount for Spring
  - Rotating Bracket Mount for Spring and Arm
  - Motor Bracket Mount on Arm







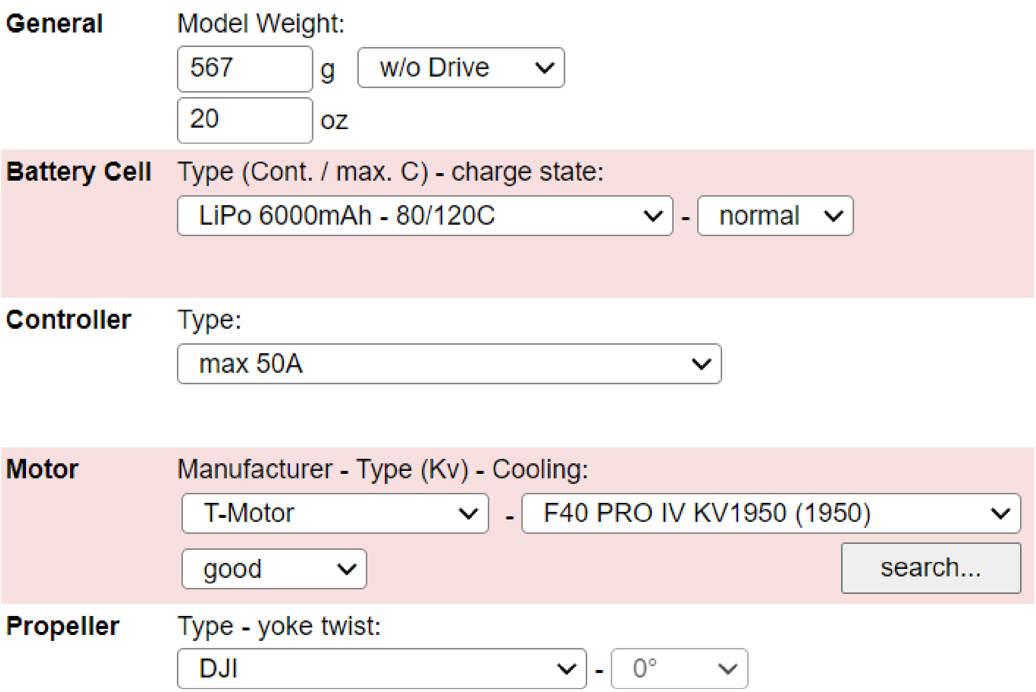
System Simulation - Ecalc

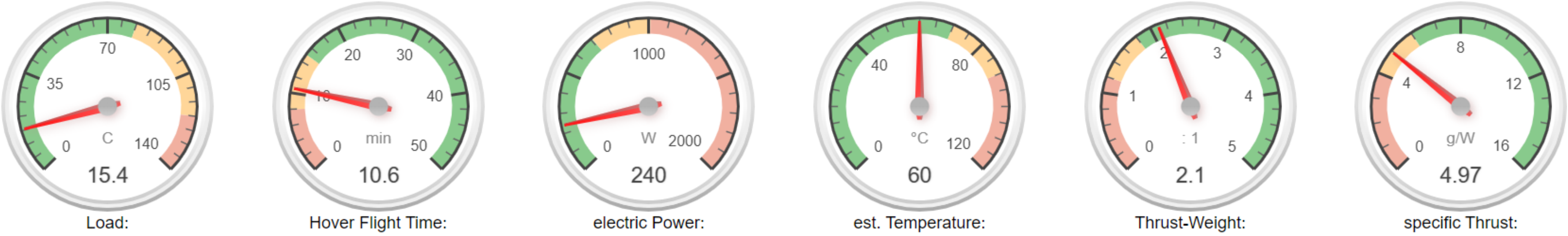
Quadcopter Simulation

- Estimates performance based off off-the-shelf components (~15% accuracy)
- Includes a KV Wizard which gives an estimated motor size based off estimated vehicle size

Design Choices

- Main goal to maximize endurance and range while minimizing weight
- Best choices are a battery between 6000-8000 mAh and a motor between 1800-2400 Kv



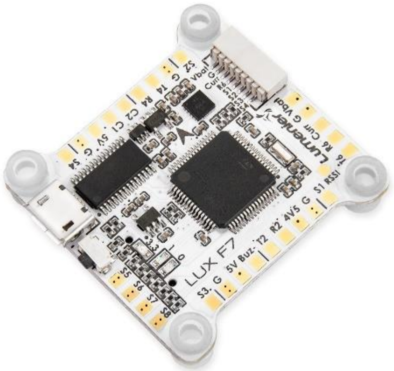


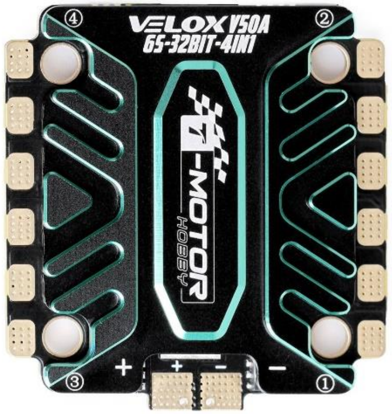
Design Details – Quadcopter Drive

- T60 IV PRO KV1750
- 6200 mAh 4 cell 25c LiPo battery
- 7-inch 2 blade propeller with a 4-inch pitch

First Iteration Design - Quadcopter Avionics

- Avionics List:
  - Flight Stack
    - Electronic Speed Control (T-Motor VELOX V50A 3-6S)
    - Flight Controller (Lumenier LUX F7 Ultimate)
  - Receiver (FrSky RX8R)
  - Radio/Controller (FrSky Taranis)
- Programs:
  - BetaFlight
  - iNav





Future Design Implementations – Quadcopter Avionics

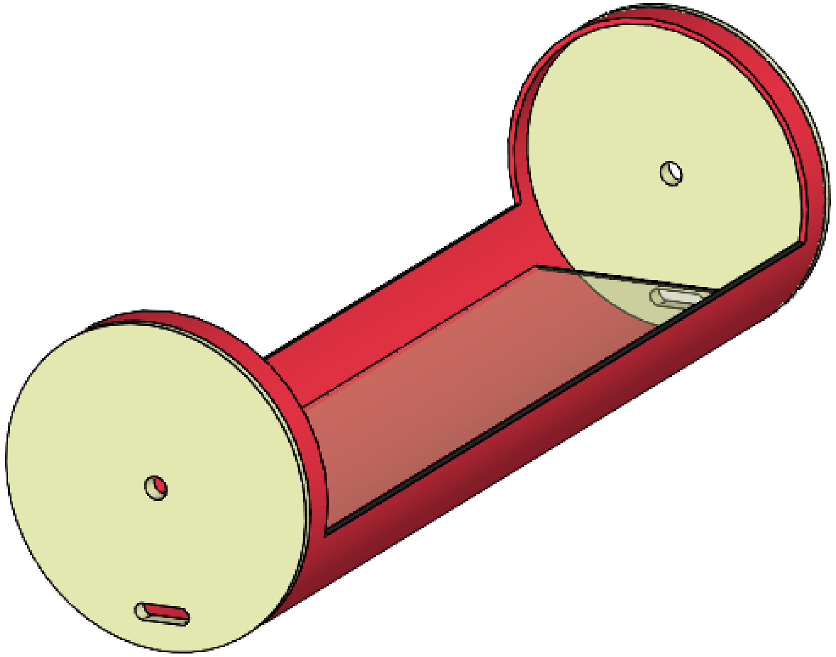
- Pixhawk Orange Cube
- Here2 GPS
- FPV System
  - RunCam Split
  - 1.2/2.4 Ghz System
- Dragon Link Advanced 915 MHZ

Design Details - Quadcopter Avionics

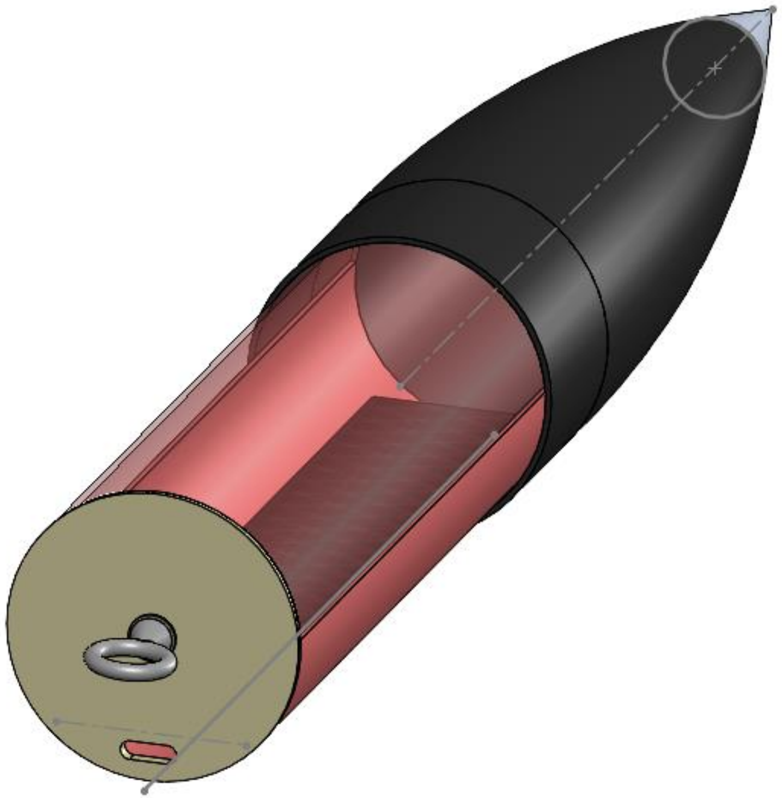
- Current avionics layout:

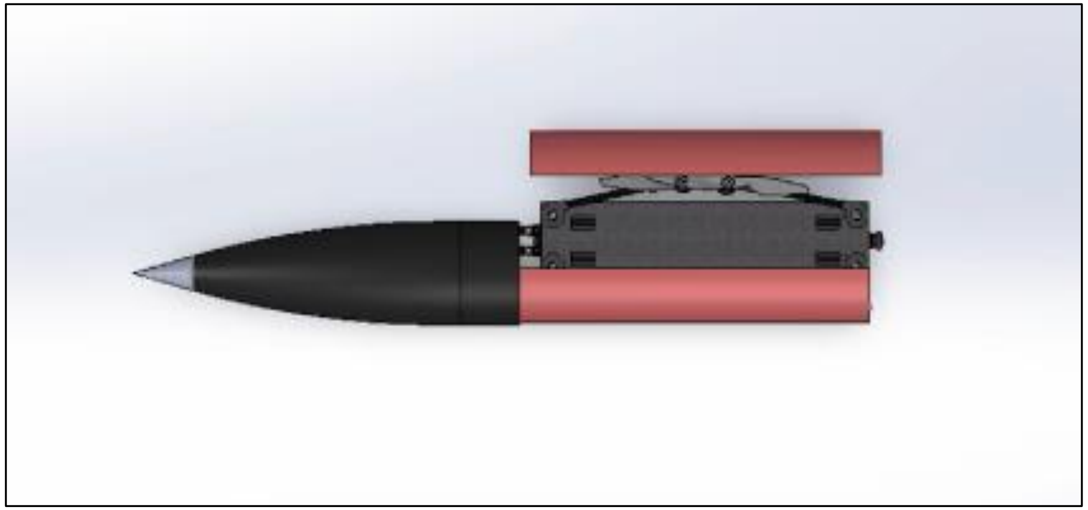
Quadcopter Deployment - Design Ideas

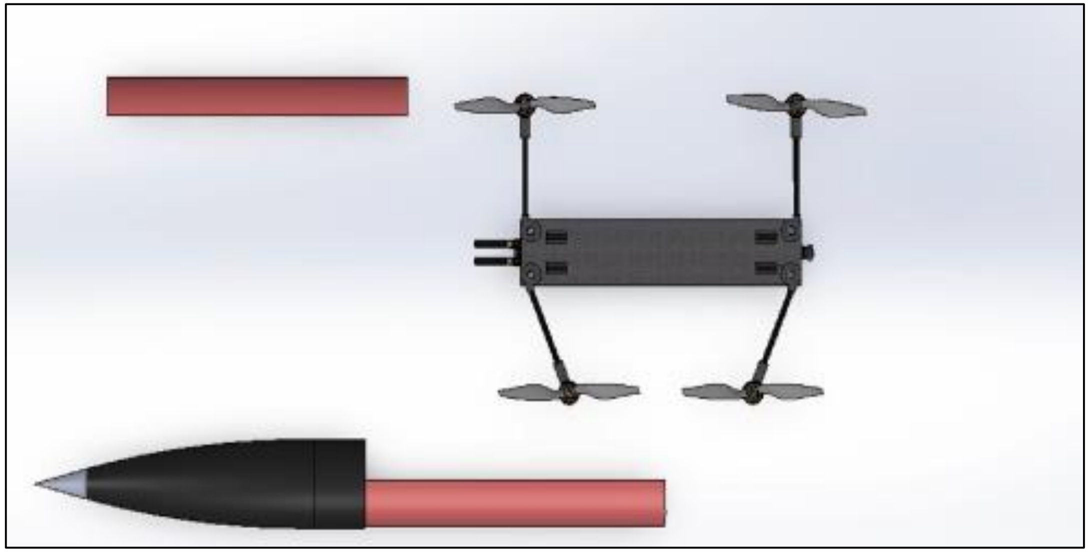
- Spring Loaded Arms
- Servos
- Sled to protect the vehicle
- Integrating the sled into the nose cone



Quadcopter Deployment - Current Design

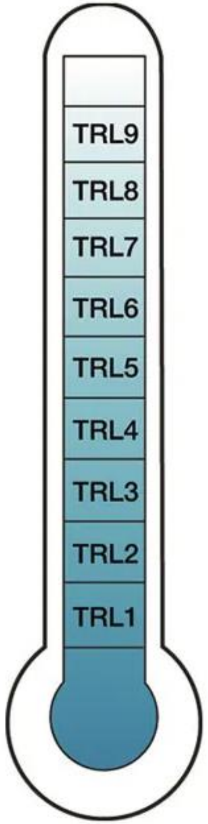






Technology Readiness Level

- Start of project
  - TRL 1
- CDR
  - TRL approaching 5
- Argonia Cup
  - TRL 8



Trip to Argonia, KS (2/12)

The team went up to the Kloudbuster Rocket Pasture last Saturday

Patrick Attempted His L2

- Passed the Written Exam
- But the rocket shredded during deployment
- Will try again March 12th.

Budget

Product Name	Part	Quantity	Cost estimate
Quadcopter			
Lumenier 8000mAh 4s 25c Lipo Battery	Battery	2	$ 200.00
APC 8x4.5MR	Propellers	2	$ 6.00
APC 8x4.5MRP	Propellers	2	$ 6.00
APC 7x5E	Propellers	2	$ 5.00
APC 7x5EP	Propellers	2	$ 5.00
DALProp Cyclone 7040	Propellers	2	$ 6.00
Holybro Micro OSD V2	OSD	1	$ 16.95
Pixhawk Power Supply	Power Supply	1	$ 27.00
RunCam Swift 2 FPV Camera 130deg 2.5mm	FPV Camera	1	$ 32.00
TBS Unify Pro 5G8 HV	VTX	1	$ 56.00
TBS Circular 5.8 GHz Polarized Antenna	Antenna	1	$ 27.00
T-Motor F60 PRO IV V2.0 1950KV	Quad Motors	4	$ 108.00
Lumenier Flight Stack	ESC/FC	1	$ 170.00
		Subtotal	**$ 670.00**
Rocket			
TBD	L-Class Motor	4	$ 750.00
TBD	K-Class Motor	2	$ 260.00
Scratch Rocket	Scratch Rocket	1	$ 530.00
RA75P	Motor Retainer	1	$ 51.00
2052-LG RAIL GUIDES	Rail Buttons	1	$ 10.00
Shear Pin 4/40	Shear Pins	1	$ 5.50
Screw Switch	Screw Switch	3	$ 12.00
Low-Voltage Cable 24 Gauge	25 ft Cable	1	$ 4.50
20 Pairs Amass XT30U Male Female Bullet Connectors Power Plugs	Male-Female Adapters	1	$ 11.99
		Subtotal	**$ 1,640.00**
Connections			
4" Harness Set	Shock Cord	1	$ 79.00
1/8 Quicklink Stainless Steel	Quick Links	4	$ 9.00
316 Stainless Steel Washer for 1/4" Screw Size, 0.281" ID, 0.625" OD	Washers	1	$ 10.01
from rocket room or Medium-Strength Steel Hex NutGrade 5, Zinc-Plated, 1	Nuts	1	$ 5.56
High-Strength Steel Nylon-Insert Locknut	Nylock Nut	1	$ 4.49
Grade 8, 1/4"-20 Thread Size	Threaded Rods	4	$ 3.40
Zinc-Plated Steel Wing Nut, 1/4"-20 Thread Size, 31/64" Base Diameter	wing nuts	1	$ 18.29
		Subtotal	**$ 130.00**
Rocket Sled			
G12CT-4.0	16" Couple/AV Bay	1	$ 42.56
AV-Bay Lid 98mm	Lid for Sled	2	$ 40.00
		Subtotal	**$ 90.00**
Assembly			
RocketPoxy	Rocket Poxy 2 Quart	1	$ 65.00
Thermal Weld		1	$ 8.00
Screw Tap 4-40		1	$ 6.67
Carbon Fiber Sheet Stock	60TY84	4	$ 148.44
Carbon Fiber 1/4" Tubing	DragonPlate Carbon Square Tube	2	$ 31.36
Left-hand 4.5 lb spring		1	$ 5.57
Right-Hand 4.5 lb spring		1	$ 5.57
Left-hand 7.9 lb spring		1	$ 7.70
Right-hand 7.9 lb spring		1	$ 7.70
		Subtotal	**$ 290.00**
		Total	**$ 2,820.00**

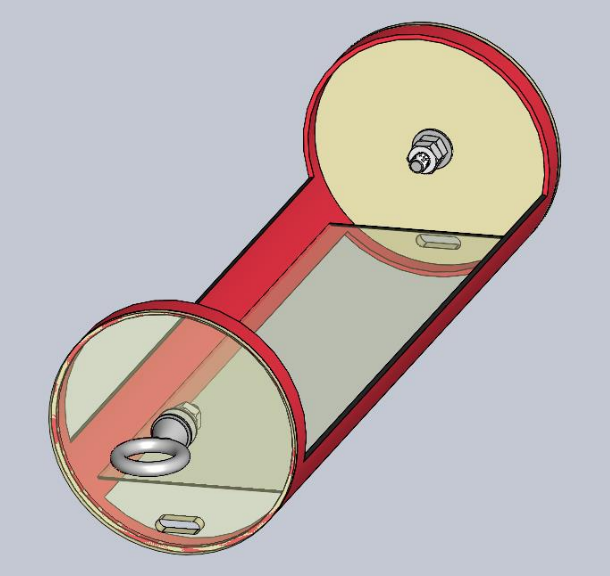
- Budget total is estimated at **$2,820.**
  - Reused parts left out
  - Reusing more parts to lower budget if possible
- Expensive line items
  - Rocket Motors
  - New Rocket Body
    - Wildman Components
  - Batteries and Avionics
  - Carbon Fiber Structure

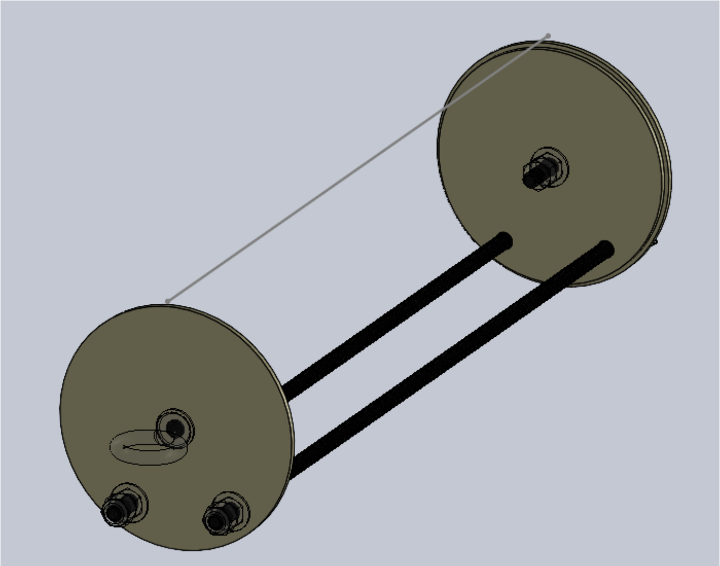
Alternative Sled Designs

These Designs can be integrated into the Nosecone or the Payload tube, the goal is to protect the drone for black-powder ejections.

Possible solutions to release/deploy the sled from the rocket

- Gravity & Spring Potential Energy
- Pin Servo
- Electromagnet
- Clamp
- Quick-release system
- Rubber band cut servo





Available Motors

These are the motors ordered for the 2020 team at Excelsior

- We would like to split them with the club team for testing if possible

- 75mm
  - L851 x1
- 54mm
  - K780-15A x1
  - K270W-PS x1
  - K480W-PS x2
- 38mm
  - K570W-14A x4
  - J94-P x1

Motor (Base Assumptions)	Apogee (ft)	Max Accel. (G)	Max Vel. (ft/s)
K780	5337	10.2	688
K270W	4817	3.68	470
K480W	5697	9	651
K570W	5174	9.2	627
J94-P	272	1.06	124

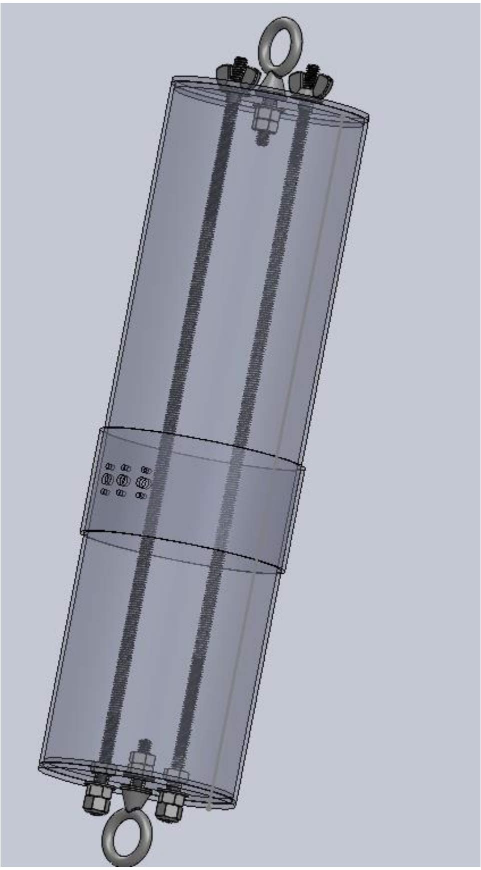
Rocket Avionics Layout

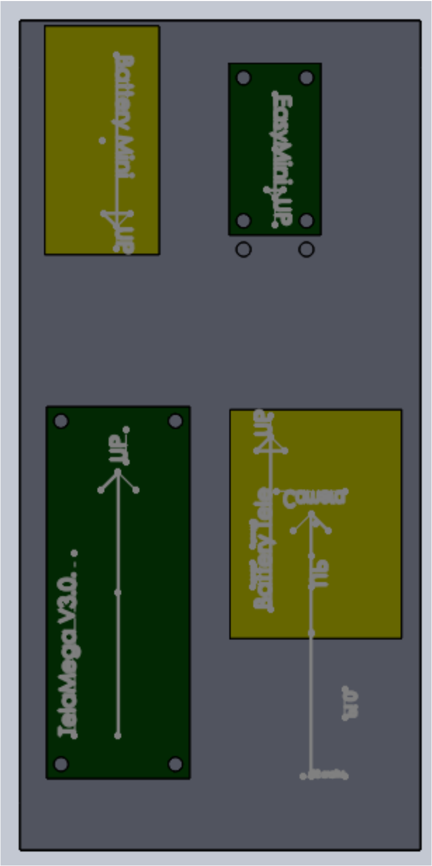
Possible Rocket Avionics Sled Showing

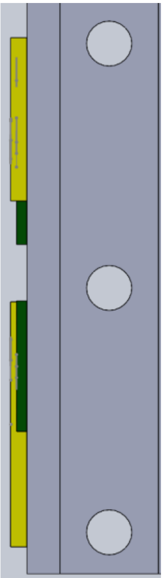
- Placement of batteries
- Placement of Flight Computers
- Orientation
- Holes for Threaded Rods

Total Components

- Two Batteries
- TeleMega
- Easy Mini
- 2 Threaded Rods
- 4 Securing Bolts

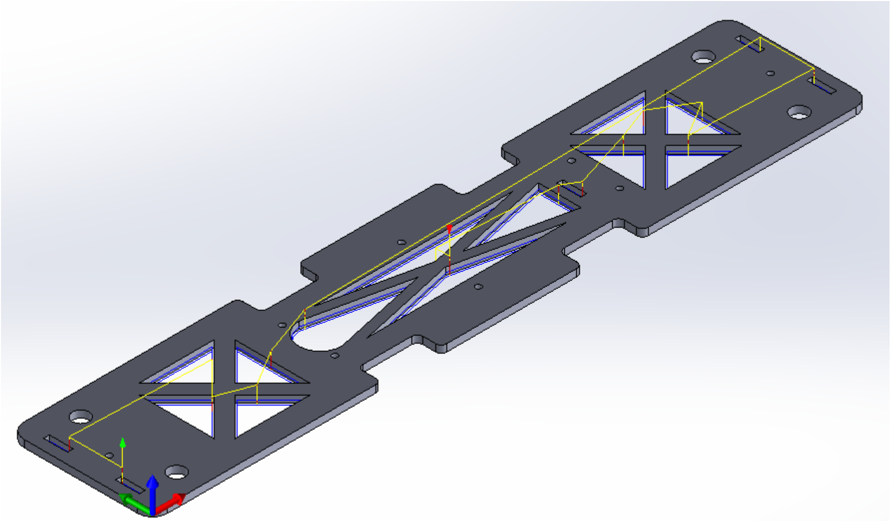






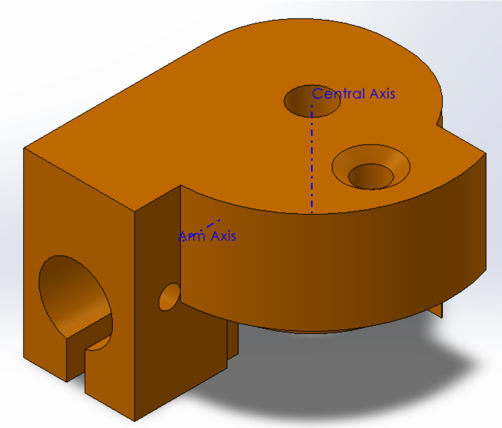
Part Manufacturing: Carbon Fiber

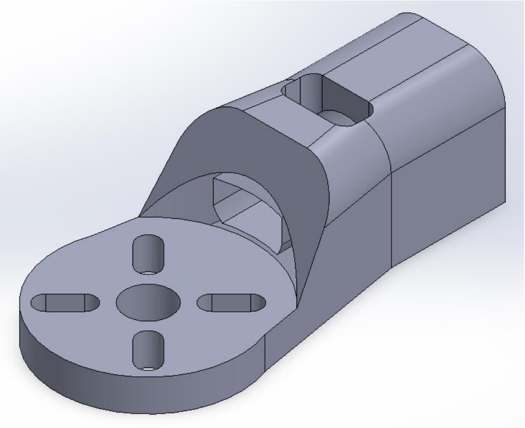
- The entirety of the quad's carbon fiber structure was optimized and cut on the CNC machine to achieve a perfect fit within the rocket
- Desired part modelled in Solidworks
- Machine pathing created in HSMworks
- Carbon fiber composites were first created (or scrapped), and prepared
- Parts imported and prepared to CNC with machine at Excelsior

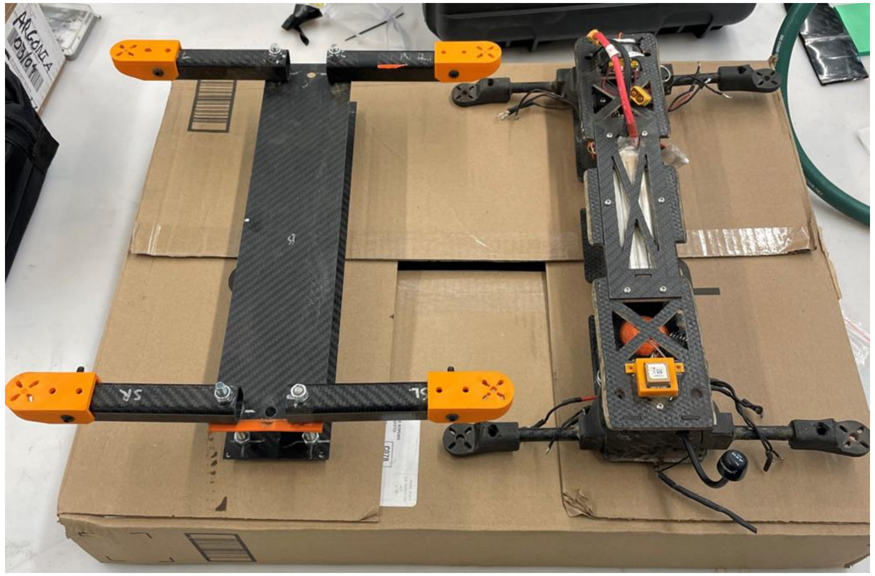


Part Manufacturing: 3D Prints

- Many of the brackets and intricate pieces of the structure was 3D printed to perfectly integrate into the quad
- Part first modelled in Solidworks
- Printed in Endeavor
- These prints allowed us to rapidly go through iterations and find the failure points in our design
- PLA used for rapid iterations
- Onyx used for final quad iteration



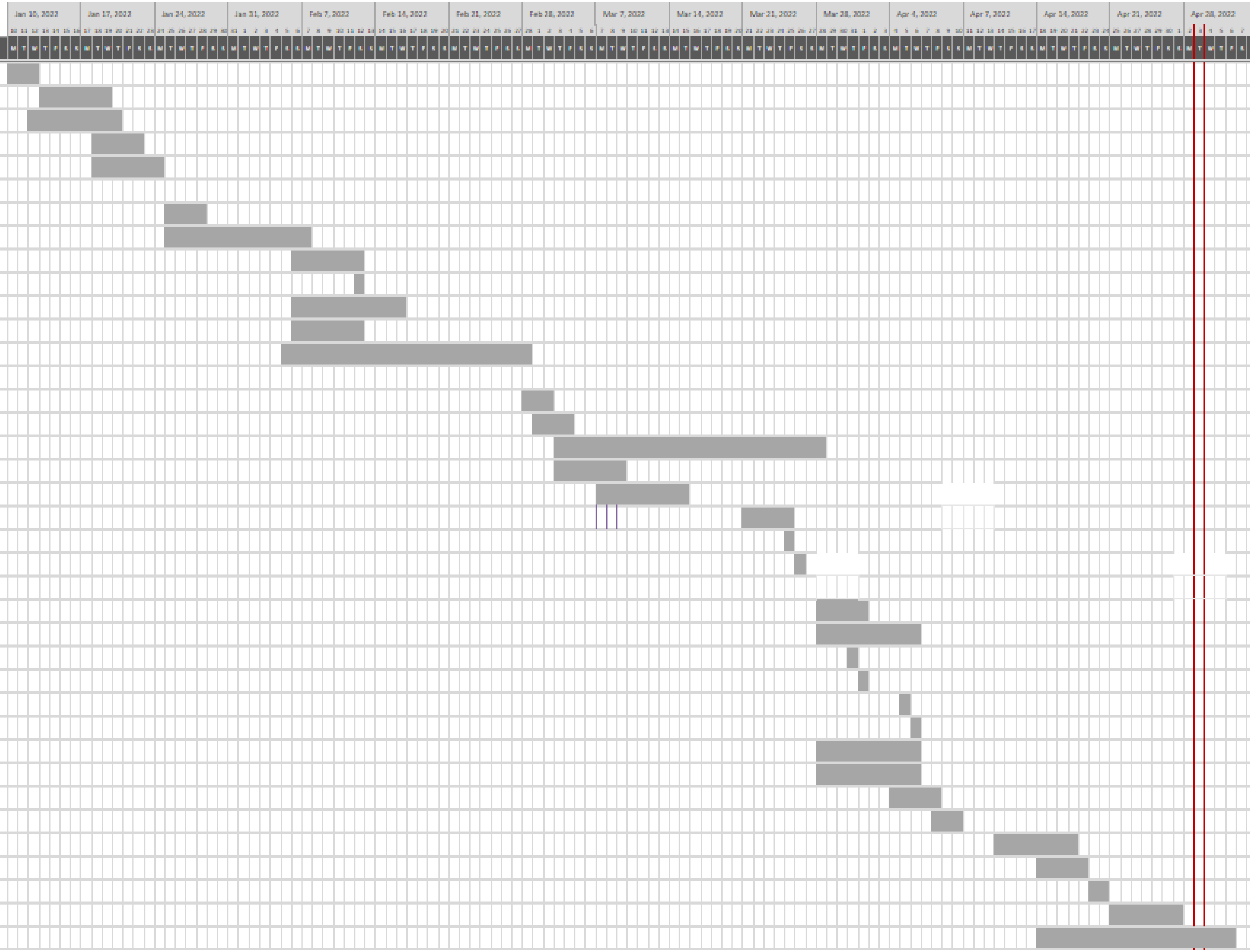




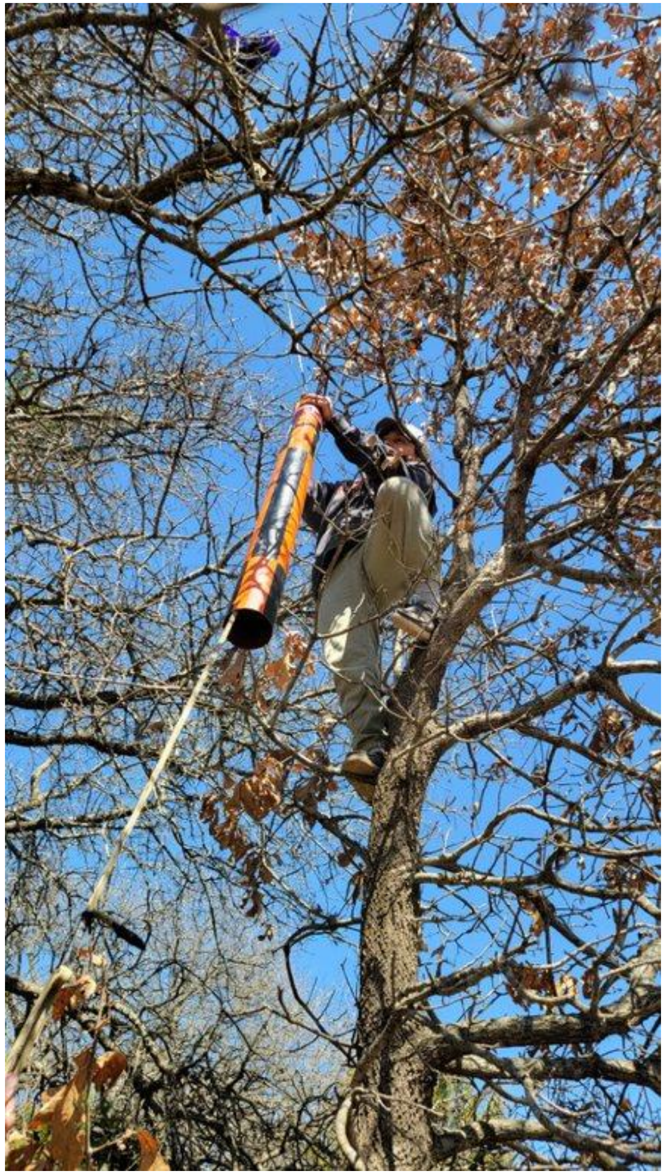
Timeline of Entire Project

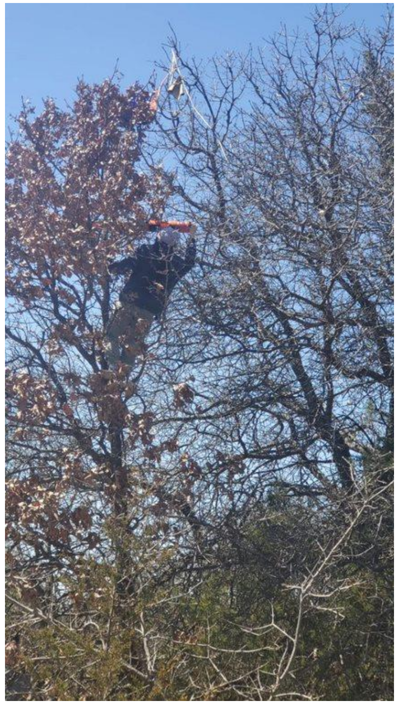
Display Week: 1

TASK	DESCRIPTION	PROGRESS	START	END
Work Plan	develop team structure & meeting times	100%	1/10/22	1/12/22
SDR	due Wednesday 19th	100%	1/13/22	1/19/22
Initial Design	initial design brainstorming	100%	1/12/22	1/20/22
PDR Rough Draft	begin writing PDR	100%	1/18/22	1/22/22
PDR	due Monday 24th	100%	1/18/22	1/24/22
Phase 2 - February				
Work Plan	develop new milestones for Feb	100%	1/25/22	1/28/22
Design	finalizing design	100%	1/25/22	2/7/22
CDR Rough Draft	begin writing CDR	100%	2/6/22	2/12/22
Argonia Trip	team trip to watch launches	100%	2/12/22	2/12/22
CDR	due Wednesday 16th	100%	2/6/22	2/16/22
Get parts	order parts for 1st build	100%	2/6/22	2/12/22
Manufacturing	start building 1st prototype	100%	2/5/22	2/28/22
Phase 3 - March				
Work Plan	develop new milestones for March	100%	2/28/22	3/2/22
Initial testing	get quad off ground	100%	3/1/22	3/4/22
Testing Quad	testing period + more manufacture	100%	3/1/22	3/28/22
Video	submission due Mar 9th	100%	3/1/22	3/9/22
Rocket Manufacture	when rocket parts come in mail	100%	3/7/22	3/15/22
Testing Rocket	after rocket is built	100%	3/21/22	3/25/22
Ejection Test	ejection test day	100%	3/25/22	3/25/22
Flight test	flight test day	100%	3/26/22	3/26/22
Phase 4 - April				
Work Plan	develop new milestones for April	100%	3/28/22	4/1/22
Avionics Testing	more testing on quad	100%	3/28/22	4/6/22
Ejection Test #2	more ejection testing with rocket&quad	100%	3/31/22	3/31/22
Drop Test #1	drop testing quad	100%	4/1/22	4/1/22
Flight Test #2	another flight test with i motor	100%	4/5/22	4/5/22
Flight Test #3	another flight test with i motor	100%	4/6/22	4/6/22
Backup Quad Manufacture	manufacturing more vehicles	100%	3/28/22	4/6/22
Rocket Manufacture	manufacturing rocket backup parts	100%	3/28/22	4/6/22
Packing for competition	last minute changes and packing	100%	4/4/22	4/8/22
Argonia Cup	competition 9am Saturday	100%	4/8/22	4/10/22
Design Expo Poster	prepare a poster and such for expo	100%	4/14/22	4/21/22
Prepare for Speedfest	get quad and rocket ready for demo	100%	4/18/22	4/22/22
Speedfest	public demo/expo	100%	4/23/22	4/24/22
Rocket Room/Excelsior Cleaning Days	time to clean	100%	4/25/22	5/1/22
Final Presentation	working on slides	100%	4/18/22	5/6/22



Rocket Stuck in Tree





PID Tuning

- Trial and error process to smooth out the flight controls

Name	Proportional	Integral	Derivative	Control Derivative
Basic/Acro				
Roll	50	60	23	60
Pitch	54	75	25	60
Yaw	45	80	0	60
Barometer & Sonar/Altitude				
Position Z	50	0	0	
Velocity Z	100	50	10	
Magnometer/Heading				
Heading Hold	60			
Nav Heading	0	0	0	
GPS Navigation				
Position XY	50			
Velocity XY	50	25	50	40
Surface	0	0	0	