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

MARCH 2023

USRC – HARDWARE DESIGN REVIEW #3

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.

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MISSION SCOPING - VINCENT

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

Vincent

Goal 1: Manufacture a prototype

- Collaborate with sensors and communications to design an electronics mounting plan
- Manufacture the electronics mounting plate
- Collaborate to develop a soldering diagram and become familiar with said diagram
- Solder the electronic speed controller (ESC) to the motors
- Maintain the airframe

Vincent

Goal 2: Collaborate effectively

- Meet with sensors and communications as appropriate to discuss necessary action items
- Share documentation on accessible platforms
- Discuss system level details with simulation and estimation

Goal 3: Develop a testing plan

- Identify capabilities to be tested based on semester scope
- Identify relevant hardware and manufacturing plans
- Design electronics testing equipment
- Understand safety regulations and department standards
- Research FAA drone pilot licensing

Vincent

Goal 4: Complete deliverables and onboarding

- Develop a project website following NASA requirements
- Identify work areas for new members based on project needs
- Integrate new members into communications and documentation storage
- Provide tasks and training for new members for technical and administrative work

Vincent

Goal 5: Plan for future work

- Conduct a manual flight test
- Identify items within and outside the scope of the semester
- Design and manufacture items within the future project scope in parallel with other actions
- Augment project documentation with new requirements and subsystem details
- Prepare for a transfer of project ownership to new members

Vincent

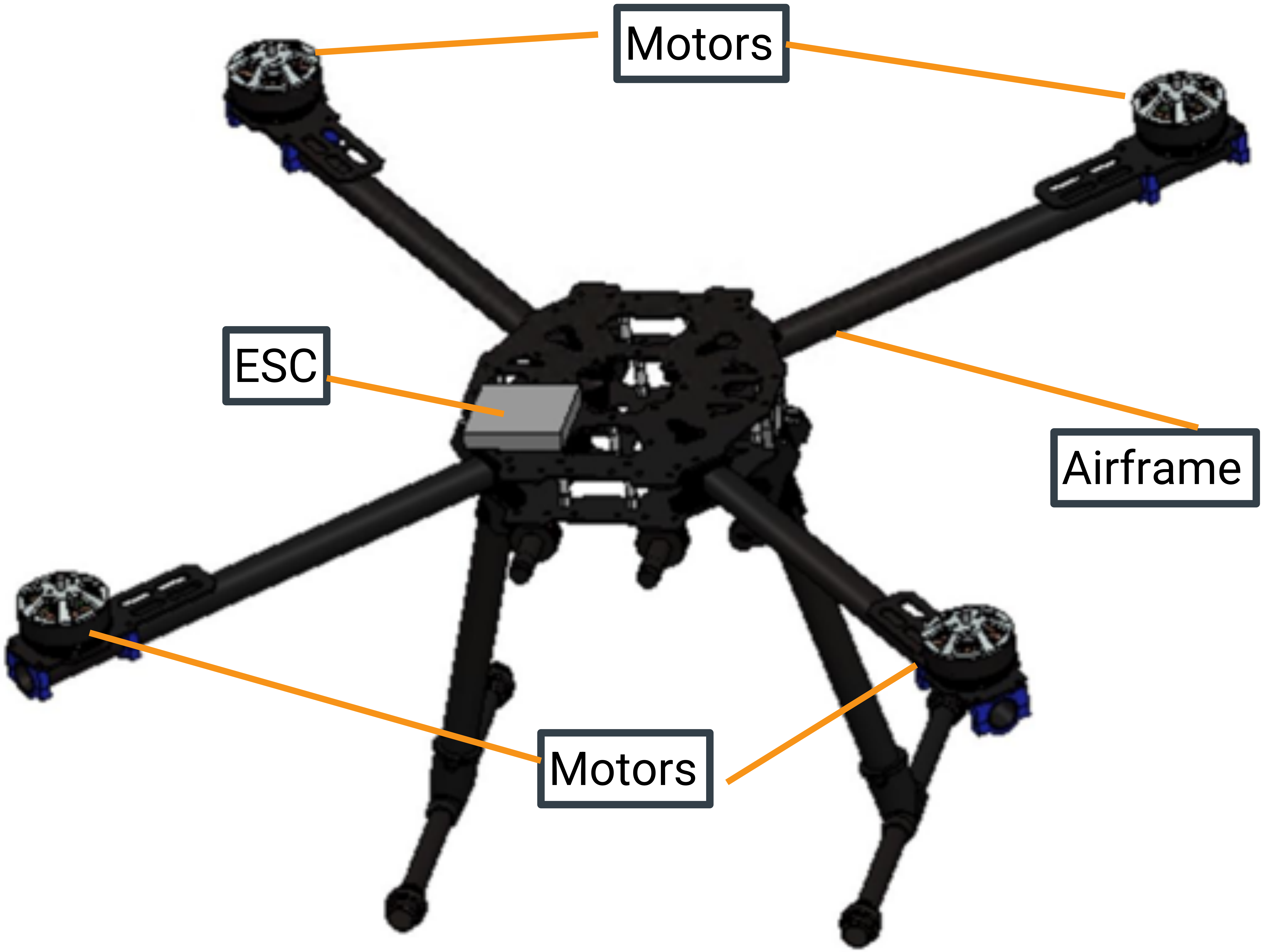
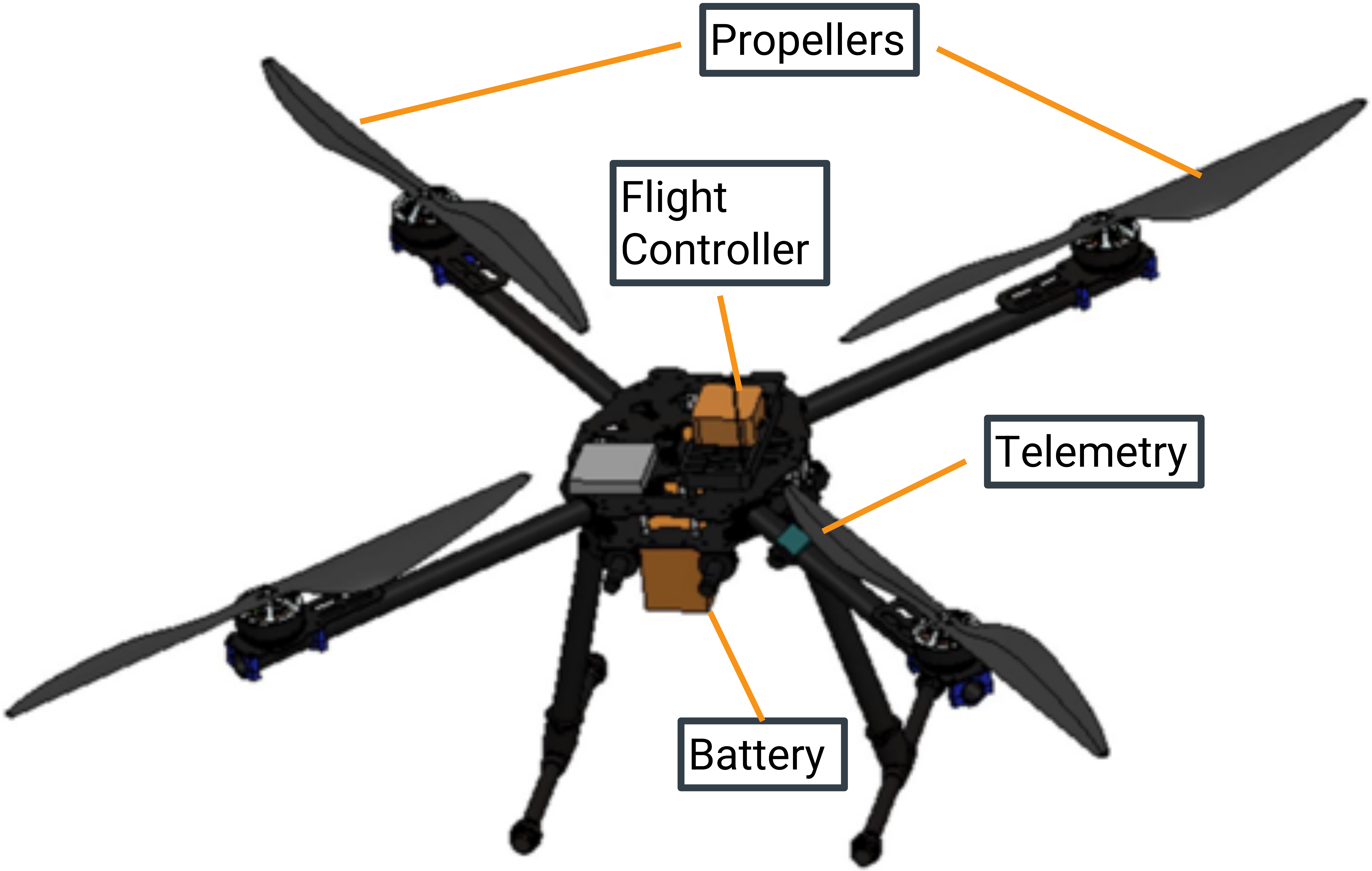


Figure 1: State of the drone. Although not shown, the electronic speed controller (ESC) is soldered to the motors and power cables.

Vincent

Figure 2: Manual flight prototype plan. Powering, manufacturing, and testing plans are ready for implementation.



Vincent

REQUIREMENTS - VINCENT

DERIVED REQUIREMENTS

- The project shall not exceed Budget (less than $60,000)
- The project shall follow NASA guidelines
- The project shall follow proposal specifications
- The project shall address safe, efficient growth in global operations and in-time system-wide safety assurance
- A key deliverables schedule shall be followed according to NASA guidelines

Vincent

HIGH LEVEL REQUIREMENTS

- Drone shall operate with a power source of voltage no more than 14.8 V
- Drone shall be capable of being modeled in a CAD program
- Drones shall be able to function in a swarm of ten
- Drone shall be able to autonomously avoid static obstacles
- Drone shall be able to autonomously avoid dynamic obstacles
- Drone maintenance shall be conducted following TBR standard procedure
- Equipment log shall be maintained following TBR standard procedure

Vincent

HIGH LEVEL REQUIREMENTS

- All team members shall use a common CAD software
- Manufacturing activities shall be documented following TBR standard procedure
- X amount of documentable meeting time shall be dedicated to sub-team collaboration
- X amount of documentable meeting time shall be dedicated to new team member training
- A document storage system shall be maintained following TBR standard procedure

Vincent

INTERNAL REQUIREMENTS

- Drone blades shall produce X (units) amount of thrust at least
- Drone shall be able to land at a downward speed of X (units) with landing gear at an angle of X degrees from the horizontal without failure of the airframe.
- Drone performance shall not be impeded by foreign object debris (FOD)
- Drone shall be able to communicate with other drones in flight

Vincent

INTERNAL REQUIREMENTS

- Drone shall be capable of moving omnidirectionally
- The drone shall be compatible with TBR FAA standards
- Drone shall have a flight endurance of 20 minutes
- Electronic mounting plate shall dissipate X (units) of structural vibration
- LiDAR mount shall be angle adjustable by X (units) as measured from the horizontal

Vincent

ASSEMBLY MODIFICATIONS - LUIN

Hardware Modifications

- Labeled front from back
    - Allows anyone to know drone orientation immediately

Hardware Modifications

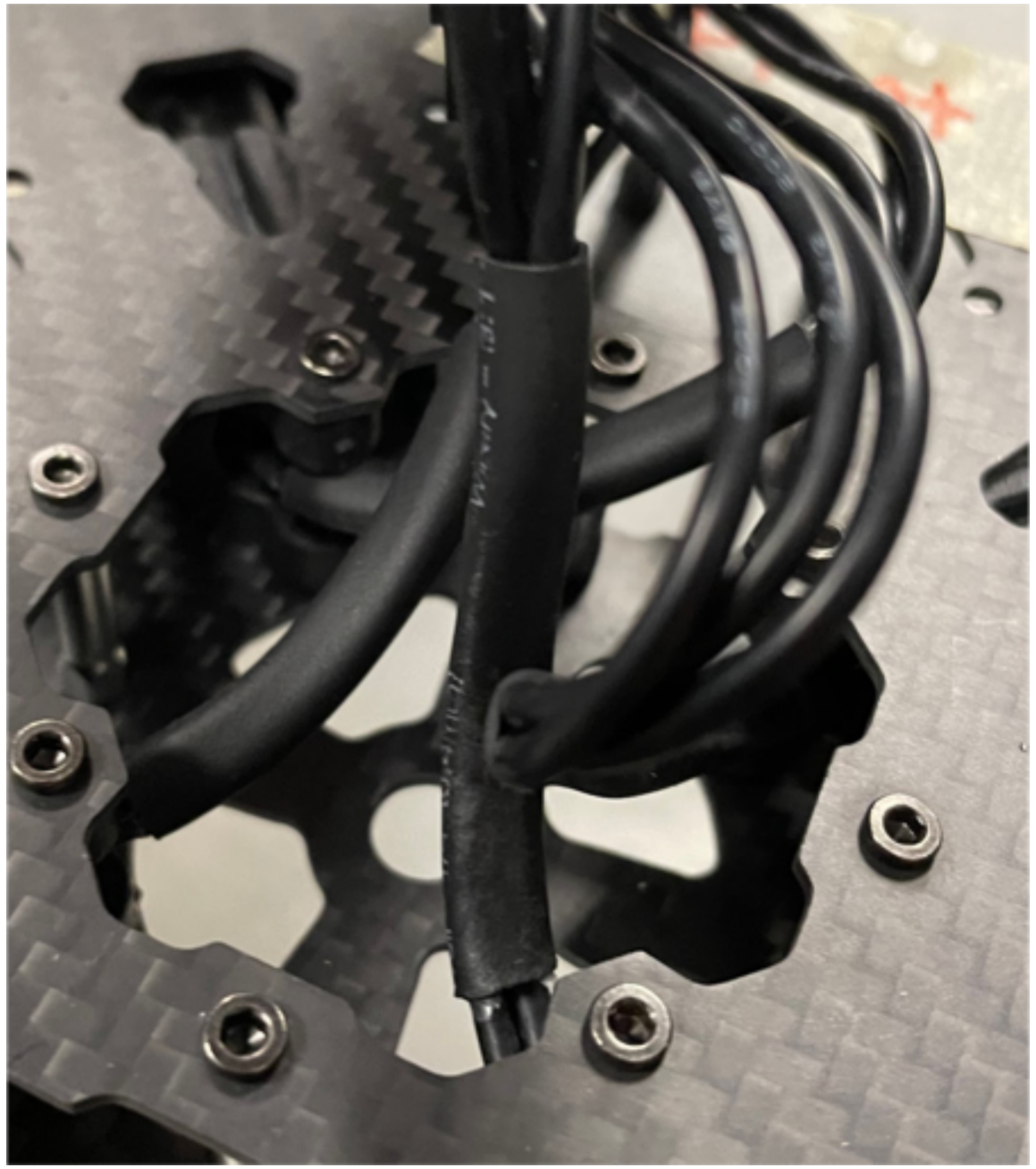
- Numbered the arms/motors
  - Will assist motor testing so we can tell which motor is performing which function

Hardware Modifications

- Removed propellers for safe and easy storage
  - They stick out and the shelf is crowded. Removal/addition is simple and fast, so it is worth storing them separately for now

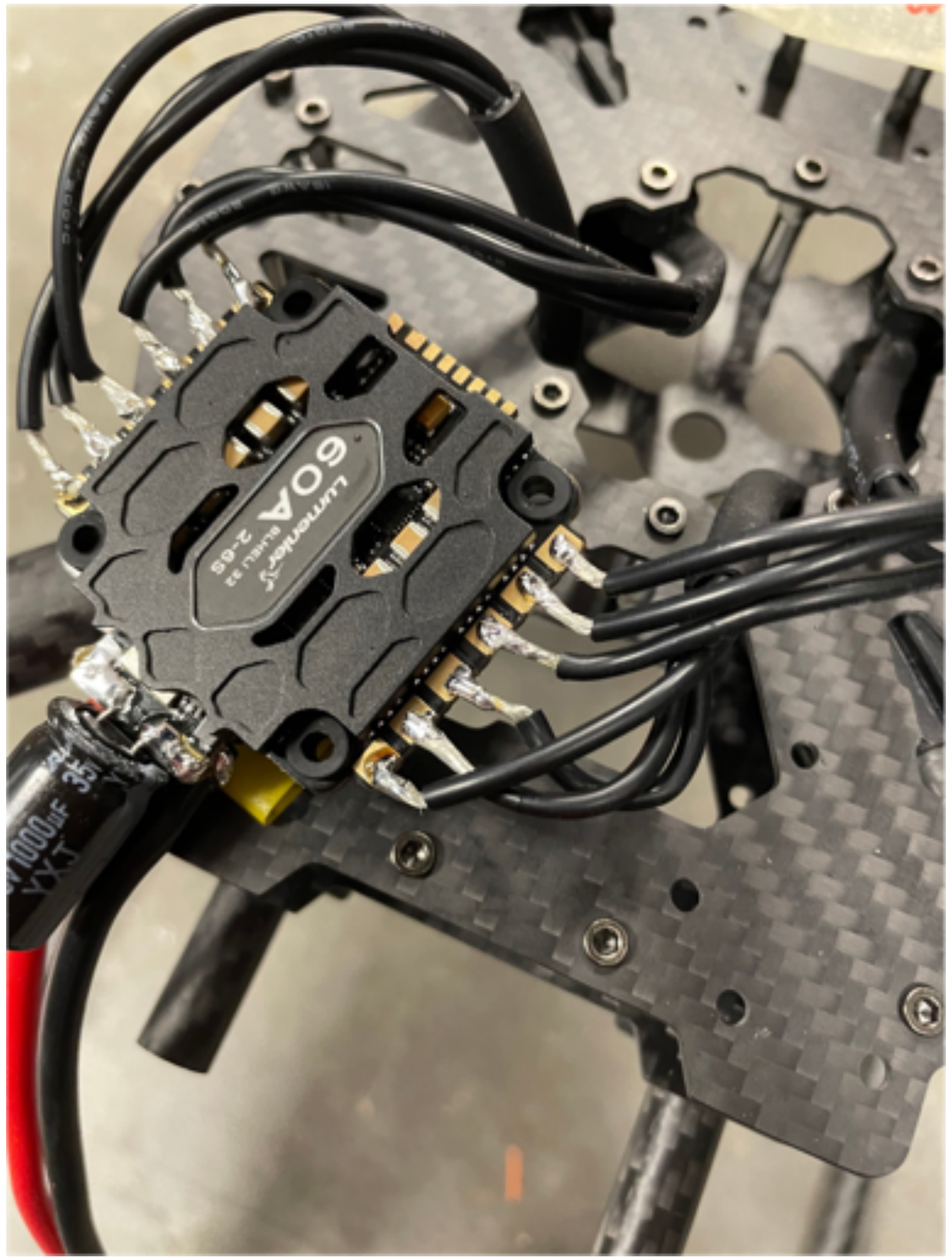
Hardware Modifications

- Extended wires to enable motor-ESC connection
  - Shrink wrapped extensions onto original motor wires so that they are long enough to allow for flexibility in ESC location



Hardware Modifications

- Soldered wire tips to ESC
  - Used new soldering iron
  - Tested functionality afterwards, correctly powers on as indicated by sound

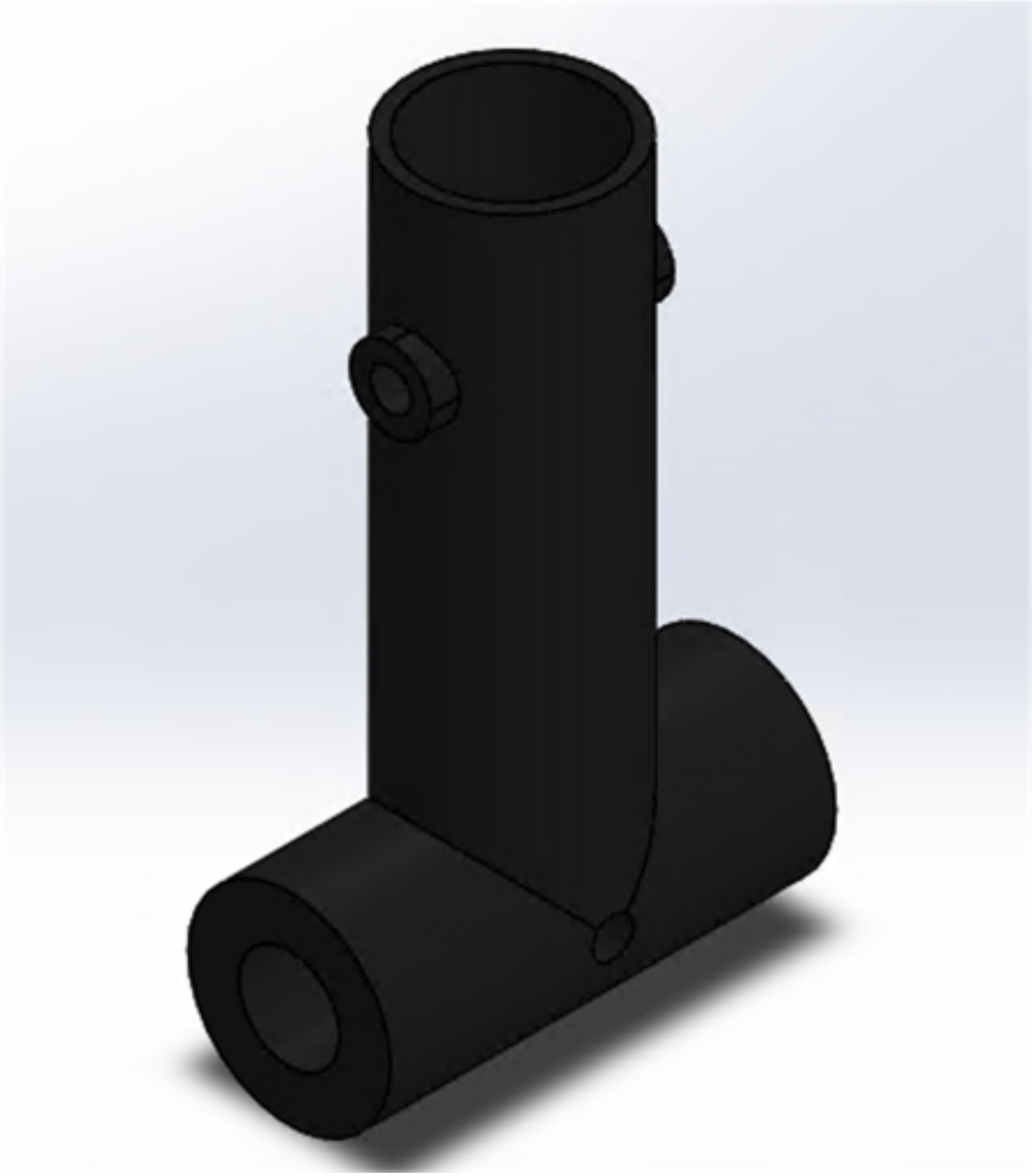


Hardware Modifications

- Glued landing gear to limit movement of T-bracket
  - Currently working on a design to replace it

Hardware Modifications

- This modified design has more height above the horizontal holes, which cracked, so they should be stronger
- All other dimensions are the same, just simplified



Potential Placements

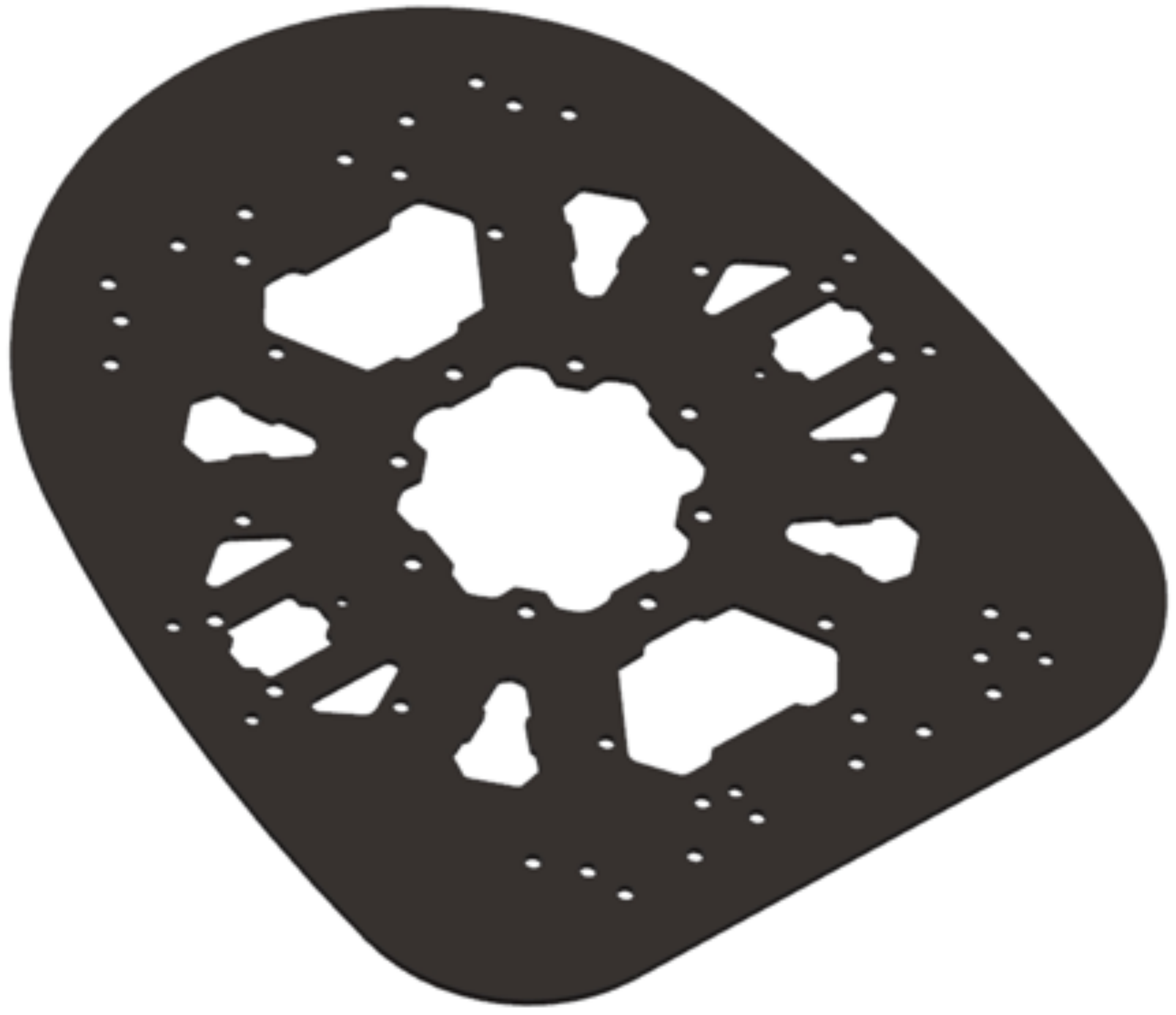
- Battery below system
  - Will use velcro straps/zip ties around bottom tubes
- Yellow tape showing where ESC may go

INTEGRATION - STEFANO

Full Drone CAD

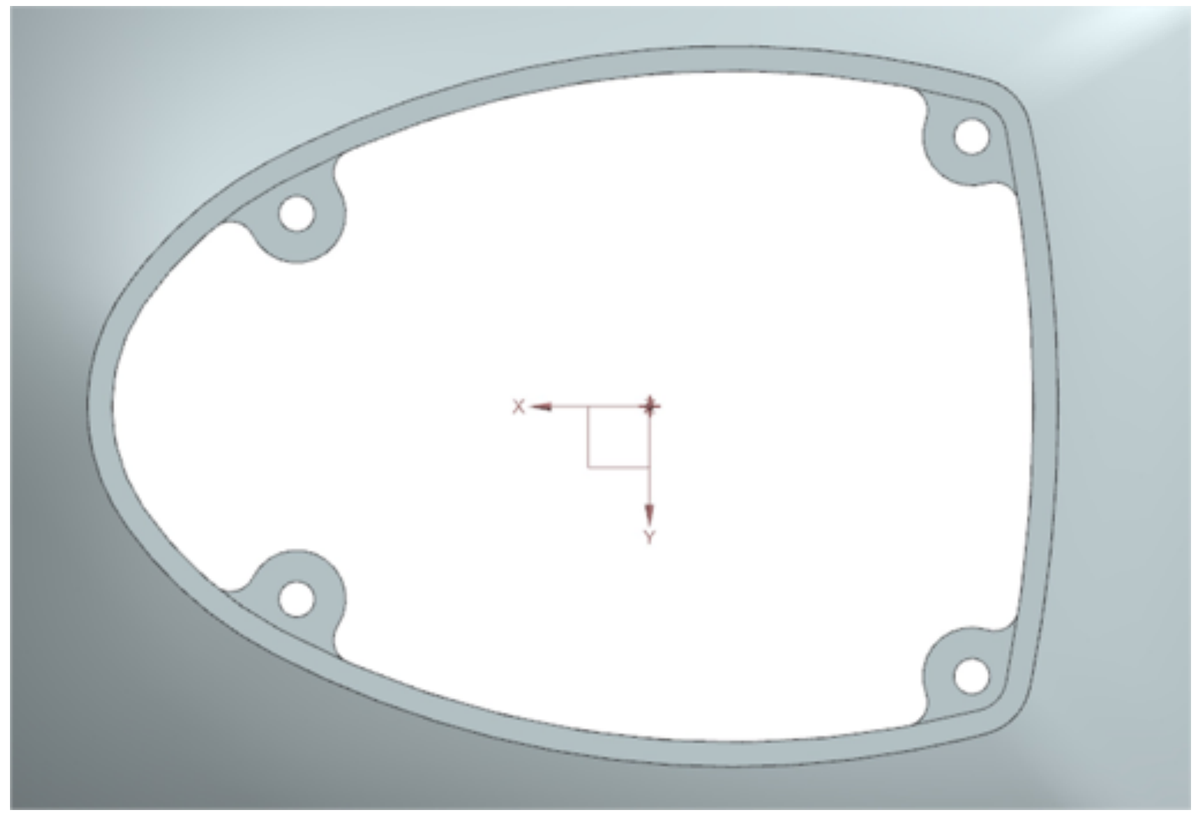
Mounting Plate

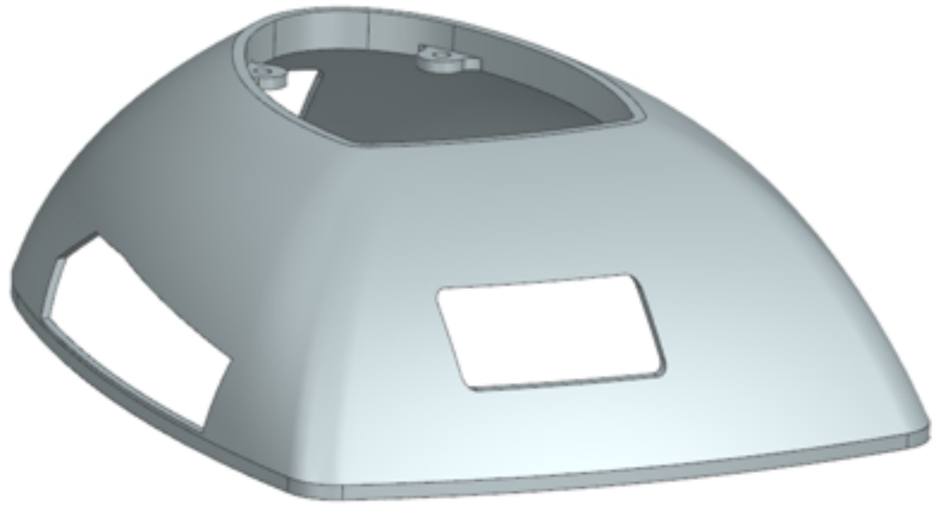
- New plate replaces current top drone plate.
  - Reasoning: Lighter than adding an additional mounting plate with standoffs.
- Holes in correct mounting locations for ESC, PDB, Jetson, and Pixhawk
- Initial material: Acrylic
- Final material: Carbon fiber plate stock



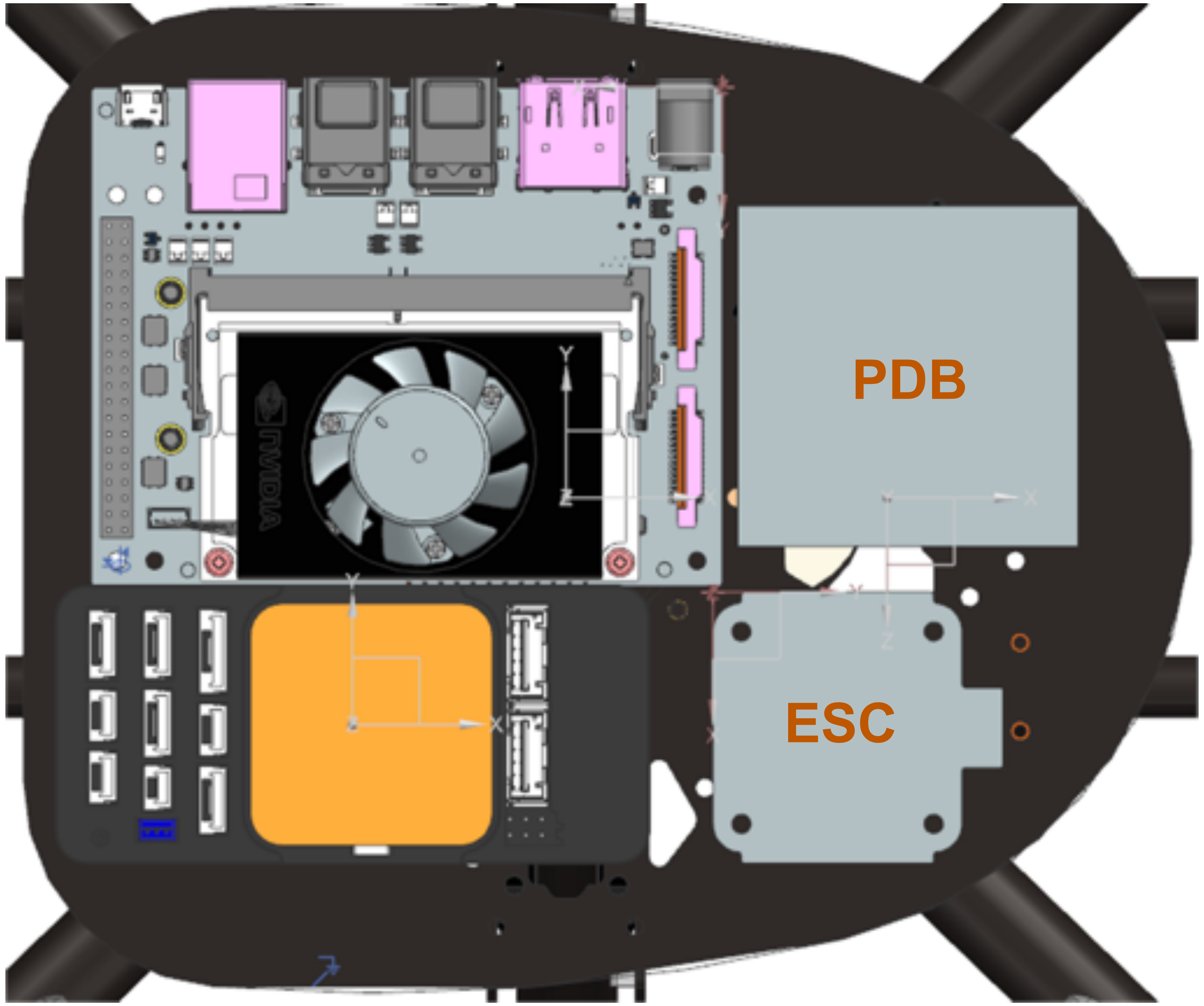
Drone Cover

- Nylon/Carbon or SLS
- Holes for access to Jetson and Pixhawk
- Cooling holes for Jetson
- Integrated LIDAR mounting
- Attached to mounting plate with 4 screws, threaded inserts bonded to cover





Flight Control Electronics Layout



Mounting Solutions

- Anti-Vibration Foam Tape
  - Current mounting option for manual flight testing
  - Vibration reduction for electronics
- Rubber grommets (“gummies”)
  - More permanent mounting option for autonomous flight
  - Attaches components to mounting plate with screws
  - Vibration reduction for electronics

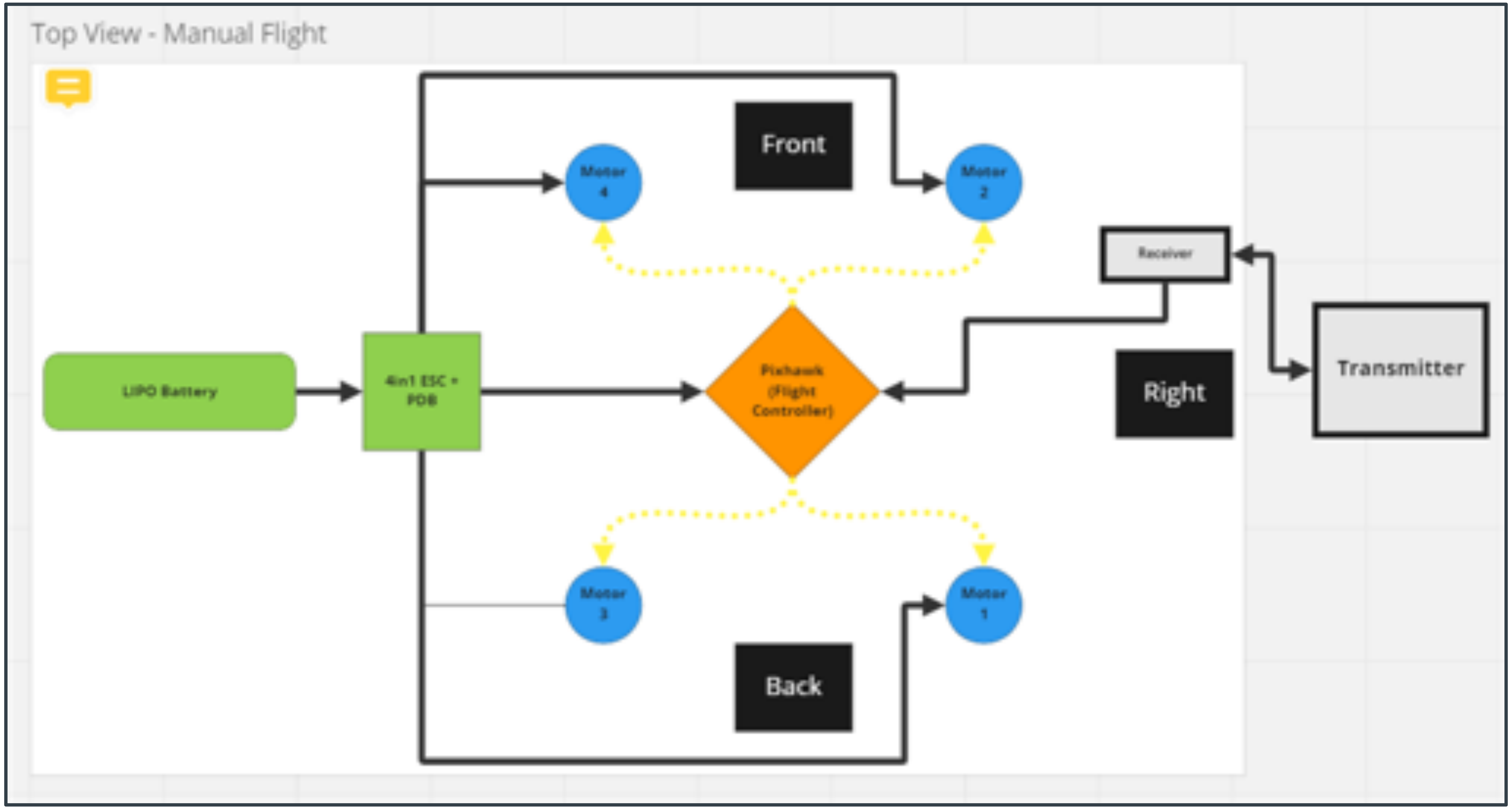
TEST STAND - SHAYLA

TEST STAND REASONING

The test stand provides the hardware and software teams an outlet to test and modify the drone without actually touching the drone. The main drivers for test stand development are:

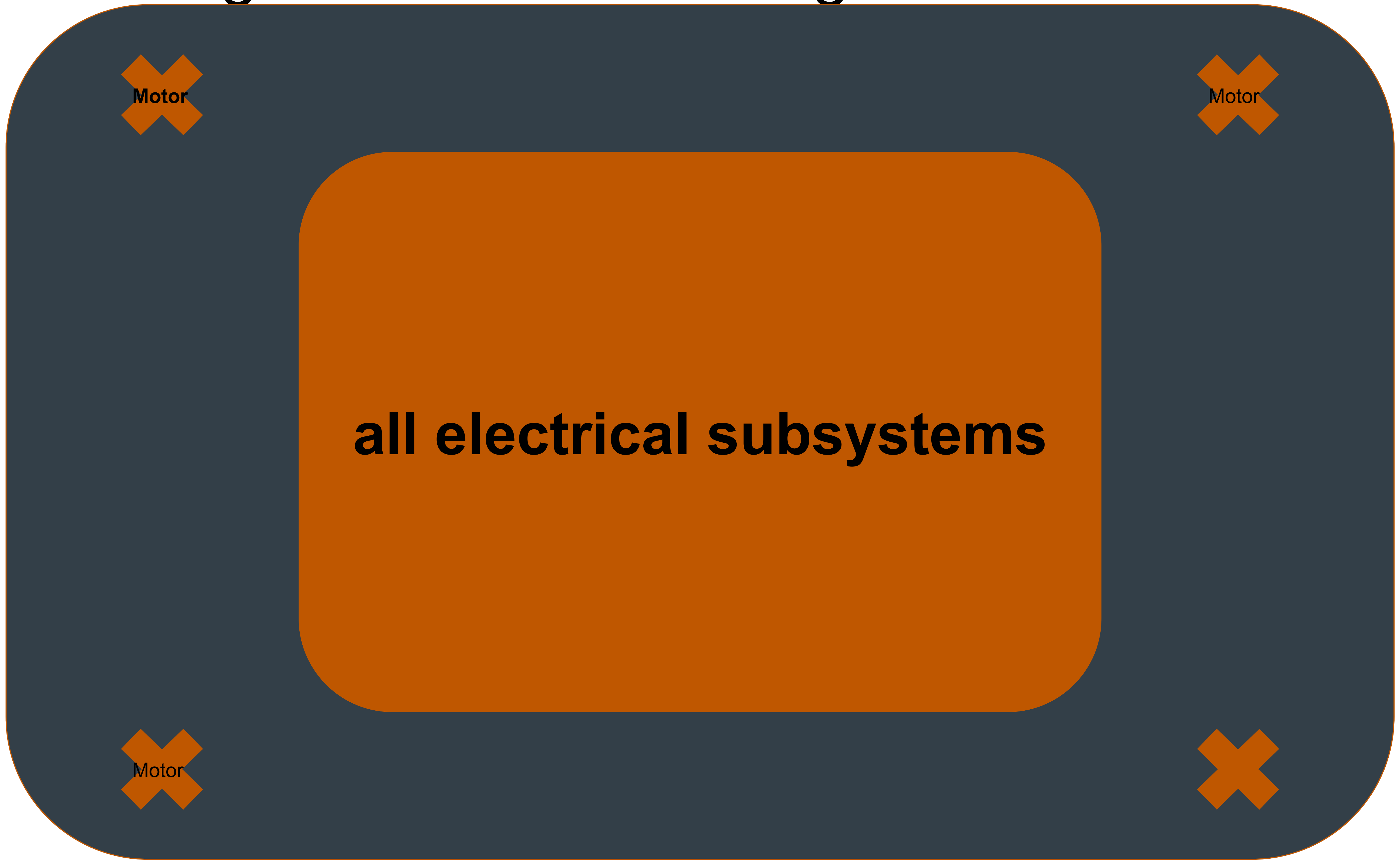
- Running test software for drone sensor and motor checkouts.
- Testing varying configurations and sensors in the case of drone modification.
- Testing sensor longevity and runtime.

TEST STAND OVERVIEW



TEST STAND DESIGN

The test stand is designed as the following:



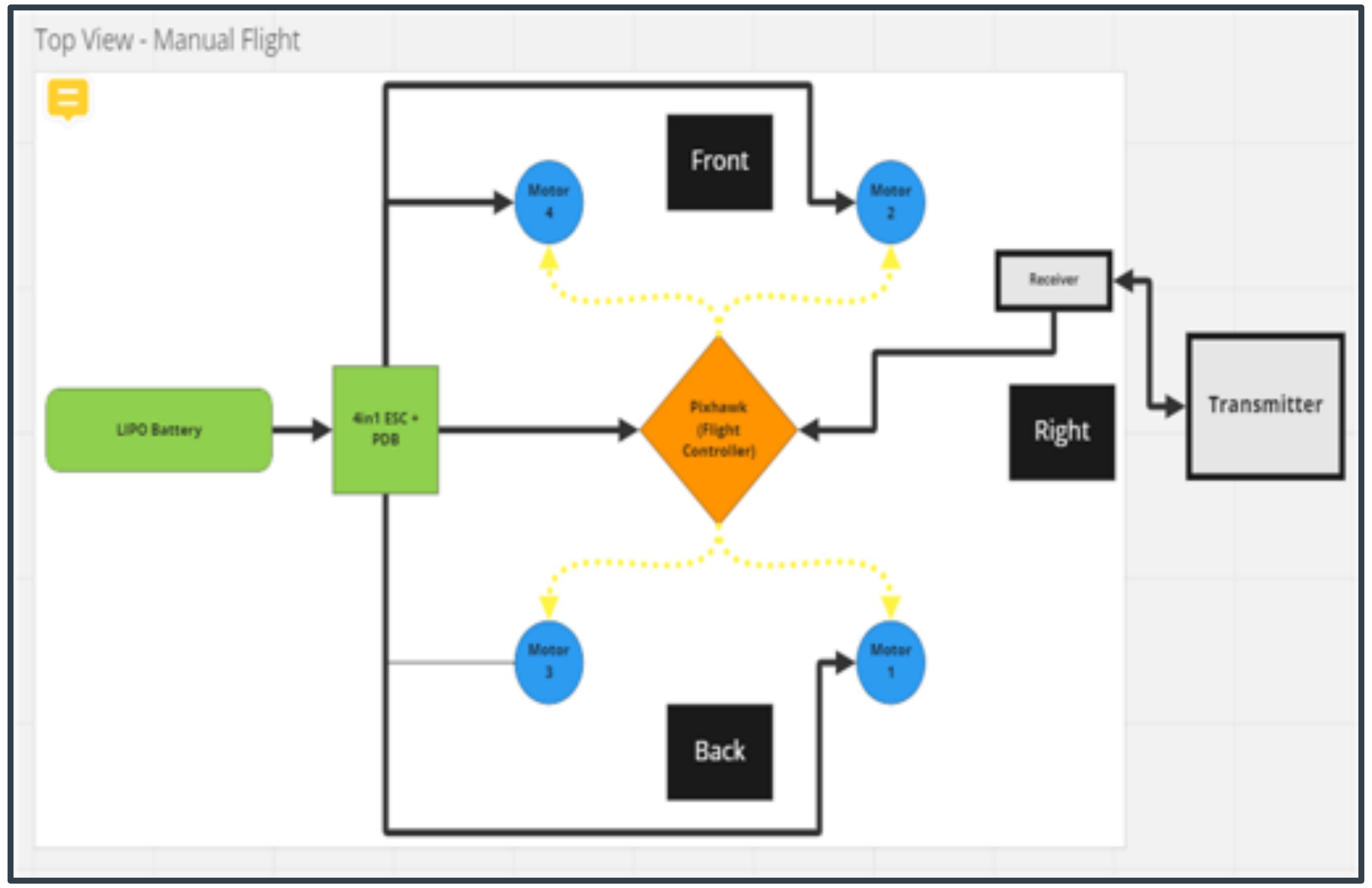
MANUAL FLIGHT HIGH LEVEL TEST PLAN - TRACE

Test Goals

1. Ensure all components are properly wired and functioning.
2. Ensure the drone functions and responds as desired to control input.
3. Find issues before they cause damage to the drone.
4. Characterize the performance of the drone.
    a. Thrust
    b. Speed
    c. Range
    d. Battery Life
    e. Payloads

Test Stand Tests

1. Transmitter to receiver connection
2. Pixhawk flight controller calibration
3. Motor spin direction
4. Transmitter input response
5. Object detection
   a. RPLiDar, Zed 2 stereo camera
   b. Range
   c. Field of view



Safety: Remove the propellers if they are not necessary to the test being conducted.

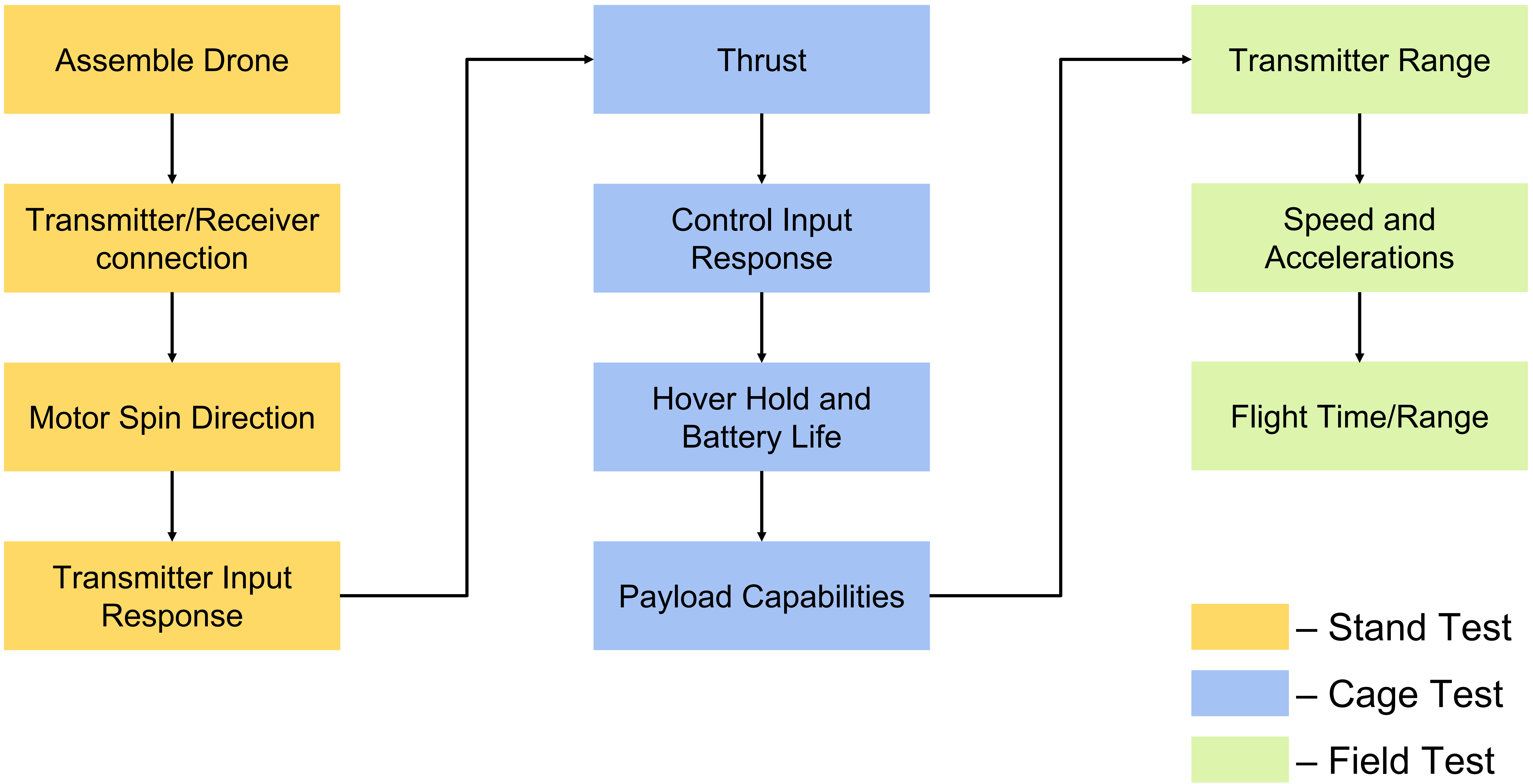
Drone Cage Tests

1. Thrust
2. Control input response
3. Hover
   a. Position hold
   b. Battery life
   c. IMU readings
4. Payload capabilities
5. Object avoidance
   a. Stopping speed

Field Tests

1. Transmitter range
2. Flight time
   a. Varying payloads
3. Flight range
   a. Varying payloads
4. Speed and accelerations
   a. Takeoff/Landing
   b. XYZ directions
   c. Rotating motions
   d. Varying payloads

Test Flow for Manual Flight



DRONE CAGE SAFETY - AUDREY

Drone Cage Flight Procedures

Location and Contact

We will be flying our drone in the drone cage on the top floor of the ASE garage. Permission can be obtained by emailing Dr. Todd Humphreys at todd.humphreys@utexas.edu

Safety Procedure and Pilots

All personnel, including the drone pilot, must be standing on the outside of the drone cage at all times during testing. Regarding drone pilots, currently the only students holding licenses to fly a UAV are Ishani and Nick.

Flying on University Property

Obtain Approval by University

In order to fly a UAV on University property as part of a University-associated project, we must submit a flight request listing faculty member endorsement, maps, etc.

Filming and Photography Approval

Filming and photography on UT property for a UT class project requires an email to be sent by the endorsing faculty member to (utfilming@utexas.edu) for approval.

WEBSITE DEVELOPMENT - AUDREY

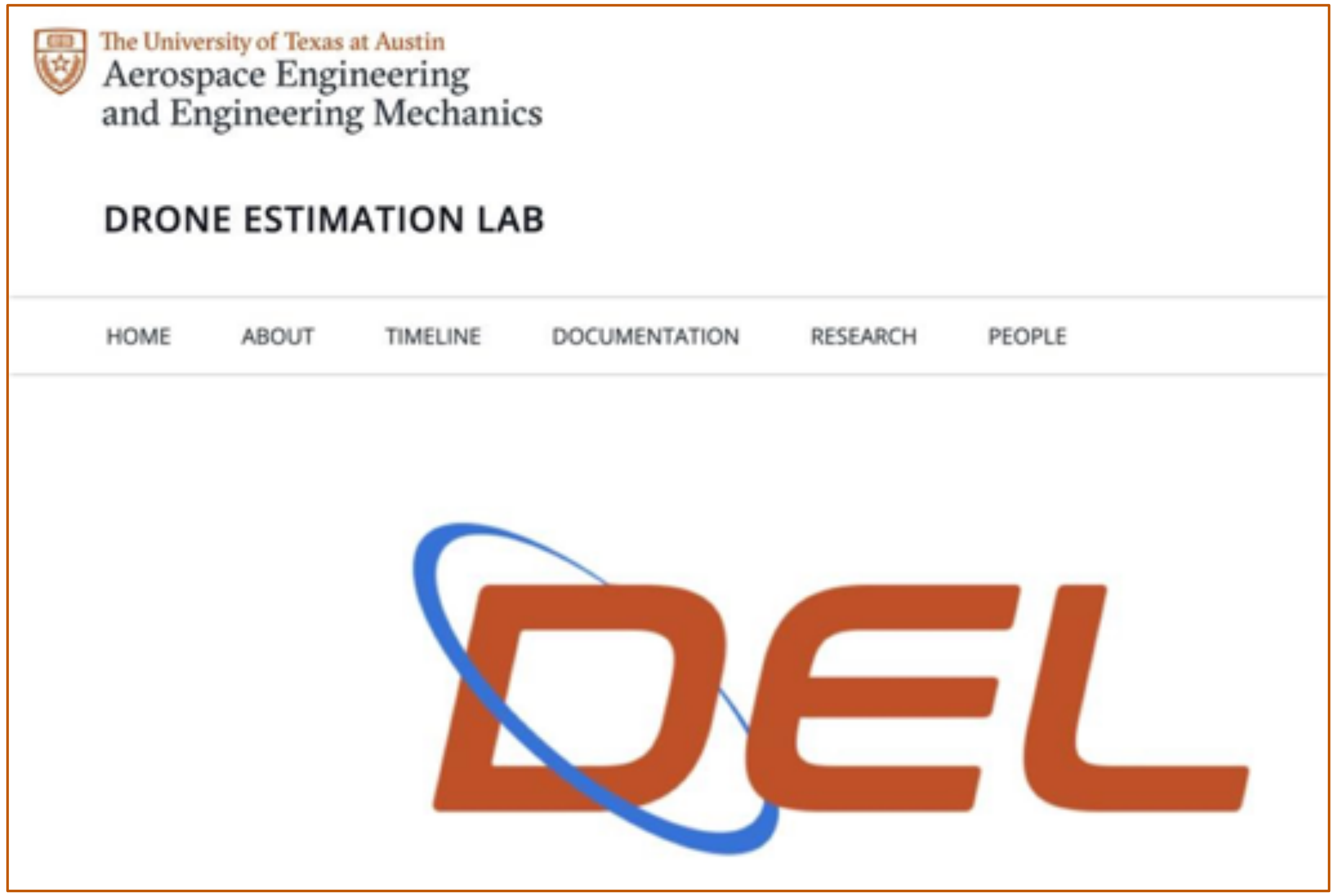
Website Development

Main Objective

To provide a more detailed update of our project to NASA and the general public in a user friendly and succinct way.

We organized our site into various tabs:

- About
- Timeline
- Documentation
- Research
- People



Link to the website: https://sites.utexas.edu/del/

Future Uses

Our hope is to update this website periodically as we continue to conduct more research and begin flight tests.

Future Changes

In the future, we may add a *Flight Testing Tab* to explain in further detail our flight test plans and the data we obtain from them as well as any photo or video documentation that may be interesting to NASA.

In addition, we thought it may be helpful to add subpages to the research tab for each subteam so that each team has an opportunity to share the research they have been conducting.

ONBOARDING PROCEDURE - JORDAN

USRC Google Drive

Share the google drive folder for USRC to all new members.

Allowing new members access to the teams resources and documents is ESSENTIAL

Show-Off Design Reviews

Show most recent design reviews to new members. An in-depth presentation is not necessary, but highlight the most prominent work that semester as well as current state.

This will help catch up newer members on the project's progress, as well as allow them to have some semblance of how to work with the project in its current state

Review Hardware Users Guide

New team members should review the USRC Hardware Users Guide. Specifically, they should review the **Parts List** and the **Assembly Guide**.

The Parts List will allow them to understand the different parts of our drone and what their purposes are, while the Assembly Guide will provide future members vital information regarding building and modifying future drones.

Table of Contents

End of Semester Updates

At the end of each semester, the current team members should begin updating the Hardware Users Guide with any new information (new drone parts, instructions for new operations, etc.).

This will allow the team to have some essence of winding down, while still keeping up productivity. This also enables the passing down of knowledge to off-season members as well as the next team.

POC Reassignments

Last but not least, a new Person of Contact (POC) must be assigned for the Design Course as well as with NASA. These two roles can be filled by one or two people.

The POC for the Design Course will be interacting with Professor Nokes mostly, while the POC for NASA will be communicating directly with a NASA representative. Just make sure all members can agree on a POC and report the representative(s) to Professor Nokes.

OUTLOOK - VICTOR

Future Works

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

Semester Gantt Chart

Parts List & Budget

Part Number	Part Name	Quantity	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	$39.98	$399.80	Link	Amazon	Y	Y
2	Lumenier Elite PRO 60A 2-6S BLHeli_32 4-in-1 ESC - 60 Amps	3	$112.19	$336.57	Link	Amazon	Y	Y
3	APD PDB500[X] 12S 52V 500A Power Distribution Board	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	$91.23	$91.23	Link	Amazon	Y	N
5	Amass AS150 Male and Female Anti Spark Connector Plug Set for Battery, ESC, and Charge Lead	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	$27.99	$27.99	Link	Amazon	Y	Y
7	Ethix Quad-Builder Cable Set	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	$6.99	$6.99	Link	Amazon	Y	Y
9	Tiger Motors T-Motor Polymer Straight Propellers - MS1302 (Pair) - 13" - Black	1	$14.57	$14.57	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	$158.88	$158.88	Link	Amazon	Y	Y
	Total $ Spent			$1,179.97				

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				

References

- Kamrath, Luke, and James Hereford. “Development of Autonomous Quadcopter.” *IEEE Xplore,* https://ieeexplore.ieee.org/abstract/document/7925262.
- Lochau, F. (2022, December 1). Flying your drone in bad weather? 4 things you should consider. FlyNex. Retrieved December 4, 2022, from https://www.flynex.io/news/flying-your-drone-in-bad-weather-4-things-you-should-consider/
- Pilot Institute. (2022, August 6). Who needs a license to fly a drone? Pilot Institute. Retrieved December 4, 2022, from https://pilotinstitute.com/drone-license-requirements/
- Become a drone pilot. Become a Drone Pilot | Federal Aviation Administration. (n.d.). Retrieved December 4, 2022, from https://www.faa.gov/uas/commercial_operators/become_a_drone_pilot#:~:text=In%20order%20to%20fly%20your,procedures%20for%20safely%20flying%20drones.

THANK YOU.

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