

**Building Process Log  
And  
Maintenance Manual  
For *Denver***

**by Paper Midnight Flashers**

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# Part 1: Building Process

## I. Parts

### a. Frame Parts

<b>Part Category</b>	<b>Part Name</b>	<b>Quantity</b>
UAS platform	Level 1 - Large square with 8 unique holes for landing gear bushings plate	<b>1</b>
	Level 2 - Large square plate	<b>1</b>
	Level 3 - T shape plate	<b>1</b>
	Level 4 - Small ellipse-rectangle plate	<b>1</b>
Arm and Motor Mount	Golden Square Arm	<b>2</b>
	Black Square Arm	<b>2</b>
	Motor mount	<b>4</b>
	Motor mound reinforcement part	<b>4</b>
Barrel Connector	M3*14.9 Hexagon Barrel	<b>6</b>
	M3*15 Circle Barrel	<b>8</b>
	M3*25 White Hexagon Barrel	<b>3</b>
Landing Gear	Landing gear bushings – Metal Rings	<b>4</b>
	Landing gear bushings - Rubber landing gear circles	<b>4</b>
	Main connecting rods	<b>2</b>
	Main connecting rods - Rubber caps	<b>4</b>
	Plastic landing struts	<b>2</b>
	Landing gear skids	<b>2</b>
Battery Mount	V Shape Connector	<b>2</b>
	Platform	<b>1</b>
	M2.5*8 Battery Mount Screws	<b>4</b>
	Cable Straps	<b>1</b>
Screws (Including frame, power, and control)	M3*25 Long Screws	<b>16</b>
	M3 Hexagon nut	<b>13</b>
	M3*4 Short flat “+”	<b>8</b>
	M3*6 Short rounds hexagon	<b>38</b>
	M3 White Nylon Washers	<b>16</b>

### b. Power Parts

<b>Parts Category</b>	<b>Part Name</b>	<b>Quantity</b>
Main Power	XT60 Male Connector	1
	Red 14 AWG Wire	1
	Black 14 AWG Wire	1
	Red Heat Shrink Tube	1
	Black Heat Shrink Tube	1
	Power Distribution board	1
	Power Distribution board Nylon Barrel	4
	Power Distribution board Nylon Barrel Nut	4
	Power Distribution board Nylon Barrel Screw	4
	Female Bullet Connector	12
	Female Bullet Connector	12
	2-4S 30A ESC	4
	SunnySky Angel 2212 1250 KV Brushless Motor	4
	1045 Propeller CW	2
	1045 Propeller CCW	2
	Propeller-motor adaptor	4
	Propeller-to-motor connector	4
White zip tie	16	

### c. Control Parts

<b>Parts Category</b>	<b>Part Name</b>	<b>Quantity</b>
Control	Pixhawk 4 Cube Flight Controller	1
	Here 2+ GPS	1
	Flysky FS-i6X Transmitter	1
	FS 6 Channel Receiver	1
	White-red-black servo signal cable	1
	Buzzer	1
	Flight Control Mount - Base	1
	Flight Control Mount – Top	1
	Rubber Anti-vibration Barrel	4
	GPS Mount	1



## II. Frame Construction

### a. UAS platform

1. Screw 4 hexagon barrels with 4 short rounds hexagon screws to the holes in the middle of each edge of the Level 1 platform
2. Drill 4 holes on Level 2 plate that can fit the power distribution board.
3. Take the arms and add them to the platform sandwiched between the Level 1 and Level 2 platform by using 8 long screws, 16 white washers, and 8 hexagon nuts. They should extend at a 45-degree angle outward from the center of the platform
4. Further connect the Level 1 and Level 2 platforms with short rounds hexagon screws on each of the flat sides – 4 hexagon barrels are attached in total with 8 round top screws
5. Torque down the screws connecting the arms to the Level 1 and Level 2 platform



Figure 1: Frame assembly.

### **b. Battery Mount**

1. Screw the platform onto the bottom of the V shape connectors – utilize 4 short flat screws
2. Install the cable tie.

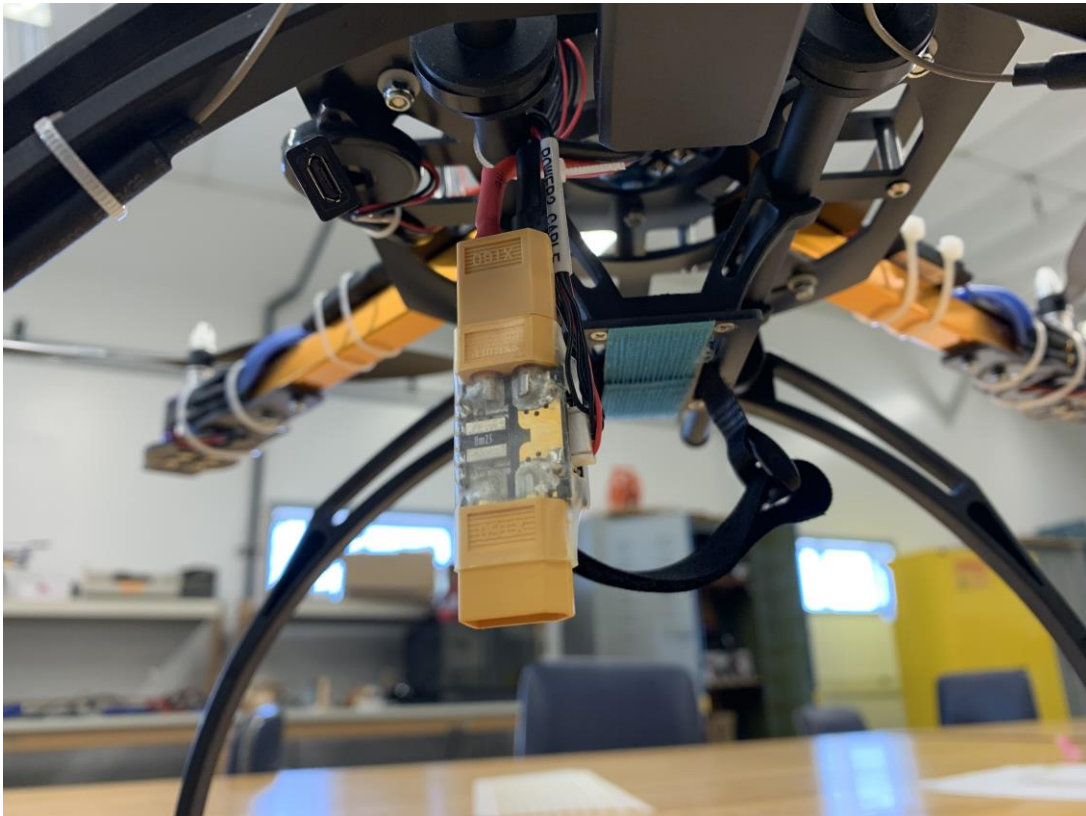


Figure 2: Battery mount.

### **c. Landing Gear**

1. Attach 4 landing gear bushings to Level 1 part with 8 short flat “+” screws
2. Slide in the two rods halfway through two of the bushings, meanwhile attach the battery mount.
3. Slide two rods all the way through the other bushings. Adjust the rods until they have four equal lengths on both sides.
4. Attach landing gear struts – might need to flex the struts
5. Attach the landing gear skids to the landing gear strut to the rest of the landing gear assembly
6. Attach the rubber caps to the connecting rods

#### d. Motor Mount

1. Mate four top and bottom motor mount surfaces to armatures with eight 2.0mm screws and eight 2.5mm screws. (Attach the motor mounts and motor reinforcement part to each arm with two long screws and nuts.)



Figure 3: A motor on a motor mount.

### III. UAS Electronics and Power

#### a. Soldering and Heat-shrink

1. Turn on the soldering iron.
2. Unpack the motor sets and ESC sets. Connect the bullet female and male parts to make sure they can be connected (usually they will).
3. Use a clamp to hold the bullet connector. Push the liquid solder into the shallower hole and push the wire of the ESC and motor in there. Hold the wire until the solder cools to solid.
4. Repeat the process for each bullet connector, there should be  $4*2*3=24$  in total.



5. Strip the main power wires on both sides for each one (one red and one black), twist them, and tin them. The length of the exposed parts should be just long enough to place them in to the XT60 connector.
6. Use two clamps to hold the wire and the XT60 together and apply the solder. Do the same thing to another wire after the first one is cooled.
7. Inspect the joint carefully, re-solder the parts if necessary. Cover the bullet connector with heat-shrink tube.
8. Push the other side of the main power wires to the power distribution board, hold them and put them on the frame and see if the connection like that would work.
9. Solder the main power wires and the ESC power wires to the distribution board where their wires come out from the opposite of the board. That is, the main power comes from the bottom and is distributed out from top.
10. Inspect the joint carefully, re-solder the parts if necessary.

#### **b. Motor, ESC, and Power Distributor Installation**

1. Attach the short nylon spacers and their nuts to the Level 2 Platform
2. Attach distribution board to the frame using four nylon spacers screws
3. Attach the motors to the center of the motor mount with M3\*6 screws while letting the wire face the center of the UAV.
4. Connect the motors to the ESC. Warp the wires around the arm to avoid extra wires that could make sharp turns, meanwhile carefully choose a side so that the wire will not get stuck and cut on the Level 2 platform and the foldable arms. A zip tie will be used after the rotation direction of the motors is confirmed.

#### **c. Balancing Propellers**

1. Form a bond to the props such as naming them based on their characteristics (Our props names: (1) Charlotte (2) Rochester (3) Savannah (4) Anchorage)
2. Check the current balance of each propeller on a propeller balancer
3. If the prop is not balanced, use tape to balance the blades and hot glue to balance the hub as necessary
4. Check if every propeller will stay at any incline angle (if this is the case the prop is balanced)

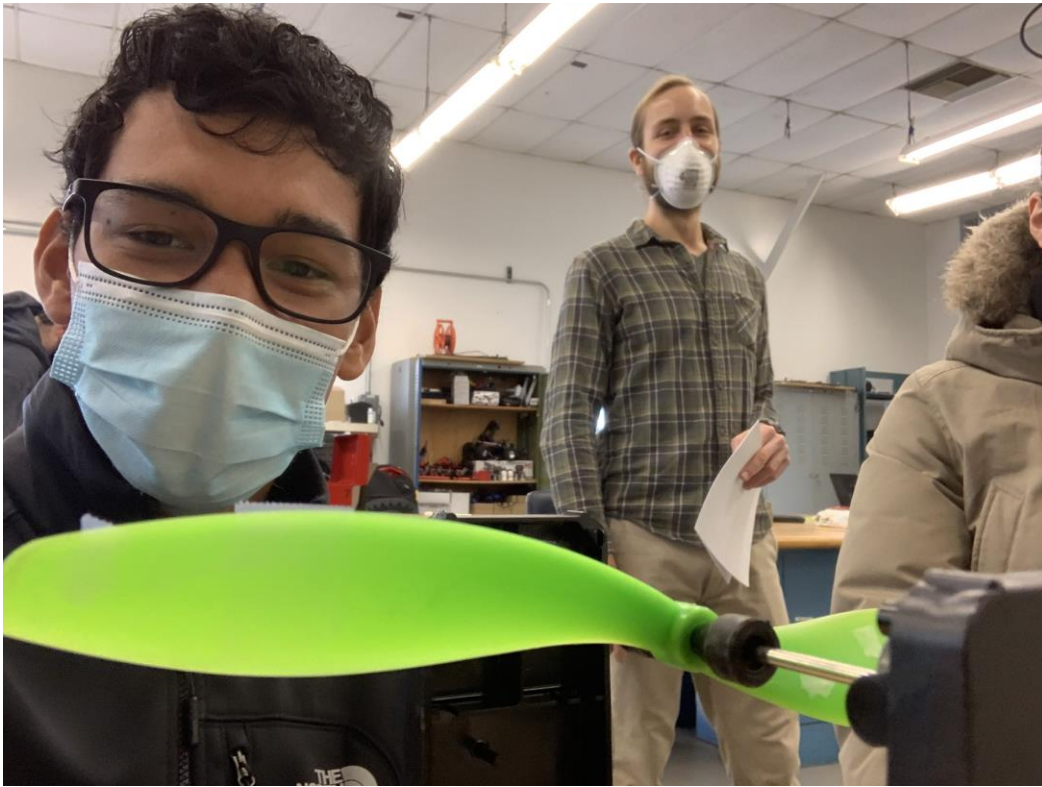


Figure 4: Balancing Propellers.

## **IV. Control Related Accessories Installation**

### **a. Flight Controller (FC) Mount and GPS Mount Installation**

1. Design the FC mount and GPS mount on Siemens NX CAD software.
2. Review the dimensions and direction of the parts
3. 3D print the mounts

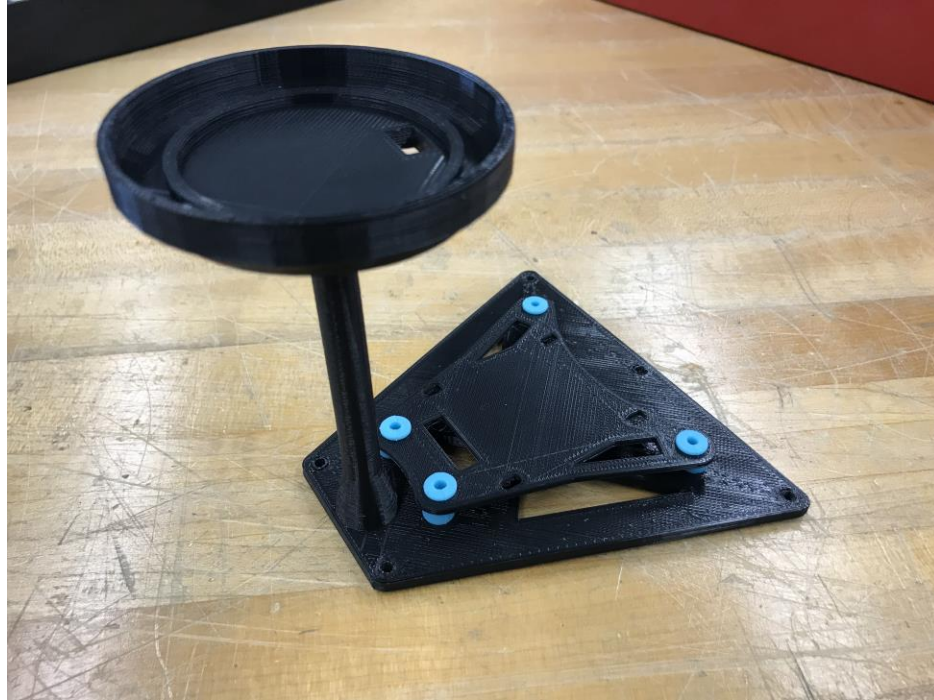
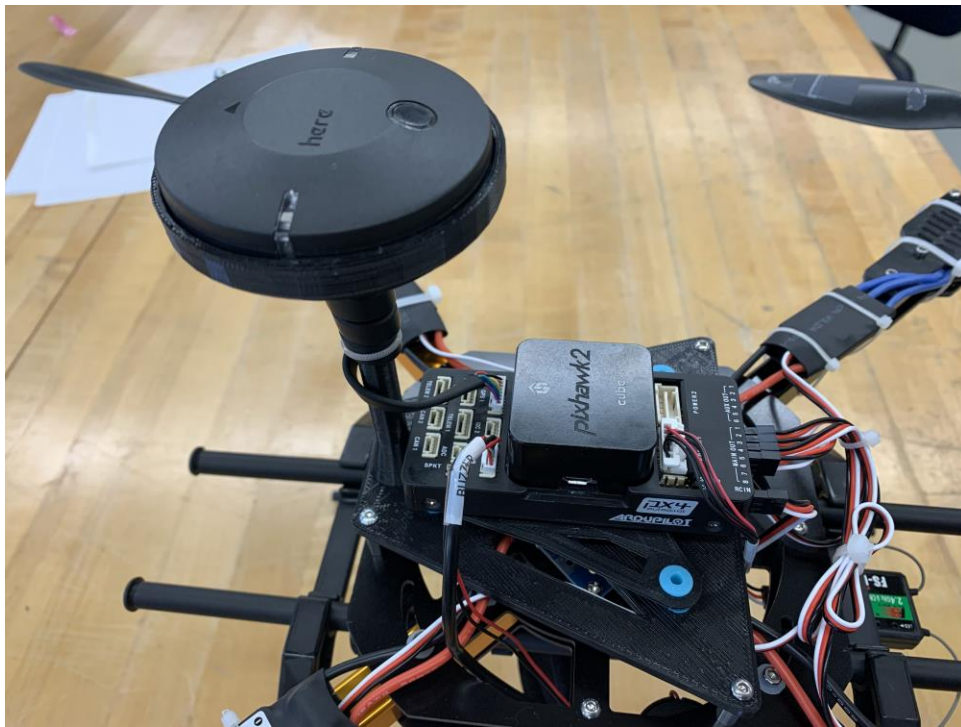


Figure 5: 3D Printed FC and GPS mount.

4. Install the FC mount top part to FC mount base using four rubber anti-vibration barrels. Install the GPS mount onto the FC mount
5. Put the FC and GPS on the mount and confirm the position without tapes.
6. Use double sided tape to secure the FC and GPS. Make sure they are facing the correct direction.



Figure 6: Install FC and GPS.



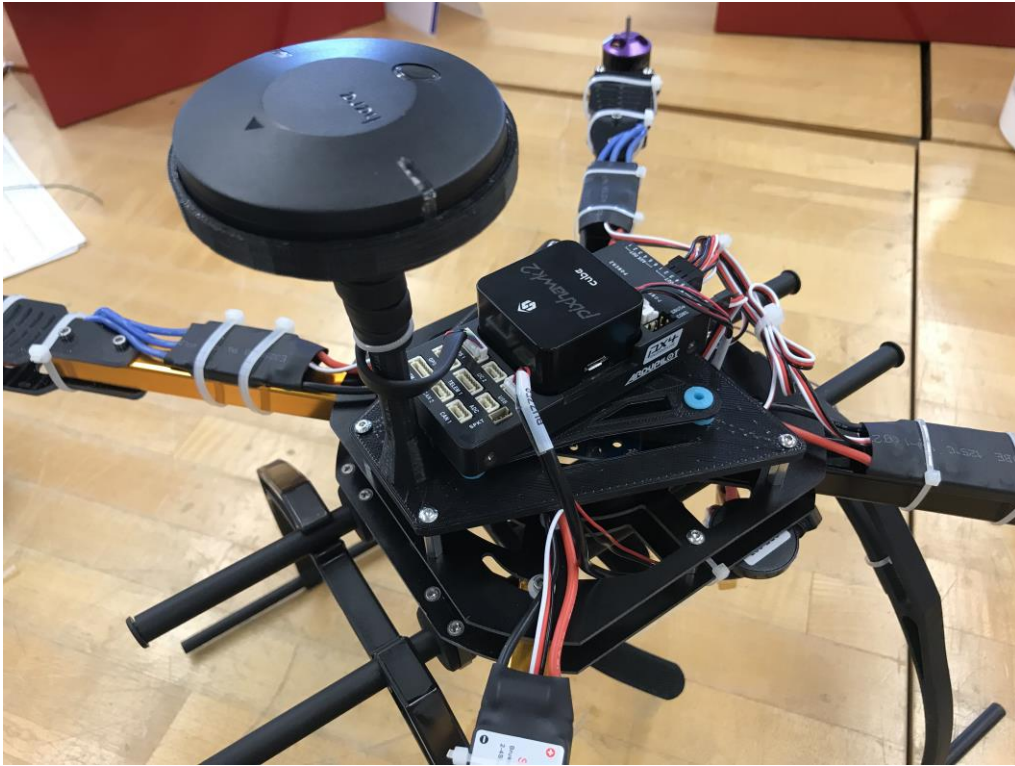


Figure 7, 8: Install FC mount onto the frame.

### **b. Receiver, Buzzer, and Ammeter Installation**

1. Use a servo signal cable, insert it into i-bus servo port
2. Install the receiver on the landing gear with double sided tape.
3. Secure the antenna on the landing gear with zip tie
4. Use double sided tape to install the buzzer under the Level 1 frame at least 5 centimeters away from the Cube.
5. Connect the Ammeter to the XT60 male connector which is connected to the power distribution board.

### **c. Wiring**

1. Wrap the GPS cable around the mount, secure it with a zip tie, and connect it to GPS 1 on the FC
2. Connect front-right motor ESC to MAIN OUTPUT channel 1
3. Connect rear-left motor ESC to MAIN OUTPUT channel 2
4. Connect front-left motor ESC to MAIN OUTPUT channel 3

5. Connect rare-right motor ESC to MAIN OUTPUT channel 4
6. Connect receiver signal cable to RCIN port
7. Connect ammeter to POWER 1.

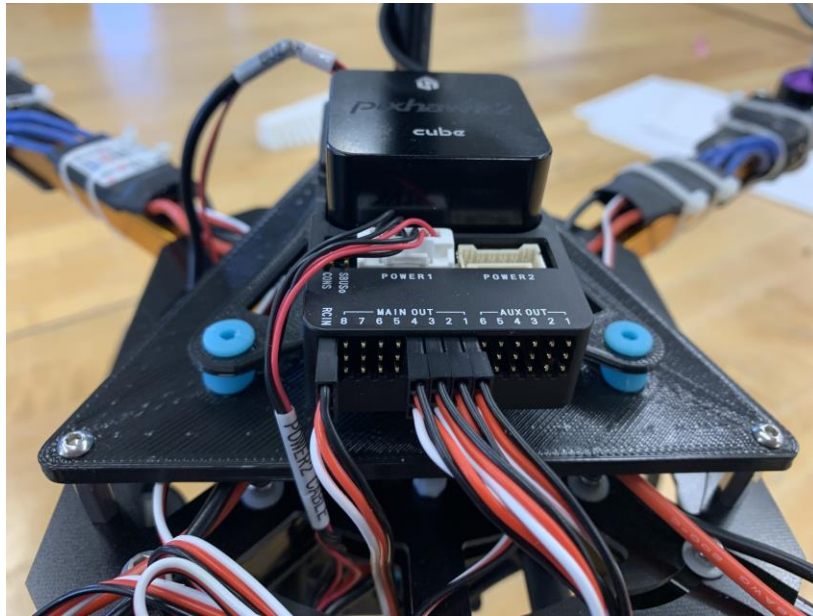


Figure 9: Wiring

## V. Flight Controller, GPS, and Receiver Parameter Setup and Calibration

### a. Receiver and Transmitter Setup

1. Install four AA batteries to the transmitter
2. Set the model's name to *DENVER!!*
3. Set the model type to Fixed Wing
4. Center the output of the joysticks by pushing the fine-tuning rod and hear the unique sound.
5. Set channel 5 to a three-stage-switch, switch C
6. Set channel 6 to a two-stage-switch, switch B



Figure 10, 11: The transmitter.

#### **b. Flight Controller Setup and Calibration**

1. Download and install QGroundControl on a computer.
2. Use a USB and micro-USB cable to connect the cube and a computer.
3. Go to set up, "Firmware", update the newest firmware.
4. Go to "Airframe", choose Quad X
5. Go to "Radio", start the radio calibration.
6. Go to "Flight Modes", in channel 5, set the first two to "Stabilize", the middle two to "Auto", and the last two to "Loier". In channel 6, choose RTL (Return to land). Flip switch B and C to see if different flight modes are highlighted.
7. Go to "Sensors", calibrate compass, gyroscope, and accelerometer.

## **VI. Pre-Test-Flight Check and Preparation**

### **a. ESC Calibration**

1. Remove the propellers and turn all the switches to neutral on the transmitter
2. Push the throttle to the max, and turn on the transmitter.
3. Connect a Li-Po battery to the XT60 male connector on Denver
4. After 10 seconds (the lights are stable), disconnect the battery. Then after 5 seconds, reconnect the battery
5. Hold the safety button the GPS until the lights are solid red.
6. After hearing the sound from the motors, pull the throttle all the way to the minimum.

### **b. Motor Direction Check**

1. Push the throttle up, check if the motors spin faster.
2. Use a piece of a sticky note to touch the motor and check the direction.
3. Front-right and rare-left motors should spin counterclockwise
4. Front-left and rare-right motors should spin clockwise.
5. Unplug the battery and change the ESC wiring if necessary.
6. Plug in the battery, hold the safety button, push the throttle all the way to down-right to arm.
7. Push up the throttle and check the direction of the motors.
8. Use zip ties to secure the motor wires. (Remove excess zip-tie)

### **c. Control Direction Check**

1. Install the propellers. Pick a proper ring that can fit on the clamp perfectly from the propeller pack and push them into the notch on the propeller. Attach the prop hub and motor clamp to the prop, the side that has the number of dimensions is facing up, and the thicker edge is facing the direction of rotation.
2. Secure the battery to Denver.
3. Connect the battery and hold Denver overhead.
4. Arm Denver.



5. Check the four channels of control.
6. Pushing right joystick to the left and right should feel Denver is going left and right.
7. Pushing right joystick forward and backward should feel Denver is going forward and backward.
8. Pushing left joystick forward and backward should feel Denver is going up and down.
9. Pushing left joystick to the left and right should feel Denver is rotating counterclockwise and clockwise.

## **Part 2: Maintenance**

### **I. Frame Check**

- a. Check if the screws are tight.
- b. Check if the screws are crushing the frame.
- c. Check if there is any visible crack on the plates, arms, and the barrels.
- d. Check if there is any wear down on the moving parts.

### **II. Power Check**

- a. Check if the propellers have deformation.
- b. Check if the propellers have cracks.
- c. Check if the propellers are pushed all the way down and tight.
- d. Check if the motor is free to move without any resistance (other than magnetic force)
- e. Check if t
- f. Check if the cables are tight on the arms.
- g. Check if there is anything on the power distribution board.
- h. Check if the insulation of the wires is smooth without cuts and slits.
- i. Check if the battery holder is not losing any grip.
- j. Check if the battery holder has no cuts.

### **III. Firmware Check**

- a. Check if the firmware is updated to the latest version (once every month).
- b. Check if the Pixhawk Cube is secure on the FC mount
- c. Check if the GPS is secure on the GPS mount
- d. Check if the GPS mount is secure on the FC mount
- e. Check if the wires are in place (no loose wires)
- f. Check if the receiver is secure on the landing gear.