Chiropter Build Log

Mickey Horn | July 1, 2019

This document will describe the build process of the new Chiropter so that it can be repeated in the future, improved upon, and be used for troubleshooting/repair if needed. Note that the order in which these steps are written is somewhat different than the order in which it was assembled. This is due to changes made after or during the build, such as moving the motor pods out. This will be reflected in some of the pictures.

List of Materials

Flight Components

- Tarot 690S Frame (1x)
- DJI E800 Tuned Propulsion System (1x)
    - DJI 3510 Motors (6x)
    - DJI 620S ESCs w/ LEDs (6x)
    - DJI 13” x 4.5” Propellers (6x)
- Pixhawk 2.1 Flight Controller (1x)
- Here+ RTK GPS System (1x)
    - Here+ Rover Module (1x)
    - Here+ Base Module w/ Antenna (1x)
- Holybro Micro M8N GPS Module (1x)
- FrSky X8R Receiver (1x)
- Holybro 915MHz Telemetry Radios (2x)
- Taranis -plus Transmitter (1x)

Power Components/Wiring

- Genstattu 6S 16000mAh LiPo Battery (1x)
- ProfiCNC Power Brick Mini (1x)
- DJI Power Distribution Board (1x)
- EC5 Male to XT60 Female Adapter (1x)
- XT60 Male Connector with Wires (1x)
- Craft and Theory Telemetry Cable (1x)
- Pixhawk Power2 Cable (1x)
- Pixhawk Telemetry Cables, Spliced (2x)
- Pixhawk GPS2 Cable Spliced w/ Holybro 6-pin Cable (1x)
- X8R 3-pin Cable (1x)
- USB to MicroUSB Cable (2x)

Mechanical Components/Fasteners

- Aluminum Folding GPS Mast (2x)
- Command Strips
- Electrical Tape
- Hex Screws
    - M2.5 x 5mm
    - M2.5 x 8mm
    - M2.5 x 22mm
    - M2.5 x 30mm
    - M3 x 5mm
    - M3 x 6mm
- Loctite
- Velcro Strips and Straps
- Zipties

Tools

- Allen Wrenches (M2, M2.5, and M3)
- DJI ESC Updater
- Hand Drill (7/64” and 5/64” bits)
- Heat Shrink
- Laptop with
    - QGroundControl
    - DJI ESC Assistant
    - Misson Planner
- Pliers
- Scissors
- Soldering Iron with Solder and Flux
- Wire Cutters
- X-acto Knife

Step 1: The Legs

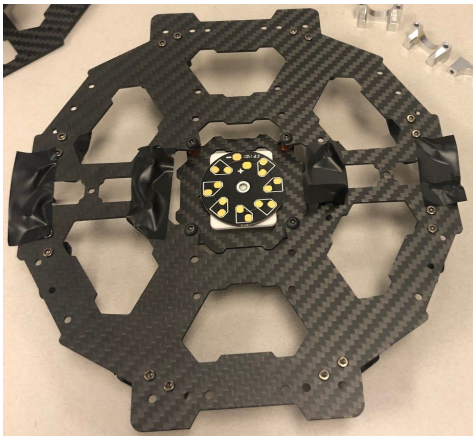
1. Using 2 small M2 set screws, attach the T-junction to the leg bar. It may be easier for you to start putting the screws into the T-junction before inserting the leg, as you have to thread through it yourself. Ensure it is level by placing it on a flat surface. The flat part of the T-junction and the carbon fiber plates at the top of the leg should lie flat on the table at the same time, like the leg on the left in the picture below step 1.2.

2. Use a third set screw to attack the foot bar to the T-junction. Ensure it is centered, the feet are approximately 11” long. Attach the rubber feet to the ends of the foot bar.

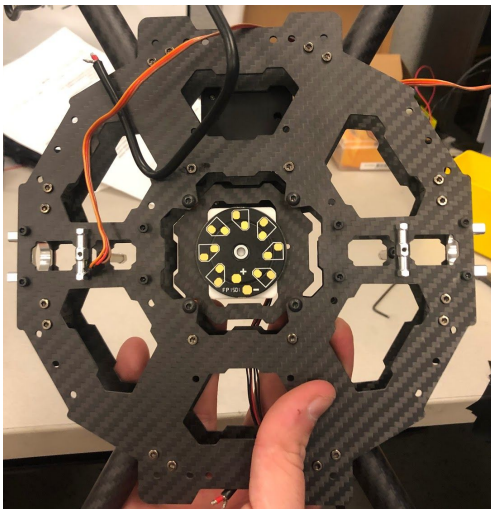
3. Detach the silver bracket and rod from the top of the legs with the M2.5x6mm screws. These will be mounted to the bottom frame in the next step.

Step 2: The Body

1. Remove the top frame by unscrewing the 16 M2.5x5mm screws along the outside edge that go into the plastic arm brackets.
2. Attach the metal rods to the bottom of the bottom frame with the M2 screws that were in the rods perpendicularly. They mount to the holes between the electrical tapes on each side of the picture below.

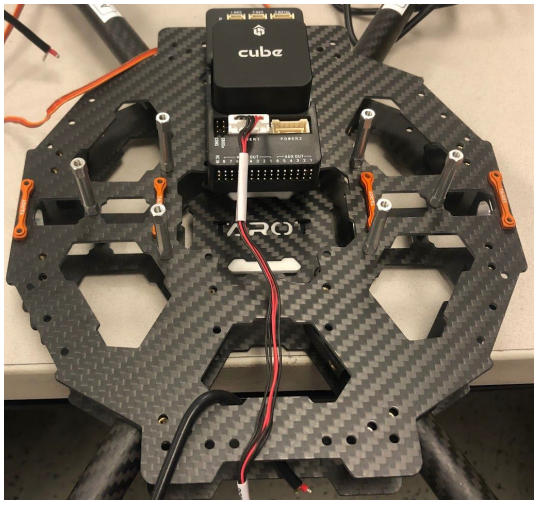


3. Attach the 2 metal brackets taken from the legs and the 6 others to the top of the bottom frame with M2.5x30mm screws. The brackets from the legs have 2 additional screw holes (seen in the picture above), which should be placed in the outermost positions. Temporarily tape the long screws to the bottom of the frame to hold them in place. Put the recesses in the brackets towards each other on each side, and they should form 4 circles for the 2 side arms to go through.
4. Screw the 2 front and 2 back arms into the top of the bottom frame with M2.5x5mm screws. They are the 4 greyish hex flathead screws closest to the center in the picture below.



5. Place the top frame in position over the M2.5x30mm screws going through the arm brackets, and attach the 4 orange bars on top of the top frame. Do not tighten the screws at the bottom fully until the 2 side arms are placed. Ensure the arms are level and spaced correctly when tightening the screws. The end of the arm should be flush with the innermost side of the inner brackets. Additionally, tighten

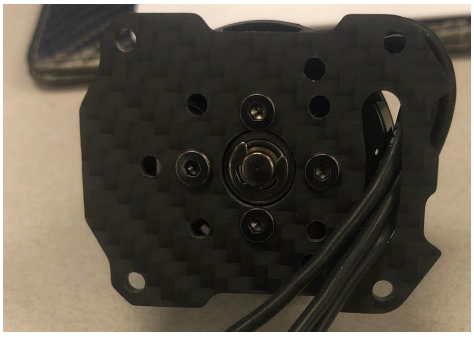
the two screws per bracket evenly with each other. If one side is tighter than the other, there will be a slight tip in the frame.



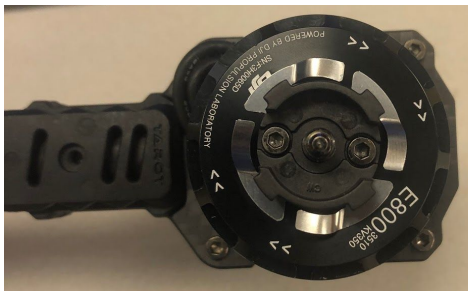
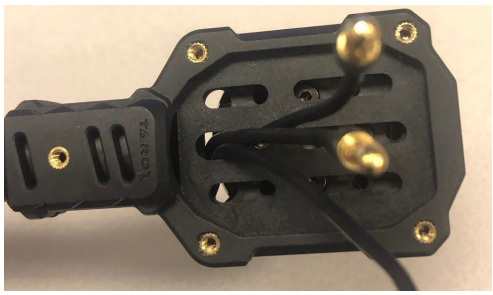
6. Screw in the tops of the front/back arms just like in Step 2.4. Also re-screw the 16 M2.5x5mm screws you removed previously to take off the top frame.
7. Reattach the legs to their brackets and metal rod with 4 M2.5x5mm screws. Make sure the bottom frame slides into a gap in the carbon fiber plates.

Step 3: The Arms

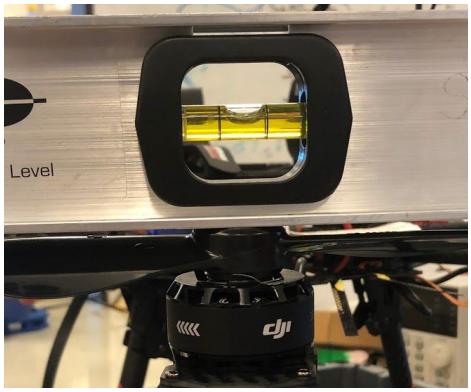
1. Mount a motor to a small carbon plate using 4 M2.5x5mm screws from the DJI toolkit. Put the 3 wires from the motor through to the other side of the plate as shown below. Flatten the wires down so that they do not touch the spinning part of the motor.

2. Mount the motor plate to the motor pod with 4 M2.5x5mm screws from the Tarot set. 1 screw will be right beneath the motor wires and will need some wiggling. Thread the motor wires through a gap in the pod.
    a. Make sure that the motor spin is correct with respect to the pods. There are 3 pairs of pods that need 1 of each motor spin direction. The pairs are a) black and pre-attached to the arm, b) black and unattached, and c) red and unattached.

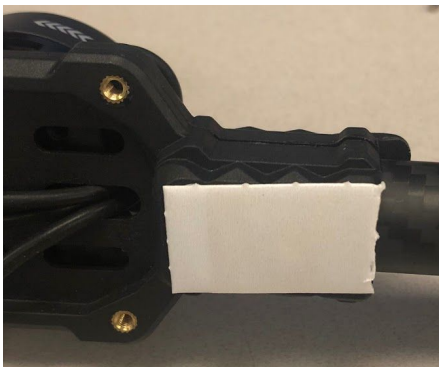
3. The four arms that don't have the motor pods pre-attached need to have new pod mounting holes drilled into them, as the default mounting position would cause the propellers to hit each other while spinning. Line up the motor pod so that the single slanted gap shows the default mounting hole. This will move the mounting hole of the pod about 5mm out from the hole in the arm.

    a. Attach a propeller to the motor, and place a level on the center of the propeller to ensure it is leveled.

b. Then, take your hand drill and drill into the arm, going through the motor pod mounting hole. Use a 7/64” bit from the top, and a 5/64” bit to start the bottom. Once both holes are started, remove the pod and drill all the way through with the 7/64” bit. Clean up any debris.

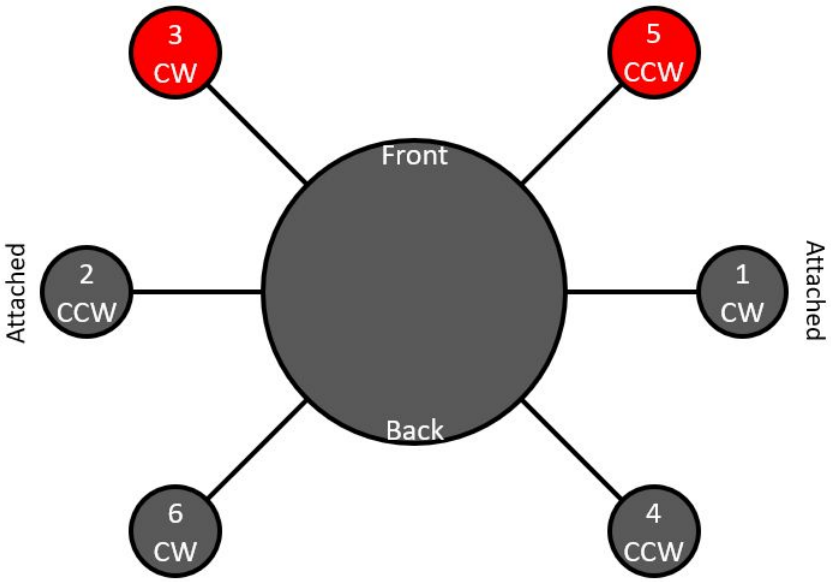
4. Place a command strip on the bottom of the part of the motor pod that is attached to the arm. Center an ESC on the other side of the command strip with the wires facing down the arm (towards where the body will be). Wrap a ziptie around the ESC and arm as tightly as possible, preferably with the straighter part on bottom. Plug the motor wires into the ESC; order does not matter yet, as it can easily be switched if needed when testing.



5. Screw a M2.5x20mm screw with loctite through the pod and the arm. It may be stopped by the command strip/ESC.
6. Attach a small command strip to the end of the motor pod and stick the ESC LED on. Plug it into the ESC and place the wires under the motor wires. Also wrap them around the ziptie on the opposite side of the LED port so that the wires are contained beneath the pod (not shown in this picture).

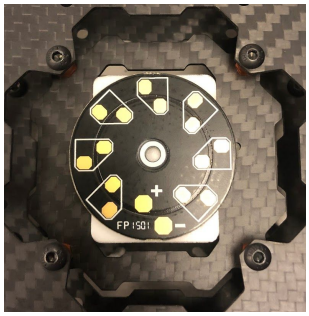
7. Wrap electrical tape around the ESC and motor pod, making sure to leave the LED and DATA ports exposed.

8. Repeat until you have 6 arms finished. REMINDER: Make sure your motors are mounted to the correct arms!

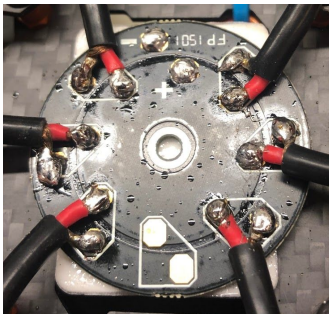


Step 4: The Components

1. Place a command strip on the bottom of the raised platform in the body for the power distribution board (PDB). Orient the PDB such that the +/- input leads are towards the back.



2. Route the signal and power wires from the ESCs towards the center of the body. Keep them tight to the arm and frame with electrical tape.
3. Solder the +/- input pads and 12 other pads on the PDB. I left the two directly opposite the input pads unsoldered as I don't plan on using them. Then, tin the power wires from the ESCs, and solder them to the appropriate pads. Think about how you are going to hold down the wiring before you finish your solder so that you can route the wires accordingly. Ziptie the wires down once finished.



4. Solder the wires from the male XT60 connector that will go to the PBM onto the input pads of the PDB. Attach this male XT60 connector to the PBM output and the EC5 to XT60 adapter to the PBM input.
5. Assemble the GPS masts by attaching the pivot to the base with the bulkhead hex screw. Attach the platform to the mast with a set screw, and slide the screwable lock onto the mast. Place the mast into the pivot and secure it with a set screw. Mount the masts to the top frame with M2.5x5mm screws from the DJI toolkit.

6. Place command strips on the top frame for the Pixhawk, telemetry radio, Frsky receiver, and power brick mini (PBM). Place command strips at the top of the 2 masts for the GPSes. Mount all of the

mentioned components to their command strips. If you want to mount it temporarily, just put it in place and secure it with a ziptie.

a. Make sure the Pixhawk and GPS are oriented with the arrows facing the front of the drone. Everything else can be oriented in whatever way will fit best and allow all the cables to reach.


7. Route the ESC signal wires up through the center of the frame and plug them into the Main Out ports 1-6 on the Pixhawk, matching the port number to the arm number. Twist, pinch, and ziptie the wires so that they are stable and out of the way. Also ziptie the ESC power and signal cables to the bottom frame before the PDB.

8. The cable set that came with our Pixhawk requires splicing the 2 telemetry cables together so that the white 6-pin connector goes to another white 6-pin connector. Our telemetry radios do not use the tan 6-pin connector that comes on the telemetry cables out of the box. Ensure all wires are spliced with their appropriate partners.
9. Additionally, splice the GPS2 cable from the Pixhawk set with the 6-pin cable that came with the Holybro M8N GPS.
10. Wire everything else up according to the table below.

From		With	To	
Component	**Port**		**Component**	**Port**
Pixhawk	GPS 1	Here+ GPS Cable	Here+ GPS	Main
	GPS 2	Spliced Holybro 6-pin with Pixhawk GPS2 Cable	Holybro GPS	6-pin
	Main Out 1-6	ESC Signal Cables	ESCs 1-6	Signal
	Power 1	Pixhawk Power2 Cable	PBM	6-pin
	RC In	3-pin Cable	X8R Receiver	SBus
	Telem 1	Spliced Pixhawk Telemetry Cables	Telem Radio	6-pin
	Telem 2	Craft and Theory Telemetry Cable	X8R Receiver	Smart Port
Here+ GPS	Main	Here+ GPS Cable	Pixhawk	GPS 1
Holybro GPS	6pin	Spliced Holybro 6-pin with Pixhawk GPS2 Cable	Pixhawk	GPS 2
Telem Radio	6pin	Spliced Pixhawk Telemetry Cables	Pixhawk	Telem 1
X8R Receiver	SBus	3-pin Cable	Pixhawk	RC In
	Smart Port	Craft and Theory Telemetry Cable	Pixhawk	Telem 2
PBM	6pin	Pixhawk Power2 Cable	Pixhawk	Power 1
	Power In	EC5 Male to XT60 Female Adapter	Battery	EC5 Plug
	Power Out	XT60 Male Connector with Wires	PDB	Power In
PDB	Power In	XT60 Male Connector with Wires	PBM	Power Out
	Power Outs	ESC Power Cables	ESCs	Power
ESCs	Power	ESC Power Cables	PDB	Power Outs
	Signal	ESC Signal Cables	Pixhawk	Main Out 1-6

11. Attach the battery mounting frame to the top of the body using the tall silver standoffs and the M2.5x5mm bulkhead hex screws. Add two strips of velcro on top; the other half of the velcro will be on the batteries.

Step 5: The Radio

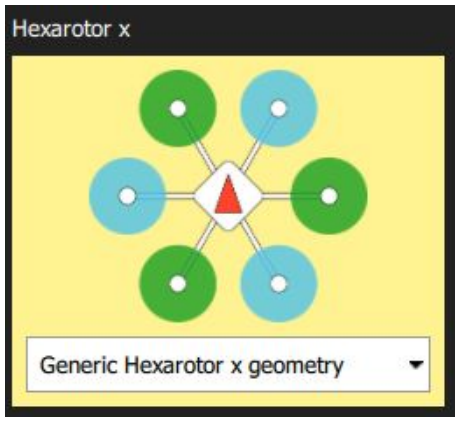
Note: I recommend setting up your Taranis radio before you start working on the drone firmware. This is because some steps will involve having your radio already configured the way you like it. You could set up the drone firmware first and come back to the radio if you wanted, however.

For this section, some words will be formatted to add clarity. [word] is a physical button on the Taranis, **word** is a page name, *word* is an option name, and "word" is an option input.

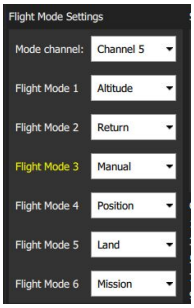
1. Power on the Taranis, press [Menu] and scroll down to an empty model. Long press [Ent] and then choose "Create Model". Choose the picture that looks like a multirotor (no wings).
2. Assign throttle to CH1, roll to CH4, pitch to CH3, and yaw to CH2.
3. Press [Menu] then [Page] to go to the **Model Setup** page. Name the model whatever you'd like, such as "Chiropter".
    a. Set *Timer 1* to "THs". Call it "Flight", don't touch the other options. This will give you an approximate flight time, counting up whenever the throttle is not idle.
    b. Make sure the *Throttle Source* is set to the "Thr" switch.
    c. Under *Preflight Checks*, have *Throttle state* checked and all *Switch positions* up.
    d. Under *Internal RF*, set the *Mode* to "D16" and *Channel Range* to "CH1-16". *Receiver no.* can be anything that is not used on other models.
4. Skip over the **Heli Setup** and **Flight Modes** pages.
5. On the **Inputs** page, Thr, Rud, Ele, and Ail should all be set up for you. You can reorder them if you like to match the channel order (TREA instead of TAER).
    a. Make a new input and call it "Mode". Set the *Source* to "SA" (Switch A), or whatever switch you want to control your flight modes. Leave everything else as is.
6. On the **Mixer** page, Thr, Rud, Ele, and Ail should all be set up again.
    a. Make a new mix on CH5 by long pressing [ENT]. Name it "Alt Hold". *Source* is the "Mode" input you set up in the last step. Set *Switch* to "SA ↑" and leave the rest as default.
    b. Long press on CH5 again and select "Insert After". Call this Mix "Pos Hold", *Source* is the "Mode" input again, but this time *Switch* is "SA-".
    c. Do this one more time, but the name is "Auto" and the switch is "SA ↓".
7. Skip over **Outputs**, **Curves**, **Global Variables**, and **Logical Switches**.
8. We'll use the **Special Functions** page to override CH5, to give us more flight modes on other switches.
    a. Set *SF1* to "SE-", "OverrideCH5", "-50", and checked.
    b. Set *SF2* to "SE ↓", "OverrideCH5", "-50", and checked.
    c. Set *SF3* to "SF ↓", "OverrideCH5", "50", and checked.
    d. Set *SF4* to "SC ↑", "OverrideCH5", "-25", and checked.
9. The **Telemetry** and **Display** pages will be set up later.

Step 6: The Firmware

1. Open the QGroundControl (QGC) application on your laptop. Click the gear icon in the top left, and then the firmware tab on the left side. Plug the Pixhawk into your laptop with a USB to microUSB cable.
2. When prompted, install the most recent stable release of PX4. Once completed, you should have a bunch of new tabs on the left hand side, many with red circles next to them. These red circles require your attention.
3. *Airframe*: Select "Hexarotor x > Generic hexarotor x geometry.



4. *Sensors*: Follow the calibration procedure for all the sensors listed. All red circles should be green when you are finished. I had to calibrate compass, gyroscope, accelerometer, and level horizon. Any time it asks for the rotation or orientation of a component, the answer is always "None" if you pointed all the arrows towards the front while mounting.
5. *Radio*: Before you're able to calibrate your Taranis radio, you'll need to bind it to the X8R receiver on the drone. Following the fpvblog guide linked under Resources...
    a. Power off the drone and Taranis, and attach the little black jumpers that came with the X8R to the signal pins on channels 1&2 and 3&4 on the receiver. This will put the receiver in mode 4. Then power on the Taranis.
    b. With the new model you set up on your Taranis, scroll down until you reach the *Receiver no*. option. The number doesn't really matter, as long as it's not used for another model. Hit "Bind".
    c. Press and hold the F/S button on the X8R and then power up the drone through the LiPo battery. Once you hear a beep from the Taranis, the bind was successful and you can power down and remove the jumpers.
    d. Once bound, go back to the Radio page in QGC. Click "calibrate" below the controls sliders in the center of the screen. QGC will walk you through moving the sticks and switches. Make sure to flip them all to all possible positions. The rest of the Radio page can be ignored.
6. *Flight Modes*: Due to setting up your flight modes and special functions on the Taranis earlier, this step should be relatively quick and straightforward.
    a. Set the Mode channel to "Channel 5". Now, one of the 6 flight modes below should be highlighted yellow, meaning it is active. This will change between the different flight modes whenever you move SA, SE, SF, or SC, based on our settings from earlier.

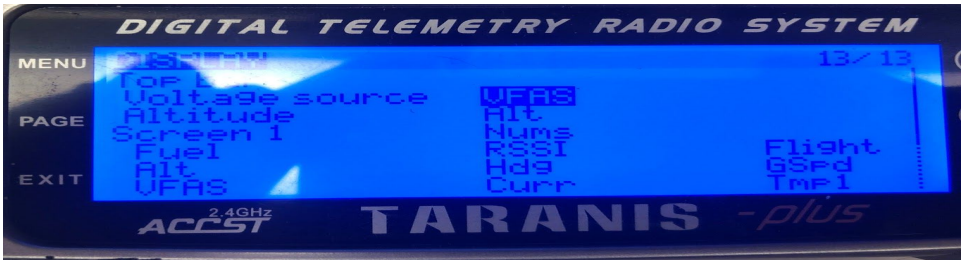


b. Assign the 6 flight modes to the flight modes of your choosing. We set it up like the image to the right. Our primary flight mode switch is SA, and it's 3 positions are assigned to Altitude (Alt Hold), Position (Pos Hold), and Mission (Auto). When SC is up, it overrides to Manual mode (this may only be for testing). Moving SE to middle/down will override to Return (RTL). Moving SF to down will override to Land. SC middle/down, SE up, and SF up are all inactive positions.
c. All other switches on this page are unassigned, but could be used similarly to our overrides.

7. *Power*: Input the following values for the parameters on this page.
    a. Number of Cells (in Series) = 6 S. This may differ if using a different battery.
    b. Full Voltage (per cell) = 4.2 V. This is a safe value that aligns with our battery checker.
    c. Empty Voltage (per cell) = 3.6 V. This is a safe value that aligns with our battery checker.
    d. The Voltage divider and Amps per volt parameters will vary depending on your power module. If you're using the mRo module, its configuration manual says they should be 12.7 and 37.5, respectively.
        i. The Voltage divider is easy to calculate yourself by just checking the battery's voltage through its balance tap while it is plugged into the drone. Ours is set to 12.71610737.
        ii. The Amps per volt is trickier and I suggest sticking with the manual's value.
    e. All other settings can be ignored.
8. *Safety*: You can tweak these settings if you'd like, we left them as default except for changing the low battery failsafe to "Return mode".
9. *Tuning*: We left this as default.
10. *Camera*: We left this as default.
11. *Parameters*: This is where you can fine tune some settings of your drone. Do not touch these parameters if you do not know what they are doing. We change the ones listed below.
    a. BAT_V_OFFS_CURR = 0.52499998 per mRo power module manual
    b. MAV_PROTO_VER = Always use version 2
    c. PWM_MAX = 1920 us per DJI ESC expected pwm range
    d. TEL_FRSKY_CONFIG = TELEM 2 to send telemetry to Taranis

Step 7: Final Component Tweaks

1. The Holybro telemetry radios need to be updated to Mavlink 2.0 firmware. Do this by opening QGC, navigating to the firmware page just like in Step 6, and then plugging in the radio through USB. The rest should be self-explanatory.
2. Back on the Taranis controller, navigate to **Telemetry**. Power on the drone, and once it is ready, scroll down and click *Discover new sensors*. The screen will then populate with many different sensors (ours has 15). You can configure how to display these sensors on your Taranis on the **Display** page. Ours is set up like the picture below.



3. The ESCs need to be individually updated with the DJI ESC Assistant app and then calibrated through QGC.
    a. Do this by powering the drone through a LiPo, plugging one ESC into the DJI ESC updater and plugging that into your computer. Select the 3510 motors, red lights for the left 3 arms, green for the other 3, and the most recent firmware. Do this for all 6 ESCs.
    b. Back in QGC, go to the *Power* page. Under "ESC PWM Minimum and Maximum Calibration", click "Calibrate" and follow the instructions. It should be a quick process.

Congratulations! You should now be ready to fly!

Resources

Youtube build:
https://www.youtube.com/playlist?list=PL_k-9XIaCitc6HN4QkUpovUAComvUtS6Z

Forum post build:
https://forum.dji.com/thread-8628-1-1.html

Taranis to X8R binding:
https://www.fpvblog.com/rctech/how-to-bind-x8r-to-the-frsky-taranis-in-different-modes

GPS guides:
http://www.hex.aero/wp-content/uploads/2019/01/Herev2-User-Manual.pdf
http://www.hex.aero/wp-content/uploads/2017/01/Here-Datasheet.pdf
https://static1.squarespace.com/static/5619914ce4b07e497b442de9/t/5851f4856b8f5b8b5d86be48/1481766023755/Here+and+Here%2B_MANUAL.pdf

PX4 guide:
https://docs.px4.io/v1.9.0/en/