The University of Texas at Austin
Aerospace Engineering
and Engineering Mechanics
Cockrell School of Engineering

April 2023

USRC – HARDWARE DESIGN REVIEW #4

Jordan Burton, Audrey Smith, Luin Larson, Shayla Patel, Stefano Bonilla, Trace Larue, Victor Johnston, Vincent Spada

MISSION INTRODUCTION

ASE 374K/L
CAPSTONE DESIGN SEQUENCE
PROFESSOR NOKES
TEACHING ASSISTANTS SRAVYA, ERIKA
DEL FOUNDER AND MENTOR MITCH

TEXAS DRONE ESTIMATION LAB
A NASA USRC CHALLENGE MISSION

TEXAS DRONE ESTIMATION LAB - HARDWARE TEAM

Audrey Smith

Shayla Patel

Victor Johnston

Vincent Spada

Jordan Burton

Luin Larson

Stefano Bonilla

Trace Larue

Need Statement

The overall need of this project is to develop drones capable of sensing and avoiding obstacles with a minimized risk of collision or damage to property in GPS denied environments.

GOALS

1. Manufacture a drone prototype capable of manual flight
2. Collaborate effectively with other sub-teams
3. Develop testing equipment and a flight test plan; learn about flight test safety
4. Complete key deliverables and integrate new team members
5. Plan for future work with a focus on flight testing more capabilities

Figure 1: Manual flight prototype plan. Powering, manufacturing, and testing plans are ready for implementation.

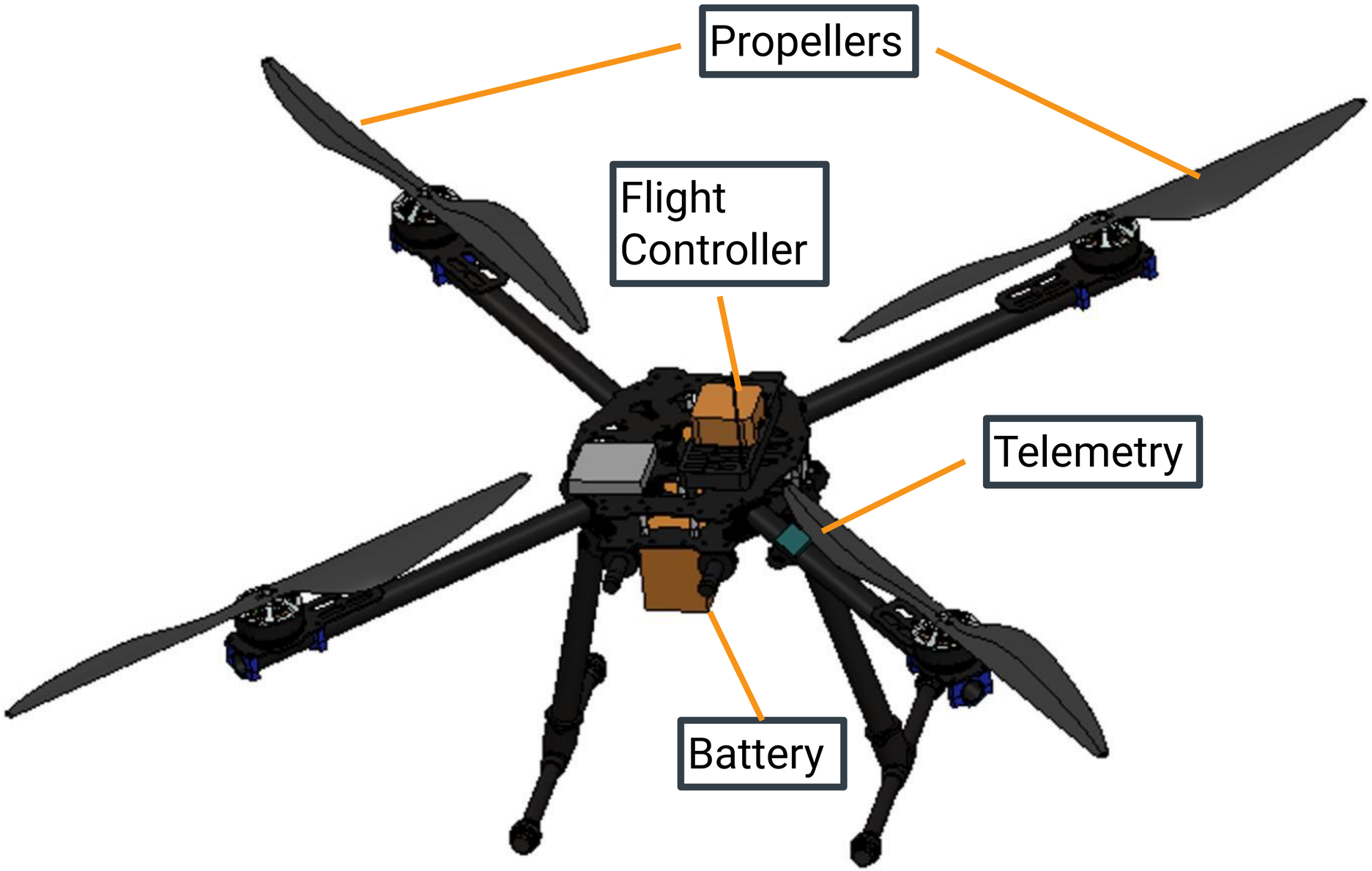
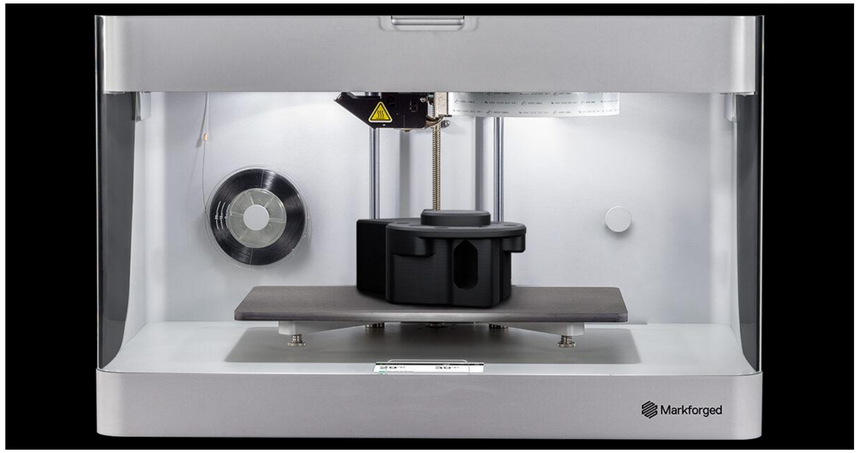


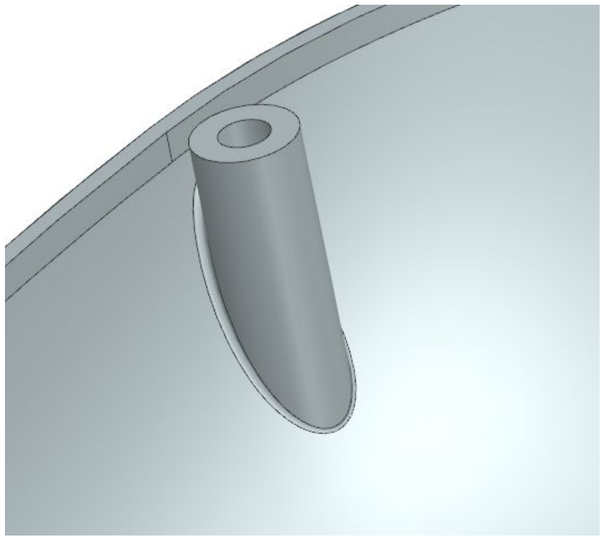
TABLE OF CONTENTS

PART MANUFACTURING - STEFANO

DRONE COVER



- Drone cover will be 3D printed on a Markforged Mk2 or SLS 3D printer (both available in Texas Inventionworks.
- Markforged Mk2 option:
  - 330 Grams
  - $71.25 raw material
- SLS option (preferred):
  - 279 Grams
- 4X #6 Brass Threaded Inserts
  - Secured with JB Weld adhesive



TOP PLATE LONG TERM MANUFACTURING

- Future top plates will be made of carbon fiber.
- Supplier: Dragon Plate
  - 1/32” 12”x12” EconomyPlate Carbon Fiber Sheet
  - 0/90 ply direction
  - $37.49 per sheet
- Waterjet (in house, ME machine shop):
  - Use wood face sheets to prevent delamination
- Dragon Plate CNC cutting service:
  - Parts manufactured and shipped in a completed state from Dragon Plate
  - Only need to send DXF file
  - May be more expensive, need to request a quote

EconomyPlate Solid Carbon Fiber Sheet ~ 1/32" x 12" x 12"

$37.49

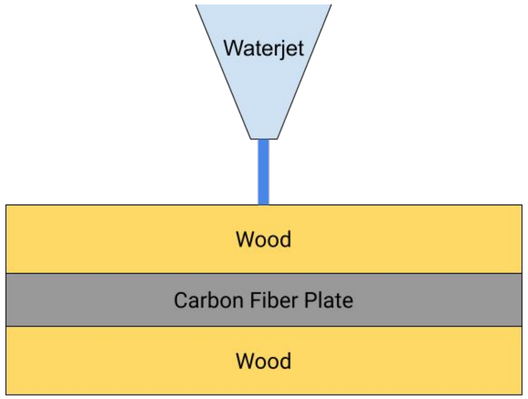
Shop our wide selection of carbon fiber sheets and plates

SKU: FEPL01T*90*1212

Finish * Texture/Texture

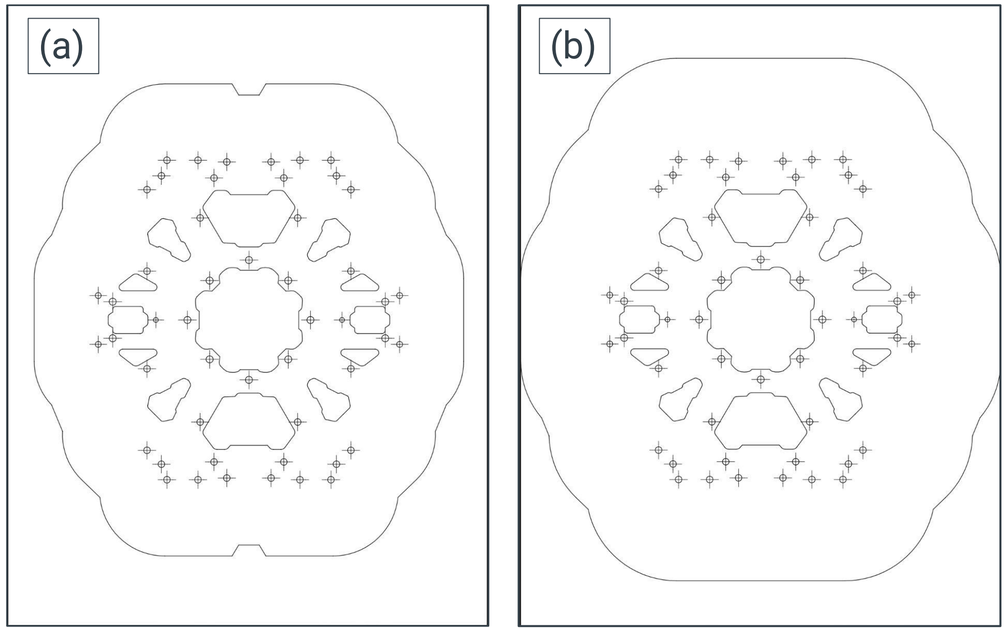
1 ADD TO CART

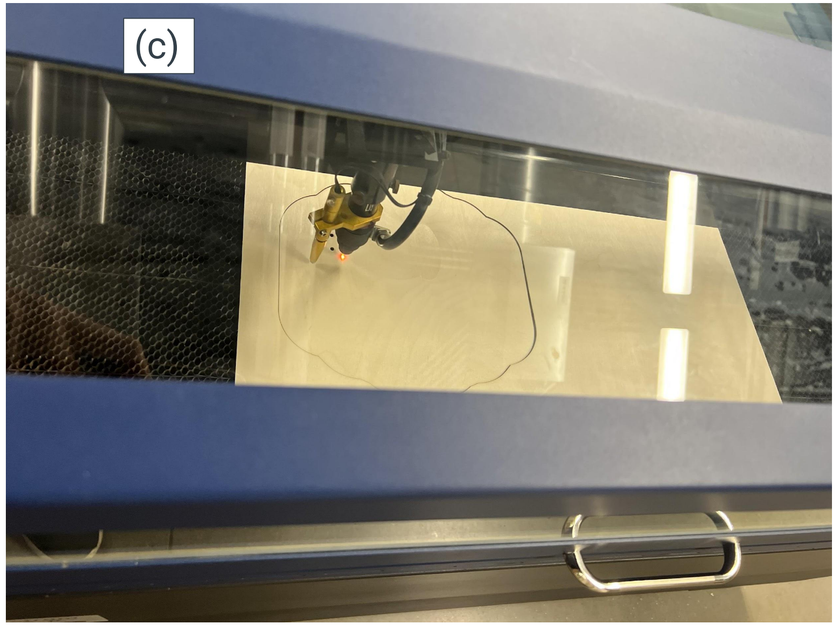
Share:



Laser Cut Plywood Electronics Mounting Plate

- The new plate designs extend the perimeter of the previous plate included in the Tarot frame.
- Designed on Solidworks by converting a STP file of the Tarot frame to a SLDPRT file, and then using an offset tool to automatically extend the perimeter line.
- Two designs completed – a r*1.41and r*1.1 version.
- Laser cutting completed at TIW – training is required to use equipment, but TIW staff *may* assist without training. PDF files are supported by the laser cutter. Total time is < 30 min, < 5 min per part. Price per part is ~ $5.





(a) Radius*1.1 plate design on 8.5 x 11 in pdf. (b) Radius*1.41 plate design 8.5 x 11 in pdf. (c) Laser cutting operation at TIW.

ASSEMBLY MODIFICATIONS -LUIN

Hardware Modifications

- Numbered propellers
  - Assists assembly
- Leveled motors
  - Ensures steady flight
  - Must be consistent between flights for calibration

Level used to straighten motors

Propellers with numbers

TEST STAND
-LUIN

TEST STAND

- Main goal: to test sensors without risking safety or components
- Positions replicate positions on drone
- No propellers
- Clamped to table/weight or held

TEST STAND

- Motors mounted with provided screws
  - Triangular pattern, 1.125 inches apart
  - Drill center hole to fit motor flush
- Battery connected with straps
- Other components attached with foam tape
- Base can be modified in the future
  - Wooden bird is a low-stakes baseline, avoids analysis paralysis

MANUAL FLIGHT RESULTS - SHAYLA

Manual Test Flight Procedure

In order to complete the manual test flight the drone had a specific flight sequence it followed to ensure safe flight practice. This procedure included:

- Completing a software configuration via laptop
- Completing motor and spin checkouts
- Validating prop directions
- Validating all wiring and battery connections
- Validating all hardware mounts and security

Manual Test Flight Videos

Future Hardware Adjustments

Based on the results from the past flight tests, there are hardware modifications to be made to ensure a more successful flight. These modifications include:

- More powerful motors
- A higher quality battery
- Fine tuning the PID for improved turning
- A more robust frame for better landing capabilities
- A carbon fiber base plate
- A stronger receiver

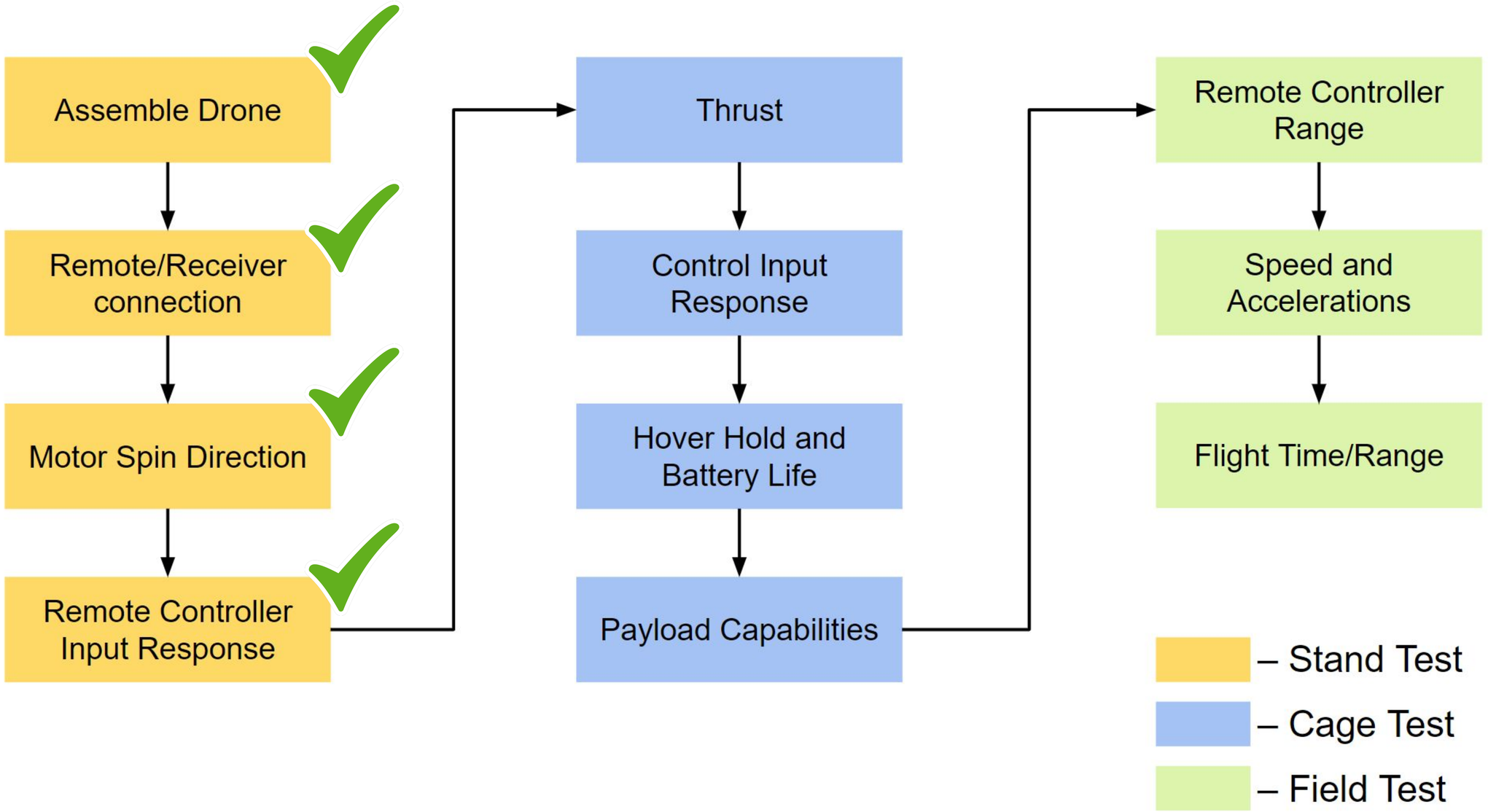
Future Motor and Battery Upgrades

- Current drone is capable of manual flight, but may be sluggish with added weight of autonomous flight equipment.
- T-Motor Navigator MN4010 KV475
  - More powerful, requires a 6s battery
  - Compatible with currently used Lumenier ELITE PRO 60A ESC
- Tattu 22.2V 6s 80C series
  - Same capacity range as currently used battery
  - 22.2V 6s
  - 80C discharge rate

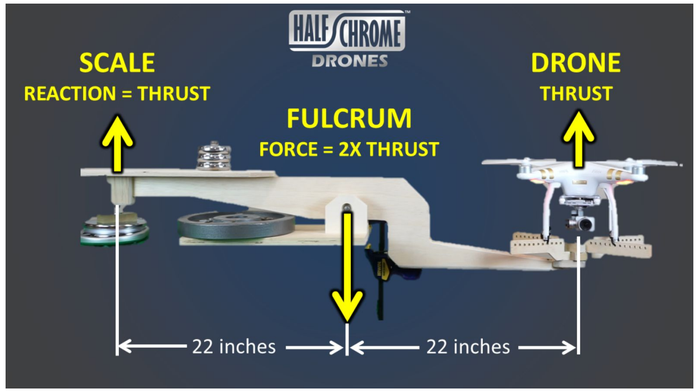
	Tarot 4006 (Current)	MN4010 KV475 (Upgrade)
Thrust with 13” prop	1580g	1870g (+18.4%)
Battery Voltage	4s 14.8V	6s 22.2V (+50%)
Mass	82g	112g (+36.6%)
Required Current	14.0A	14.1A (+0.7%)
Price	$39.88	$86.90 (+118%)

FUTURE TEST PLAN - TRACE

Test Flow for Manual Flight



Tests and Goals



1. Thrust
   - Method - Use of a fulcrum to press on a scale as drone is throttled.
   - Goals - Obtain data for max thrust available

2. Control Input Response
   - Method - Test flights in the drone cage
   - Goals - Validate that the drone responds as desired to controller inputs.
   - Results - We have already seen that it does not yaw as fast desired.

3. Hover Hold and Battery Life
   - Method - Low hovering flight in the test cage.
   - Goals - Evaluate the drones ability to hold position in hover. Obtain data on battery life.

Tests and Goals

4. Payload Capabilities

   Method - Design a payload carrying device and test different payload masses.

   Goals - Obtain data on payload carrying abilities of the drone.

5. Wind Effect Testing

   Method - Use a large fan/blower to generate wind in the drone cage.

   Goals - Obtain data on how well the drone holds position in high wind.

6. Transmitter Range

   Method - Secure the drone in the drone cage. Test control input response at various distances on speedway.

   Goals - Determine maximum control range.

Tests and Goals

7. Field Testing

Method - Test flights at Pickle Research Center (Or other large empty field.)

Goals - Obtain data on:

- Drone control response
- Speed and Acceleration
- Flight performance with a payload

* Need PRC permission

Future Tests

- RP-LiDAR and 3D-Stereoscopic Zed 2 camera
    - Range
    - Field of view
    - Resolution - Smallest object that can be detected
- Simple automated flight sequence using on board computer
    - Accuracy
    - Disturbance response
    - Object Avoidance
    - Increasing complexity

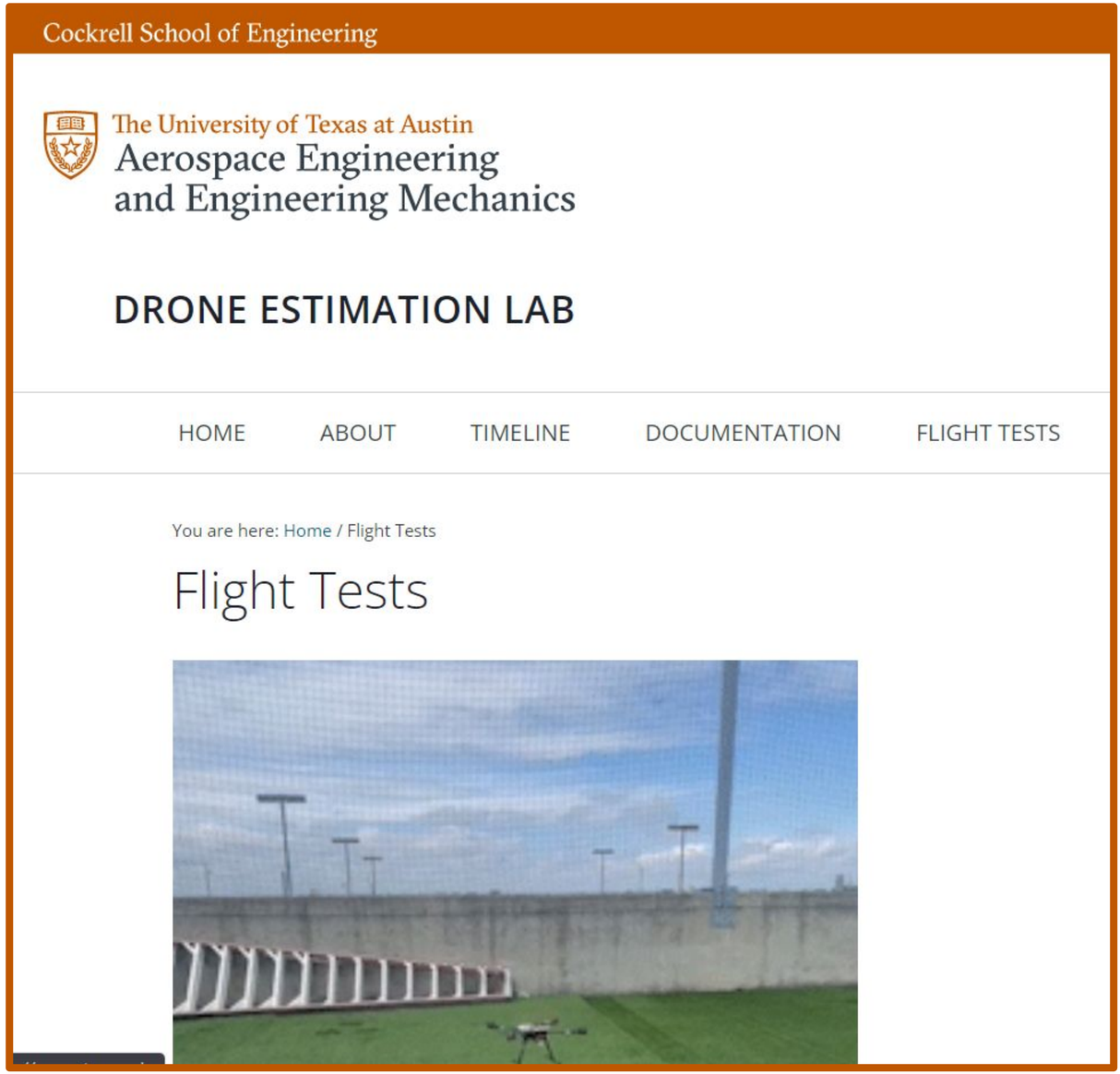
*Coordinate with Sensors/Comms and Sims to develop and conduct these tests.

CONTINUED WEBSITE DEVELOPMENT - JORDAN

FLIGHT TESTS ARE HERE!

- ***We have added a tab for flight testing updates as well as test videos***
- ***It might be preferable to create a separate tab for testing videos in the future***

Link to the testing section of the website:
https://sites.utexas.edu/del/flight-tests/

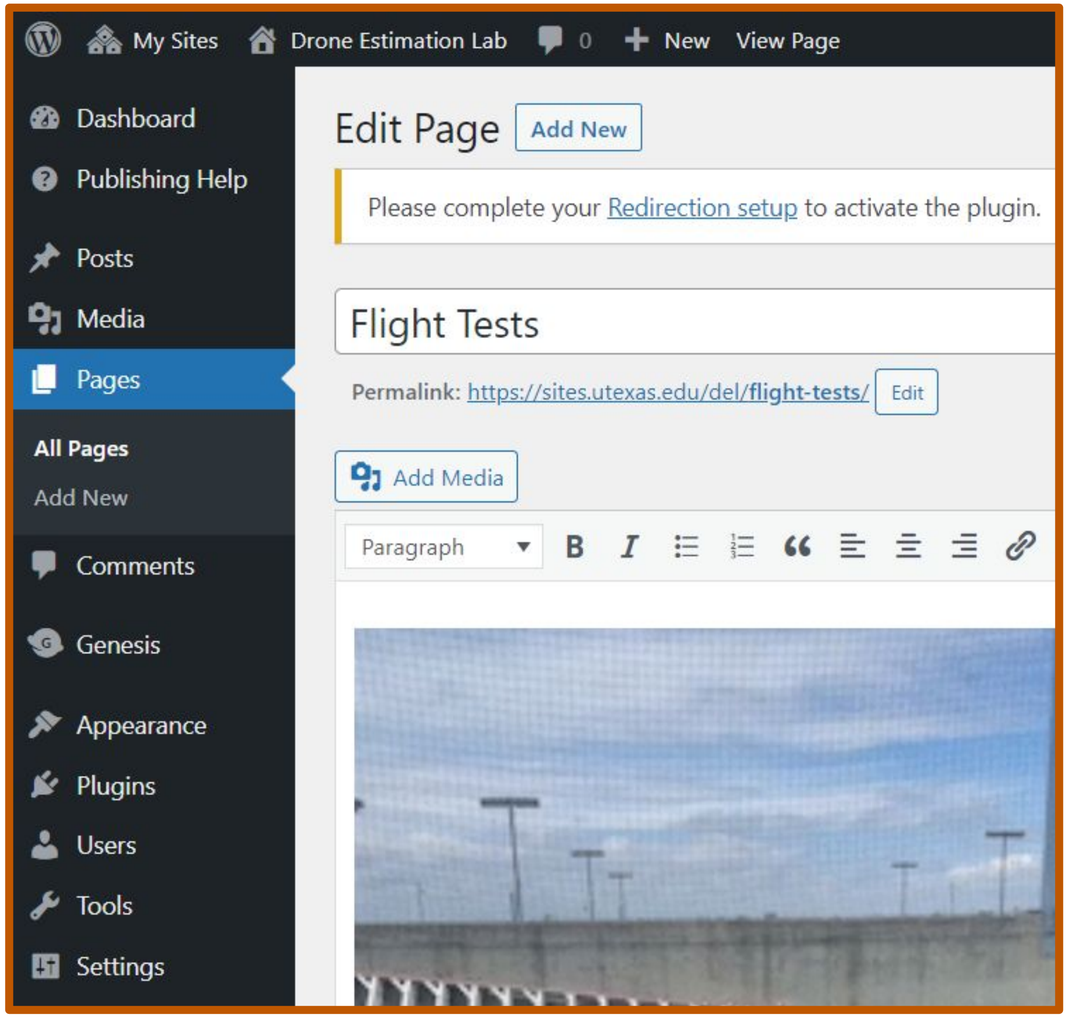


Transfer of Admin Privileges

- *Certain pages (the home page) can only be edited by those with admin privileges*

- *In addition, we are in the works of creating a very simple tutorial explaining how to navigate the website and edit*

**After transferring admin privileges to those necessary, we will begin removing ourselves as admins/editors*



Future Concerns/Interests

- *Again, certain pages (the home page) can ONLY be edited by those with admin privileges*

- *Editing of website is very finicky (updates late) and not user-friendly.*
  Updating the website tutorial often to make it easier on future members

- *The website is still not searchable through the google search engine*

TRANSFER OF CONTROL - AUDREY

NASA POC POSITION

- ***Email Documentation***
  I am aiming to add a strictly documentation folder filled with my email correspondences with our NASA contact so the next POC can be updated and on the same page.
- ***Contact Sheet***
  A document with any useful contacts for NASA as well as any alumni would also be useful.
- ***Transfer Control to Vincent***
  Update NASA on the POC change.

ADMINISTRATIVE FUTURE OBJECTIVES - AUDREY

DEL EMAIL/SOCIAL MEDIA CREATION

- ***Create a Cohesive DEL Email***
  In order to create a more streamlined emailing process, we want to create a general DEL email so that in the future, transfer of control can be a lot smoother.

- ***Create a Social Media Platform***
  In the future, once more flight tests are conducted, it would be beneficial to display video footage and photos on another social platform such as an Instagram account.

ONBOARDING

- ***Relevant Trainings***
  Members have expressed interest in learning QGroundControl as well as getting a Power Distribution Board walkthrough.
- ***User's Guide***
  Incoming members should familiarize themselves with the Hardware User's Guide as well as the structure of the Drive and Website.
- ***Rearranging Team Structures***
  While up to the next team's discretion, it may be valuable to combine sensors and hardware team for communication purposes.

TECHNICAL FUTURE OBJECTIVES - VINCENT

Hardware Goals in Context

- Hardware may be off-schedule with simulation and estimation capabilities: goals should be tailored to maximize team efforts and position DEL for future semesters.
- A list of goals for next semester include:

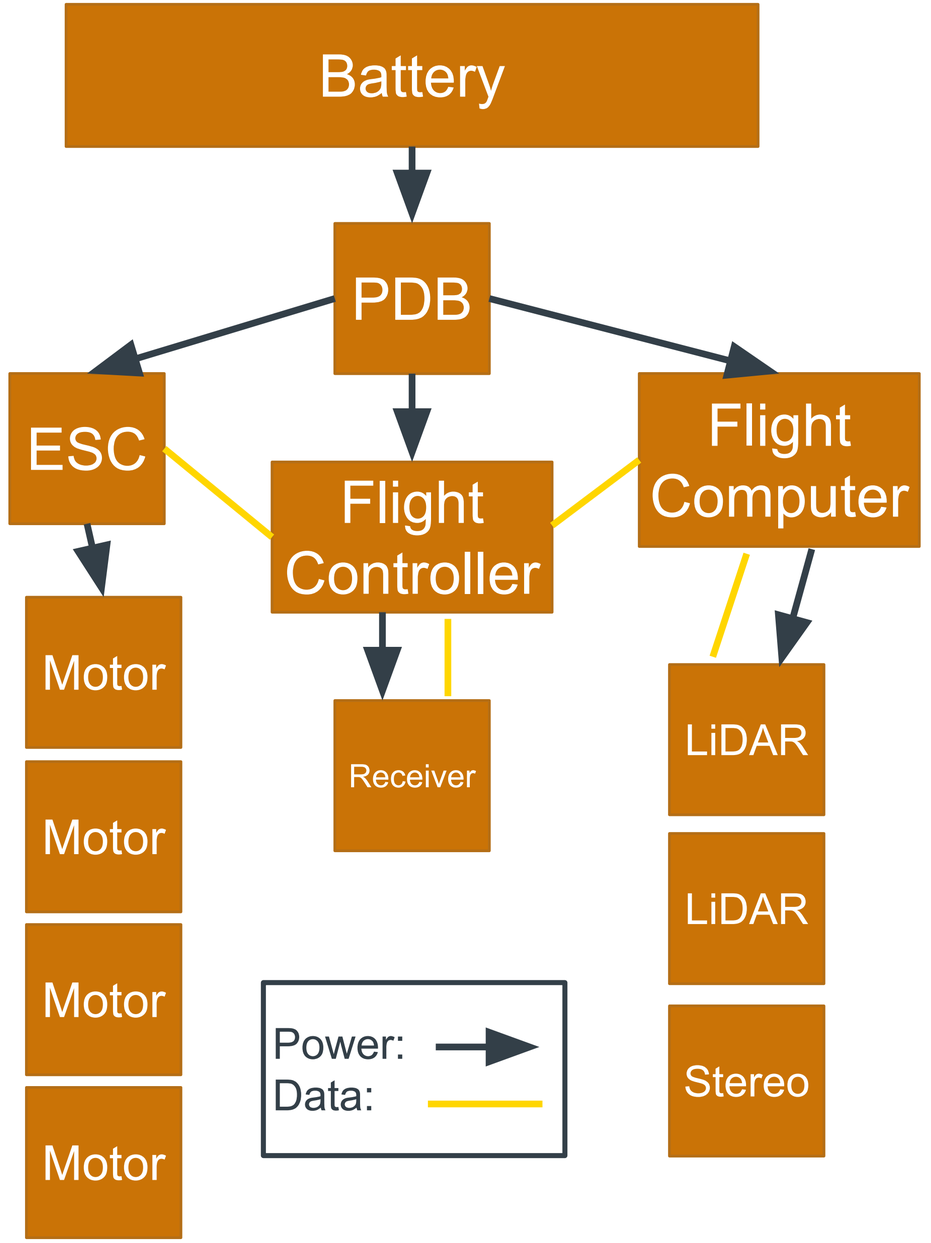
1. Provide flight data to sims team for position estimation.
2. Design/re-design avionics to accommodate computer and sensors. Including mounting solutions and airframe mods.
3. Set up software/hardware interactions for autonomy. Test on wooden bird in parallel with drone implementation
4. Complete GPS-based autonomous flight (and object detection and swarm, ambitiously).

Vincent

Powering Plan – Modifications for Computer and Sensors

- Flight computer and sensors are currently not included in the avionics design and may have communications parts that need power
- Wiring and mounting plans are paramount to an effective final system.
- Safety mitigations will be a primary concern where testing using a wooden bird will prove capabilities.
- Deciding to integrate with the current system or use a separate avionics battery should be analyzed based on schedule cost and future value.

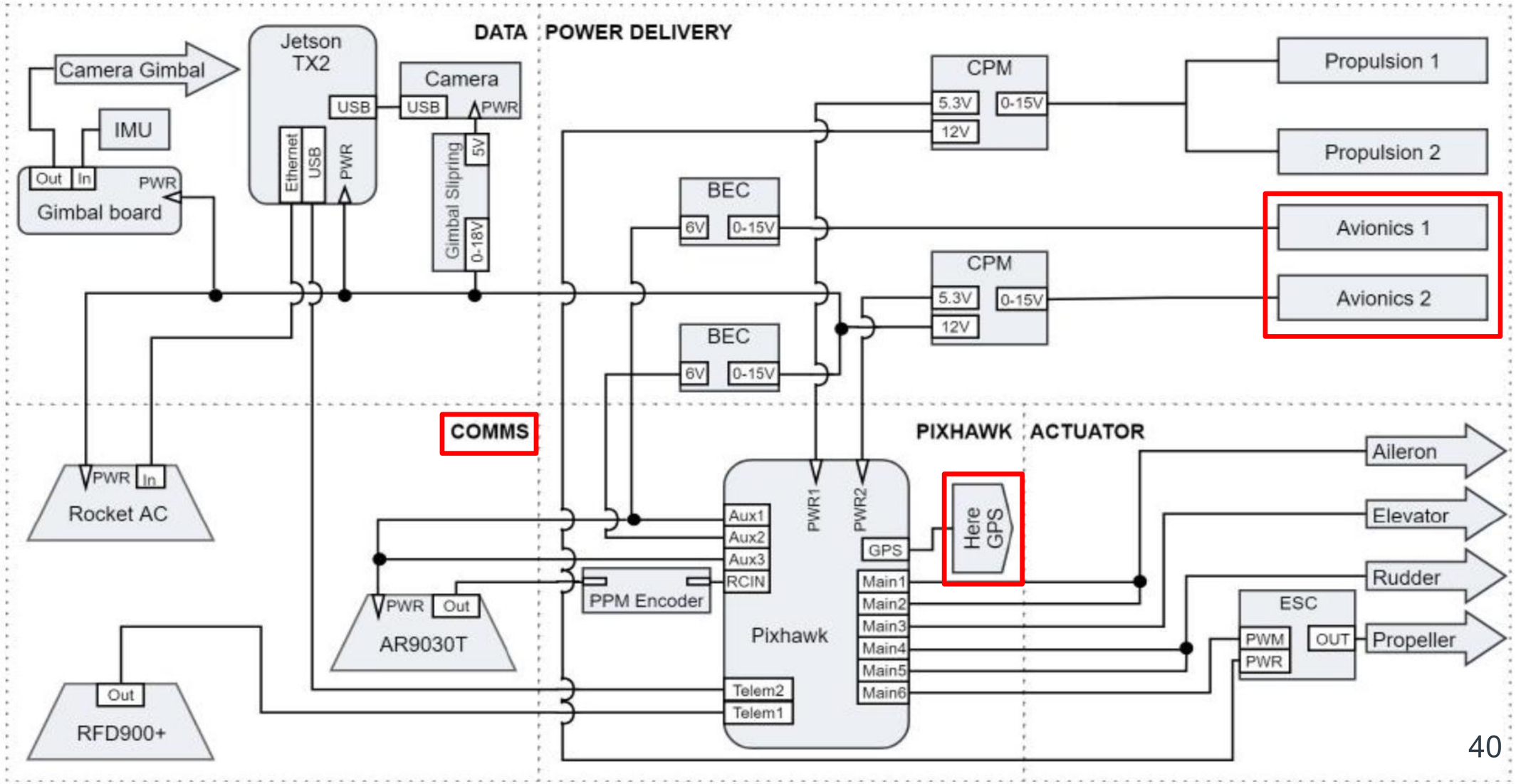
Vincent



Current soldering diagram design including Jetson flight computer and sensors.

Avionics Plan 2 – Heritage Diagram

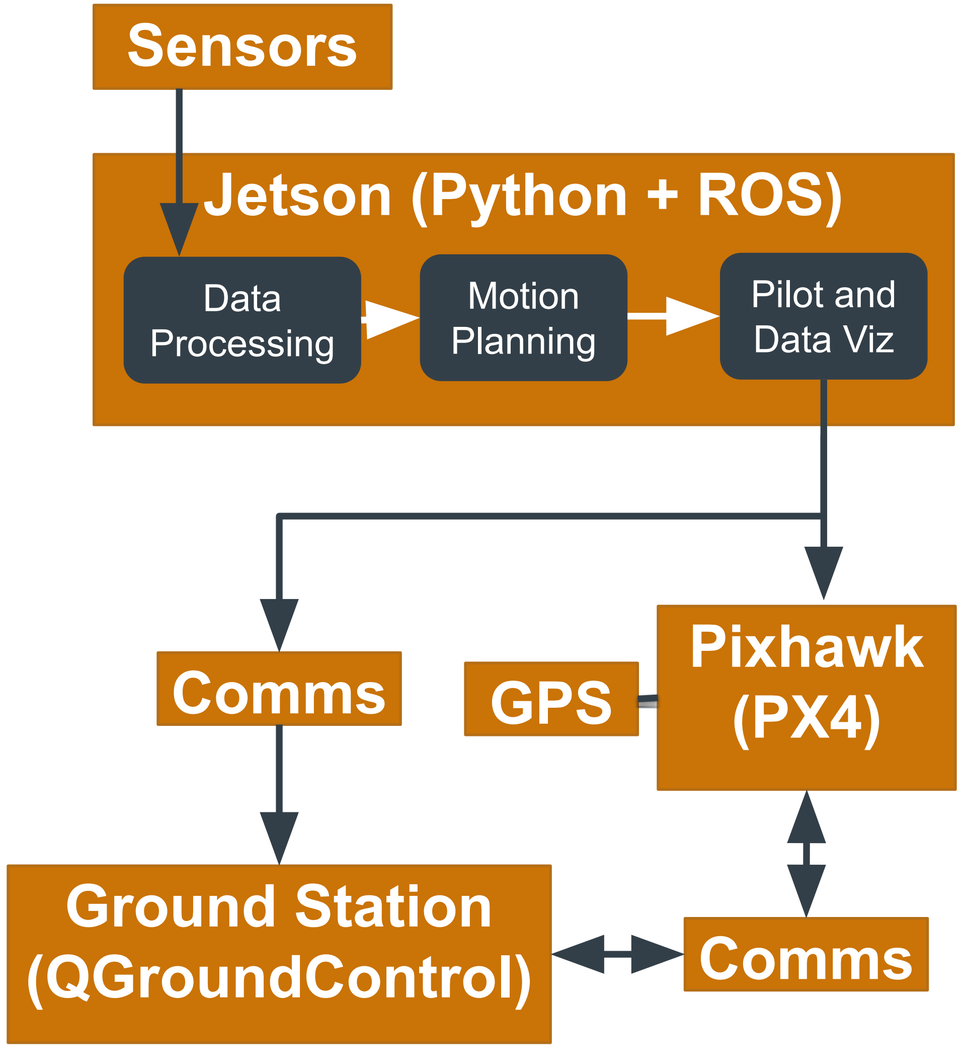
UAVA avionics diagram [5].



Vincent

Flight, Ground Station, and Autonomy Software

- Current flight software is Ardupilot, but PX4 should be researched. Ground station is QGroundControl.
- QGroundControl and Python/MATLAB (ROS) will be used for autonomous flight. Software details needed to implement sensor data is TBD and an action item for hardware.
- Hardware/software interactions should be tested highlighting communications, GPS sensor, computer speeds and reliability, and the current flight controller.
- Software should be understood for piloting and data acquisition.



Hardware software integrations where some parts are within the scope of hardware and some should be provided by sims and estimation.

Vincent

Procurement and More Details

- Components to be procured include batteries, flight computers, communications parts, GPS parts, and sensors for other drones and the wooden bird.
- Important fringe topics needing work/testing reiterated:

1. Data acquisition from LiDAR and Zed with Jetson and Python/MATLAB.
2. Jetson and Pixhawk interactions for autonomy (test).
3. Communications for autonomy, swarm, and Jetson (test).
4. New airframe and current airframe significant modification.
5. Permanent sensor mounting.

Vincent

Pilot Training and FAA Info

- FAADroneZone: FAA provided one-stop site for independent and small organization drone operators.
- Drones between 0.55 and 55 lbs should be registered under a DroneZone account holder. Registration should be posted on the exterior of the drone.
- Our drone has a certification under my account for recreational flight.
- Drone pilots should receive relevant amounts of training. Recreational training through the TRUST system takes < 15 minutes. Part 107c training requires registration with IACRA and proctored training.

Vincent

(a)

Congratulations!

Your registration number is **FA3XFFMFFR**

Your registration certificate has been sent to the email address you provided in your registration.

You can also print your certificate.

Be sure to have your registration certificate available when you fly your UAS.

(a) Drone user registration number from FAADroneZone. (b) List of FAA regulations to follow for recreational drone piloting.

(b)

THE EXCEPTION FOR RECREATIONAL FLYERS

To fly under **The Exception for Recreational Flyers**, you must:

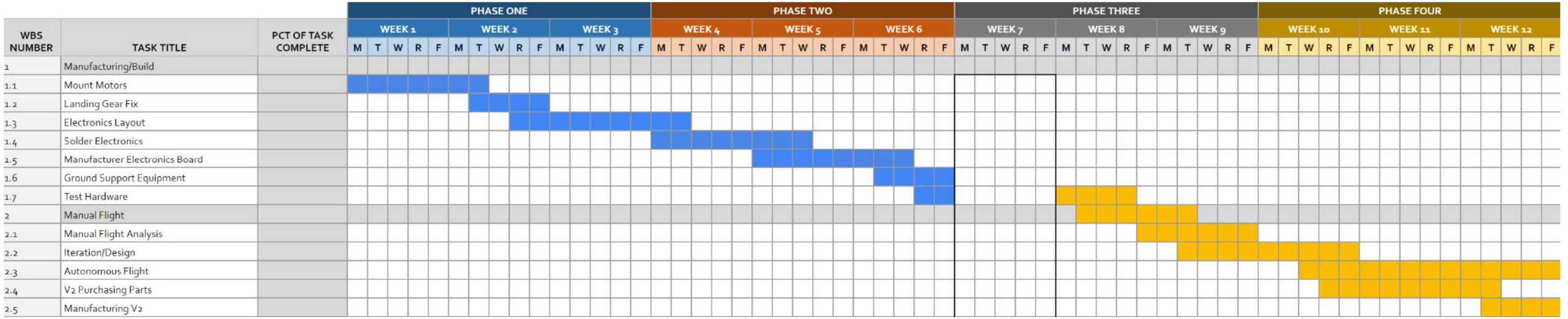
- Have a current registration
- Fly only for recreational purposes
- Follow the safety guidelines of a community based organization
- Keep your drone within your visual line of sight
- Give way and do not interfere with any manned aircraft
- Fly at or below 400’ in controlled airspace and only with prior authorization
- Fly at or below 400’ in uncontrolled airspace
- Comply with all airspace restrictions
- Pass The Recreational UAS Safety Test

OUTLOOK - VICTOR

Future Works

- Purchase Final V2 Drone Parts
- Iterate Drone
- Automated Flight

Old Gantt Chart



WBS NUMBER	TASK TITLE	PCT OF TASK COMPLETE
1	Manufacturing/Build	
1.1	Mount Motors	
1.2	Landing Gear Fix	
1.3	Electronics Layout	
1.4	Solder Electronics	
1.5	Manufacturer Electronics Board	
1.6	Ground Support Equipment	
1.7	Test Hardware	
2	Manual Flight	
2.1	Manual Flight Analysis	
2.2	Iteration/Design	
2.3	Autonomous Flight	
2.4	V2 Purchasing Parts	
2.5	Manufacturing V2	

Updated Gantt Chart

WBS NUMBER	TASK TITLE	PCT OF TASK COMPLETE	PHASE ONE															PHASE TWO														
			Spring Break					WEEK 1					WEEK 2					WEEK 3					WEEK 4					WEEK 5				
			M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F
1	Manual Flight																															
1.1	Manual Flight																															
1.2	Manual Flight Analysis																															
1.3	Iteration/Design																															
1.4	V2 Purchasing Parts																															
1.5	Manufacturing V2																															

Old Parts List & Budget

Number	Part Name	Quantity	Used	Unit Price	Total Price	Link	Vendor	Ordered	Received
1	Tarot 4006 / 620KV Multiaxial Brushless Motor TL68P02 for RC DIY Quadcopters Multicopters Drone, Tarot FY680 Pro Spare Parts (1 Pcs)	10	4	$39.98	$399.80	Link	Amazon	Y	Y
2	Lumenier Elite PRO 60A 2-6S BLHeli_32 4-in-1 ESC - 60 Amps	3	1	$112.19	$336.57	Link	Amazon	Y	Y
3	APD PDB500[X] 12S 52V 500A Power Distribution Board	1	1	$106.91	$106.91	Link	Amazon	Y	Y
4	4S Lipo Battery 14.8V 5200mAh 120C RC Battery Soft Case for Traxxas/RC Car/Truck/Plane/Quadcopter/Helicopter/Jet/UAV Drone/FPV(2PCS)	1	1	$91.23	$91.23	Link	Amazon	Y	Y
5	Amass AS150 Male and Female Anti Spark Connector Plug Set for Battery, ESC, and Charge Lead	1	1	$9.95	$9.95	Link	Amazon	Y	Y
6	oGoDeal 155 in 1 Precision Screwdriver Set Professional Electronic Repair Tool Kit for Computer, Eyeglasses, iPhone, Laptop, PC, Tablet,PS3,PS4,Xbox,Macbook,Camera,Watch,Toy,Jewelers,Drone Blue	1	1	$27.99	$27.99	Link	Amazon	Y	Y
7	Ethix Quad-Builder Cable Set	1	1	$27.08	$27.08	Link	Amazon	Y	Y
8	Cable Zip Ties,400 Pack Black Zip Ties Assorted Sizes 12+8+6+4 Inch,Multi-Purpose Self-Locking Nylon Cable Ties Cord Management Ties,Plastic Wire Ties for Home,Office,Garden,Workshop. By HAVE ME TD	1	1	$6.99	$6.99	Link	Amazon	Y	Y
9	Tiger Motors T-Motor Polymer Straight Propellers - MS1302 (Pair) - 13" - Black	2	2	$14.57	$29.14	Link	Amazon	Y	Y
10	TAROT 650 Carbon Fiber 4-Axis Aircraft Fully Folding FPV Drone UAV Quadcopter Frame Kit for DIY Aircraft Helicopter TL65B01	1	1	$158.88	$158.88	Link	Amazon	Y	Y
11	Wirefy Heat Shrink Tubing Kit	1	1	$13.99	$13.99	Link	Amazon	Y	Y
12	X-Tronic 3020-PRO • 75W Soldering Iron Station - Pro Style - 5 Extra Tips	1	1	$68.75	$68.75	Link	Amazon	Y	Y
	Total $ Spent				$1,277.28				

Current Parts List & Budget

Number	Part Name	Quantity	Used	Unit Price	Total Price	Link	Vendor	Ordered	Received
1	Tarot 4006 / 620KV Multiaxial Brushless Motor TL68P02 for RC DIY Quadcopters Multicopters Drone, Tarot FY680 Pro Spare Parts (1 Pcs)	10	4	$39.98	$399.80	Link	Amazon	Y	Y
2	Lumenier Elite PRO 60A 2-6S BLHeli_32 4-in-1 ESC - 60 Amps	3	1	$112.19	$336.57	Link	Amazon	Y	Y
3	APD PDB500[X] 12S 52V 500A Power Distribution Board	1	1	$106.91	$106.91	Link	Amazon	Y	Y
4	4S Lipo Battery 14.8V 5200mAh 120C RC Battery Soft Case for Traxxas/RC Car/Truck/Plane/Quadcopter/Helicopter/Jet/UAV Drone/FPV(2PCS)	1	1	$91.23	$91.23	Link	Amazon	Y	Y
5	Amass AS150 Male and Female Anti Spark Connector Plug Set for Battery, ESC, and Charge Lead	1	1	$9.95	$9.95	Link	Amazon	Y	Y
6	oGoDeal 155 in 1 Precision Screwdriver Set Professional Electronic Repair Tool Kit for Computer, Eyeglasses, iPhone, Laptop, PC, Tablet,PS3,PS4,Xbox,Macbook,Camera,Watch,Toy,Jewelers,Drone Blue	1	1	$27.99	$27.99	Link	Amazon	Y	Y
7	Ethix Quad-Builder Cable Set	1	1	$27.08	$27.08	Link	Amazon	Y	Y
8	Cable Zip Ties,400 Pack Black Zip Ties Assorted Sizes 12+8+6+4 Inch,Multi-Purpose Self-Locking Nylon Cable Ties Cord Management Ties,Plastic Wire Ties for Home,Office,Garden,Workshop. By HAVE ME TD	1	1	$6.99	$6.99	Link	Amazon	Y	Y
9	Tiger Motors T-Motor Polymer Straight Propellers - MS1302 (Pair) - 13" - Black	2	2	$14.57	$29.14	Link	Amazon	Y	Y
10	TAROT 650 Carbon Fiber 4-Axis Aircraft Fully Folding FPV Drone UAV Quadcopter Frame Kit for DIY Aircraft Helicopter TL65B01	1	1	$158.88	$158.88	Link	Amazon	Y	Y
11	Wirefy Heat Shrink Tubing Kit	1	1	$13.99	$13.99	Link	Amazon	Y	Y
12	X-Tronic 3020-PRO • 75W Soldering Iron Station - Pro Style - 5 Extra Tips	1	1	$68.75	$68.75	Link	Amazon	Y	Y
13	Cube Orange+ Standard Set ADS-B (IMU V8)	1	1	$700.00	$700.00	Link	irlock	Y	Y
14	UJIAJIA Pink Collapsible Storage Bins with Lids 2-Pack	1	1	$34.99	$34.99	Link	Amazon	Y	Y
15	iFlight 10pcs RC LiPo Battery Tie Rubberized Straps 10x 130mm with Metal Buckle	1	1	$8.99	$8.99	Link	Amazon	Y	Y
16	Radiolink T8S 8 Channels 2.4GHz RC Transmitter and Receiver R8EF RX	1	1	$56.99	$56.99	Link	Amazon	Y	Y
17	TAROT 650 Carbon Fiber 4-Axis Aircraft Fully Folding FPV Drone UAV Quadcopter Frame Kit for DIY Aircraft Helicopter TL65B01	1	1	$158.88	$158.88	Link	Amazon	Y	Y
18	3DR 500MW Radio Telemetry Kit 915Mhz 915 Kit Air and Groud Data Transmit Module	1	1	$83.33	$83.33	Link	Amazon	Y	Y
19	Double Sided, Heavy Duty, Waterproof Mounting Foam Tape	1	1	$16.14	$16.14	Link	Amazon	Y	Y
	Total $ Spent				$2,336.60				
	USRC Support Equipment								
	USRC Comms								

THANK YOU.

The University of Texas at Austin
Aerospace Engineering
and Engineering Mechanics
Cockrell School of Engineering