Crossfire 2 Build Guide

The Crossfire 2 is the result of over a year of open source development by the Thingiverse community. It has all the elements that made the original Crossfire a success with many small improvements that make the Crossfire 2 stronger, lighter and much easier to build and maintain.

Special thanks to everyone who has printed an original Crossfire and to everyone who has submitted feedback to me. I hope to see many more of these in the air. Print, fly and enjoy!

Printing

Printing the crossfire can be time consuming and tricky but if you follow some simple guidelines you should have very good results. I have printed the original Crossfire and the Crossfire 2 in ABS. I have spent considerable time testing my quadcopters with ABS and I feel that it is the way to go. It is very strong and has a bit of flex to it. ABS however is known to warp and can be tricky to print some parts with, but following these guidelines should produce very high quality prints. That being said others have printed in PLA and also had very good results. PLA does not have as much of a problem with warping but it is also less flexible and more brittle than ABS. If you decide to print with PLA I would print with higher percent infills than with ABS to help with the strength.

This guide will concentrate on printing with ABS. All settings that follow are for ABS, please refer to the original Crossfire page: http://www.thingiverse.com/thing:32281 for PLA settings that others have used with success.

Many people who are experienced 3D printers will already know this information but if you are new or your prints are failing please pay special attention to this section.

3 Rules for Successful Prints:

1) LEVEL, LEVEL, LEVEL the bed! Leveling the bed is by far the most important step in getting a successful print. Without a level bed you are shooting yourself in the foot. I cannot stress enough how important a level bed is for a successful print especially for the quadcopter arms which are the most likely to warp. However most of the the prints, including the Top and Bottom Plate, the Top Cover and

the Battery Tray take up most of the build platform which will show very quickly if the bed isn't level.

2) Apply ABS “slurry” to the heated build platform to form a layer of ABS that the print will adhere to. ABS slurry is simply ABS scraps dissolved in Acetone. Pour a couple ounces of Acetone in a jar and drop in scraps or waste ABS plastic and allow to fully dissolve. I make ABS slurry for each color that I print with as the slurry will impart its color on the bottom surface of the print. Apply the ABS slurry to the heated build platform at roughly 75-80C with a Q-tip in a scratchy or circular pattern. The entire platform does not need to be coated completely, applying too thickly may make the object very difficult to remove when finished, however special attention should be taken at the edges or corners of the object as that is where the object will start to pull up from.
3) Monitor the first layer very carefully. The first layer of the print is by far the most important. Monitor the first layer entirely and make small adjustments to the level if needed. The first layer should be laid down in a nice flat bead. If the extruded plastic is being laid down too thinly or not at all its because the bed in that area is too high, lower the bed by 1/8th of a turn or until you get a nice flat bead. If the bead is too thin or not bonding to the platform the bed is too low and needs to be raised. If the first layer doesn't bond well to the platform the odds that the print will fail are very high. Just remember it is much easier to start the print over after the first layer if it doesn’t look good than it is to leave it and have it fail after hours of printing.

Quadcopter Arms:

HBP Temp: 110C Extruder: 225-230C Infill: 50% (At least 40% to keep the arm from flexing too much) Supports: ON

It is best to print at least two arms at a time as they are the longest prints by far. Also as slow of an extruder and travel speed as you can stand. I print at about 100mm/ 100mm per second. The arms will probably take at least 6-7 hours for two arms and can take as long as 9 or 10 hours without acceleration. Supports are required on this print because of the insets for the lock nuts.

Bottom and Top Plate and Top Cover:

HBP Temp: 110C Extruder: 225-230C Infill: 10-20% Supports: ON

The plate and cover prints are fairly strait forward. They are not very prone to warping as they are very thin. As long as the HBP is level and a little slurry is applied you should have no trouble printing them. As far as infill goes keep in mind that the Top and Bottom Plate along with the top cover is what provides the frame with it′ s strength. The frame has been tested with as little as 10% infill on the plates and cover but caution should be taken if you are not experienced with quadcopters. There is much to be said about a light quadcopter but under a brisk landing the plates may crack. Supports will be required for the rubber dampener inserts.

Battery Tray:

HBP Temp: 110C Extruder: 225-230C Infill: 10-20% Supports: ON

Just as above the Batter Tray is strait forward and simple to print and care should be taken with lower infills. The Battery Tray will carry the battery and if you choose either a GoPro gimbal or just a GoPro case, you definitely don′ t want it too weak. Supports are required for the rubber dampener inserts because of the overhang.

GoPro Case:

HBP Temp: 110C Extruder: 225-230C Infill: 10-20% Supports: ON

The GoPro case can be prone to warping because it is thin and tall. Printing with a slower speed or adding a small delay between layers can help with this. Supports are required if printing out the GoPro Gimbal Assembly but not for the standard lightweight case.

APM Mount and Gimbal Controller Mount:

HBP Temp: 110C Extruder: 225-230C Infill: 10% or less Supports: OFF

The APM Mount and the Gimbal Controller Mount are very strait forward. They have little or no issues with warping and are non structural so infill can be kept very low.

Quadcopter Assembly

The assembly of the Crossfire 2 is very strait forward and has converted to standardized hardware over the previous version which used a few different types of hardware.

Hardware List:

Most of this hardware can be ordered through Hobby King, or if you have a specialty hardware store such as Ace, Jax or McGuckins they can be found there a lot of times.

Socket Head Bolts M3x8mm (38)

-Used in attaching the arms, attaching the controllers and the standoffs.

Socket Head Bolts M3x6mm or M2.5x6mm (12-16)

-Used for mounting motors depending on type. Check your motors.

Nylon Standoffs M3x5.6x Assorted lengths (You can never have too many of these)

-Used to mount the various types of controllers used and to mount the Top Cover

Nylon Nut M3 (15-20)

-Used to mount the various types of controllers used and to mount the Top Cover

Washers 3.5mm (30-40)

Vibration Dampener Balls (4 for APM Mount 6 for Battery Tray)

-Depending on your setup you will need either 6 or 10 dampeners.

Gold Bullet Connectors (20ish)

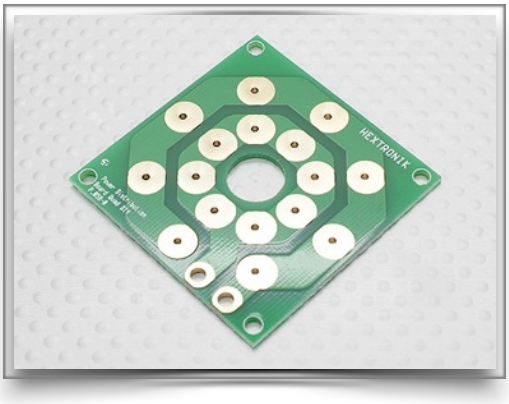
-ESCs and power distribution board.

XT60 Connectors (1 Pair)

-Power distribution board to Battery or current sensor.

Silicone Wire 16 AWG (1 meter black and red)

Multi-Rotor Power Distribution Board (1)



M3 Hex Lock Nuts (24)

3M Double Sided Tape (1 Roll)

-Mounting RC Rx, VTx, APM, Compass etc.

Zip Ties (Lots and lots)

-For mounting ESCs and tidying up wires. Zip ties are your friend!

Electronics List:

The following is my electronics list. Keep in mind that there are many different electronics combinations. There are different ESC, motor, prop and flight

controller setups. The same goes for FPV setups if that is the route you are going to take. This combination has worked very well for me but it is only one of many. Quadcopter electronics have come a long way in the last couple years and checking FPVlab.com or RCGroups.com can give you lots of different options and ideas as far as your own setup.

Motors: AX-4008D 620KV (Check Hobby King as their links change)

ESCs: Lumenier 30A with SimonK firmware

http://www.getfpv.com/electronics/electronic-speed-controllers-esc.html

Props: APC 10x4.7 Slowflyer 2 CW, 2 CCW

http://www.getfpv.com/propellers/apc-10x4-7-sfp.html

http://www.getfpv.com/propellers/apc-10x4-7-sf.html

Battery: Turnigy nano-tech 4S 35-70C (Check Hobby King as their links change)

Flight Controller: 3D Robotics APM 2.6

http://www.getfpv.com/propellers/apc-10x4-7-sf.html

Video Transmitter: Immersion RC 600mW 5.8Ghz

http://hobbywireless.com/index.php?

main_page=product_info&cPath=111_115&products_id=522

FPV Camera: CCD Killer Camera600 lines NTSC

http://hobbywireless.com/index.php?

main_page=product_info&cPath=122_6&products_id=1093

Goggles: DOMINATOR - FATSHARK MODULAR VIDEO GLASSES

http://hobbywireless.com/index.php?

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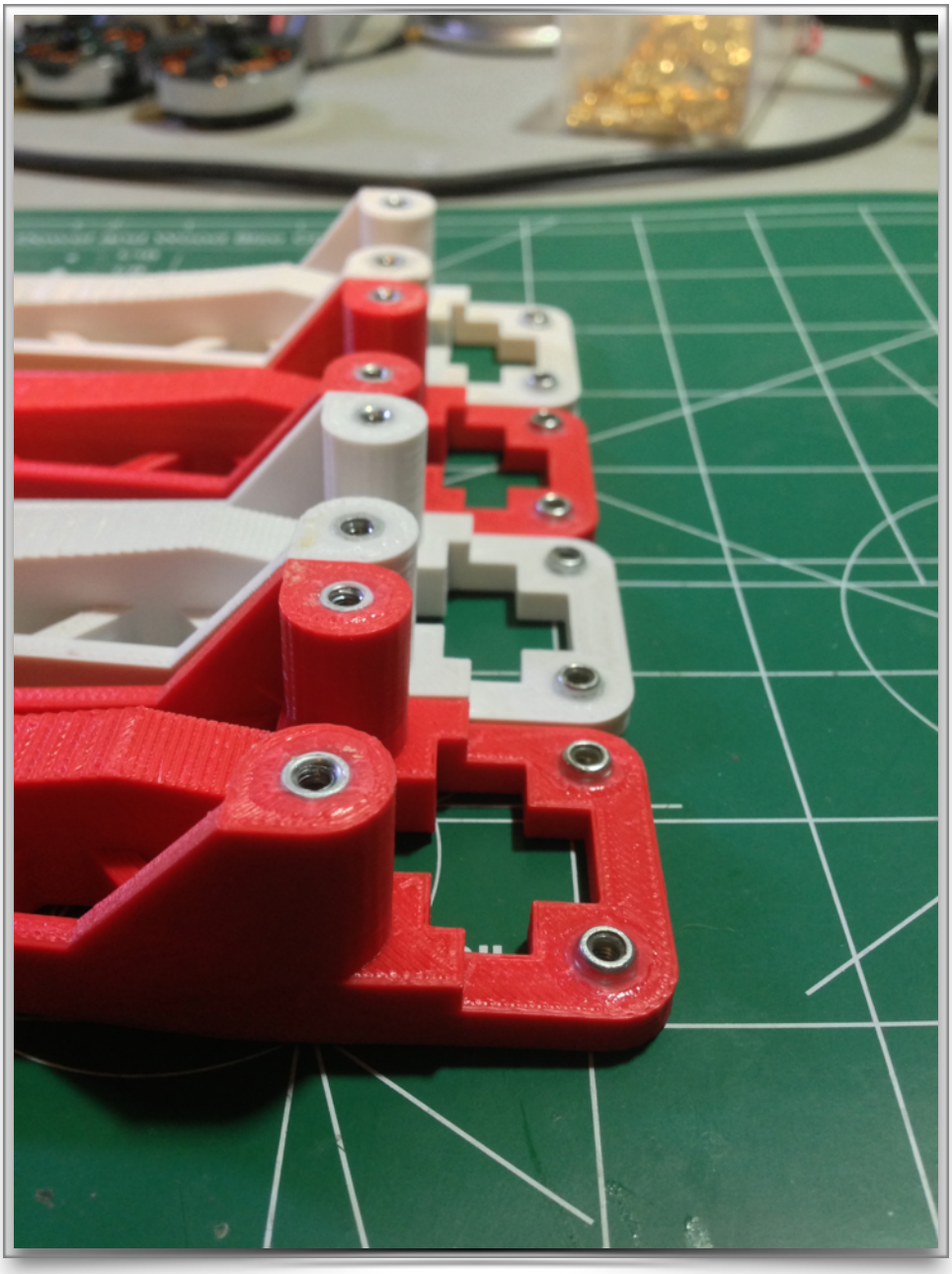
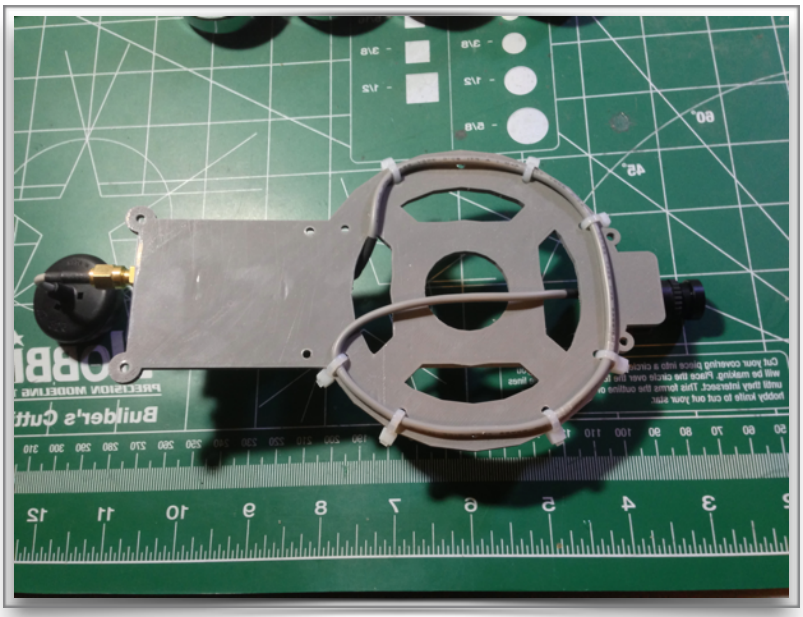
Assembly:

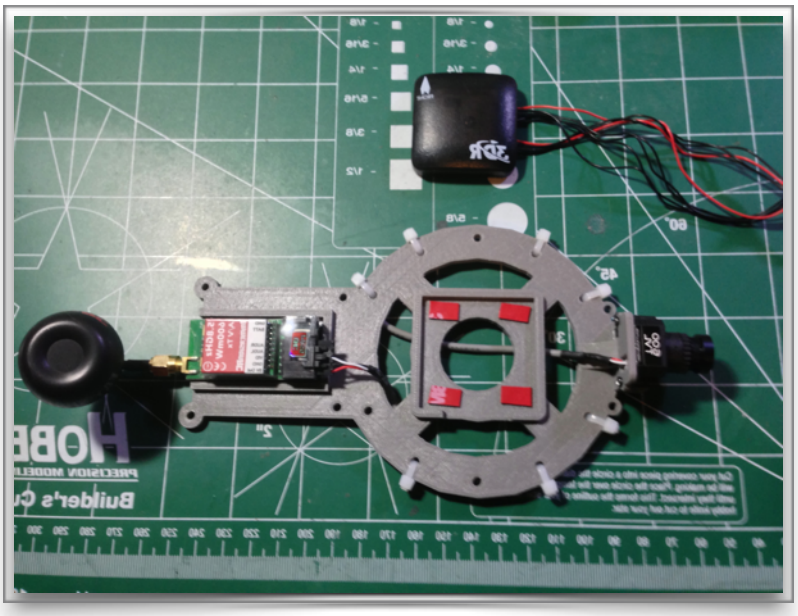
Find yourself a clean place to work, put on some tunes, find some basic tools like allen wrenches, screw drivers, dykes, hammer, super glue and a few beers (2 six packs to a case should be enough to get you through). Assembling the quadcopter also requires some basic soldering skills. If you have never done it before, it is not rocket surgery. Check out some videos on Youtube and practice a little before starting this project. One bad or broken connection anywhere in the system will cause a crash followed soon after by many (many) choice words, so do yourself a favor and do it right the first time.

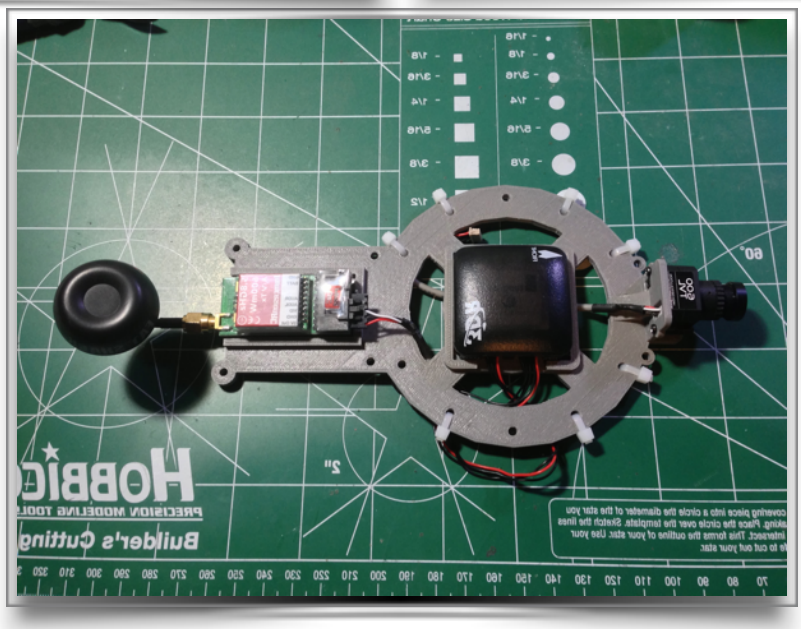
1) **Start out with the arms. The arms are designed to receive M3 hex lock nuts. Each arm takes six, four on top and two on the bottom. The tolerances are such they they need to be seated with a hammer. It helps to take an exacto knife and flare out the opening. The four outside holes (the ones towards the motors, there are two on the top and two on the bottom) need the hex nuts seated so that they are flush with the top and bottom edge. The two holes towards the inside of the arm need the hex nuts seated with the flat edge of the nut facing the the top edge of the arm. A small amount of super glue should be applied inside the holes before the hex nuts are seated. Align the hex nut on the hole and swiftly tap it in. It should seat flush. The inside hex nuts don't need glue before you seat them as they are being pulled to the inside by the bolts. Because of the flat edges it can be hard to seat and glue may cause it to get stuck at an improper angle. If the angle is wrong thread a bolt in and use it to align the angle. After all hex nuts are seated add another bead of super glue around the edges to make sure they aren't going to go anywhere. After you are done with the four arms put them aside and the the glue fully cure.**



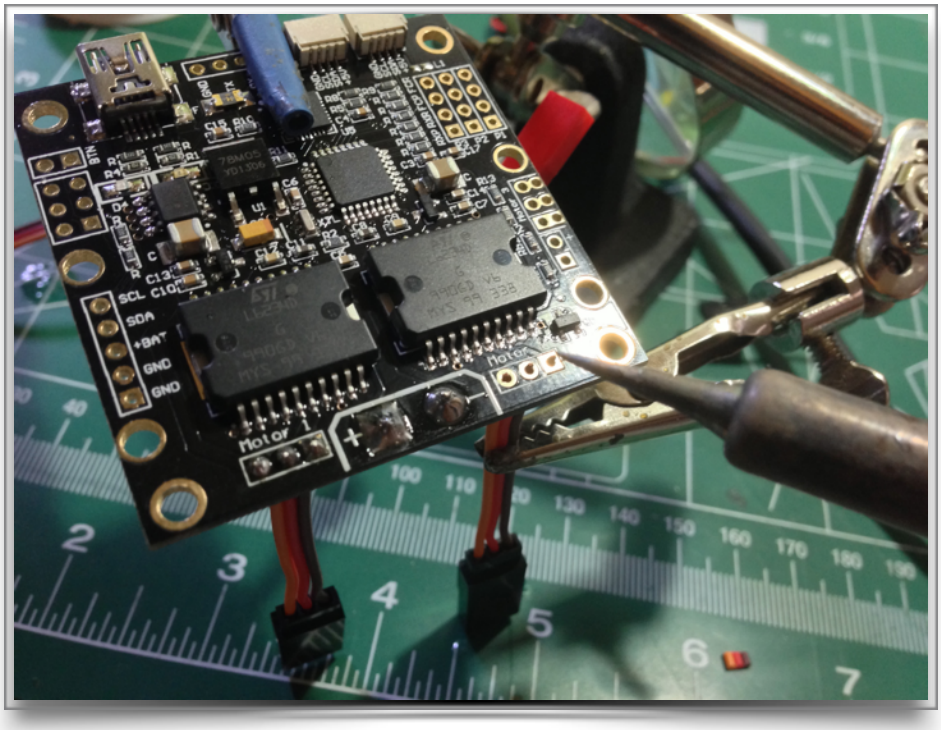
2) Assemble the Top Cover. As I mentioned earlier I am using an APM 2.6, I designed the top cover for the GPS and compass module as well as my video transmitter and FPV camera. Use 3M tape to adhere the video transmitter, GPS/compass module and FPV camera in place. Use zip ties on unused holes to route the camera cable on the bottom of the top cover. Refer to the pictures for which holes to use zip ties on and which holes to leave for the standoffs.





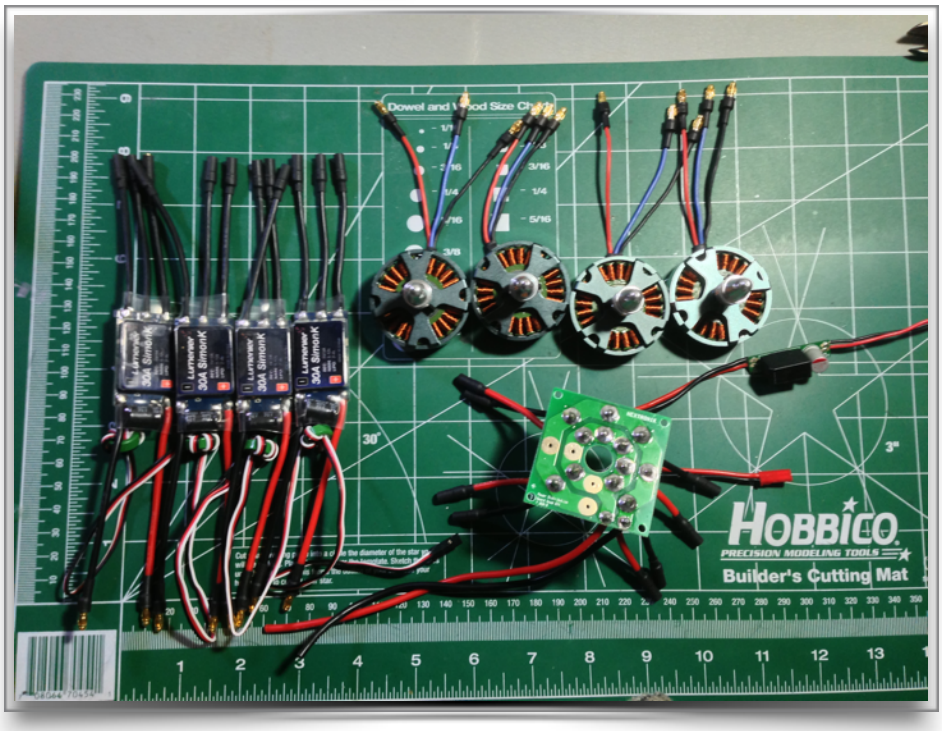


3) Solder electronics. Break out the soldering iron and get to work. Bullet connectors need to be soldered onto the motors, ESCs and the power distribution board. Use male connectors for the motors. Female connectors for the three wires from the ESC to the motors and male connectors for the positive and negative ESC wires. Use female connectors for the positive and negative leads from the power distribution board. Next solder the power distribution board. Measure out the 16AWG wire so that the ESCs will sit where you want them on the arm. Also at this point you will want to add your power leads for your video system (adding an LC



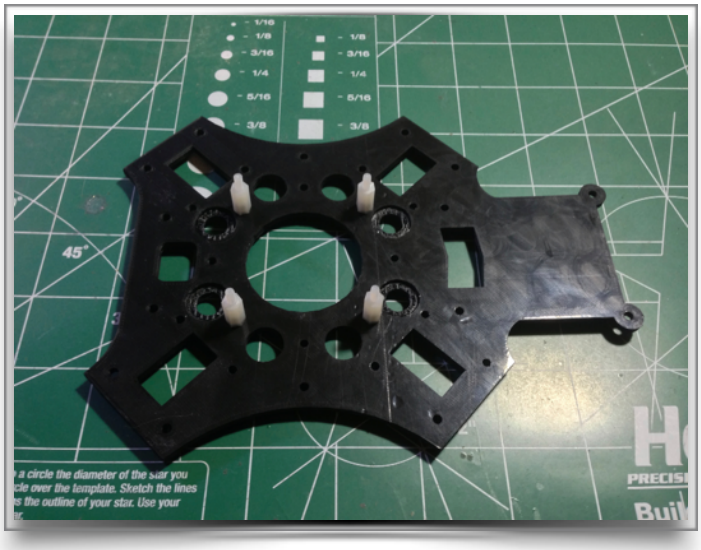
filter inline will help with clean video if you are powering everything from one battery) and your gimbal controller if you have one. Lay everything out and make sure things are where you want them before you start to solder.

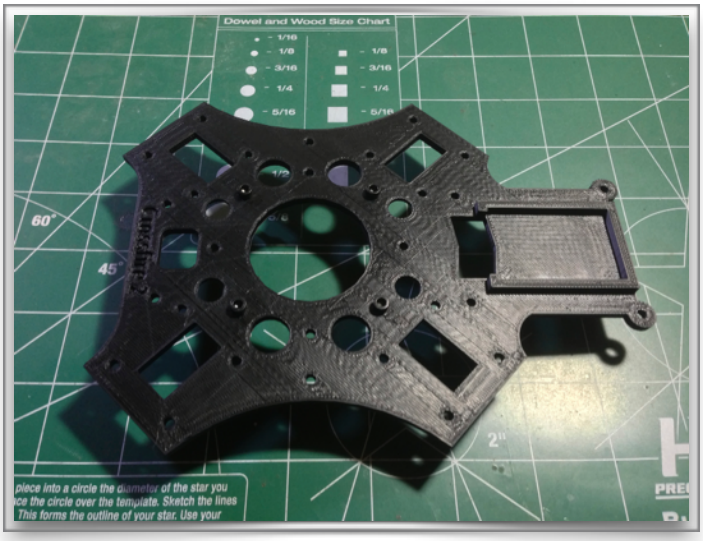
Heat shrink everything. You can leave the battery lead until later. You will want to measure out where you want your XT60 connector so leave the leads long and solder them after the quad is assembled. Pro tip: remember to put the heat shrink on before you solder the XT60, ask me how many times I have forgot!

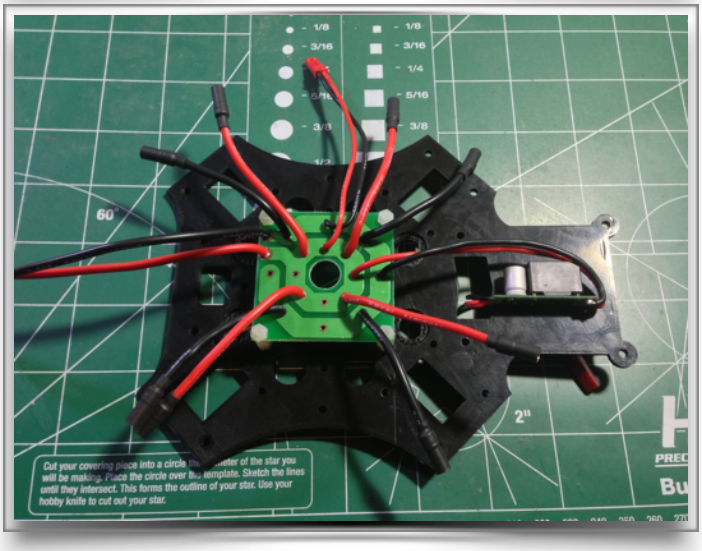


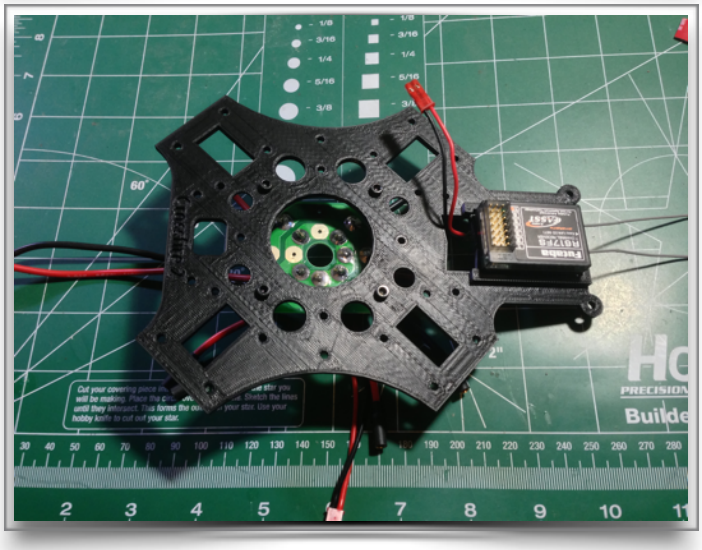
4) Mount the power distribution board to the bottom of the Top Plate using short standoffs, M3 bolts and nylon nuts. Make sure all power leads are oriented the way

they should be and that all the solder joints look good. Use the nylon nuts to attach the the power distribution board to the standoffs. Take care not to over torque the nylon nuts as they can strip their threads easily. Your RC receiver can also be affixed at this point with 3M tape.

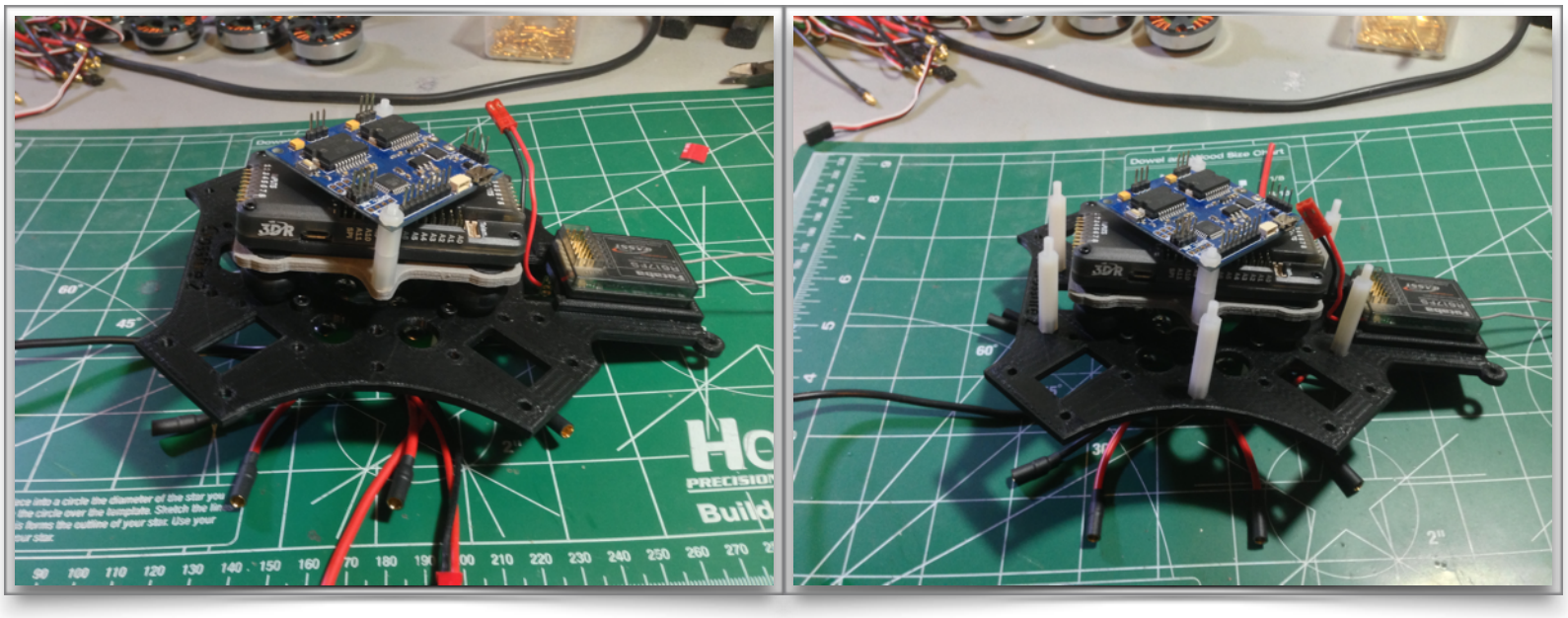




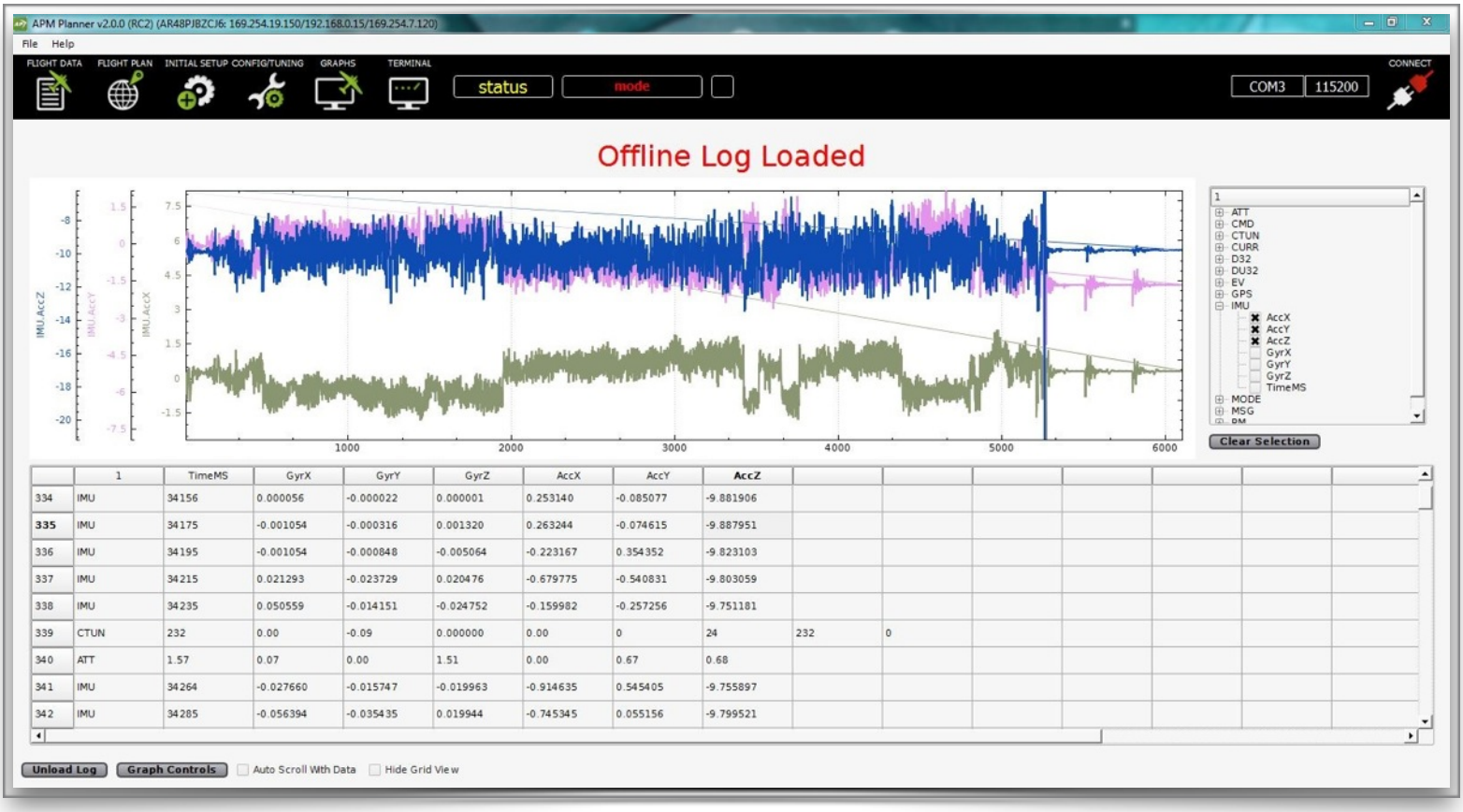




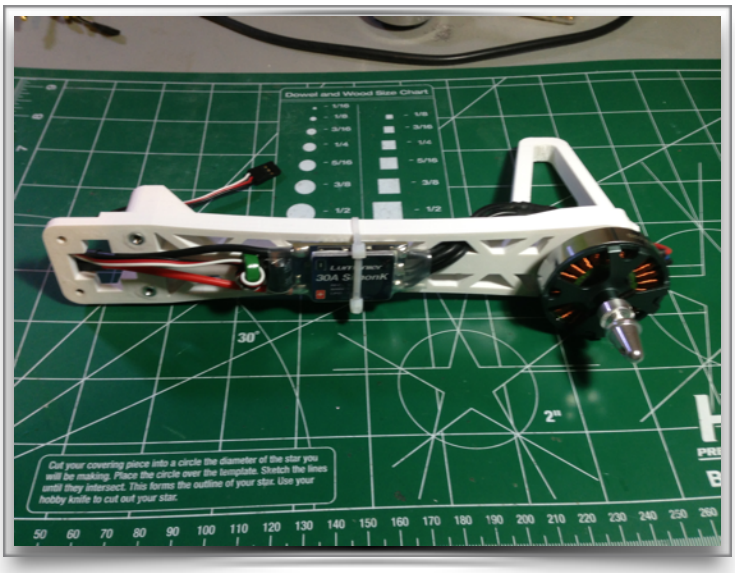
5) Pop 4 vibration dampeners into the APM Plate and affix the APM controller using 3M tape. If you are using another controller such as a KK 2.0 or KK Blackboard use the provided 50x50mm mounting holes. One set mounts at 45 deg. (Blackboard) while the other mounts perpendicularly (KK 2.0). A gimbal controller can also be



mounted above the APM either at 45 deg. or by using the Gimbal Mount Plate. Mount the APM Plate to the Top Plate with the vibration dampeners. The vibration dampener balls can be very effective at isolating vibrations from the APM. Below is a graph showing measured vibrations that are half of what is acceptable levels with no balancing of the props. Also before you are done with the Top Plate add six nylon

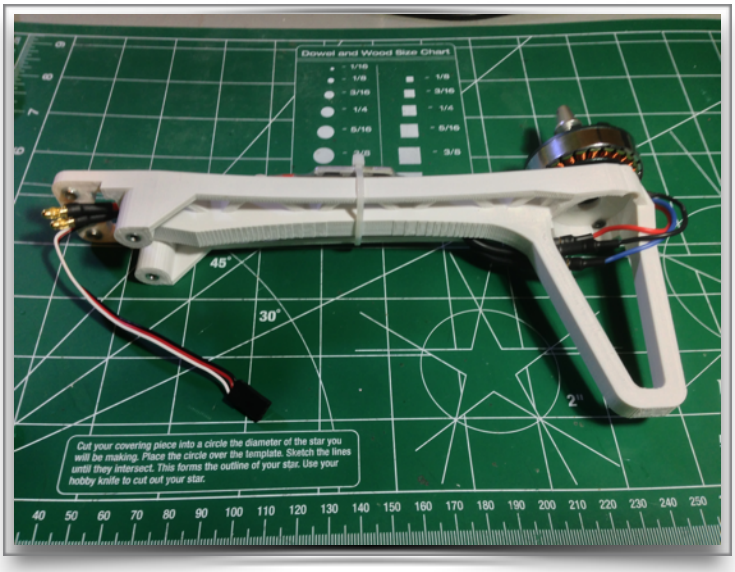


	1	TimeMS	GyrX	GyrY	GyrZ	AccX	AccY	AccZ							
334	IMU	34156	0.000056	-0.000022	0.000001	0.253140	-0.085077	-9.881906							
335	IMU	34175	-0.001054	-0.000316	0.001320	0.263244	-0.074615	-9.887951							
336	IMU	34195	-0.001054	-0.000848	-0.005064	-0.223167	0.354352	-9.823103							
337	IMU	34215	0.021293	-0.023729	0.020476	-0.679775	-0.540831	-9.803059							
338	IMU	34235	0.050559	-0.014151	-0.024752	-0.159982	-0.257256	-9.751181							
339	CTUN	232	0.00	-0.09	0.000000	0.00	0	24	232	0					
340	ATT	1.57	0.07	0.00	1.51	0.00	0.67	0.68							
341	IMU	34264	-0.027660	-0.015747	-0.019963	-0.914635	0.545405	-9.755897							
342	IMU	34285	-0.056394	-0.035435	0.019944	-0.745345	0.055156	-9.799521							

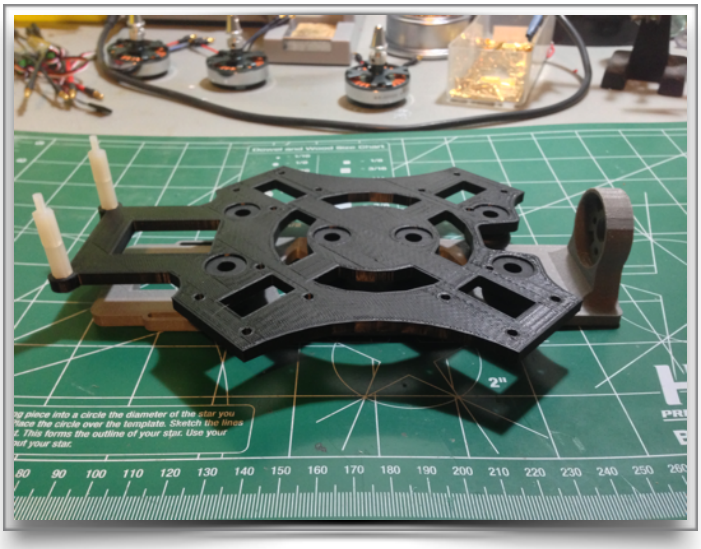


standoffs that are high enough to offset the Top Cover above the controllers

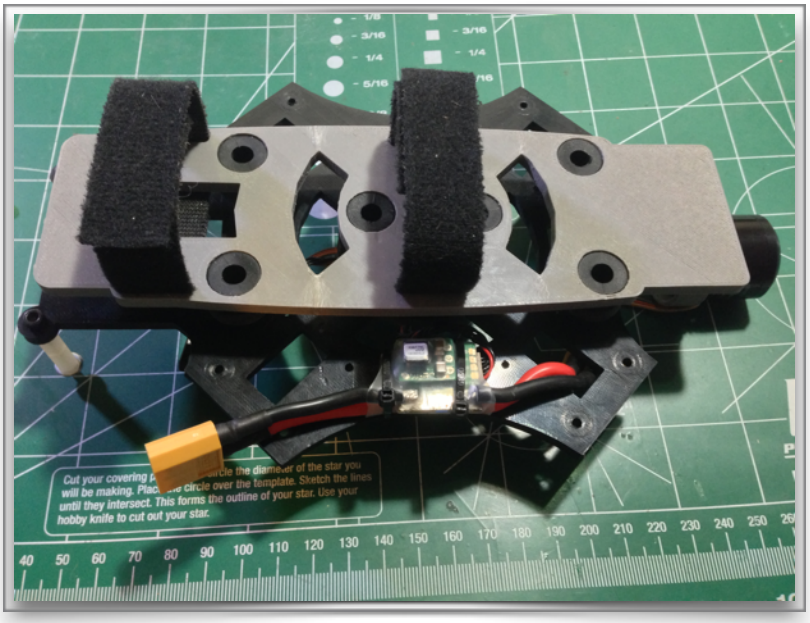
6) Mount the motors using whatever hardware your specific motor requires. Plug the motors into the ESCs. Don't worry about which wire goes where, you will fix that later when you spin the



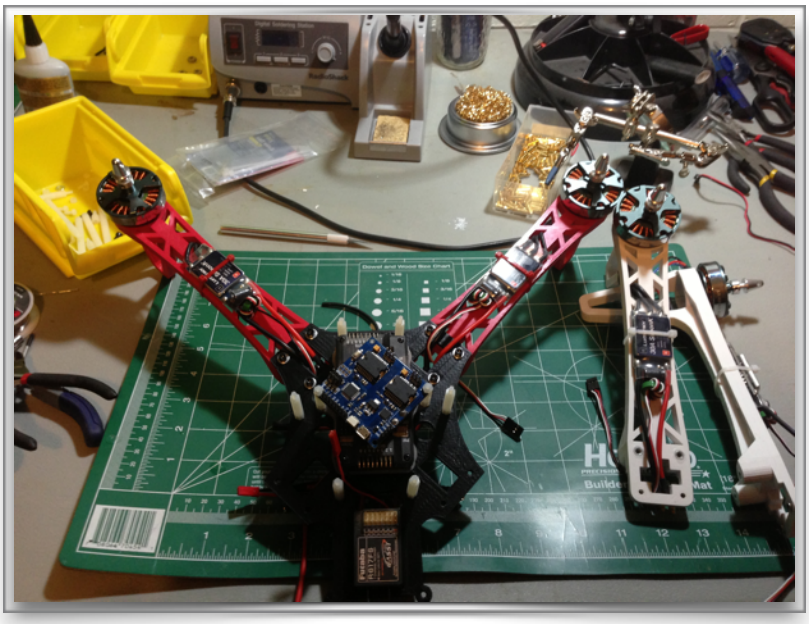
motors to determine which way they need to spin. If they spin the wrong direction just swap any two wires. Affix the ESC to the arm with either 3M or zip ties.



7) Affix the Battery Tray to the Bottom Plate using the vibration dampeners. It is easiest to thread velcro straps through

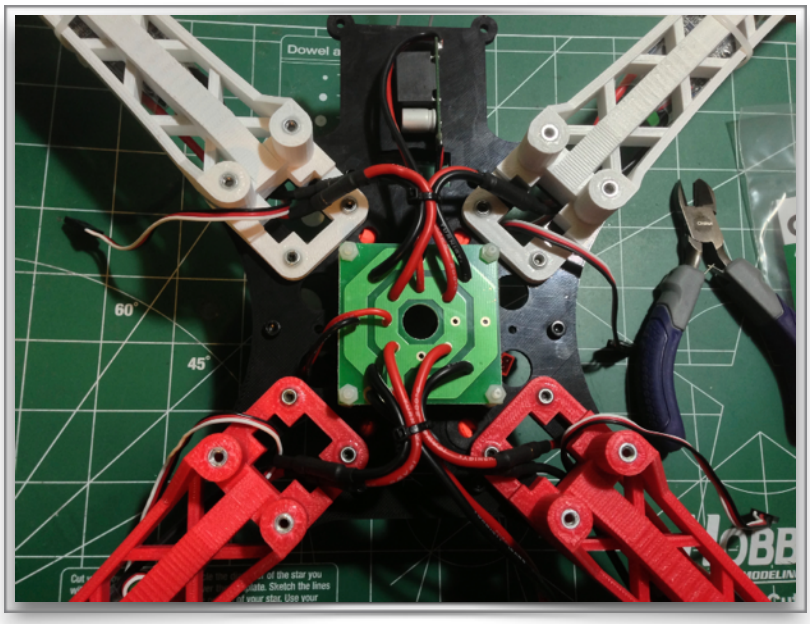


the Battery Tray before securing it to the Bottom Plate. It is also easiest to add all six dampeners to the Battery tray then attach to the Bottom Plate. Also add two standoffs (1″) at the aft part of the frame. If you are using metric standoffs you may need to add a couple washers to get the spacing correct. Its also a good idea to route and affix your current sensor if you are using an APM. This is how I secured mine. As mentioned before I left the ship′s power lead long so that I can trim it to the proper length when the quadcopter is assembled.

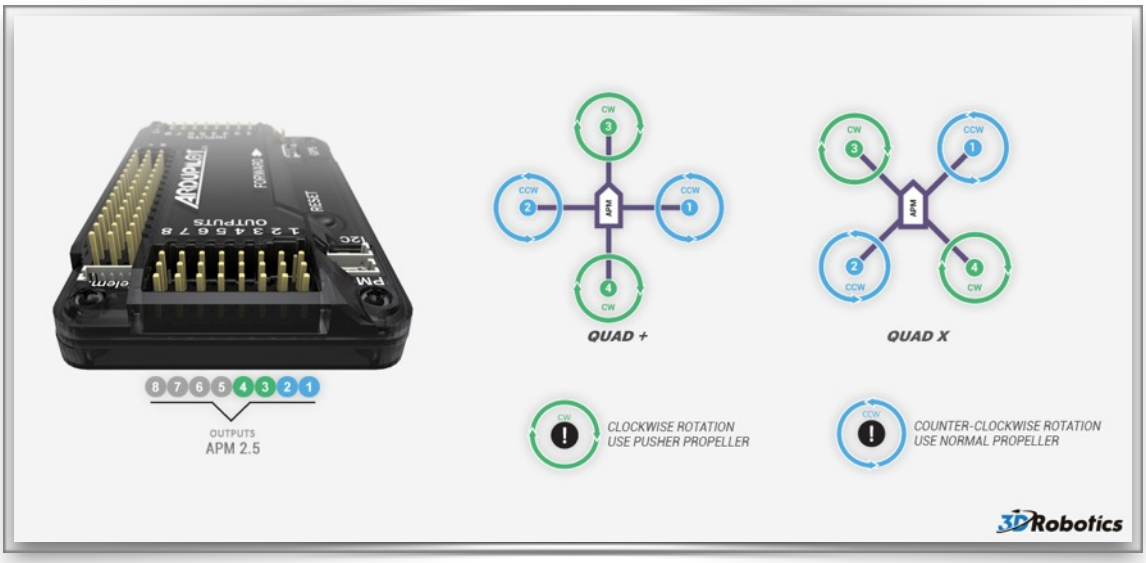


8) Putting it all together. Start by affixing the arms to the top plate using M3 bolts and washers. Thread the ESC and power wires down through the rectangular hole and plug the power wires into the Power Distribution Board. Black to black, red to red. I know it sounds stupid but double check everything is plugged in correctly. Cross a wire here and you can screw some shit up!

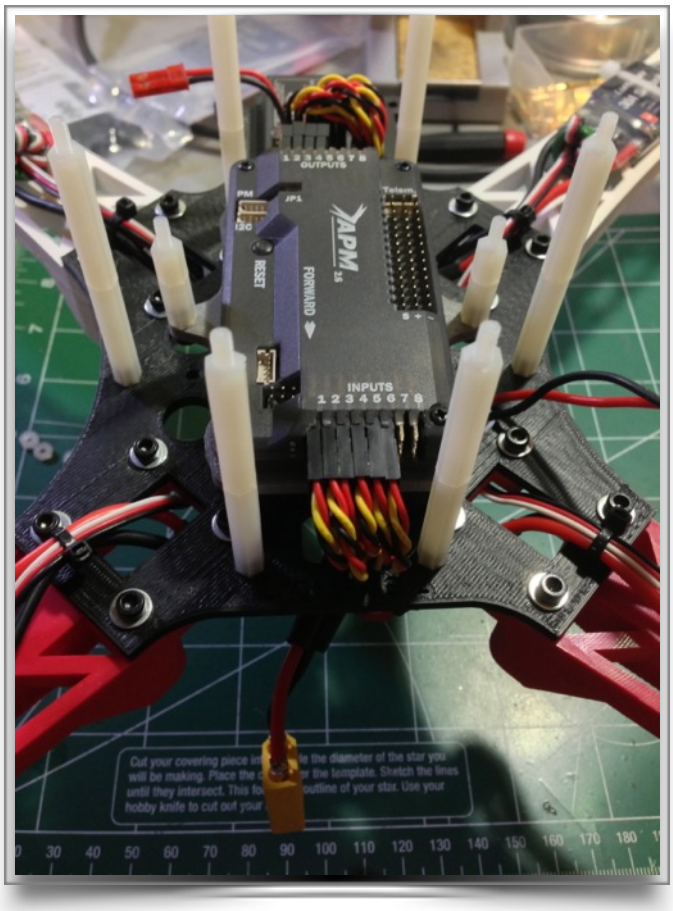
As stated earlier in the "Hardware" section, zip ties are your friend. Use them here to tidy up all that messy wiring. You may also want to mark your ESC wires at this point. Depending on your flight controller specific ESC signal wires



need to be plugged into specific channels on your controller. See the photo below for the APM motor arrangement. Simply take a sharpie marker and draw a 1-4 hash marks near the plug end to identify the wire when plugging them into the flight controller outputs. Depending on your ESC wire lengths you can decide to route them through any number of holes in the frame. Find the setup that best suits your needs. Keep it as clean as possible. Remember zip ties are your friend.

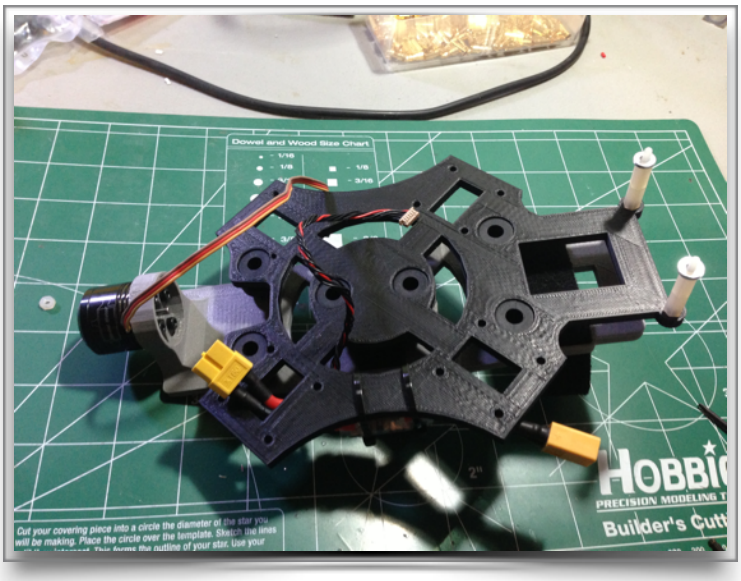


Flip the quad right side up, or shiny side up as us pilots like to say. ** Quick side note, I would say that about 90 percent of crashes can be solved by that simple adage- Keep the shiny side up.** Before you mount your gimbal controller (If you are using one) route all the signal wires between your RC receiver and the inputs on



your flight controller and all ESC signal wires to the outputs on your Flight Controller. You could also probably use some of those zip ties to keep things nice here as well.

Now flip the quad dirty side up (Again that's just a saying, the quad has no dirty side yet, and because of the four spinning blades it tends to get dirty everywhere). Route the current sensor wires up through the Top Plate and attach the Bottom Plate to the arms with M3 bolts and washers. Plug the Current sensor wires into the APM.



Now that you have the main body and all the electronics installed you should go ahead and measure out the main power lead, cut it to length and solder on a female XT60 connector. Route it through one of the rectangular holes and plug it into the current sensor "out". The only thing left to do is to install the Top Cover. Plug the GPS/ Compass wires into the APM and attach the Top cover to the nylon standoffs with nylon nuts. Again take care not to strip the threads by over torquing.

There you have it, you're all done with the assembly! Refer to your flight controllers directions for setting up and testing your quad for it's first flight. If you have never set up one before take great care and throughly understand all the instructions. Don't try to skip steps to get into the air faster, you will only end up crashing and most likely weeping into your hands as you realize how much time and effort you put into this whole endeavor for a whopping 10 seconds in the air.

There you go, you are ready to get flying!

And now for a disclaimer: I do not take any responsibility for any injury to persons, damage to property or failure of the airframe. This is an open source project and you take full responsibility for any incidents involving the operation of this aircraft. In short you are all grown adults, and if not, where are your parents?

As far as operation of this aircraft goes (this is for those of you new to multi-rotors, UAVs, FPV or RC in general) if you follow a few basic rules you will have a long and fun future flying the Crossfire, and hopefully keep all of your fingers.

Rule 1) Don't be a dumbass. This should be self explanatory. Don't do anything that could get your or someone else hurt. Use your head.

Rule 2) Don′ t be an asshole. Also self explanatory. This hobby, and industry is in it′ s infancy. The FAA still has no idea how to regulate this area of aviation. Please don′ t give them the opportunity to make a rule about something you did. Also there are many out there who are scared or leery of "drones" or being spied on. Try not to create a negative image for the community as a whole.

Rule 3) Don′ t try to run before you can walk, take small steps and build your confidence with the aircraft. Don′ t fly over anything that you would′ t want the quad to crash on. That means babies, animals, Ferraris and nuclear power plants.

Rule 4) Don′ t ever test the quadcopter with the props on until you are sure your setup is operating correctly. Props spin in excess of 5000 rpms and will literally slice through your flesh until the prop hits bone. Trust me, I know. I have the scars to prove it and so do some friends. Refer to rule number 1.

Rule 5) Have fun!

So go out there and fly the hell out of this thing. Test it.. . torture test it. Find it′ s limits (safely), its weaknesses. Tinker with and modify it. I designed the Crossfire to push 3D printing forward. Please take my ideas and make them even better! Innovate! Do something nobody has done before. Create something new. Get an image or a video that will blow people′ s mind. Use it for research or a non-profit. Run with it and make something that is yours. The open source community is amazing. All I ask is that you share your own ideas. I can′ t wait to see more of these in the air!
Blue Skies.
-Mike Bristol