Mozzie Documentation

Release 1.0

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The Mozzie

CHAPTER 1

Overview

The original idea for the Mozzie project was to create a UAV Challenge READY Quadplane based on the Mini Talon, using both commonly available and some custom 3D printed parts, all for under $1000USD.

This is a complete build instruction wiki to assemble a "Mozzie" quadplane identical to what was used by PerthUAV in the 2016 Medical Express UAV Challenge.

Our intention is that the Mozzie can be used as a base platform to develop systems and technology for UAV challenges, or even as the actual platform being used in a UAV challenge. This is also our attempt to give back to the Ardupilot and other UAV open source communities, as a thank you for all their efforts and work, which has made the Mozzie platform possible in the first place.

Through the years that we have been involved in the UAV Challenge, we found that many of the teams that attempted it were often challenged by only having a limited amount of time, funds and experience with existing systems, despite having good ideas in overcoming the challenge hurdles themselves. Operating large, complex and expensive airframe systems can often result in teams running out of time, funds and team resources before they can even participate in the event.

The Mozzie platform and documentation tries to overcome these hurdles by offering a single resource for the completion of a mission capable system that can be competitive in the event. In turn, we hope this results in a popular uptake of the Mozzie platform, so that users can contribute back with design and implementation improvements over time, to make the platform even better.

Note: This wiki page is a work in progress and will be completed as the information becomes available and the project develops.

The UAV Medical Express Challenge

The 2018 Medical Express UAV Challenge is a UAV Challenge that is held bi-annually in Queensland, Australia. Broadly, the intention of the Challenge is to promote civilian use of UAV technology for humanitarian use, and develop systems for saving lives using UAV technology. The 2018 Challenge is to fly a “robotic” autopilot controlled aircraft up to 30km away to a remote landing site, where it must accurately find and land on a ground target near “Outback Joe”, to collect a 25g blood sample vial and return it intact to base.

The main “challenges” to complete the mission objectives are:

- Overcome the range required with an aircraft of up to a total of 60km, including landing on the remote site and return, inside of 60 minutes
- Be able to land at the remote site that is cluttered and does not allow for low glide slope landings (10m radius) and so should be able to land and takeoff vertically at the remote site to receive maximum points for accuracy on target
- Must maintain a continuous communications link between the aircraft and base (even whilst on the ground at the remote site)
- Must stay within a preset geofence at all times
- Must be able to do this without a human operator influencing the mission control (For the Autonomy Challenge)
- Must be able to avoid Dynamic No Fly Zones as well as Geofence and No Fly Zones (To achieve the DNFZ Avoidance Challenge)

The current form of the Mozzie is our 2016 attempt to address the UAV challenge and, as such, does not facilitate solutions for all the latest rule change requirements. We expect to add solutions as they come to hand from users who participate in the further development of the platform, however, we offer no guarantee as to the performance of the Mozzie at the event, as this is ultimately the responsibility of the Challenge participants themselves. We sincerely hope that the information provided here will assist teams in developing their own systems and improvements to the Mozzie platform, that increases their chance of winning the challenge.

More Information on the 2018 Medical Express UAV Challenge can be found HERE

Introduction to Quadplanes

The Mozzie was specifically developed as a quadplane and to achieve the challenge range, VTOL and speed requirements. It does this by leveraging two completely separate propulsion, lift and control systems.

One of those systems is represented by the typical aircraft layout by using wings for lift, with control surfaces for manipulating aircraft attitude, and the forward electric motor for producing thrust. The other flight system is essentially a quadcopter, which produces vertical lift by producing downwards thrust using electric motors, and by varying motor revolutions it can modulate aircraft attitude control. It's noteworthy that either system can operate independently in the Mozzie, and they are only linked by using the same battery and flight controller, so either flight system is capable of keeping the Mozzie airborne should the other flight system fail in flight.

Either flight system can also be leveraged to assist the other in flight by allowing each flight system simultaneous control in certain flight situations. For example, wing stall can be eliminated by using the quad assist feature to produce lift when the forward airspeed does not suffice to produce enough lift with the wings. This also assists in control authority in low airspeeds, where the quad assist thrust can allow maneuverability beyond what the aircraft can manage with wings alone. This in turn means a more aggressive AoA of the wings can be used in flight, which reduces quad motor load in conjunction with forward motor assist, particularly in strong wind situations. This can significantly improve hover efficiency because the Mozzie wings continue to produce lift at low relative airspeeds.

Having two flight systems also affords the Mozzie a redundant flight recovery system should one system fail. The Mozzie can takeoff and land in both forward and quad mode. (forward takeoff recommended with bungee)

Another benefit of adopting two separate flight systems is the ability to optimise each of those flight systems for the intended flight profile. For the challenge, the aircraft system will predominately be operated in forward flight mode utilizing the wings for lift, as this is the most efficient way to achieve the cruise speed and range required for the mission. The quad flight system only serves a short-term secondary role, in that it allows the Mozzie to land and takeoff at the remote site, whilst it can land and takeoff in forward flight at base, should the battery not suffice for a softer quad type landing.

To optimize each of these propulsion systems, it is important to prioritize forward winged cruise over hover efficiency, because the Mozzie will typically only hover for one or two minutes in the challenge mission overall. By using a bungee or quad takeoff, it is also possible to optimise the forward propulsion so that, with the forward motor, both pitch speed and thrust equals drag at cruise velocities, without the need to ensure enough static thrust is provided by the forward motor for takeoff. The quad motors and props can also be optimised for forward flight, in that they are as small as possible, creating the least possible drag and weight for forward flight, whilst being sufficient to lift and control the Mozzie in hover. The overall gain in forward cruise efficiency, by optimising the drivetrain for forward flight over a longer period, more than compensates for the losses created by using a high disc loading quad lift system.

All of these optimisations only add value if the other systems used in the Mozzie can also achieve their mission objectives as well. The camera system is particularly important for locating the ground target and, as such, it's important to ensure that the camera system can operate in the prevailing flight conditions, and in fairly turbulent or fast forward flight. Limiting the design to only have a short hover time also means that it's not possible to use extensive hover times to image the search area and find the target. In our experience, however, forward winged flight resulted in better and more stable imaging than in hover, so having limited hover times had negligible impact on mission outcomes.

Overall, we are very happy with the potential and the performance of the Mozzie QP platform, and we look forward to seeing more projects based on this platform!

CHAPTER 2

Specifications

Hardware	Value	Note
MTOW	2.5kg	Maximum Take-Off Weight
Payload	1kg	Max Payload (incl. Battery)
Wingspan	1300mm	
Length	830mm	
Wing Area	30dm^2	
Wing Load	80g/dm^2	
Battery	4S 10Ah	Recommended battery

Performance	Value	Note
Cruise Current	4-6A	On 4S 10Ah Battery
Vno	22-29m/s	Nominal Cruise Speed (Forward)
Vne	35m/s	Never Exceed Speed (Forward)
Vs	16m/s	Stall Speed (Forward/Wings Only!)
Max Endurance	90min	In Forward Flight
Max Range	90km	In Forward Flight
Wind Penetration	14m/s	In hover + forward
Max Hover Time	12min	Hover only
VTOL & Forward	75min	2x VTOL and 72min Forward Flight

Avionics	Item	Note
Autopilot	Pixhawk	Ardupilot 3.7.1 (with Quadplane Control)
Telemetry	RFD900x	With Mesh Relay and PPM (40km range)
GPS	M8N	(Optional RTK)
Airspeed	Digital	Quad Assist Stall Prevention
Comp. Computer	Pi Zero W	Running Mavproxy, imaging, 3G modem and wifi
Camera	PiCam 8MP	With geotagging Mavproxy module and servo tilt
Redundant Power	3x	With separate Failsafe power
Flight Modes		Auto, RTL, Windvaning Loiter

CHAPTER 3

Planning and Designing for the UAV Challenge

The anatomy of a Mozzie.

As a part of the design process, one of the first steps we took was to identify the core goals of the project before we started. We found that how teams set goals also ultimately defined how successful they were in the event.

In our experience, the primary principles for developing a UAV Challenge project are:

- Ensure that all activities are safe
- Understand and interpret the competition rules correctly
- Create a list of development priorities that need to be achieved first
- Leverage the best capabilities of the team and understand and manage the capabilities that need to be learnt
- Allow time for things that will go wrong and don't leave them to the last minute to rectify and test

The result of applying those principles was a development priority to create a system that can complete the mission.

Broadly, the mission can be defined as:

- Create an airborne system that can autonomously find and navigate to Joe, before returning to base with a blood sample.

The required payload is limited to the blood sample. All the aircraft systems are only required to achieve the single task of picking up and delivering that sample. So the question became: If a 25gram payload is all that is required to be delivered, how small a system could be made to achieve that task reliably and safely?

(We didn't want to collect a big blood sample using the props!)

The resulting development priority became:

1. An electric 2kg VTOL aircraft with enough range, which it can transverse in the time allowed by the challenge
2. An autopilot that can reliably operate autonomously with the required functionality for the challenge (failsafe, geofence, VTOL, etc)
3. A communication package that can ensure continuous data to and from the aircraft with at least one redundancy
4. An imaging solution that can identify Joe and a nearby landing area from altitude in a flying (moving) aircraft

5. An overall package that was cost effective, easily built and rebuilt, and prioritised leveraging as many existing components and systems as possible

It might not be obvious from the first impression how the principles apply to the development. The key factors are size and availability.

By making a small platform, we effectively reduce the risk of damage to people and property, we reduce all the overheads for purchasing and testing various solutions, we also reduce the costs for repeating "tests" (failures and crashes), the costs for having multiple airframes that can be used at different times by different people and, most importantly, the precious time that is consumed by singular failures and issues because only one airframe was available for testing.

The availability and access to common systems and products also reduces the time consumed to develop them, by leveraging what was already available and adapting them to suit, rather than developing them from scratch. Many teams fail to even get to the event because they cannot achieve their goals in time. Creating brand new systems typically requires lots of time, so trying to avoid them should, in theory, give you more time to achieve your priorities. Any plan only works if there is enough time to complete it, so having a plan with strict milestones increases the teams' chances of getting to the event, and winning.

A real Mosquito can carry up to 3 times its own weight in blood and travel up to 50km away, and still land so softly on Joe that he would not even notice. Since training a real mosquito to hunt for Joe in the challenge is a bit tedious and difficult, the "Mozzie" is our attempt to replicate this feat as closely as we can! ;-)

CHAPTER 4

Getting Started

Complete Parts List

The first step to building the Mozzie is to organize and purchase all the parts.

Tip: The selected components listed here have undergone a series of tests for performance and reliability, however we can not guarantee their individual performance as we do not manufacture or assemble them.

Purchase List

Note: If you would like to support the Mozzie development, and if it is cost effective, please use the affiliate product links provided for Banggood to purchase those components, as that will help support the further development of the Mozzie platform at no extra cost to you. If you wish to support us with any other purchase you make through our affiliate store you can use this Banggood link or alternatively if you don't won't to use the affiliate links feel free to remove 20 digit number on the end of the BG links.

Tip: From time to time the freight options change in these stores so it is advisable to look for local stock to reduce freight costs, in particular on the larger items like the airframe or batteries.

- Talon ships from BG in single units via EMS. (currently it's expensive - so maybe try it locally)
- Batteries have limited shipping methods due to safety so try to shop locally for these if you can.

System	Item	Weight	PCS	Link
Airframe	Mini Talon	562g	1	Banggood

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Table 4.1 – continued from previous page

System	Item	Weight	PCS	Link
	Carbon Bar for QP Arms (1m)	27g ea.	1	Carbon Fibre Aus
	M4 Screws		6	1x20mm, 1x28mm, 2x 25mm, 2x 40mm
Propulsion	QP Motor Cobra 2207 2300	31g ea.	4	Banggood
	QP ESC ZTW Spider Pro HV 30A F390	6g	4	Bolt RC
	Fwd Motor Cobra C-2814/16 Kv 1050	107g	1	Innov8tive
	40A ESC (with Brake)	50g	1	
	Prop Aeronaut 10x8		1	PerthRC
	Spinner Bar Aeronaut		1	PerthRC
	HQProp Glass-Nylon 6x3.5 2xCW+2xCCW		4	Rotorgeeks
Electronics	Battery MultiStar LiHV 4S 10Ah	794g	1	HobbyKing
	UBEC ZTW 6A	12g	2	Banggood
Power Loom	XT60 Connectors (5 pairs)		1	Banggood
	XT30 Connectors (10 Pairs)		1	Banggood
	Cable 12AWG 330mm 1xBlack + 1xRed		1	Black Red
	Cable 14AWG 530mm 1xBlack + 1xRed		1	Black Red
	Cable 18AWG 160mm 1xBlack + 1xRed		1	Black Red
	Cable 20AWG 360mm 1xBlack + 1xRed		1	Black Red
Avionics	Pixhawk	39g	1	Banggood

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Table 4.1 – continued from previous page

System	Item	Weight	PCS	Link
	GPS Neo-M8N	18g	1	Banggood
	Digital Airspeed with Pitot	3g	1	HobbyKing
	I2C Hub	4g	1	Banggood
	Power Module and Sensor	22g	1	HobbyKing
	Servo ext. cables 15cm		1	HobbyKing
	Servo ext. cables 30cm		1	HobbyKing
	Screws			Countersunk Screws M3 4x10mm, 4x18mm. M2.5 4x12mm
	Damping Balls		4	HobbyKing
Comms & RC	RFD900x (1 Air & 1 Ground req) **	12g	2	RFD Aus
	Pixhawk to RFD900x Cable	2g	1	RFD Aus
	USB to FTDI Cable	50g	1	RFD Aus
	Antenna 900MHz 3dBi Dipole (RPSMA)	21g	2	RFD Aus
	Foil Antenna 300mm (or 500mm)	7g	2	RFD Aus
	FrSKy XSR	4g	1	Banggood
Servos	Corona DS-929MG	12g ea.	5	HobbyKing
Companion Pi	Raspberry Pi Zero W	10g	1	PiHut
	Pi Camera v2	3g	1	PiHut

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Table 4.1 – continued from previous page

System	Item	Weight	PCS	Link
	Pi Camera to Zero Cable	1g	1	PiHut
	Powered USB Zero4U Hub	14g	1	PiHut
	Pi Reboot Relay (pololu RC small)	1g	1	LittleBird Aus
	SD Card 8GB (or Larger)	1g	1	

Note: All RF equipment, antennas and radios should be thoroughly range tested on each aircraft and base station setup. Please see the respective build sections prior to purchasing for more details.

3D Printed Parts

3D Printed parts can be printed using a selection of materials, we made our aircraft parts from PLA as this was the easiest and was rigid enough. Using ABS, especially on the larger Avionics Enclosure parts might be difficult. Some parts are printed on the side as noted. Not every 3D printer is configured the same so some might not print at the correct size to fit the individual electronic components etc, if so, try using the scale feature on the slicer to increase or decrease the size as required. Note that all the prints that connect to each other will require the same scale so they fit together properly once assembled.

Tip: When 3D printing ABS and some other filaments, it is good practice to do so in a well ventilated area and not inhale the fumes directly as they are toxic.

3D Printed Parts List

Please either select the individual STL 3D print files individually from the list below or clone the github repo.

Tip: Clicking the 3D part link will open the part in Github where you can use the download button in the top left of the viewer.

Airframe Parts

Talon Box Bridge (Vial holder)
Talon Box Left Side
Talon Box Right Side
Front Skid
Tail Skid
Forward Motor Mount

Optional: | GPS M8 Mount | GPS Cable Conduit Long | GPS Cable Conduit Short | E-Stop Holder | ESC Air Scoop |

Avionics Parts

Avionics Enclosure Pi (bottom)
Avionics Enclosure RFD/Air (top)
Avionics Enclosure Plate (center)
Avionics Enclosure Front Mount
Avionics Enclosure Rear Mount
Avionics Enclosure Screw Washers
AE Camera Servo Mount PiCam
Camera PiCam Holder

Optional: | Airspeed Sensor Mount (v4.1) | Arm Switch Mount | 3G Modem E3351 |

Quad Arm Parts

CF Motor Mount Left
CF Motor Mount Right
CF Middle Left
CF Middle Right
Undermount 2x

Workspace

For the construction of the Mozzie you will need a large well lit table about 1.5m wide and a power plug for soldering iron, hot glue and the optional heat gun.

Tools Required

The most expensive tools required to build the Mozzie are a good soldering iron and a hot glue gun. A hot air gun is optional to heatshrink the components like the quad arms, but it is recommended for a good finish. A third hand to hold onto parts whilst soldering is also recommended.

Hand tool required:

1. Hobby knife with replacement blades
2. A good pair of sharp scissors
3. A Philips and hex screw driver with the following sizes

Consumables Required:

1. UHU Por (this glue is ideal for foam because it stays flexible and has a strong bond)
2. A good quality clear packaging tape and a mesh reinforced tape
3. 180 grit Sandpaper

Recommended

1. Soldering iron holder
2. Hot Air Gun
3. Cutting mat

Safety

The two most dangerous things in building a Mozzie are cuts and burns.

Hobby knives and scissors are very sharp and should be handled with care, try not to use too much force when cutting and cut away from yourself.

The soldering iron and heat gun can cause serious burns that may require treatment by a doctor or hospital. Use care to place the hot items on a non-flammable materials, out of the way so they can't be touched or bumped into. A soldering iron holder is recommended.

> **Caution:** Soldering also produces toxic fumes so ensure that a well ventilated room and/or small extraction fan is used. They can also present a fire danger so keep them away from flammable items and make sure they are turned off when you leave them.

Remember making the Mozzie should be fun, but getting hurt is not!

CHAPTER 5

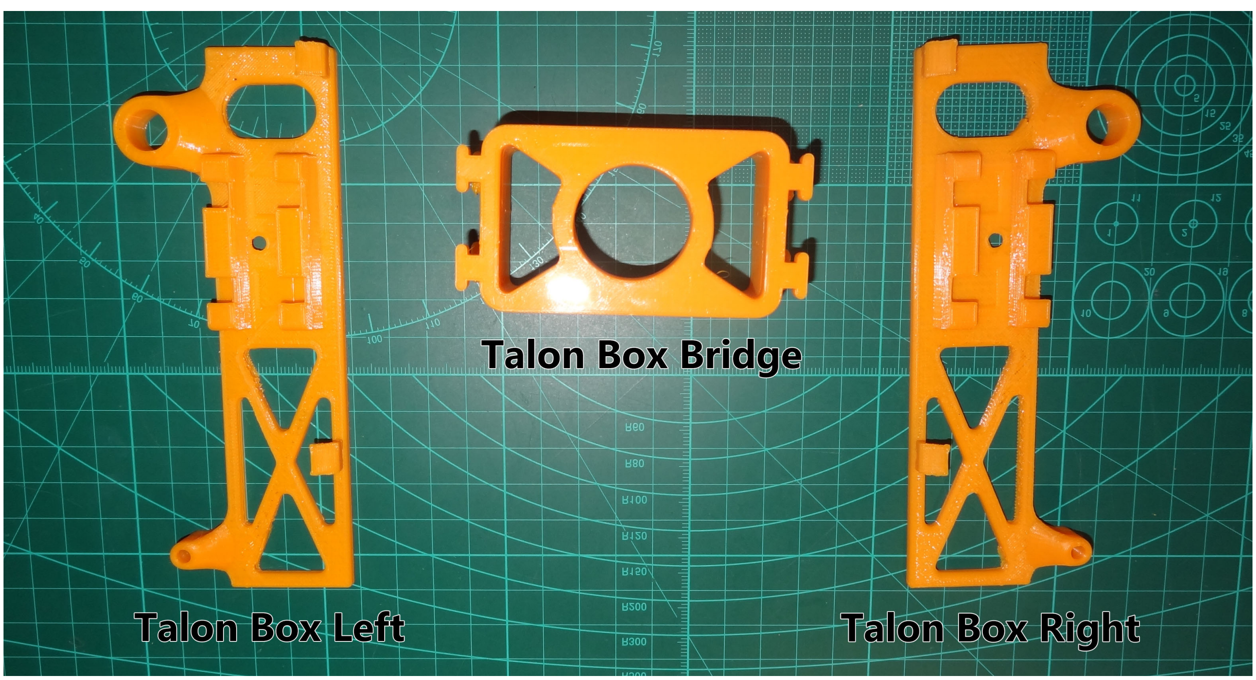
Airframe

Fuselage

Step 1 - Assembling the 3D Printed Fuselage Frame

3D Parts Required:

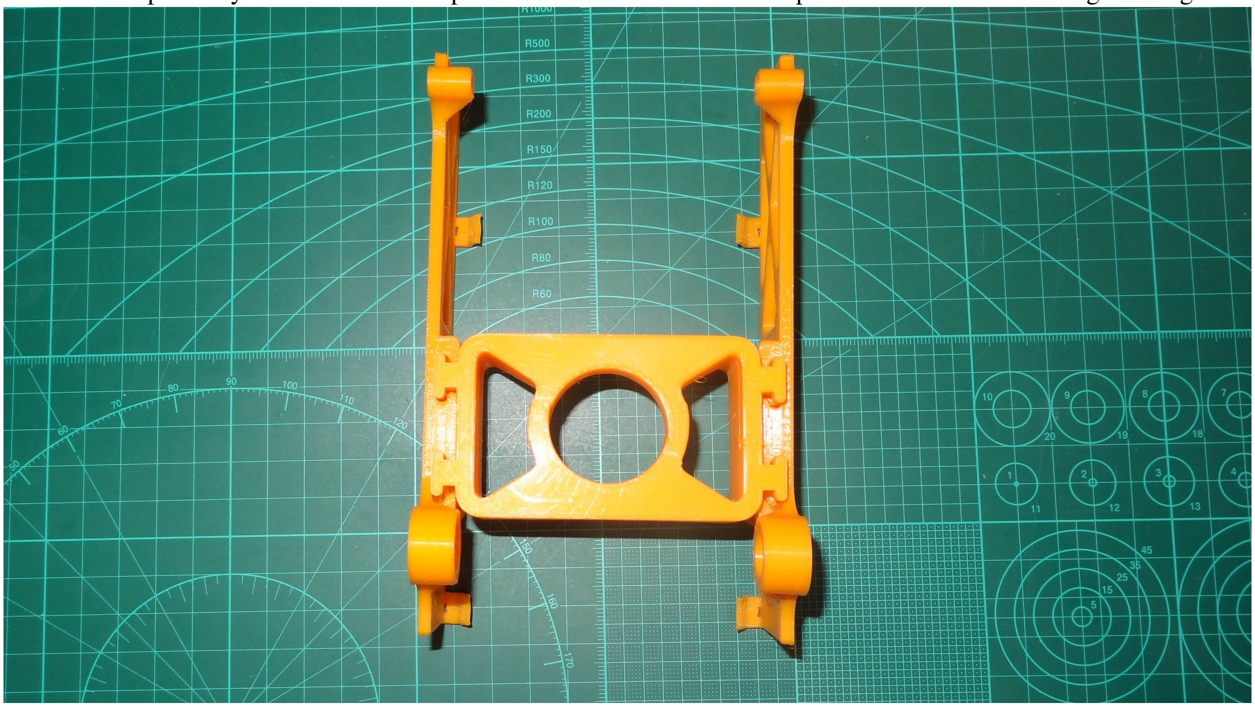
- Talon Box Bridge
- Talon Box Left Side
- Talon Box Right Side



Tip: Not all 3D parts come off the printer in perfect condition. Before assembling any 3D printed parts or glueing any 3D printed parts, ensure that the parts all fit together by carefully removing any excess plastic from the print and seeing if they dry fit together first!

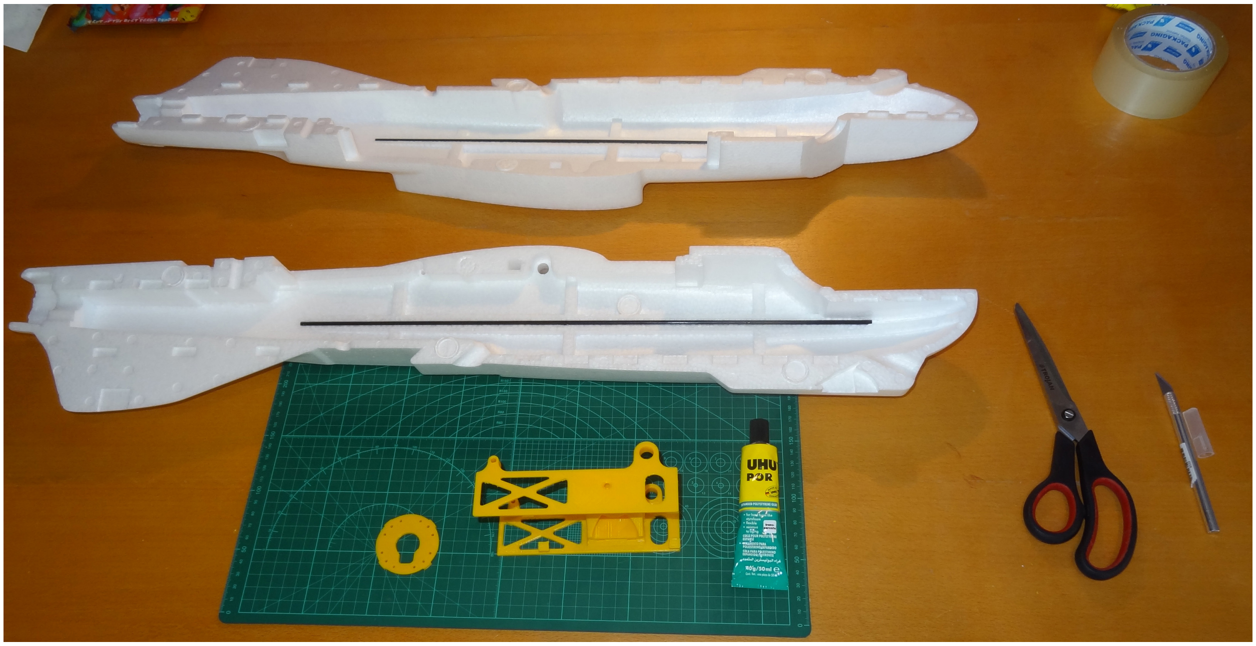
Line up the dovetails and slide the Right and Left side parts into the Box Bridge as shown. Be careful to ensure the connection points don't have any excess plastic or contortions and will slide together cleanly. The Bridge and Sides are meant to be flush across the top, otherwise the foam lid may not fit.

Note that it may take some force to slide the parts together and they will be difficult to separate afterwards because the print layers will bind the parts. This is intentional so parts do not need to be glued together.

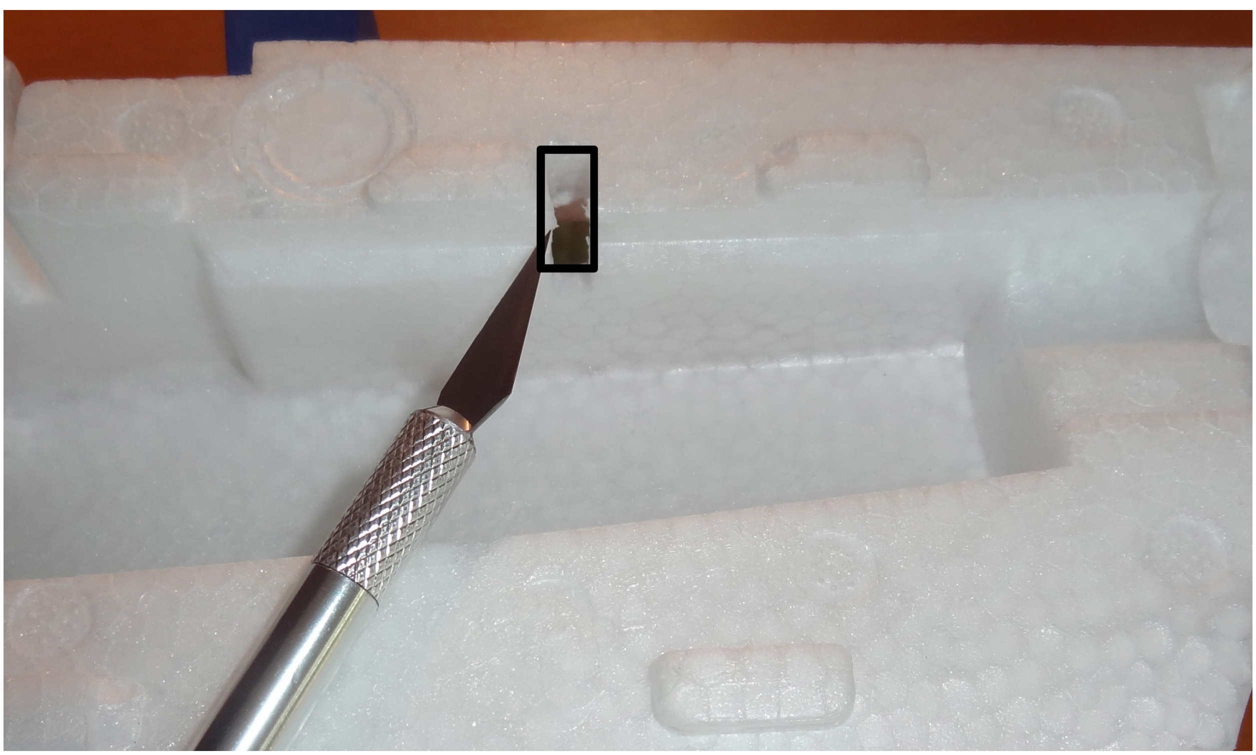


Tip: Use a 80-200 grit sandpaper to key the surfaces of the 3D printed parts (make it rough) that will come in contact with the foam when assembled. This will ensure a proper bond with UHU glue and the hard, sometimes very smooth and shiny plastic surface.

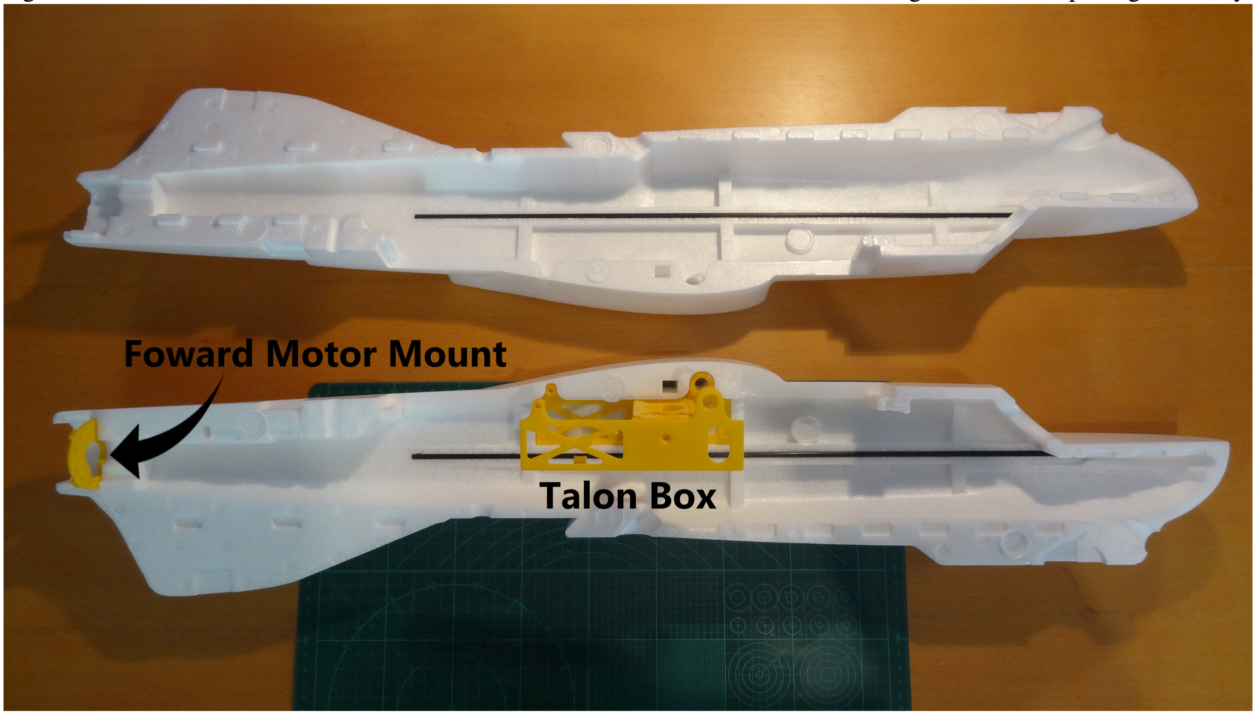
Step 2 - Assembling the Fuselage



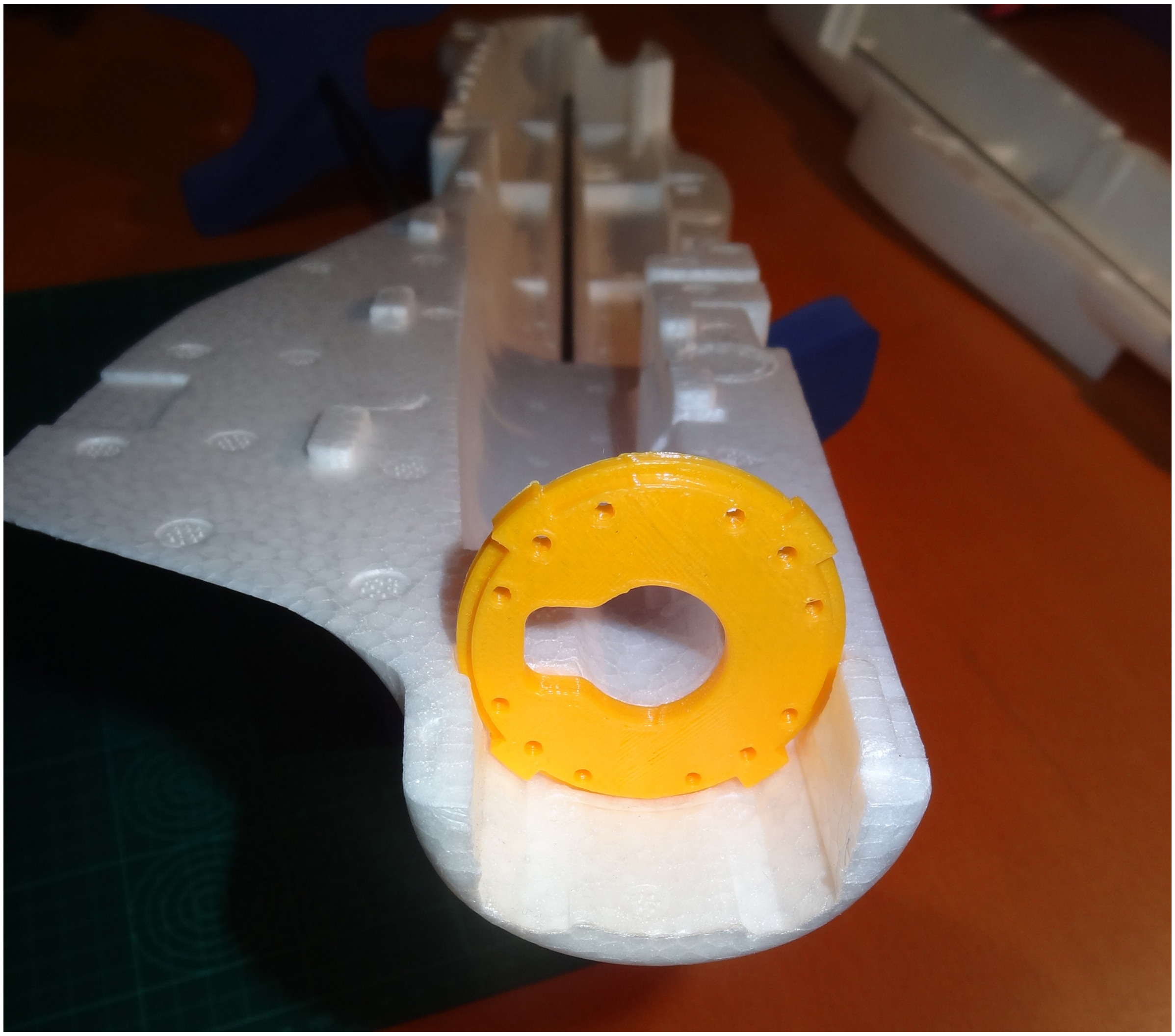
Tip: It's generally good practice when assembling a model to check that all the supplied parts fit together before glueing it. Whilst examining the parts, remove any excess foam or material left over from the manufacturing process. It's also a good opportunity to see if you have all the parts you require to complete the build step you are attempting, and lay them and any tools you need out in preparation for assembly.



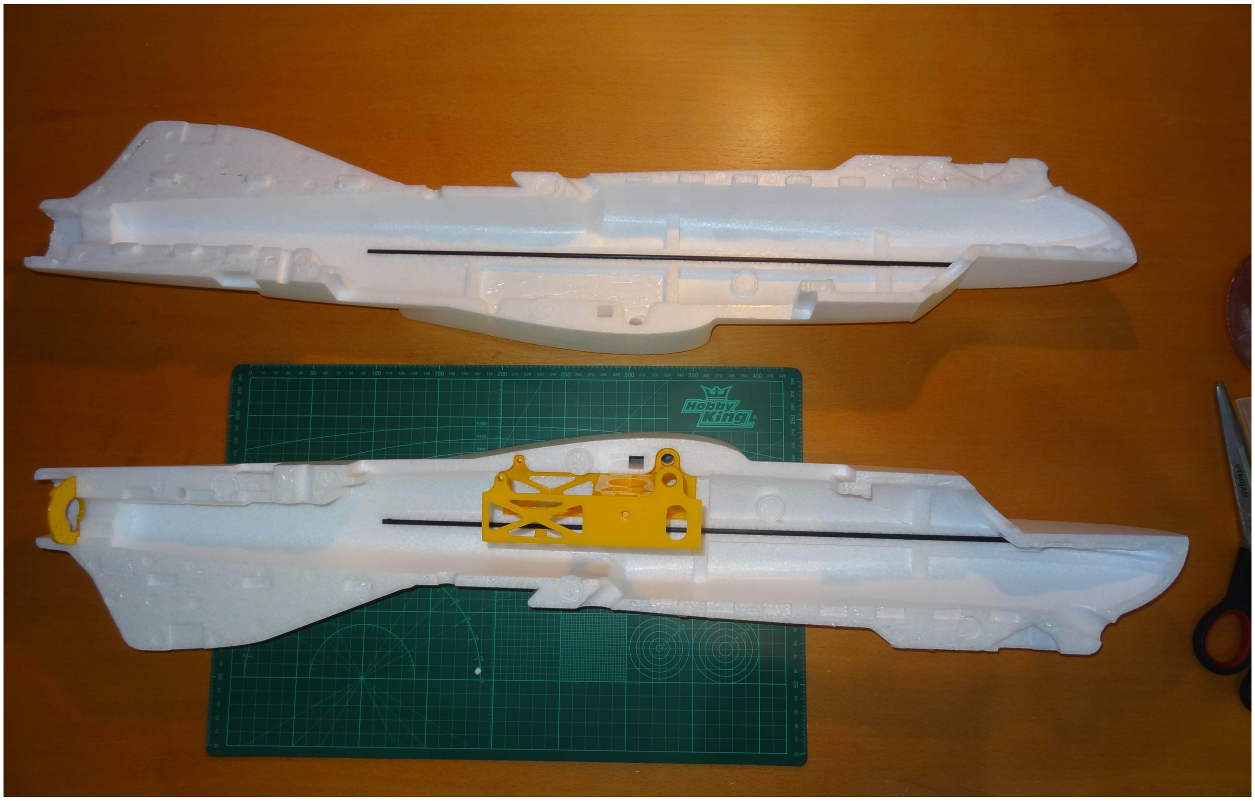
Cut out the foam with the hobby knife as shown on both pieces of the fuselage foam so that the tail servo cables can fit through the opening easily.



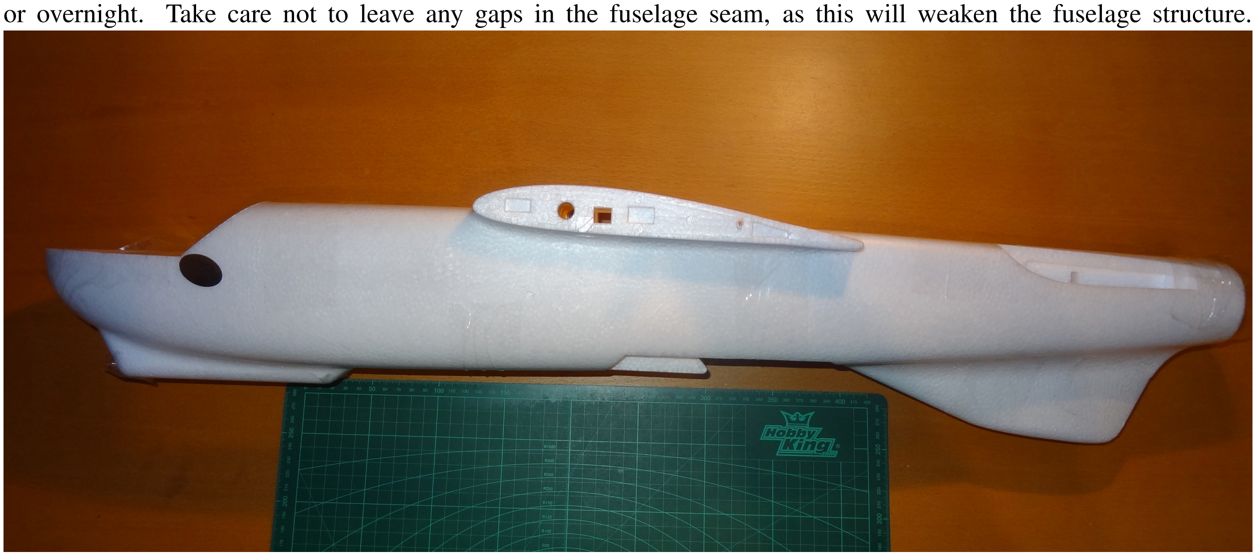
Dry fit the fuselage sides to check that they fit well together, and do not have any excess foam that prevents them from connecting completely. Then try to dry fit the 3D printed box assembly inside the fuselage halves as shown. Note the CF spar openings in the foam must be clear and be aligned with the holes in the 3D print.

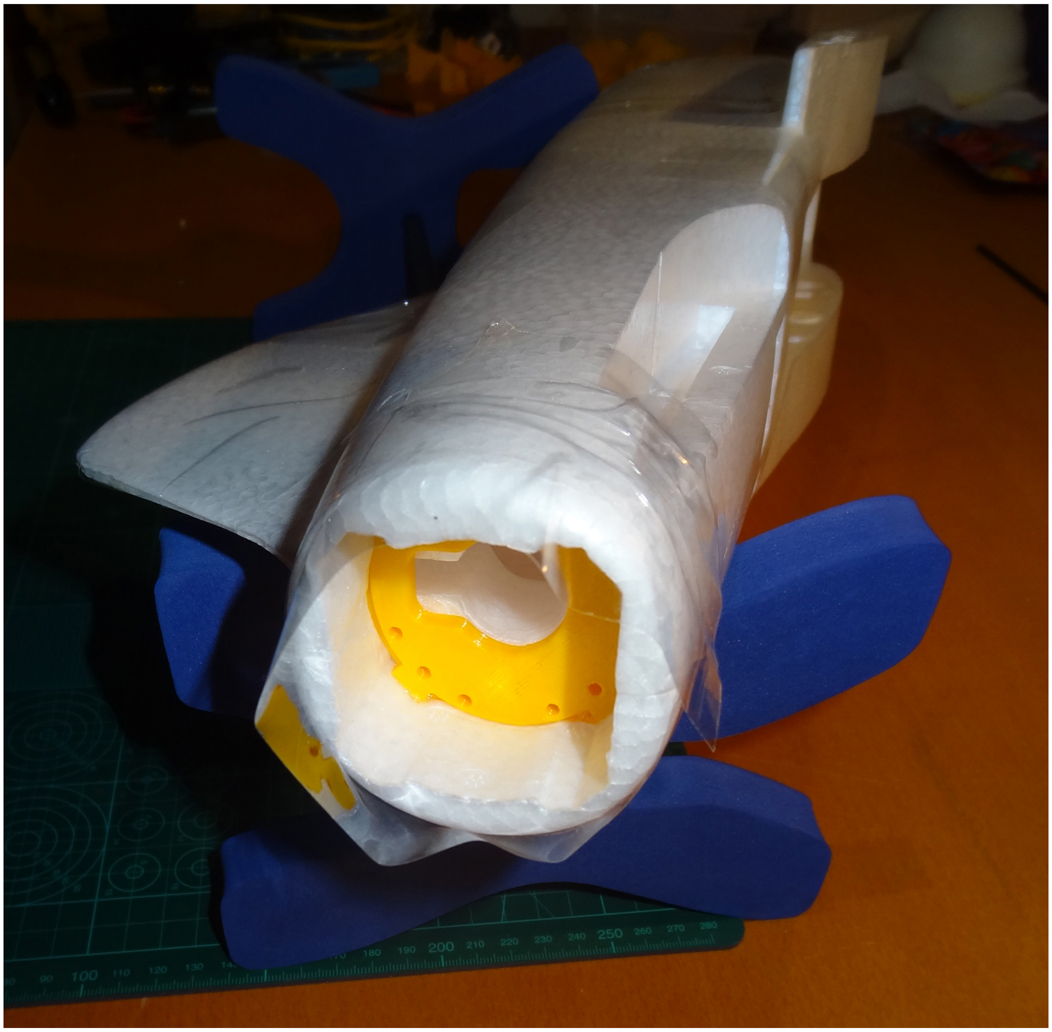


Insert the 3D printed Forward Motor Mount as shown, with the key hole pointing towards the bottom rudder wing. This needs to be pointing the correct way to ensure the motor cables can be routed through the motor mount afterwards.



Once you are comfortable that all the parts fit together without glue, UHU glue one side of the Talon Box into the fuselage as well as the Forward Motor Mount (check the orientation!). Then carefully run a bead of glue around the entire perimeter of the fuselage and over the area of the rear rudder, and the other side of the Talon Box Side that will go into the second fuselage half. Carefully place the other fuselage half over the 3D printed parts, check alignment of the parts, and press the two halves together firmly. Whilst holding the halves together, use some tape to carefully wrap around the fuselage to keep it firmly together while the glue sets over a few hours or overnight. Take care not to leave any gaps in the fuselage seam, as this will weaken the fuselage structure.



Make sure the rear motor mount is aligned, and the rudder halves and fuselage are glued and taped together to form one seamless piece. 

Step 3 - Attaching the Extra 3D parts

The 3D printed Front Skid is a useful option for the aircraft as it allows you to use it for Mozzie bungee launches. With some practice, this can be done in Manual Mode by the pilot in command in the aircraft, or via setting up the Autopilot for an Auto Takeoff, as is explained further in the Flying the Mozzie section.

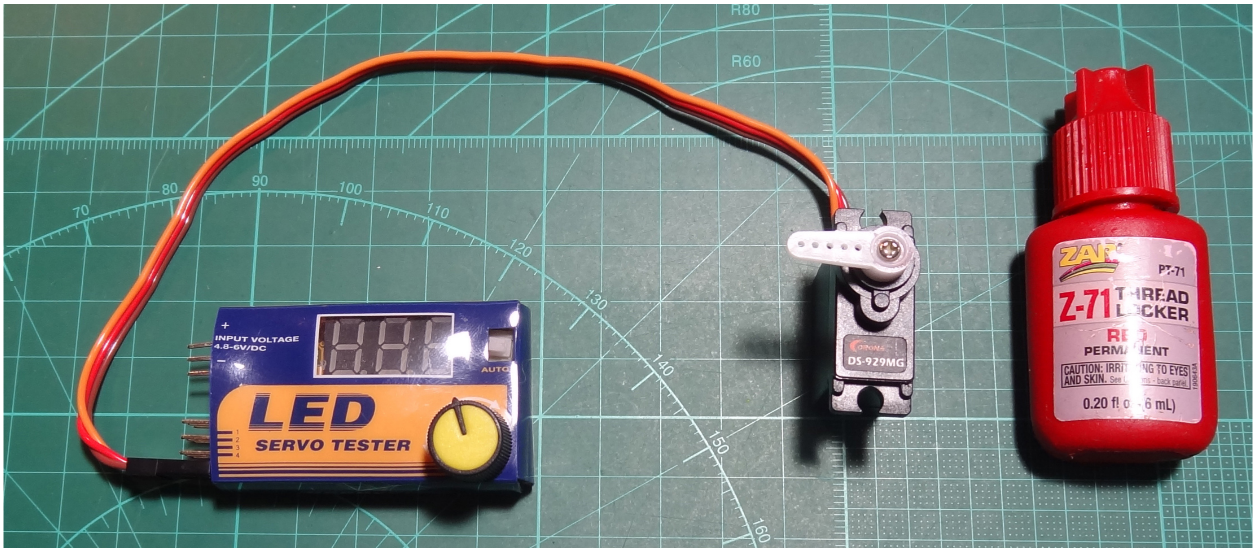
Before you attach the front skid, insert a countersunk head M4 14-15mm long screw through the Front Skid screw hole. Preferably trim the screw length so that it does not exceed the bungee hook recess in the 3D print.

Carefully mark and cut out the foam so the Front Skid fits tightly on the bottom nose of the aircraft, in particular the bungee hook recess, and attach with hot glue.

Once you have found the correct orientation that fits the tail best, you can attach the Rear Tail Skid 3D print using hot glue as well.

Wings

Step 1 - Parts Preparation

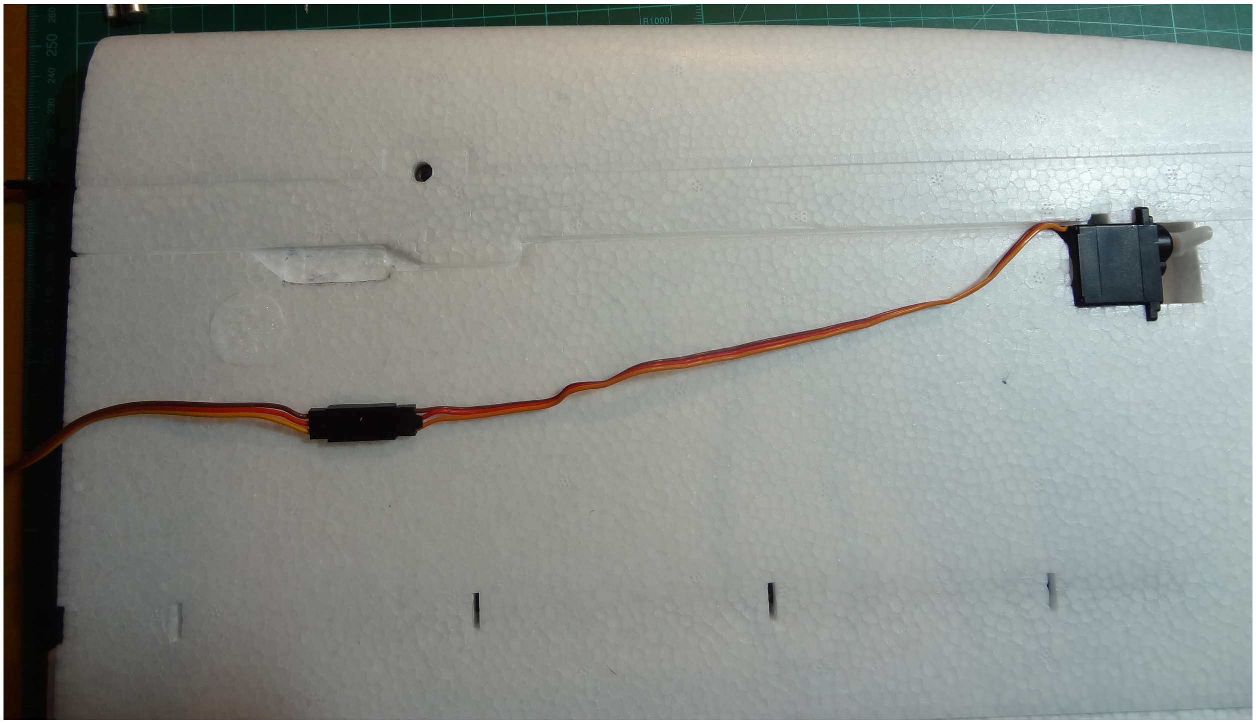


Use a servo tester to find the middle position of the servo, attach the horn at 90degrees corresponding to the wing or tail it will be used in. Use a very small drop Loctite to secure the servo horn screw into the servo. Repeat this for all the wing and tail servos (4x).

Note: Do the following for both wings:

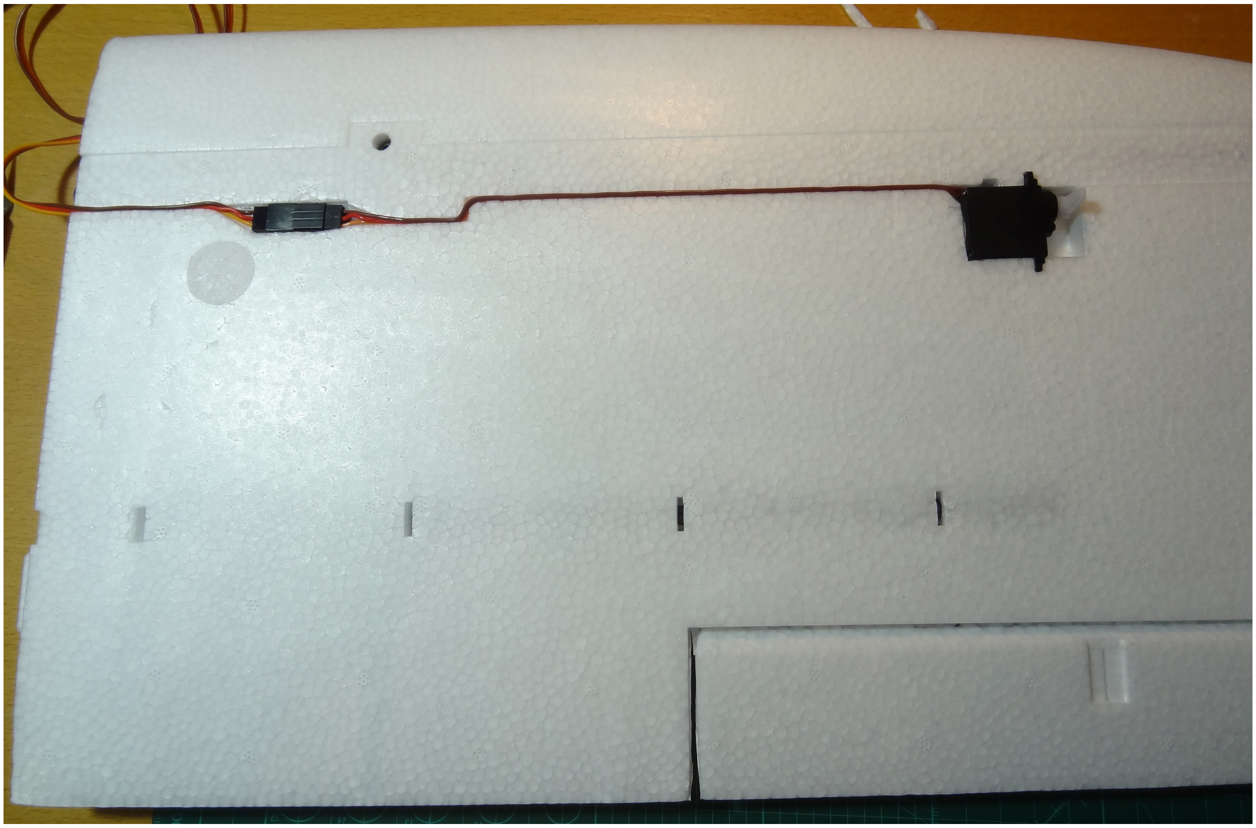
To place the servos on the wing and tail cutouts, they need to be cut out to make them fit. Place the servo over the wing cutout for the servo and mark the servo size using a marker. Carefully cut it out with a sharp hobby knife so that the servo fits snugly into the foam.

Tip: (Use the marker to put a line on the hobby knife blade to the cut depth required)



To insert the cable into the wing foam seam, use the hobby knife to cut along the seam at a depth of 5-6mm. Insert the servo into the servo cutout and place the servo cable along the wing seam to find the location that the servo plug needs to be recessed into the wing and mark it. Then cut it out to a depth of about 3mm, using multiple cuts at that depth to easily remove the foam.

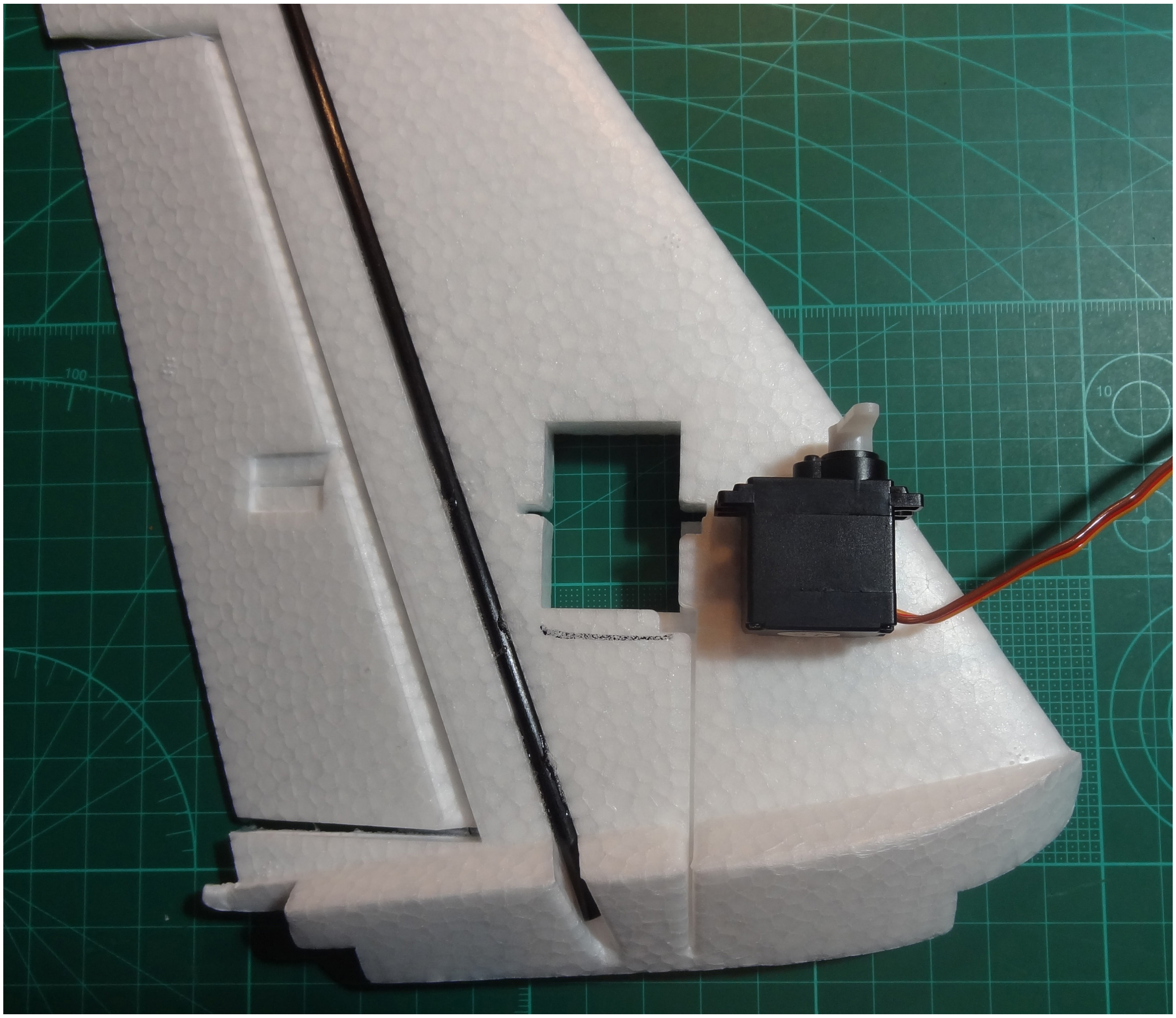
Step 2 - Assembling the Wing



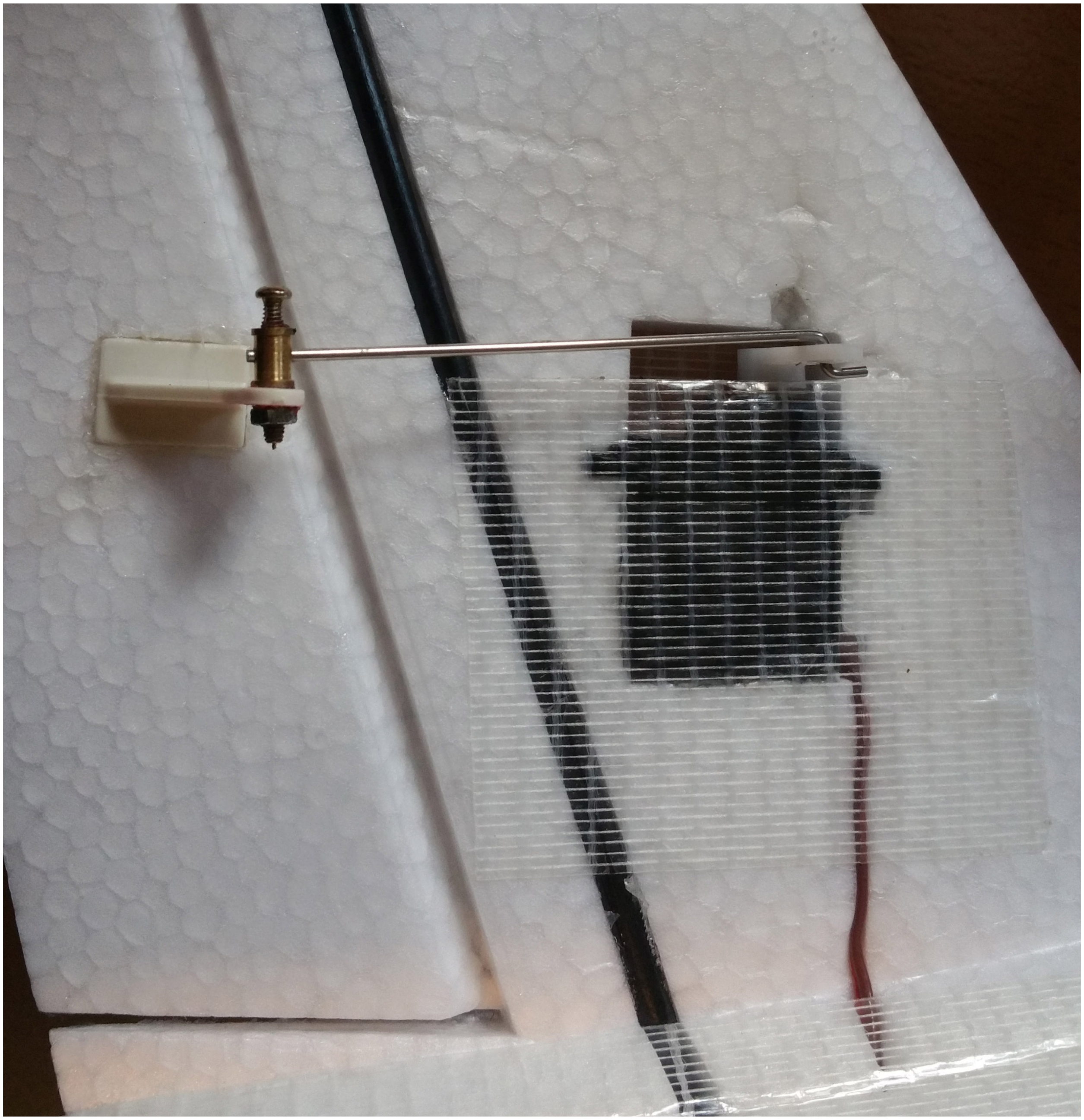
Tip: Use a 80-200 grit sandpaper to key the surfaces of the servo (make it rough) that will come in contact with the foam. This will ensure a proper bond with hot glue or glue and the hard, sometimes very smooth and shiny plastic surface.

Then use hot glue on the base and around the servo sides under the tabs to glue it into the foam recess. Try to make sure the servo is straight and flush with the wing surface. Remove excess hot glue, preferably before it cools completely. Then, insert the cable into the wing seam until flush. To secure the servo cable and connector use a piece of tape over the entire length from the servo to the end of the wing.

Step 3 - Assembling the Tail Wing



Place the servo over the tail wing recess, mark and cutout the recess to make the servo fit snug in the tail wing.



Slide the servo cable into the provided gap. To secure the servos, use a piece of tape on either side of the servo, making sure a gap remains to allow movement of the servo horn.

After keying the control horns with sandpaper, glue them into the provided recesses with the holes of the horn facing the servo. Attach the control rod and hardware as shown; however, do not yet use Loctite to secure the control rod screw until the Full System Check has been completed.

CHAPTER 6

Avionics

In an attempt to streamline the installation and the inevitable replacement of airframes after hard landings, we decided fairly early in our development process to try and condense the avionics into simple and compact units, that can be replaced and installed with just two screws into the Mozzie airframe.

The main reasons for pursuing this were:

- to simplify replacing the complete avionics because of a malfunction
- to bench-test and repair avionics hardware without the bulk of the airframe impeding access to the various components, which in turn allows for a more compact package overall
- to allow for a quick replacement of the avionics hardware in the competition and testing, and to reduce repair and maintenance time in the field (replacement being typically faster than repair)
- to allow for changes and additions in avionics hardware without affecting airframe layout
- to reduce rebuild times after a catastrophic airframe failure (crash!)

As a consequence of the integration of the various components into the avionics enclosure, including the pi Camera module and servo tilt mount, it was possible to use the mass of the enclosure to dampen the camera and FC from airframe and propulsion induced vibration. It considerably reduced the cabling complexity and cable use in the airframe, which is a challenge for a small airframe, and also simplified the camera angle setup because the FC IMU was mounted on, and moved with, the same mechanical structure as the camera.

Note: The Avionics Enclosure build is divided up into configuration and assembly sections. It is advisable to complete the configuration setup and bench test the configuration components prior to assembling them into the Avionics Enclosure, to avoid having to disassemble the enclosure in order to diagnose a malfunction of misconfiguration.

Avionics Enclosure Assembly

3D Parts Required:

- Avionics Enclosure Pi (bottom)

- Avionics Enclosure RFD/Air (top)
- Avionics Enclosure Plate (centre)
- Avionics Enclosure Front Mount
- Avionics Enclosure Rear Mount
- Avionics Enclosure Screw Washers
- Pi Camera Servo Mount
- Pi Camera Holder

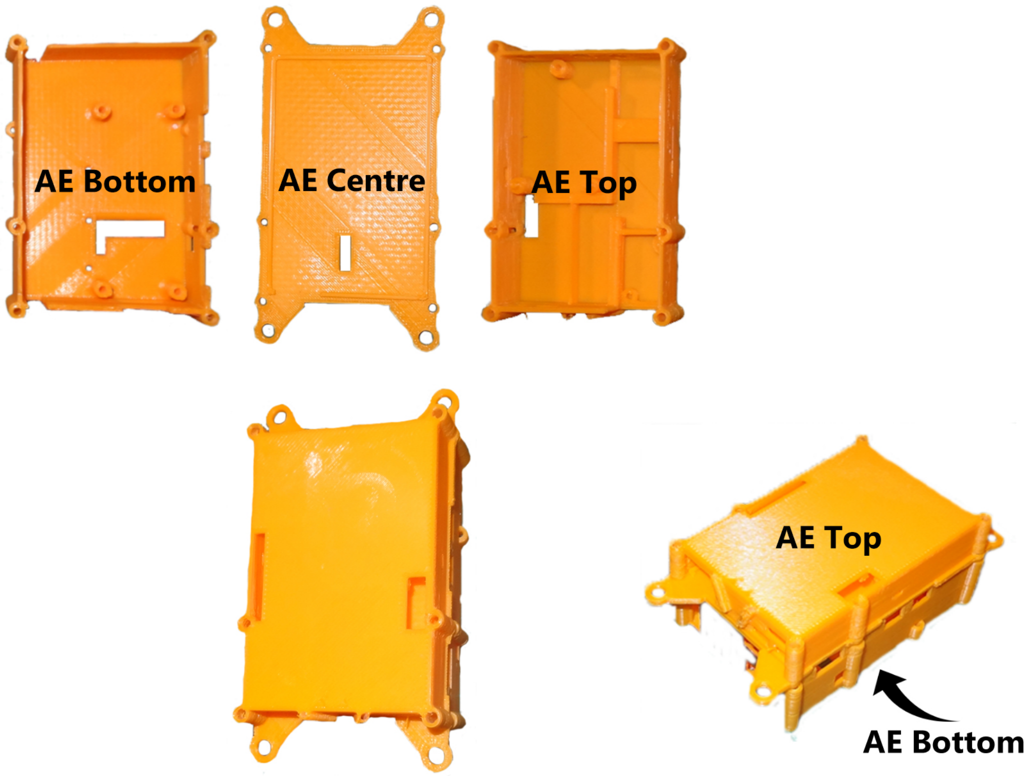
Components Required

- Airspeed Sensor
- I2C Bus
- FrSKy XSR RC Receiver
- RFD900x Radio Modem
- GPS M8N
- Pi Zero W
- Pi Camera Module v2
- Pi USB Hub Zero4U
- Pi Reboot Relay
- 1x Servo DS-929
- Pixhawk
- M4 Countersunk Screws 1x20mm and 1x28mm long
- M3 Countersunk Screws 4x10mm and 4x18mm long

Step 1 - Pre-Assembling the Avionics Enclosure

Tip: Not all 3D parts come off the printer in perfect condition. Before assembling or glueing any 3D printed parts, ensure that the parts all fit together by carefully removing any excess plastic from the print and seeing if they dry fit together first!

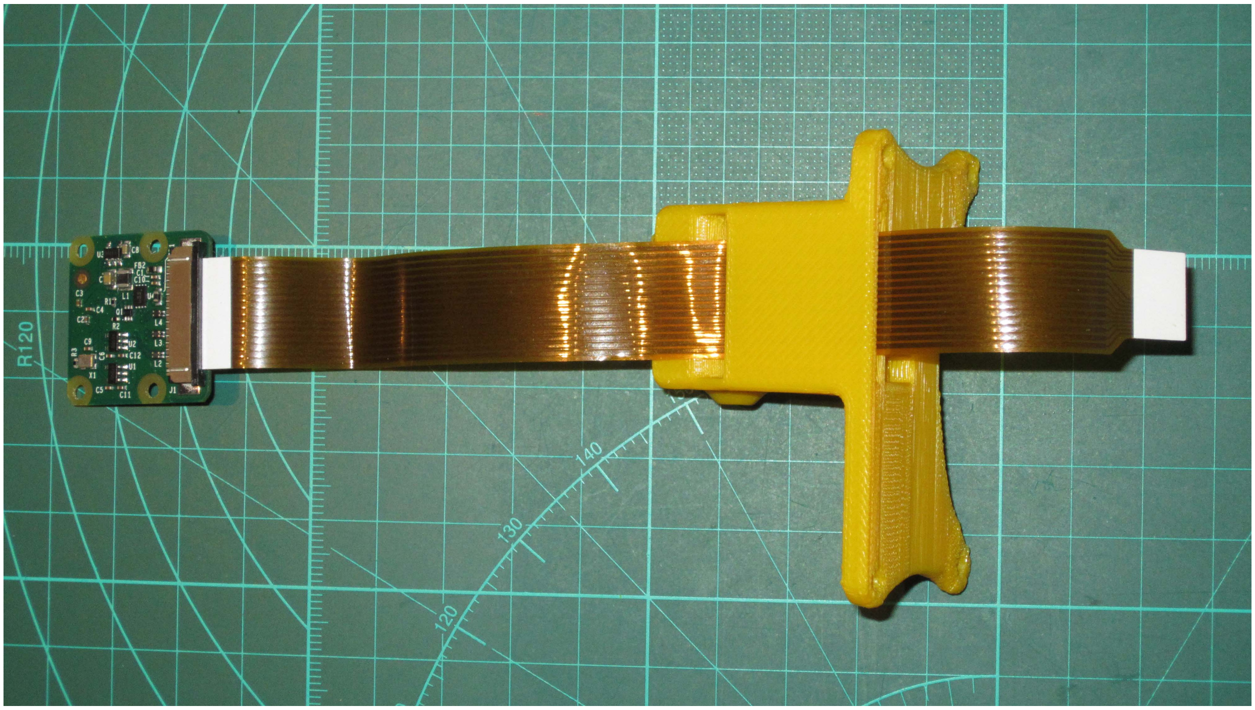
As always, it's a good idea to make sure the 3D printed parts fit first without any components installed.



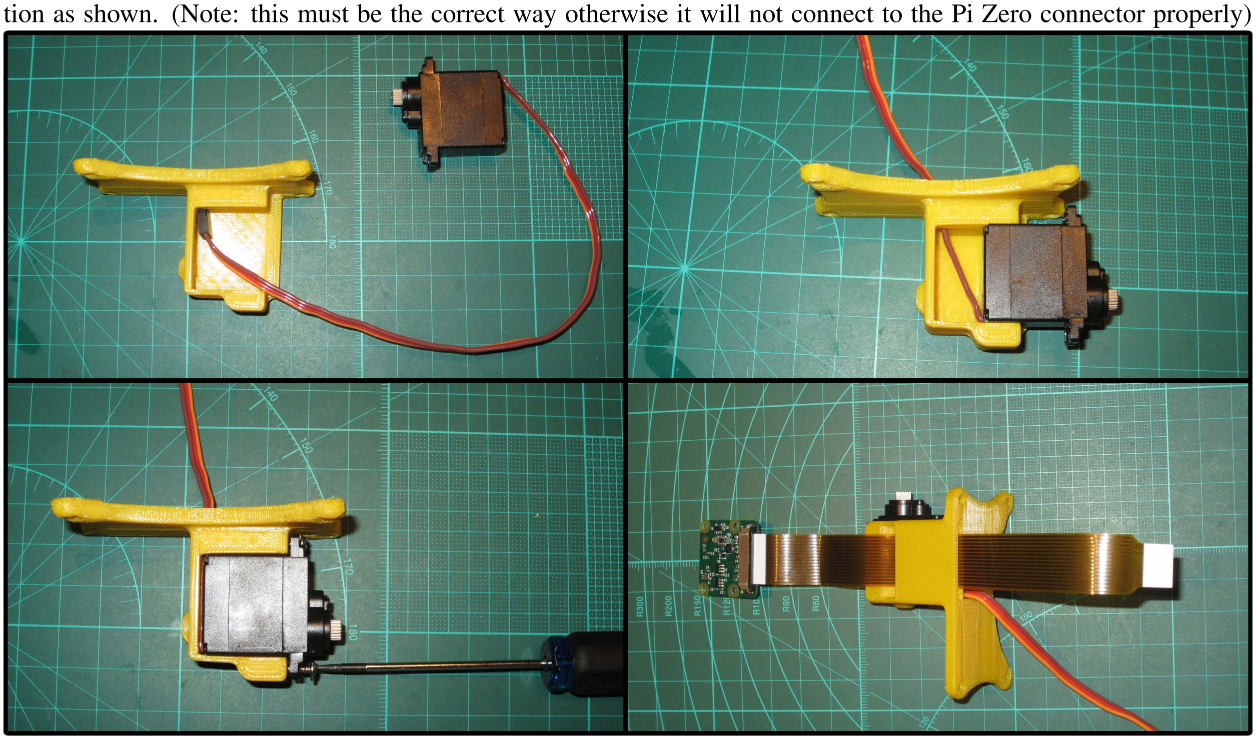
Assemble the Avionics Enclosure (AE for short) Pi, RFD/Air and Centre plate as follows, taking care to align the plastic and making the parts fit together seamlessly.

Step 2 - Assembling the Pi Avionics Enclosure

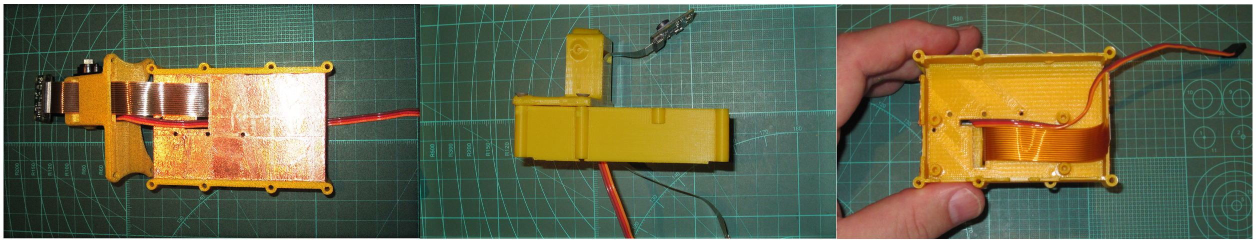
Carefully pull out the black plastic locking mechanism 1mm on the Pi Camera connector and insert the Pi Camera ribbon cable to the Pi Camera, with the contacts of the ribbon cable facing the Pi Camera PCB. Then, lock the ribbon cable in place by sliding the black plastic back in whilst the ribbon cable is fully inserted. Make sure the slot for the Pi Camera ribbon cable in the Pi Camera Servo Mount 3D print is clear and carefully test that the ribbon cable can be inserted through the slot.



Then ensure the slot on the Pi Camera Servo Mount is clear and insert the Pi Camera ribbon cable in the orientation as shown. (Note: this must be the correct way otherwise it will not connect to the Pi Zero connector properly)

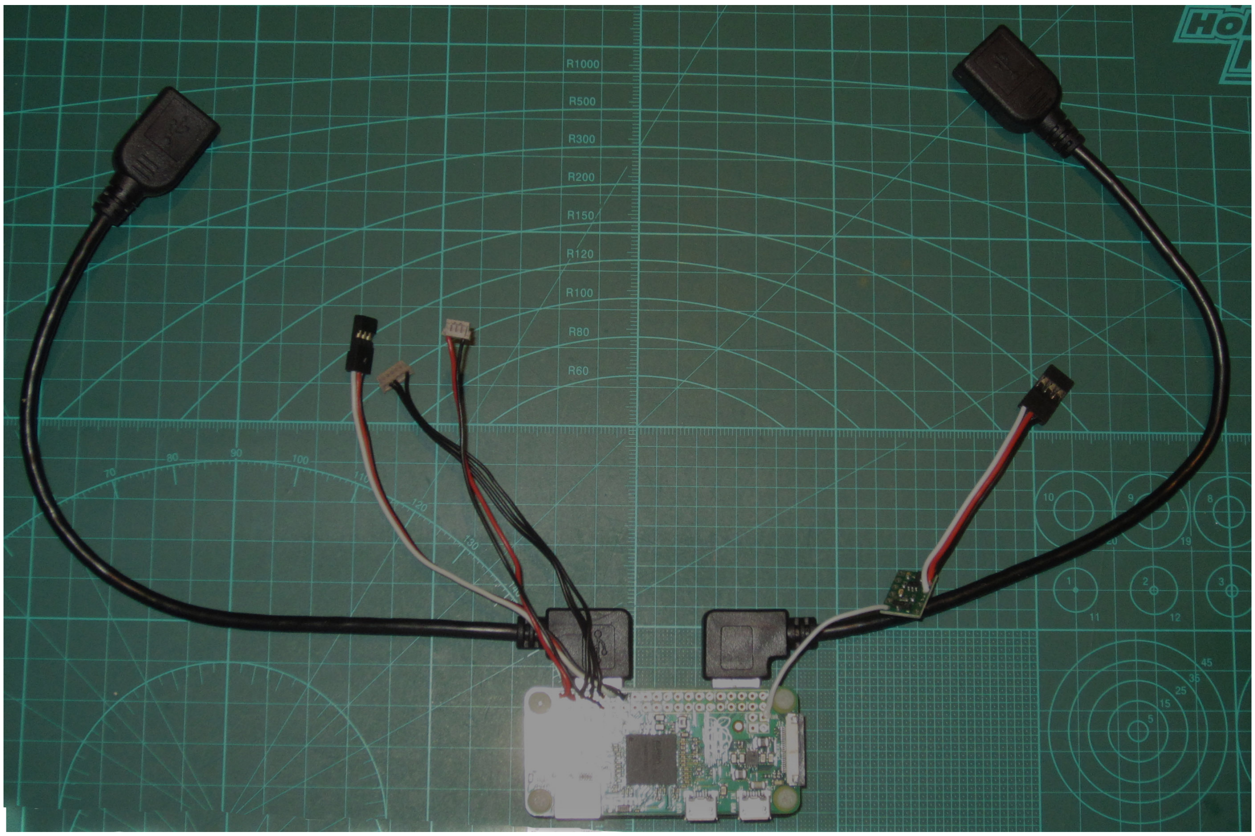


Insert the Servo plug into the Camera Servo Mount as shown, making sure there are no twists in the cable so the Servo fits seamlessly into the mount. Screw the servo to the mount using the screws provided with the servo.



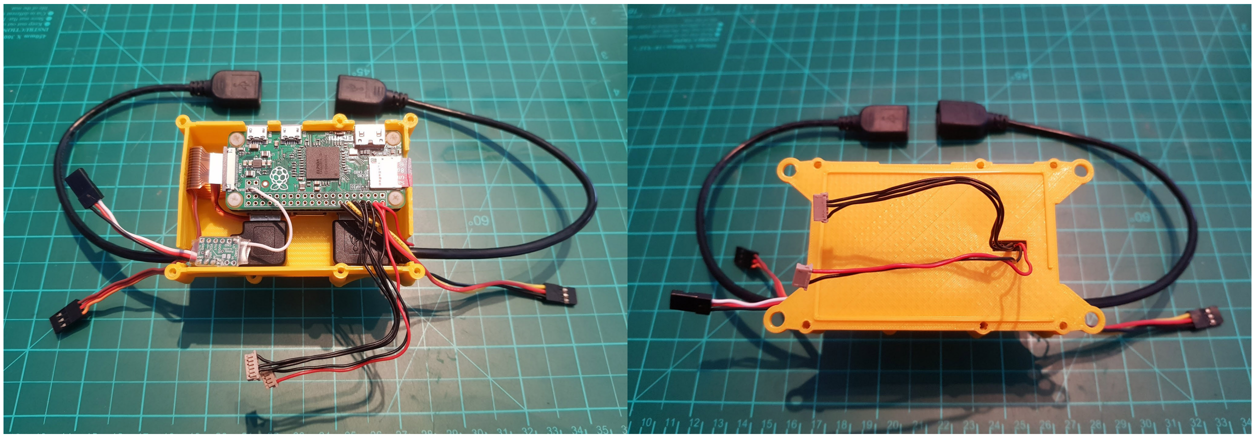
Insert the cables through the Pi AE as shown, attach the Camera Servo Mount to the Pi Avionics Enclosure using the M3 10mm screws, and route the cables internally as shown above.

Note: The servo cable should be flat and routed in between the Pi Enclosure 3D printed screw risers and then towards the rear of the enclosure to the Pi Zero ribbon connector.



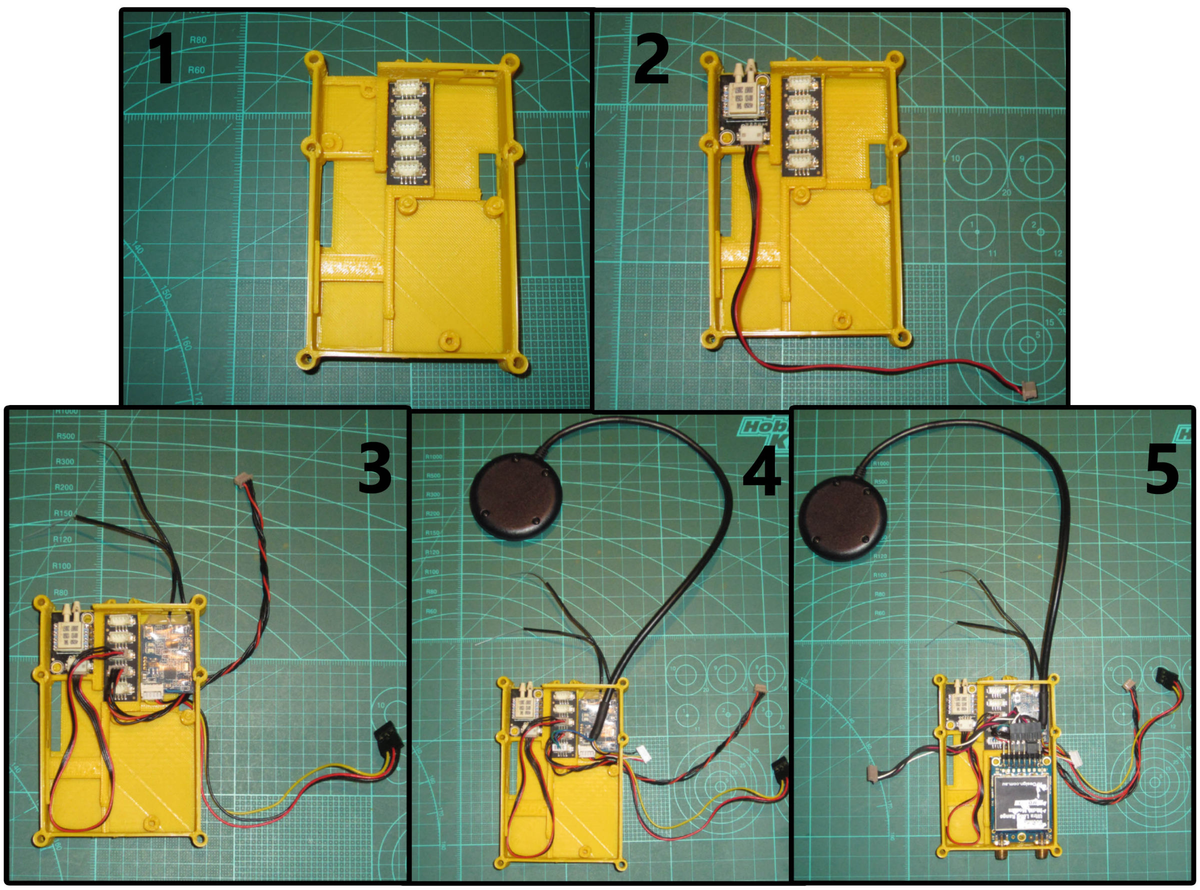
Tip: Use an M2.5 12mm metal screw to thread the 3D printed extrusions prior to using plastic screws to attach the Pi to the enclosure.

Take the completed Pi and USB assembly constructed Pi Setup phase, place it into the Pi AE and attach it with the USB HUB supplied plastic or equivalent metal screws. Route the cables as shown.

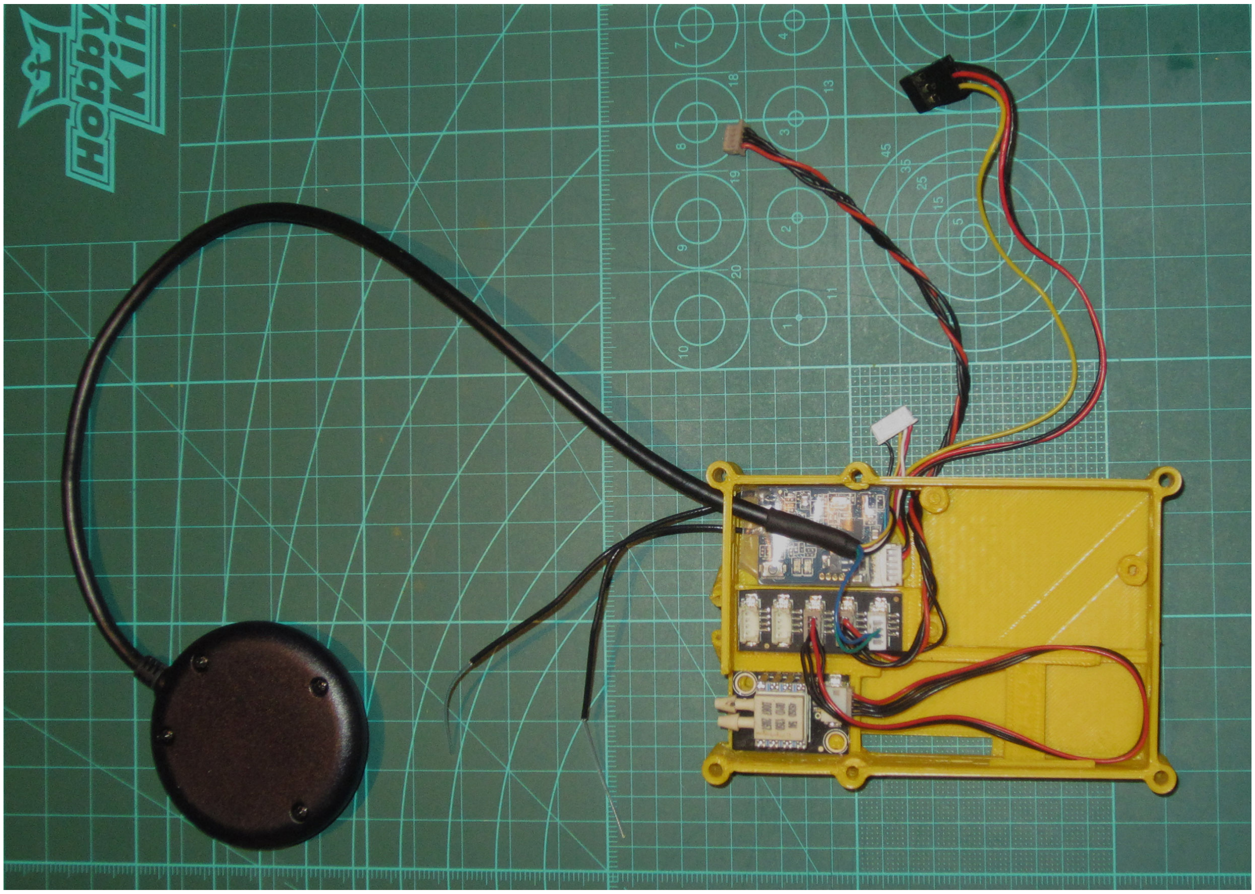


Route the two DF13 Cables as shown through the Centre Plate and place the Centre plate on Pi AE.

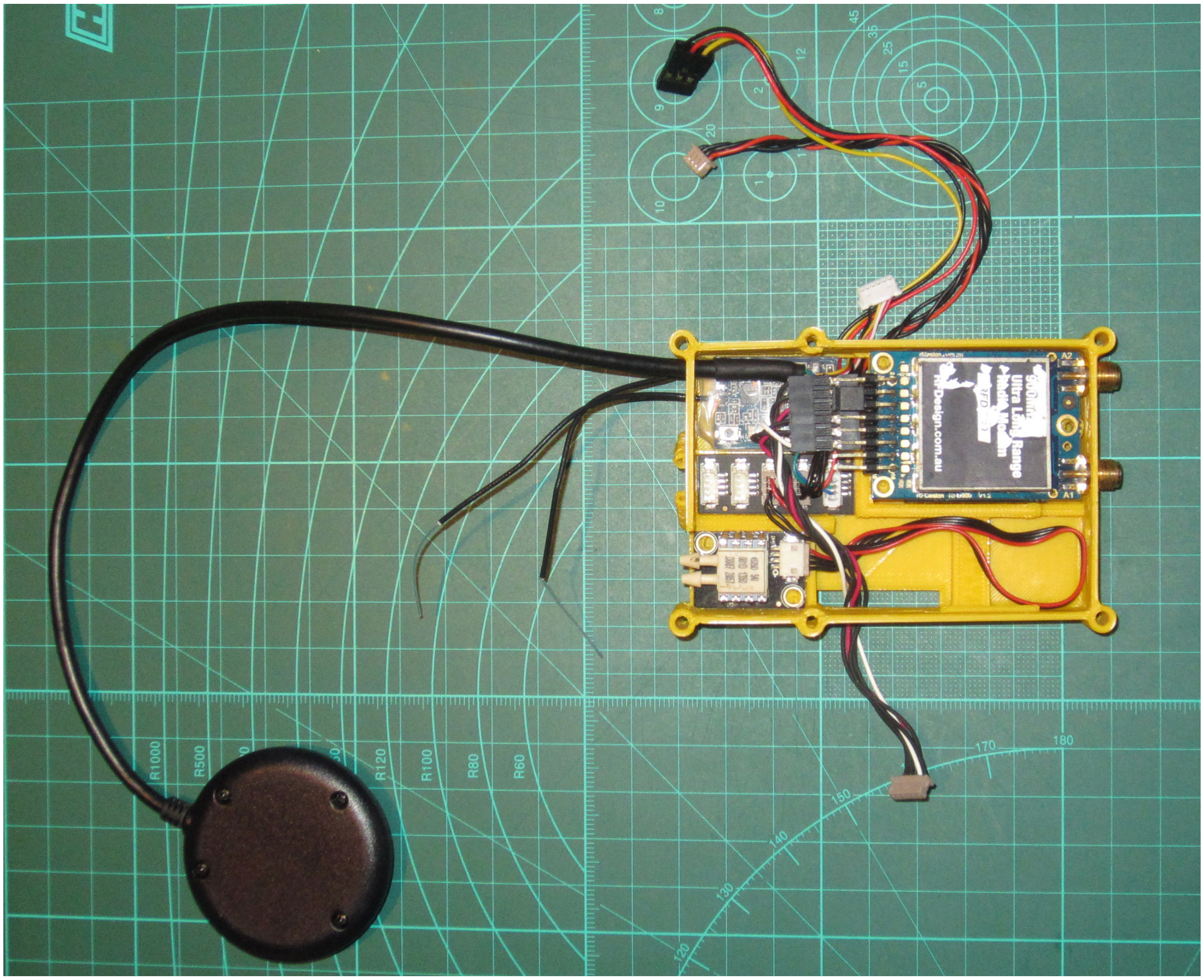
Step 3 - Assembling the Air/RFD Avionics Enclosure



Insert I2C Hub into Air AE, then the Airspeed Sensor and XSR RC receiver (if used) with the binding button facing upwards as shown. Attach and route the two I2C cables, one between the Airspeed and I2C bus, and one I2C cable to the outside of the enclosure via the opening under the XSR receiver. Route the XSR servo connector out through the opening under the XSR.



Next, insert the connectors of the GPS module on an angle through the top left opening of the Air AE, the GPS 4pin Connector plugs into the I2C hub and the 6 pin connector is routed out through the opening underneath the XSR.

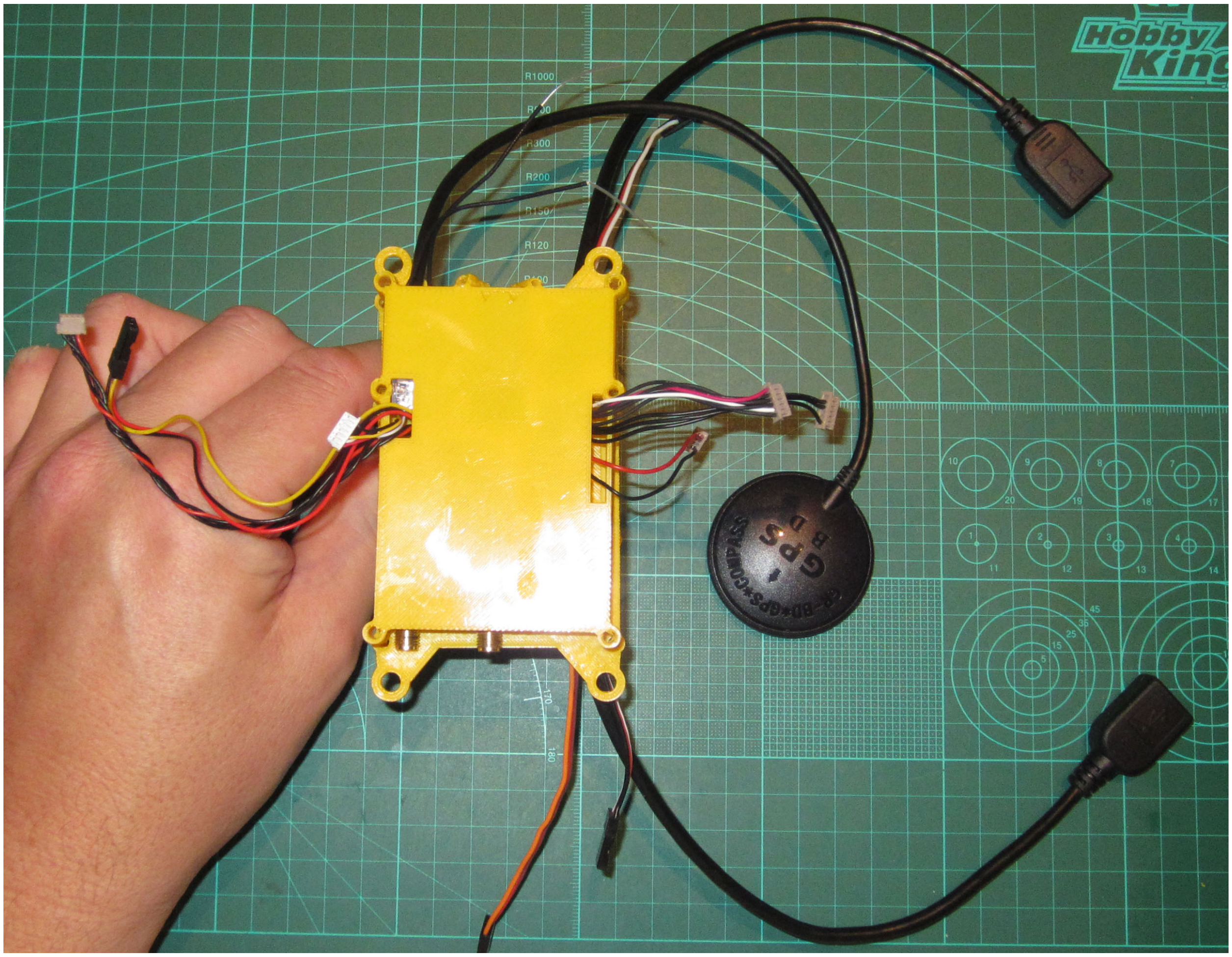


The RFD900 module cable can then be routed through the Airspeed sensor side opening, and can be placed with the antenna plugs through the enclosure and clipped into place. (The extra space in the Air/RFD AE can also be used to connect a secondary 3DR modem if required. For example for 433MHz)

Note: Make sure that various cables are routed correctly, and are not taut, or caught between components.

Step 4 - Assembly of the Enclosure

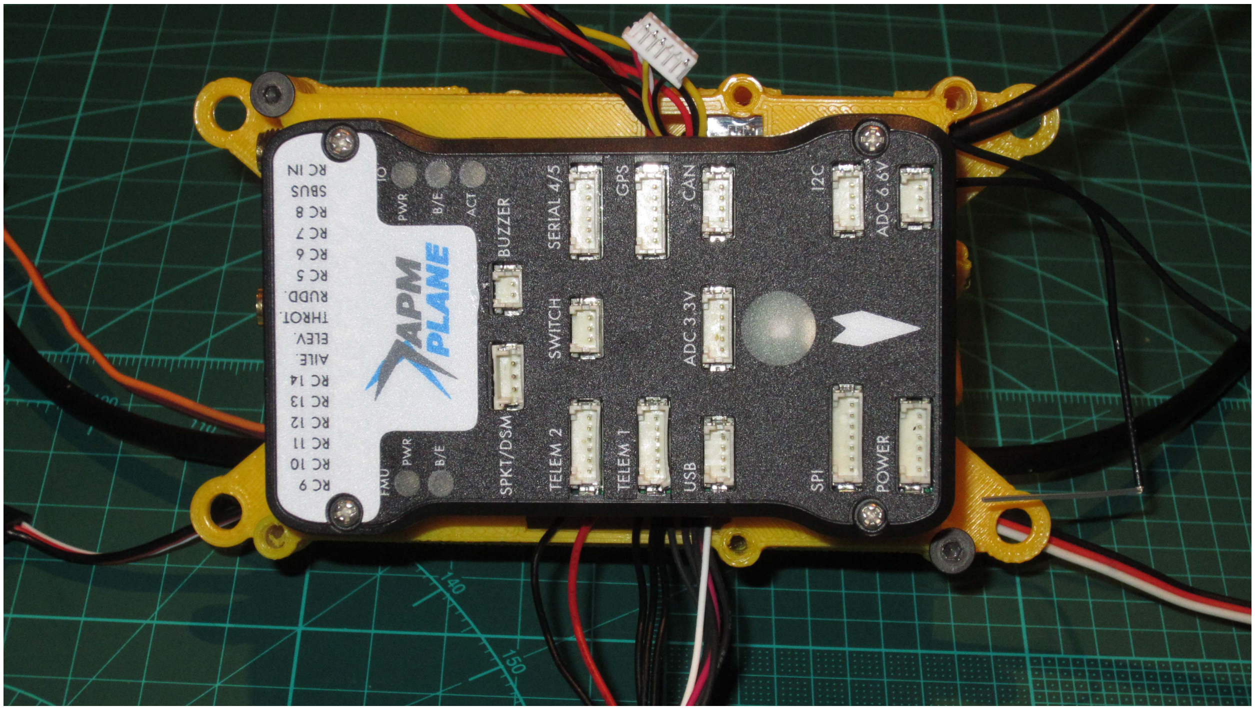
Route the two DF13 cables from the PiAE enclosure through the opening of the Air AE next to the Airspeed Sensor and back to the outside of the enclosure. These will need to be plugged into the Pixhawk later.



Carefully place the Air AE over the Centre Plate, making sure that the cables are clear of the contact areas and are long enough to reach their respective PXH connectors. You can use two screws to hold the enclosure together while you organize the PXH connectors and check cable lengths.

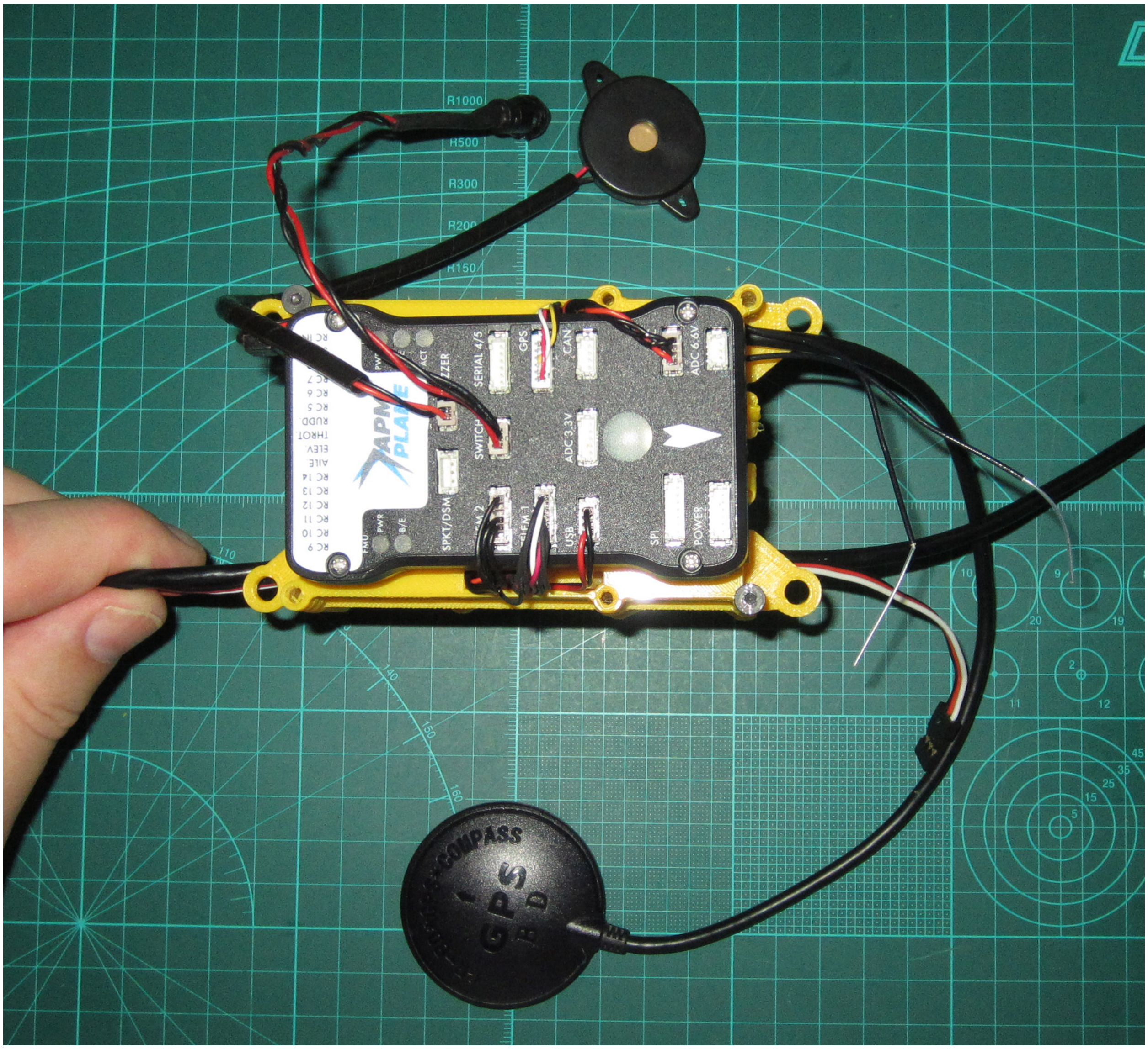
Tip: Some cables might be longer than necessary so, if required, the extra length can be contained in the enclosure to make the cable management neater.

Step 5 - Attaching and Connecting the Pixhawk



The Pixhawk can now be mounted, using double sided foam tape, on the top of the Avionics Enclosure with Servo rail of the Pixhawk facing the same side as the RFD antennas.

Tip: Try to align the PXH straight onto the enclosure before sticking it in place.



The cables can now be connected to the Pixhawk as follows:

On the left side of the Pixhawk:

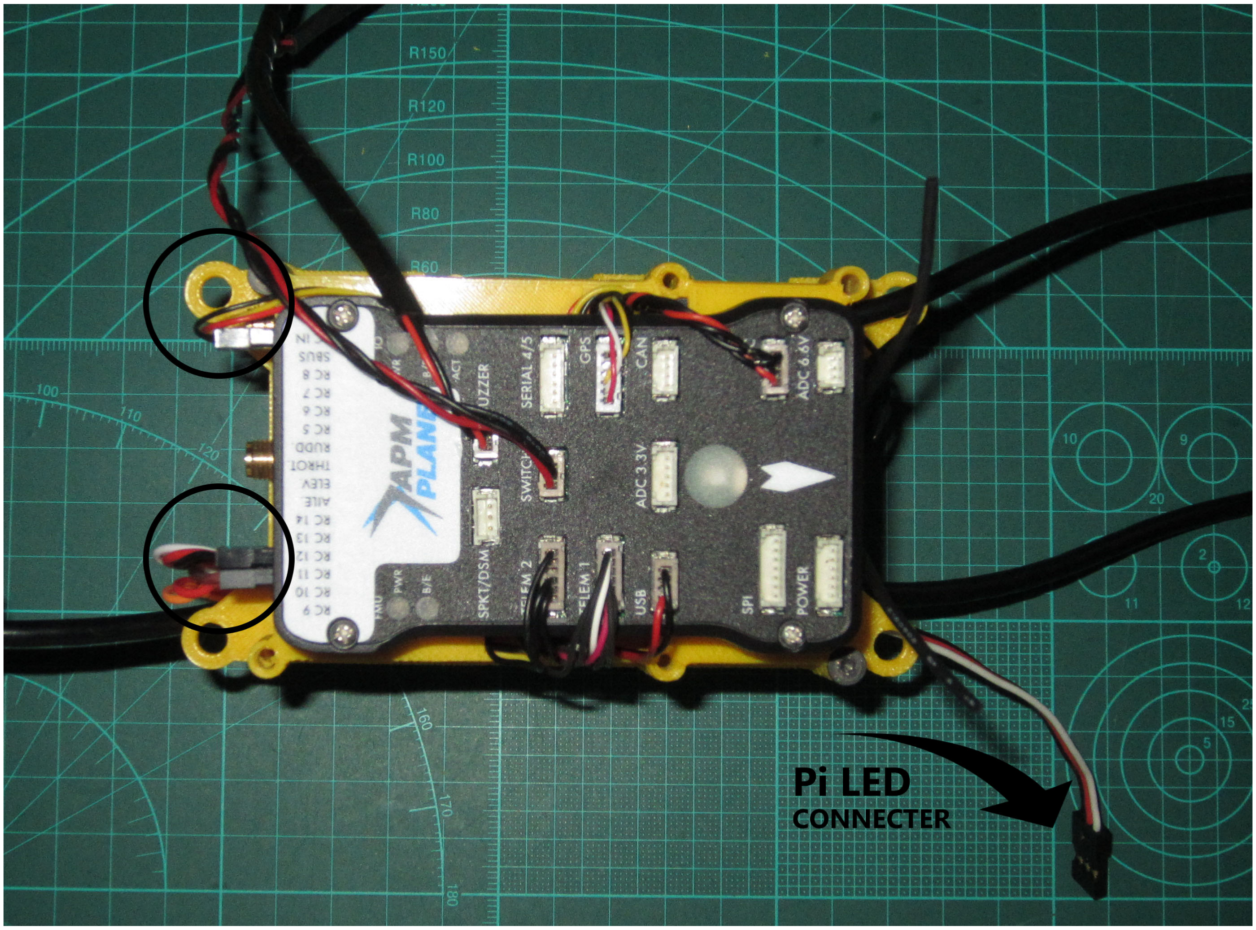
1. RFD cable to Telem 1
2. Pi Serial to Telem 2
3. Power from Pi to USB (This is the third redundant power supply)

On the right side of the Pixhawk:

1. GPS cable to GPS
2. I2C bus cable to I2C

And in the middle:

1. The Switch to the Switch and
2. The speaker/Buzzer to the Buzzer



And then, finally insert:

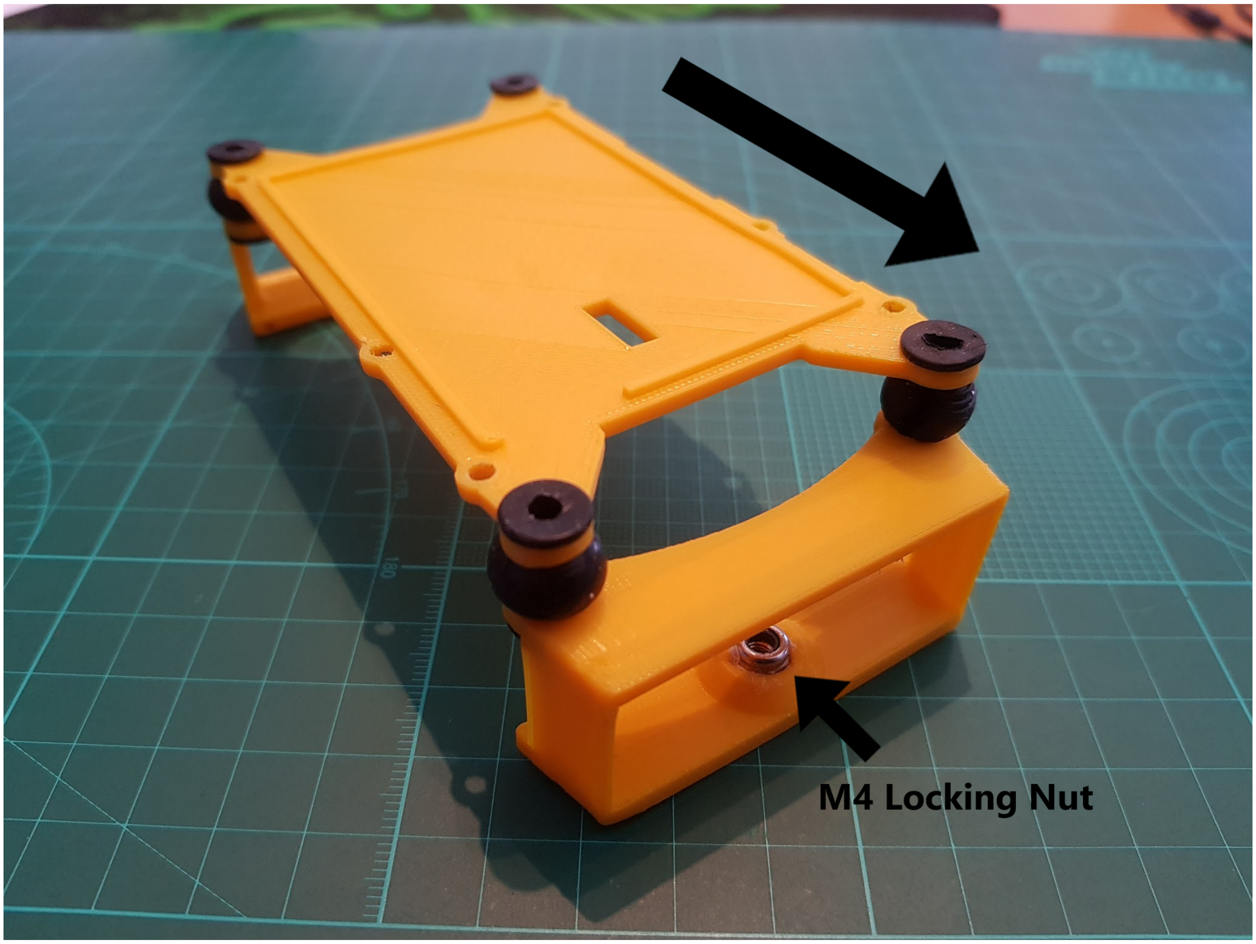
1. the XSR Servo connector into RC IN
2. the Camera Servo Connector into RC 11 (Aux 3)
3. the Pi Reset Relay Servo connector into RC 12 (AUX 4)

The last thing to do is route the XSR Antennas through the top opening and through the Antenna holder tubes. (Heat shrink the antenna cables once attached to the enclosure to strengthen the frail cables against damage)

> **Caution:** The Front Pi LED servo connector that comes from the Pi Zero header should never be inserted into the Pixhawk or any standard servo connector, as it is not compatible and can only be used with the LED strip as specified. Do not use this connector for anything else otherwise the Pi IO might become damaged.

Step 6 - Installing the Avionics into the Fuselage

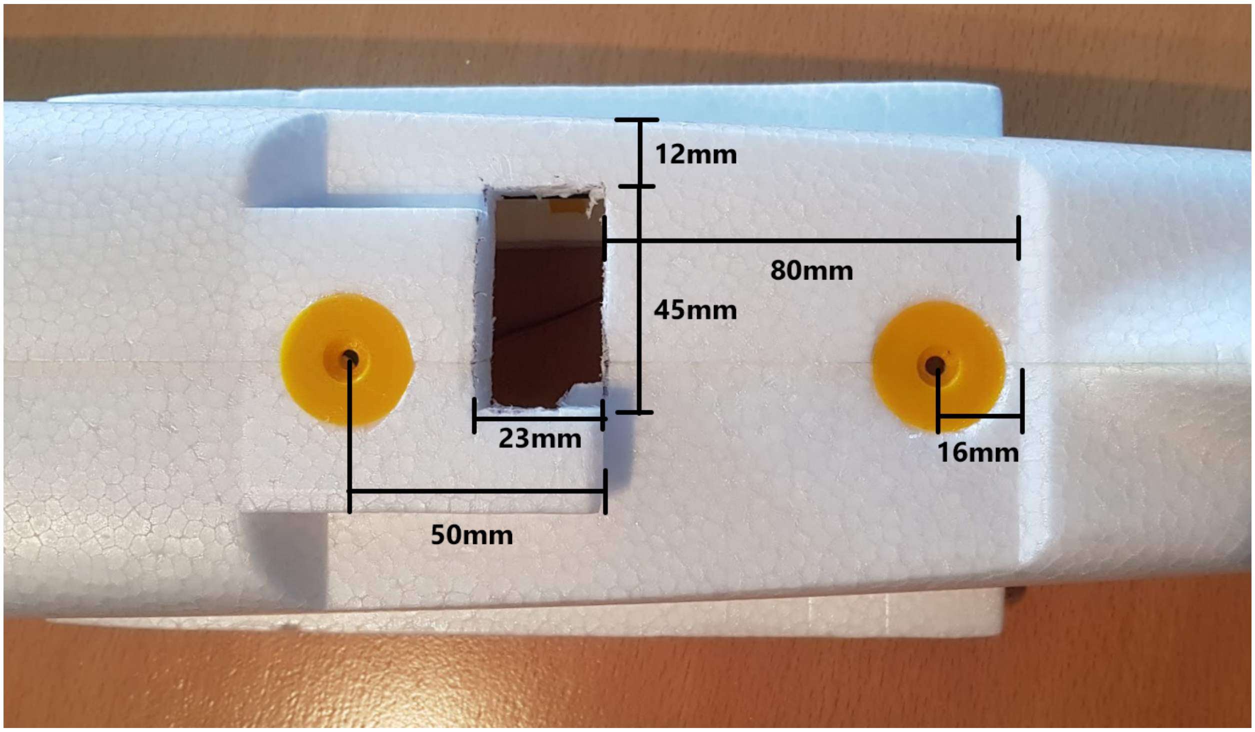
Insert the M4 locking nuts into the recess provided in the 3D printed Front and Rear Mounts. The locking nuts can also be glued in if they are loose in the 3D Print; just keep the nut thread clear of glue. Install the damping balls on the Avionics Enclosure into the four large holes of the 3D printed Base plate. Then insert the other side of the balls into the 3D printed Front and Rear AE mount. The Front mount is higher than the Rear mount.



*Picture for damping ball setup illustration only.

Tip: To mount the rubber balls into the mounts and enclosure centre plate, insert them on one side first then carefully pull the rubber ring through the hole until the rubber is flush all the way around the hole.

Note: The front of the Avionics Enclosure is the direction the arrow should be pointing on the Pixhawk. The RFD antenna SMA connectors are on the rear of the enclosure.



Use the 3D printed AE Screw Washers to mark the a circle where the foam needs to be recessed, according to the dimensions on the photo above, and in the middle of the fuselage foam seam. Use a hobby knife to only recess a cone shape for the washers into the foam so that they fit flush to the outside. Do not cut all the way through the fuselage foam! Then, hot glue the 3D printed Screw Washers in place, making sure they are straight and flush with the underside of the fuselage.

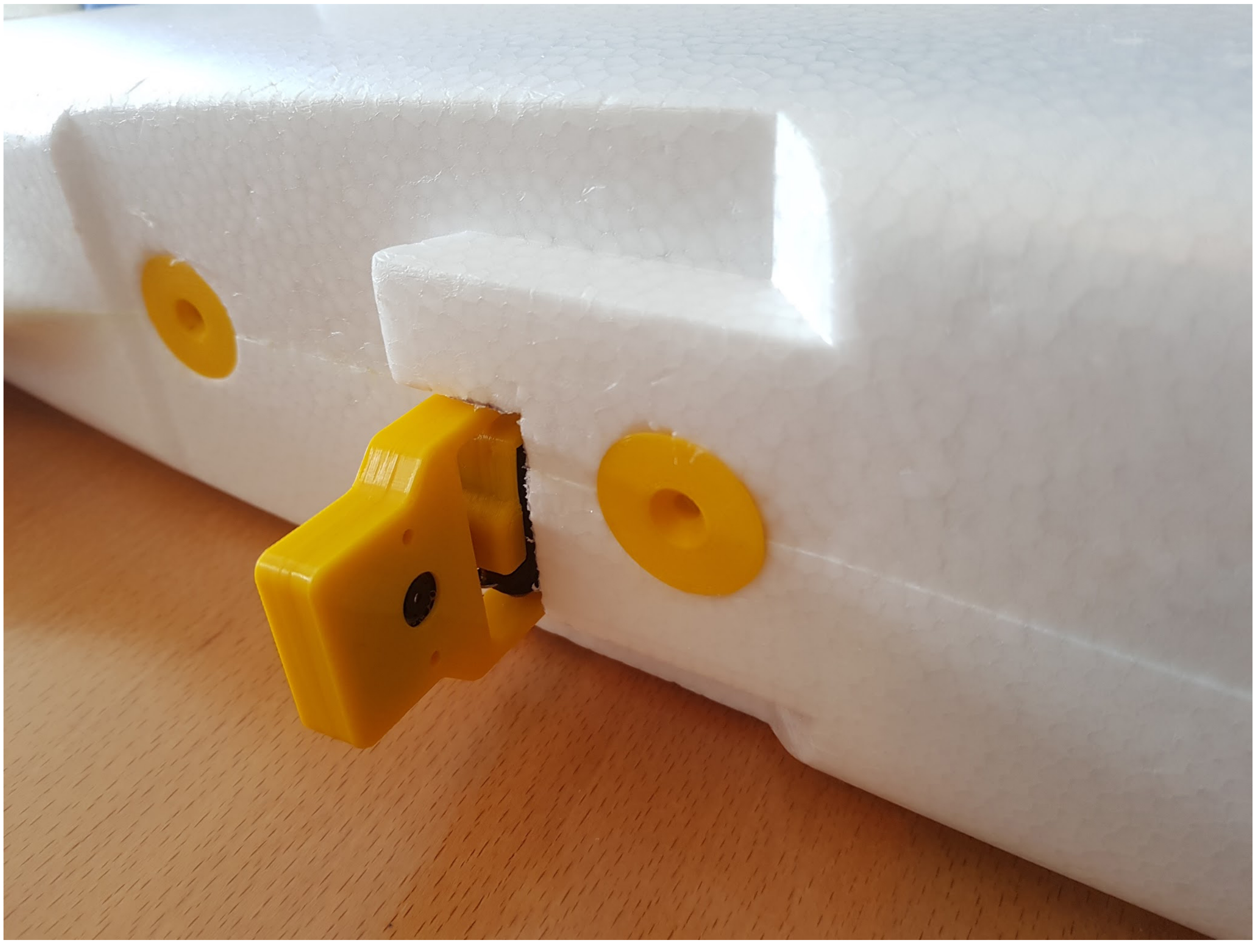
Mark the cutout for the camera gimbal as shown on the photo above. Try to keep the dimensions of the cutout as close as possible and only about 2-3mm larger than the Camera gimbal itself.

Tip: Once the AE is installed, the camera gimbal should be able to freely move inside the foam cutout, so that it is only attached by the enclosures damping ball system and does not touch anywhere else. This should then provide the camera with enough vibration damping in flight.

Carefully position the gimbal so that the camera is facing forwards and inline with the gimbal Servo so that it fits through the foam cutout in the fuselage.

Slowly and carefully insert the Avionics Enclosure into the fuselage, and guide the camera gimbal out through the bottom of the fuselage at the same time. Carefully use the M4 20mm screw to attach the Rear Mount and the 28mm screw to attach the front mount to the fuselage, whilst ensuring the camera gimbal is free to move in the foam cutout, and the Avionics Enclosure is aligned in the fuselage.

Finally, tighten the screws so the mounts cannot rotate and they partially compress the foam.



Pixhawk

The Mozzie platform is currently pre-configured to run on the Ardupilot Pixhawk platform and is heavily reliant on the Arduplane quadplane development. To avoid overlap and the need for updating the Mozzie build documentation pages on each Arduplane release, we have predominately linked to the Arduplane pages for configuring the Pixhawk and have only added our Mozzie specific customizations here.

Any VTOL capable autopilot that can be configured for a quadplane should be able to operate the platform as well and we welcome any such additions.

Note: For ease of configuration, we have a pre-configured parameter file for the Pixhawk that should get the airframe airborne with some basic tuning. The Mozzie parameter file is dependent on a similar propulsion setup and airframe layout, and should always be tuned for each aircraft separately.

Tip: If a custom propulsion setup is used, we recommend that the quad components have a lift to weight ratio of over 1.7 (so 2.5kg MTOW should have around 4.2kg lift).

Ground Control Software GCS

For ease of use and compatibility with the latest Arduplane development we recommend using the Mission Planner GCS that can be downloaded here:

Latest Mission Planner Download

Mission Planner installation instructions for Windows can be found here:

MP Installation

Mission Planner can install the firmware, modify and upload the parameter files and be used for Mission Control. A full list of instructions and features can be found here:

Mission Planner Docs

Pixhawk Firmware

We will endeavor to release a parameter configuration file for each new Arduplane release.

Please follow these Instructions to install the autopilot firmware and select Arduplane 3.7.1 firmware version to install.

The Arduplane 3.7.1 Mozzie parameter configuration file can be downloaded here: Mozzie.param

Once the firmware is successfully installed, and whilst the Pixhawk is still connected via USB, go to the Mission Planner Config/Tuning tab and select the "Full Parameter List" Menu item on the left of the screen. Then use the green "Load from File" button on the right and select the Mozzie.param that was downloaded above and use the Green "Write Params" to write the Mozzie parameters to the Pixhawk.

Tip: Writing the Mozzie parameter file should overwrite all the parameter data on the Pixhawk. Please confirm this by using the Mission Planner compare feature.

Pixhawk Wiring

As described in the Avionics Assembly section, the Pixhawk wiring should be connected as per the following schematic: images/PXH_Wiring_SM.jpg

Tip: Further, more detailed wiring information specifically for the Pixhawk, can be found on the Ardupilot documentation pages here: Pixhawk Wiring

Note: Further information for configuring the Mozzie before flight can be found in the "Flying the Mozzie" section, which includes RC calibration and PXH configuration checks.

RX Setup

Optional FrSky PPM setup to RFD900x for RX connection or FrSky RX in Mozzie Binding with RC and Link to instruction.

Note: There are two ways to use a FrSky receiver in the Mozzie: 1. By connecting it directly to the PPM input of the Pixhawk (instead of the RFD900x PPM output) 2. By connecting it as a PPM input to the RFD900x IO pin 15 (this also means you are only relying on the RFD900x for RC control of the UAV, but you will have RFD900x RC range well beyond line of sight)

Specifications

Dimension:26x19.2x5mm (L x W x H)
Weight: 3.8g
Number of Channels: XSR- 16Ch (1-16ch from SBUS channel, 1-6ch from CPPM Channel)
Operating Voltage Range: 4.0-1OV
Operating Current: 1OOmA@5V
Firmware Upgradeable
Compatibility: FrSky X-series Module & X9D & X9DP & X9E & X12S in D16 mode
(XSR does not work with D-series Module)

Features:

- Smart Port enabled, realizing two-way full duplex transmission
- S-BUS output
- CPPM output

Binding Procedure

Binding is the process of uniquely associating a particular receiver to a transmitter module. An RC transmitter can be bound to multiple receivers (but can't be used simultaneously). A receiver can only be bound to one transmitter module at a time.

The binding procedure is as follows.

1. Turn on the transmitter while holding the F/S button on the module or by selecting bind in the on screen menu (please refer to the module instruction manual for switch positions). Release the button. The RED LED on the Module will flash, or the transmitter will beep, indicating the transmitter is ready to bind to the receiver.
2. Connect battery to the XSR receiver while holding the F/5 button on the receiver. The LED on the receiver will flash, indicating the binding process is completed.
3. Turn off both the transmitter and the receiver.
4. Turn on the transmitter and connect the battery. The GREEN LED on the receiver indicates the receiver is receiving commands from the transmitter and is bound.

If using a Taranis use mode D16 to bind.

XSR Binding Video

Range Check

A pre-flight range check should be done before each flying session. Reflections from nearby metal fences, concrete buildings or trees can cause loss of signal both during range check and during the flight. Follow the steps below to perform the range check.

1. Place the model at least 60cm (two feet) above non-metal contaminated ground (e.g. on a wooden bench).
2. The receiver antennas should be separated in the model and should not touch the ground.
3. The module antenna should be in a vertical position.
4. Turn on the transmitter and the receiver, press the F/5 button on the XJT module for 4 seconds to enter range check mode (or use menu on the Taranis), the RED LED will be off, GREEN LED will flash rapidly. The effective distance will be decreased to 1130 (at least 30m).
5. Walk away from the model while simultaneously operating the controls on the transmitter to confirm all controls operate normally.
6. Press the F/S button on the XJT module for 1-2 seconds to exit range check mode (or disable on Taranis). A steady RED LED indicates normal operation.

Failsafe

Note: For the competition flight it is advisable to turn off the RC failsafes completely and rely on the RFD900x and Pixhawk setup only to deal with RC failures or loss of signal. For flight testing outside of the competition, it is recommended to use the RC failsafe, as it can add an extra layer of protection if it is configured correctly. If failsafe is not set on the Pixhawk and RC, the failsafe default will hold the last position before signal was lost. In this case, there is a risk your model will fly away, crash or cause injury. Setting a geofence is also advisable to avoid fly aways.

Failsafe is a useful feature in which all controls move to a preset position whenever the control signal is lost for a period of time. XSR supports failsafe function for all channels. Follow the steps below to set failsafe positons for each channel:

1. Bind the receiver first and turn on both the transmitter and the receiver.
2. Move the controls to the desired failsafe position for all channels.
3. Briefly Press the F/5 button on the receiver (less than 1second). The Green LED will flash twice, indicating the failsafe position has been set in the receiver.

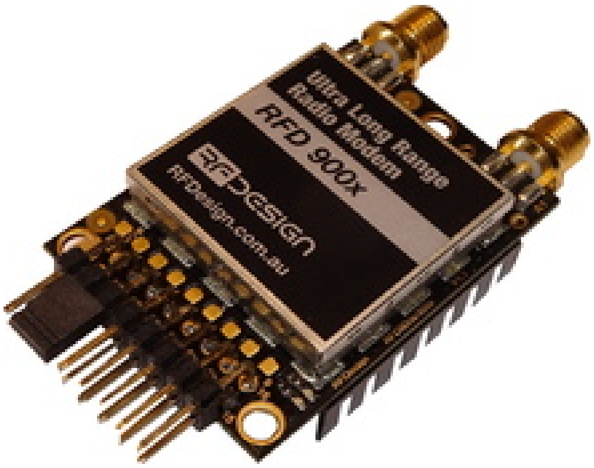
To disable the failsafe function, re-bind the receiver.

Tip: Optionally, you can set the RX failsafe to no pulses when it loses signal to the transmitter: Turn off the transmitter, power on the receiver and then briefly press the F/S button on the receiver.

FrSky Telemetry

There's also an option to add Telemetry from the Pixhawk to the Taranis LCD screen using the FrSky Receiver. This works if you connect the RC receiver to the RFD900x or directly to the Pixhawk if you follow these instructions: FrSky Telemetry

RFD900x Setup



These instructions should be read in addition to the RFD900x Manual that can be found here: RFD900x Manual

PtP software Manual can be found here: Software Manual PtP

All radio frequency components used for the Mozzie are sensitive to RF interference, from both internal and external sources. Although the setup described here has been used and tested to the ranges required for the competition this does not guarantee their performance at the event. We recommend that you investigate and carefully consider ways to improve the performance of you communication links as best as possible, for example by using:

- Higher gain antennas, like an Omni, Yagi or dish
- A mast to get the base radios high above ground
- Dedicated low noise power supplies
- Minimizing ground RF noise and interference by other equipment
- Testing all cabling, including USB/LAN extension cables in a challenge type full system setup

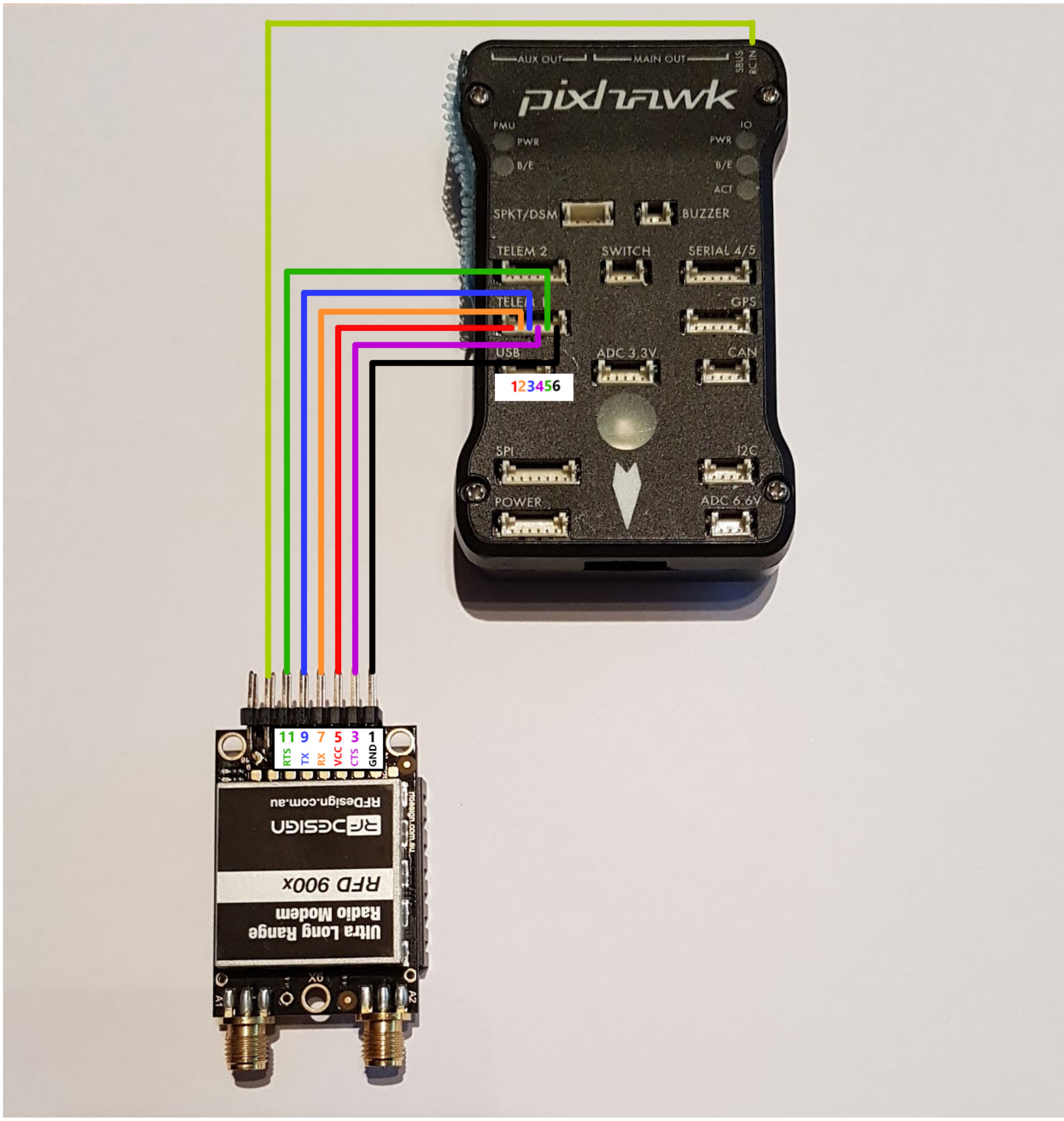
Warning: These modems are high-power RF devices and it is recommended to power these devices from a separate power supply and not directly from the Flight Controller or USB.

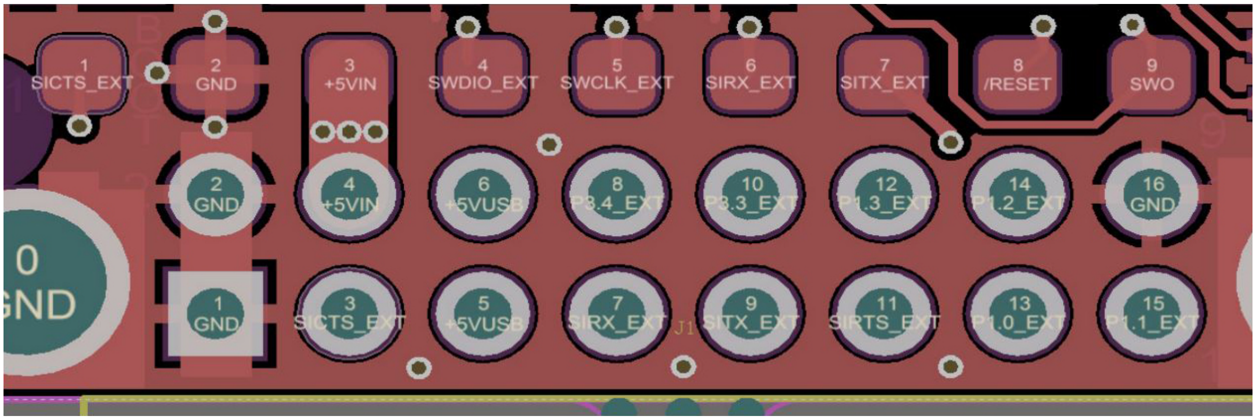
Note: As described previously in the RC Setup page, there are two ways to connect the RC to the Mozzie for manual control. Please refer to these for more details.

Connecting the RFD900 to the Pixhawk

The easiest way to connect the RFD900x to the Pixhawk is using a pre-assembled Pixhawk to RFD900 cable from RFDesign.

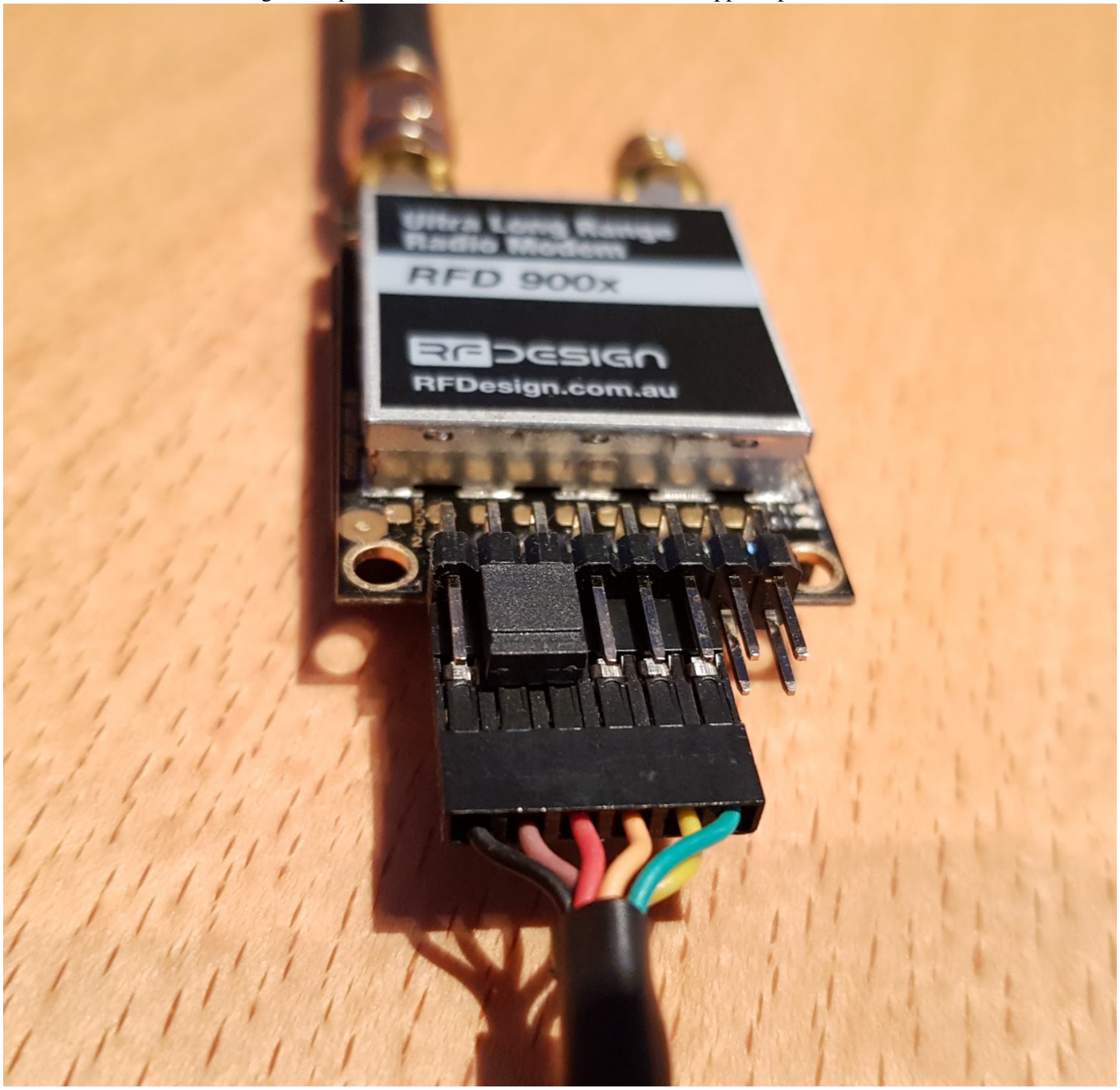
Tip: This cable will typically not include the RFD PPM output from Pin 15 of the RFD900x and this will need to be added if using the RFD900x PPM for RC control. Please see the RFD900x Manual link above for more details.


AUX OUT
MAIN OUT
SBUS
RC IN
pixhawk
FMU
PWR
B/E
IO
PWR
B/E
ACT
SPKT/DSM
BUZZER
TELEM 2
SWITCH
SERIAL 4/5
GPS
USB
ADC 3.3V
CAN
123456
SPI
I2C
POWER
ADC 6.6V
11 9 7 5 3 1
RTS TX RX VCC CTS GND
RFDesign.com.au
RFDESIGN
RFD 900x
Radio Modem
Ultra Long Range
A1
X6
A2


1
SICTS_EXT
2
GND
3
+5VIN
4
SWDIO_EXT
5
SWCLK_EXT
6
SIRX_EXT
7
SITX_EXT
8
/RESET
9
SWO
2
GND
4
+5VIN
6
+5VUSB
8
P3.4_EXT
10
P3.3_EXT
12
P1.3_EXT
14
P1.2_EXT
16
GND
1
GND
3
SICTS_EXT
5
+5VUSB
7
SIRX_EXT
9
SITX_EXT
11
SIRTS_EXT
13
P1.0_EXT
15
P1.1_EXT
J1

Connecting the RFD900 to Computer

Connect the RFD900x to a PC USB using a compatible USB to FDTI cable that also supplies power to the radio as shown below:



Plug in the USB side of the cable into a compatible USB port that can supply enough power to the RFD900x.

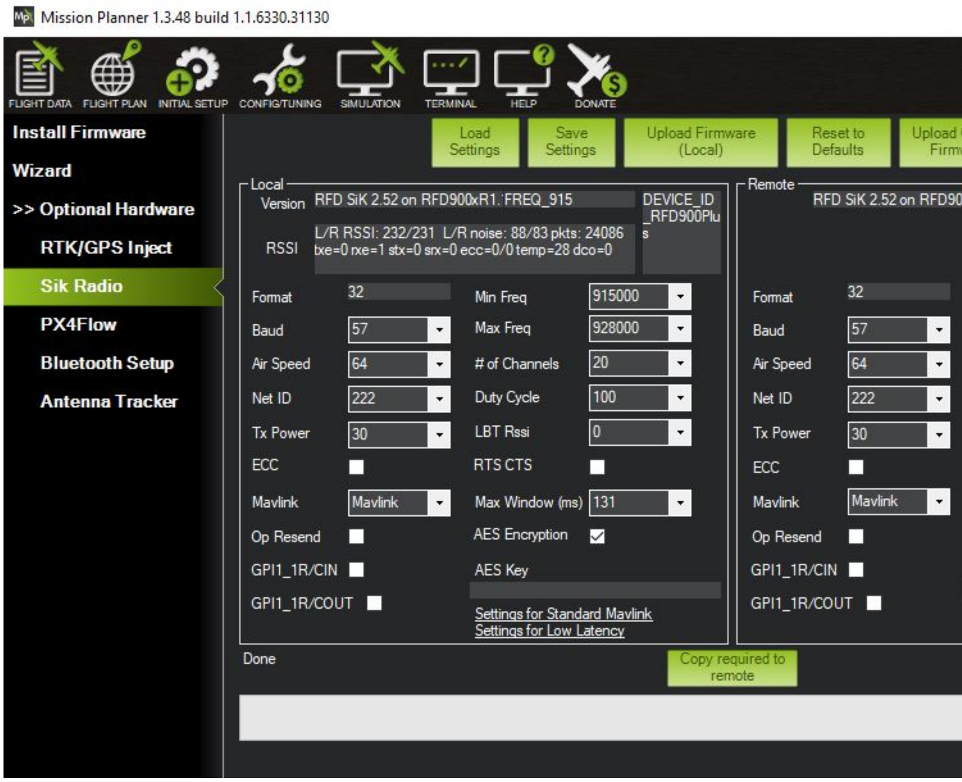
Tip: It is advisable to use an antenna whenever the RFD900 is powered and to connect the RFD900 to an external power source to avoid power brownouts, because not all USB ports can deliver sufficient power to the RFD900.

Radio Configuration using Mission Planner

The GCS software Mission Planner includes a tool to configure Sik firmware based radios like the RFD900x.

Please follow the Mission Planner configuration instructions to setup the RFD900 radios <http://ardupilot.org/copter/docs/common-configuring-a-telemetry-radio-using-mission-planner.html#

common-configuring-a-telemetry-radio-using-mission-planner>‘_

As a guide, the settings we use are as follows: 

> **Warning:** The air and ground radio setups need to match the types of antenna used and not exceed the EIRP limits of the country you are operating in. It is solely the user’s responsibility to ensure the settings comply with their country’s regulations and with the competition rules. More country settings can be found here. <http://ardupilot.org/copter/docs/common-telemetry-radio-regional-regulations.html#common-telemetry-radio-regional-regulations>‘_

CHAPTER 7

Propulsion

The Mozzie propulsion system and component selection is a result of significant testing and optimization. The configuration as per the parts list will allow the Mozzie to operate as per the specification; however, motor and propulsion setups will likely improve over time.

The most important items to check when operating the propulsion system, or configuring a new system, are:

- Make sure the ESC and motors are operating within the specified ranges, for Voltage, Current load and temperature
- The biggest killer of motors and ESCs is over dimensioning the propellers beyond the capacity of the motors
- Make sure the ESC settings meet the motor manufacture recommendations
- ONLY connect the Power Module with current sensing between the power loom and forward motor ESC connectors

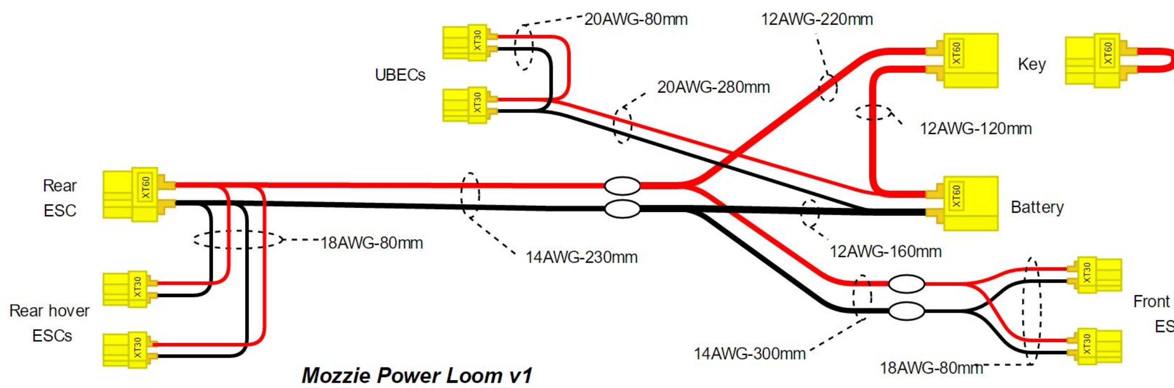
These setup and configuration pages are only for the recommended setup as per the parts list. Please consult the component manufacturer's manuals before operation.

Power Loom

To construct the power loom, you will require the following components:

- 2x Male and 2x Female XT60 connectors
- 6x Male XT30
- 20AWG cable cut to 1 set Black+Red 80mm long and 1 set of Black+Red 280mm long
- 18AWG cable cut to 3 sets of Black+Red cables 80mm long
- 14AWG cable cut to 1 set of Black+Red cables 530mm long
- 12AWG cable cut to 1 Black cable 160mm long, 1x Red cable 120mm long, and 1x Red 220mm long and 1x 30mm long for the key

Note: The power loom has been designed to minimize the use of XT60 connectors and reduce the wiring required to a minimum. It also allows for easy replacement of the various ESC, UBEC components and to allow for diagnostic capability. When removed, the XT60 key is designed to only disable the propulsion system; however, the UBEC and avionics will remain powered on. Remove the battery from the power loom to disable the whole system.



Start the power loom by first soldering all the XT30 connectors onto their respective cables as per the diagram above.

Tip: Before soldering a wire to a connector, strip just enough insulation from the cable to fit the connector you are using. Make sure to use heatshrink to protect the back of the connectors and solder joints, and remember to place the heatshrink over the cable before soldering.

Then, mark the length of the main 14AWG cable at 230mm from the rear ESC XT60 and carefully use the hobby knife to remove about 20mm of silicone insulation from that location, without cutting or damaging the copper wire itself. Then strip about 20mm of insulation from the end of the correct 12AWG cables and carefully wrap the wire around the gap in insulation on the 14AWG cable, solder in place and heatshrink. Do this for the red and black cables.

Then add heatshrink to the cables and proceed with soldering the XT60 connectors on their respective cable ends, ensuring that the polarities of the connectors and cable colors match the diagram.

Finally, attach the main 14AWG cable along the bottom right side of the fuselage with cable clips making sure the front and rear XT30 and XT60 connectors reach their respective ESC connectors. Make sure the front ESC XT30 plugs are facing forwards (that's the two long cables that are directly connected to the middle of the loom and fork at the XT30's at the other end) and the XT60 for the forward motor is in the rear of the fuselage. Connect the Pixhawk Power Module and Current sensor between the Rear power loom XT60 and the Forward Motor ESC XT60 in the rear of the fuselage.

Danger: When working on the airframe, always remove the key from the airframe to disable the propulsion and make it safe! All the propellers present significant laceration risk, which can require stitches, hospital care and even surgery. Never work on the airframe with a battery connected, without all the propellers and/or the key removed!

Warning: Do not connect a 3DR power module (with current sensing shunt) between the battery and the battery connector on the power loom! Most power modules are only rated for 90A and do not support the power capacity required to fly the Mozzie, which can be in excess of 150A in transition! To avoid any brownouts and in flight failures that will result in a crash, simply connect the power module between the rear ESC XT60 and the forward motor ESC. This is the only place current monitoring is really required as most of flight will use the forward motor only. Battery voltage will still be indicated by the power module.

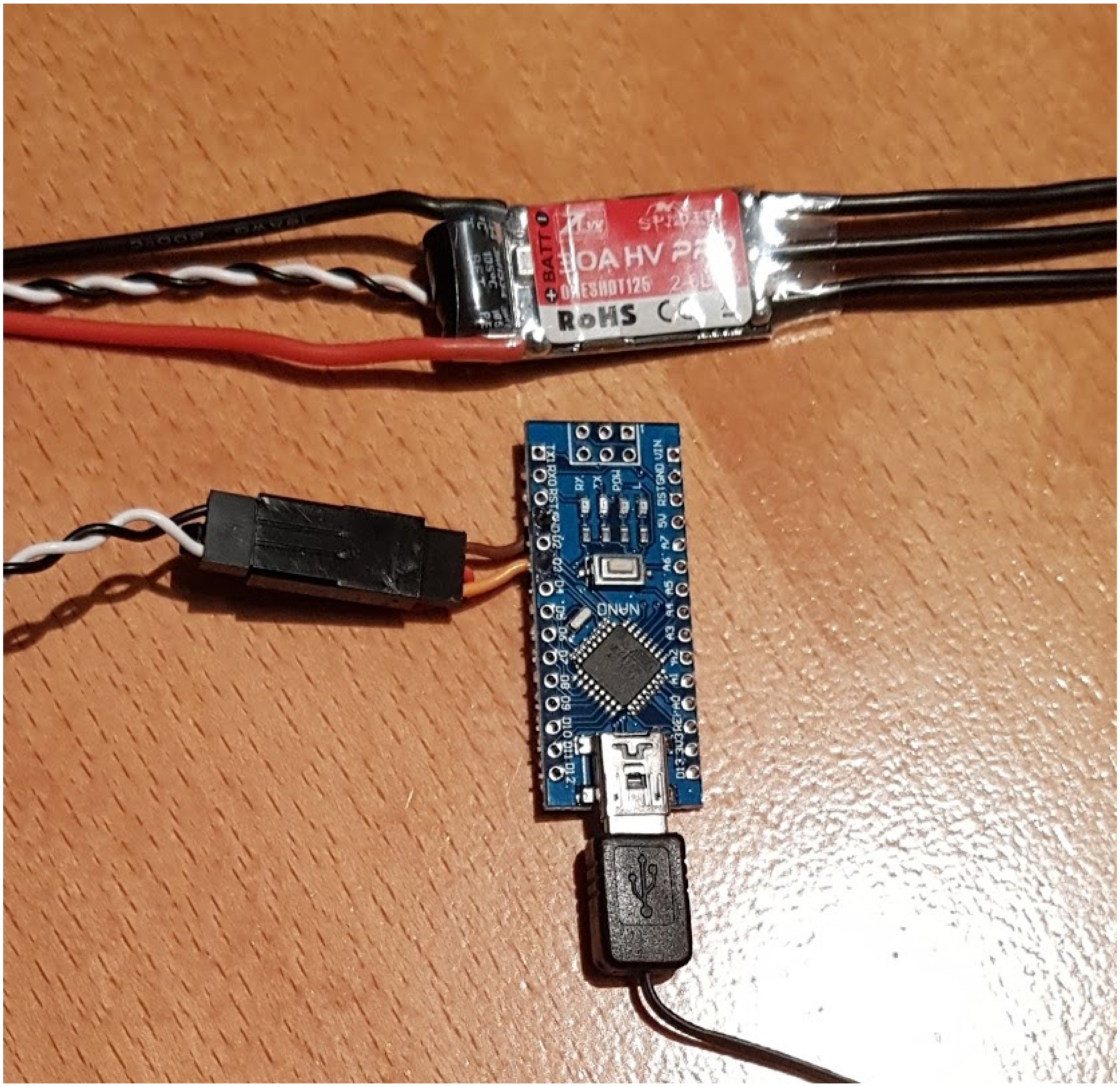
ESC Setup

It is important to configure the ESCs for all the motors correctly prior to operating the Mozzie. The critical settings are motor rotation direction and throttle calibration.

For the quad ESCs, we set the internal PWM/PPM Throttle Minimum and Maximum using the BLHeli configuration tool, which, in most cases, means an ESC throttle calibration for the quad ESCs is not required.

Quad ESC setup

Note: These instructions and parameters are specifically for the setup of the ZTW Spider Pro 30A HV ESCs, using an Arduino Nano 328 board that can be flashed with the BLHeli bootloader. If using different ESCs, please check the manufacturer's recommended settings for the specific motor and ESC used.



To set up the ZTW ESC, download the latest version of BLHeli Suite, then run BLHeliSuite.exe from the extracted folder you downloaded.

In the “Select ATMEL/ SILABS Interface tab”, choose the SiLabs BLHeli Bootloader (USB/COM) hardware option to use the Arduino Nano BLHeli Programmer.

Connect the Arduino Nano to the servo plug of the ESC, making sure the polarity is correct.

Then, select the Com port to which the Arduino programmer is connected and the correct Baud (19600) for the Arduino and click “Connect”. Use the “Read Setup” button to read the current ESC setup parameters, which should populate the settings values on BLHeli Suite.

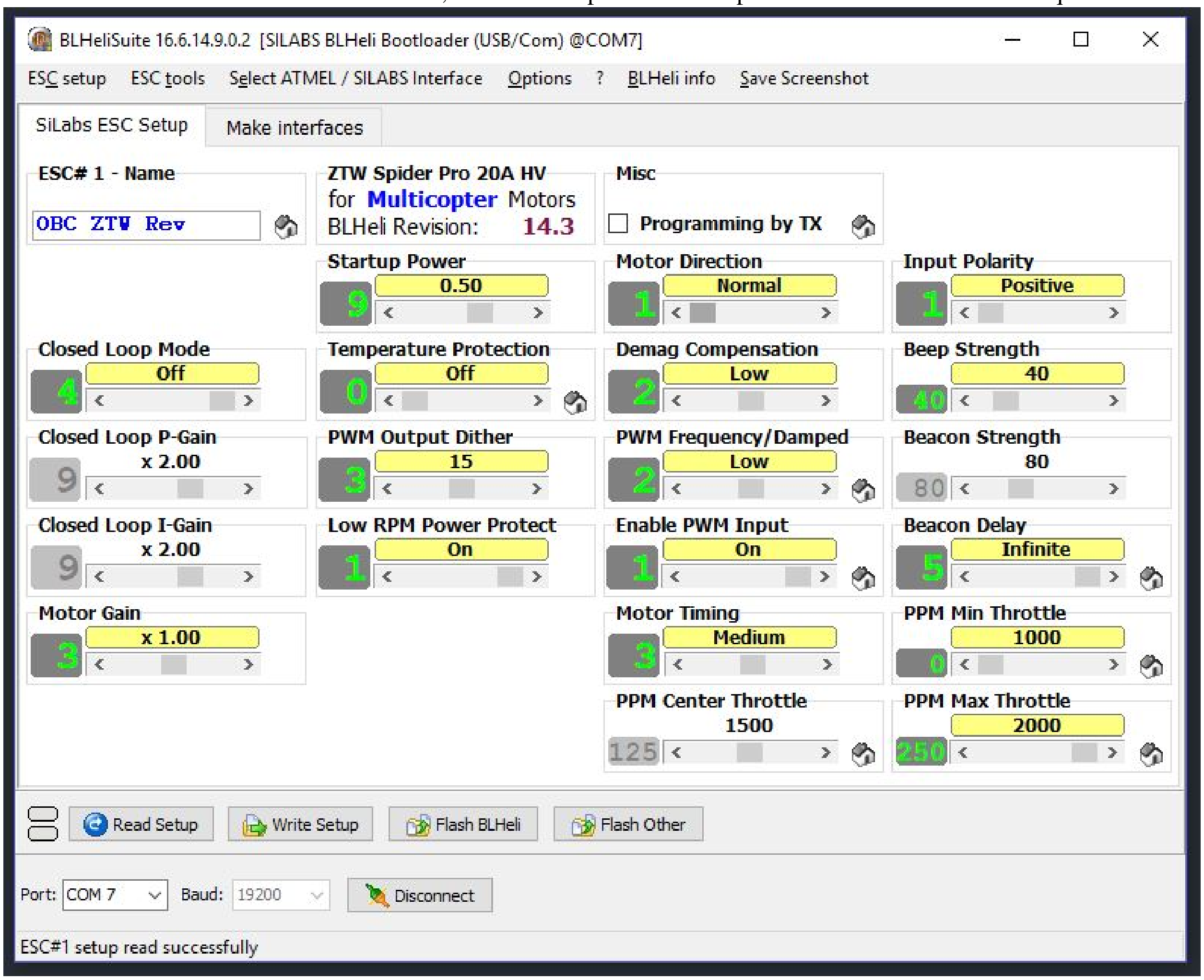
Download the BLHeli_OBC Mozzie FWD and BLHeli_OBC Mozzie REV parameter files to a folder on your PC using a right click and “save link as”.

Then, under the ESC Setup menu item, select “Read Setup from ini file” and choose the correct ini file for the motor ESC you are programming.

Note: Both ini files are identical; the only difference is the motor rotation direction, which can also be changed in BLHeli directly.

Once you are certain the settings are correct use the "Write Setup" button to write the parameters to the ESC.

Finally, read the parameters back to confirm they were written correctly and then disconnect the ESC servo wire, and repeat the process for all the quad ESCs.



Forward Propulsion

Components required:

- XT60 Male Two pole connector
- MT60 Three pole connector (Male + Female)
- ESC 40A ZTW
- Cobra Motor
- Motor Bracket

- Motor Mount Screws

images/FWDParts_SM.jpg

Soldering

First cut the three motor cables to about 250mm long, then remove about 4mm of cable insulation from each cable, tin the cable and three pole Male MT60 connector. Slip the connector cover over the cables so that the clip tabs line up with the connector properly then solder the cables onto the male connector. Remove about 4mm of insulation from the three black ESC cables, slip over the connector cover the right way, then tin the wire and female connector, and solder together. Remove 4mm of insulation from the black and red ESC wires, tin both cables and two pole male XT 60 and solder together. images/FWDMotorSolder_SM.jpg

Tip: It's also possible to permanently solder the ESC and motor cables together and heat shrink the connection. To replace the motor or ESC it will have to be resoldered. When soldering larger connectors or wires it's sometimes necessary to increase the soldering iron temperature to get the solder to flow properly.

Assembly

Attach the provided metal motor bracket to the motor using the screws provided with thread lock. Place the forward motor XT60 connector and ESC through the rear 3D printed motor mount center. images/FWDMotorCable_SM.jpg Carefully pull the ESC back towards the center of the airframe and guide the cable and motor until it is seated against the motor mount. Be careful not to damage or bend the motor cables and make sure the MT 60 connectors are still fully connected inside the fuselage. images/FWDMotorMount_SM.jpg Rotate the motor so the cables go through the recess in the 3D print and then attach the motor to the 3D motor mount using 12mm self tapping screws, whilst making sure the motor cables are not pinched or damaged. images/MountESC_SM.jpg Orientate the ESC and attach to fuselage using some Velcro, cable clips or use the optional ESC Air scoop if required (which needs to be cut out of the foam in the right position, so the ESC can be placed in it) images/MountLoom_SM.jpg Use self adhesive cable clips, cable ties and cable wrap to attach the cables in the correct position directly against the side of the fuselage, in such a way that the cables are not taught, caught or damaged. images/MountUBEC_SM.jpg Attach the two UBECs into the two nooks in the side of the fuselage with Velcro, as shown.

Tip:

Using Velcro for installing components means that:

- They can easily be attached and removed as required
- The components can come apart should the aircraft crash, typically resulting in less damage
- The components have some vibration isolation

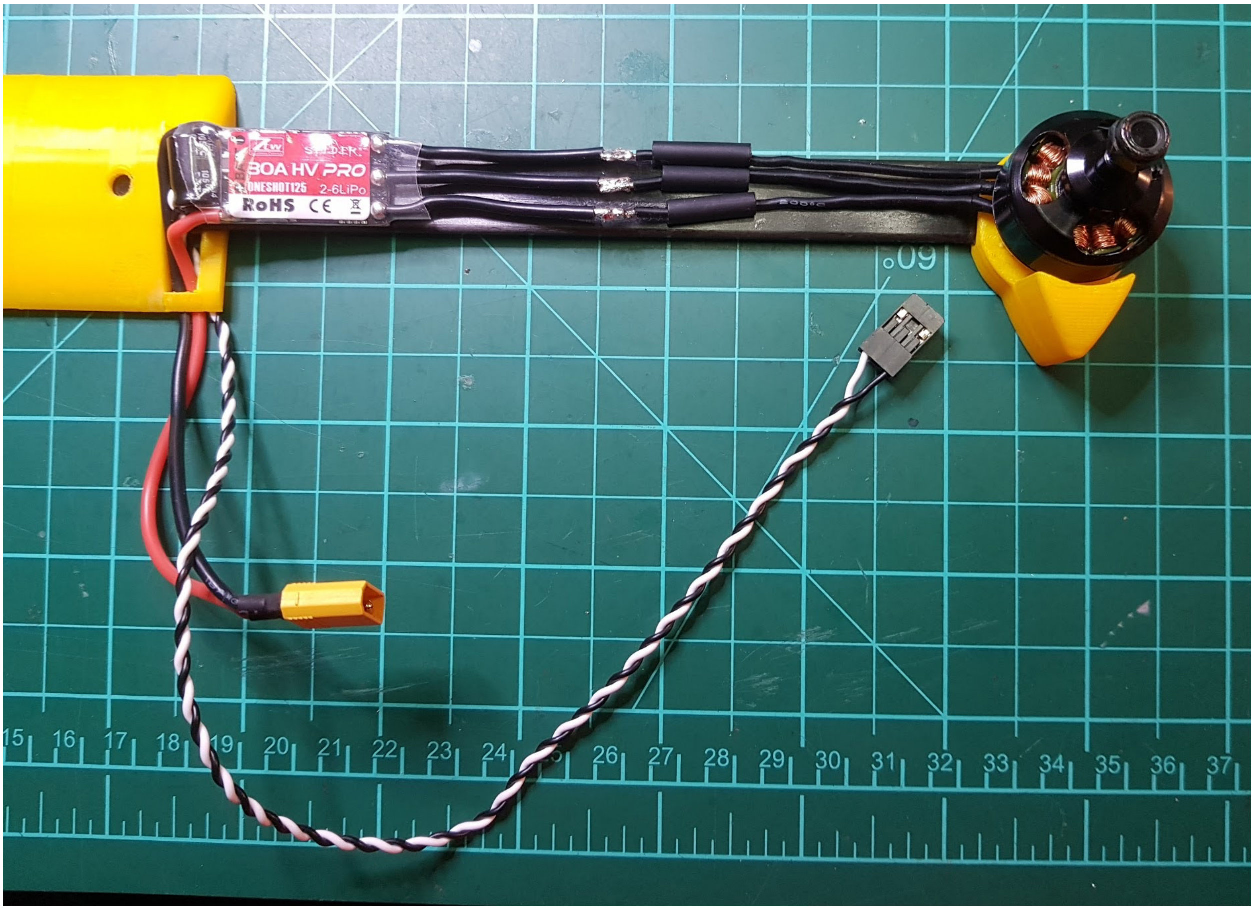
Quad Arms

Parts Required

- CF Bar 15x3mm
- CF Motor Mount Left
- CF Motor Mount Right
- CF Middle Left
- CF Middle Right
- CF Undermount
- 2x 25mm and 2X 40mm M4 screws and 4x M4 locking nuts

Note: You will require two complete quad arms for the Mozzie. The front and rear quad arms are mechanically identical; however, the ESC motor direction setting needs to match the diagram in the System Check section.

Step 1 - Soldering the Motor and ESC



Because of the compact lightweight design of the quad arms some care must be taken with their construction and assembly. Their disassembly only requires the removal of the heatshrink and the motor screws.

An important step is to ensure that the length of the three cables between the ESC and the Motor is accurate. Making it too short will mean the ESC will be mounted too far out on the quad arm, and making it too long will mean that the cables won't fit under the heatshrink neatly.

Tip: If preferred, one can assemble the quad arm parts first, using steps 2 and 3 below, to use the quad arms as a template to find the correct cable lengths between the ESC and motor.

Solder a male XT30 plug to the red and black cables of the ESC ensuring the correct connector polarity. (Red + / Black -) Don't forget to place the heatshrink on the cable first.

Then, cut the three black cables from the ESC 45mm long and the three black cables from the motor to 70mm long. Make sure the total length of cable between the ESC and motor (about 105mm when soldered) is long enough when mounted to the arm. Remove about 5mm of insulation from each cable so that these sections overlap. Then slide a piece of heatshrink over each cable and solder the ESC cables to the respective motor cable so that the cables do not cross each other. This ensures the cables are flat on the bar when they are heatshrinked onto the CF bar when completed. (The motor direction will be determined by the ESC setting later)

Use the hot air gun to carefully heatshrink each solder joint.

Caution: The hot air gun can be very hot, be careful not to hold in one place for very long and gradually go along the length of the heatshrink until it becomes taught around the cables or connector. Avoid heating the ESC and motors directly for prolonged periods. Keep hands and flammable items well clear! (including the aircraft foam parts!!)

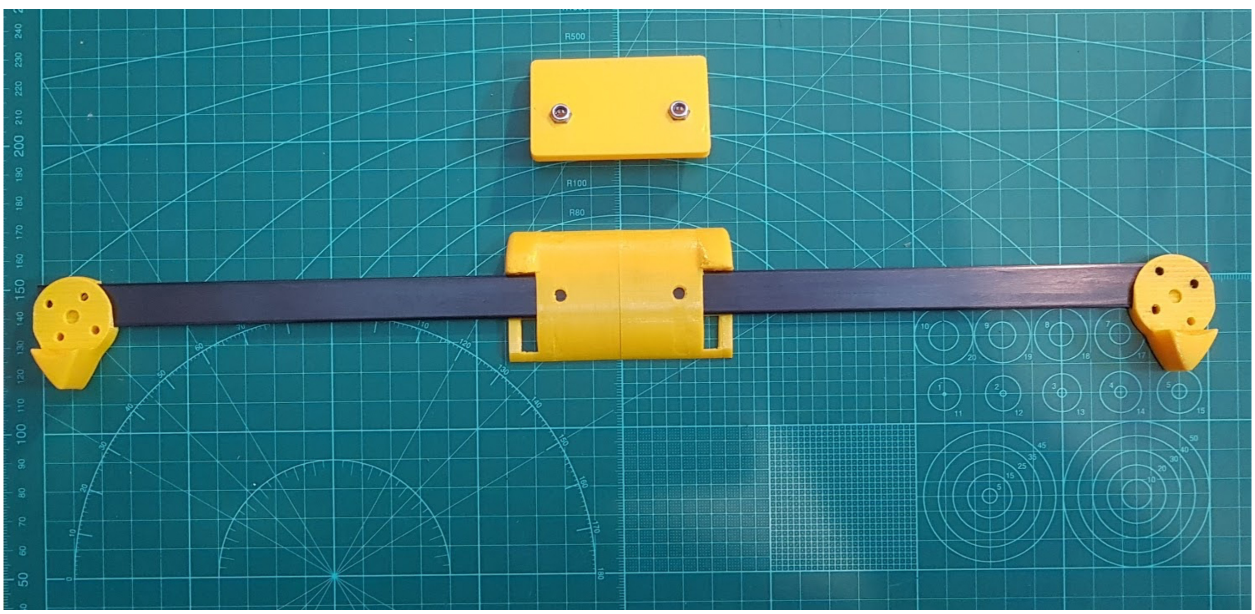
Step 2 - Mounting the 3D Printed parts

Caution: Carbon Fiber dust and particles can be potentially harmful. Do not inhale and use protective gloves in a well ventilated area to cut and work on the CF Bar. The CF bar can also be carefully cut outside with an angle grinder using a metal cutting blade.

Note: Not all 3D parts come off the printer in perfect condition. Before assembling any 3D printed parts, or glueing any 3D printed parts, ensure that the parts all fit together by carefully removing any excess plastic from the print and seeing if they dry fit together first!

Use a fine tooth metal saw to carefully cut the CF Bar into two 400mm long pieces. Try to cut the CF cleanly all the way through using the saw so it does not splinter, then carefully file the cut edges smooth to allow for an easier fit. Mark the middle of each CF bar and test that the 3D printed parts fit onto the CF bar correctly with tight tolerances. Use the middle mark to align the middle pieces symmetrically and use the end of the CF bar to position the motor mount pieces.

Tip: Make sure the pieces all have the correct orientation and that the 3D printed Motor Mounts are on the correct side of the CF bar. The 3D print screw hole layout on the motor mount is determined by where the cables exit the motor so that they can run along the CF bar to the fuselage. Normally, only two holes need to be drilled into the CF bar.



Then remove the 3D motor mounts and dry test fit the quad motors onto them to make sure they still fit.

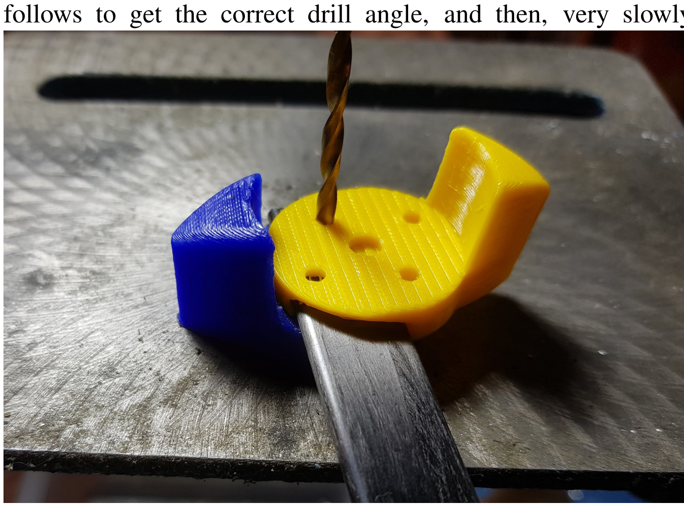
Warning: Before screwing the motors onto the mounts, make sure that the screws used to attach the motor mounts and CF Bar are the correct length! Screws that are too long will damage the motor windings! Screws that are too short will not hold the motors for prolonged use. Please use screws that just make it through the motor's lower aluminium plate (ideally by about 0.5-1mm). It's advisable to use washers underneath the screw heads to distribute the forces and adjust the length as required.

Step 3 - Drilling the Motor Mount

The 3D printed motor mounts are intentionally angled forwards at 7 degrees so that the Mozzie wing has a pitch up angle of attack for better lift generation in hover. To make sure the motor is mounted correctly, it is necessary to drill the screw holes through the CF bar on an angle. The hole angle should be 90 degrees to the top surface of the 3D motor mount.

Tip: Try not to use too much force when the drill is nearly through the CF to avoid it splintering. Use the left over piece of CF bar to practice drilling.

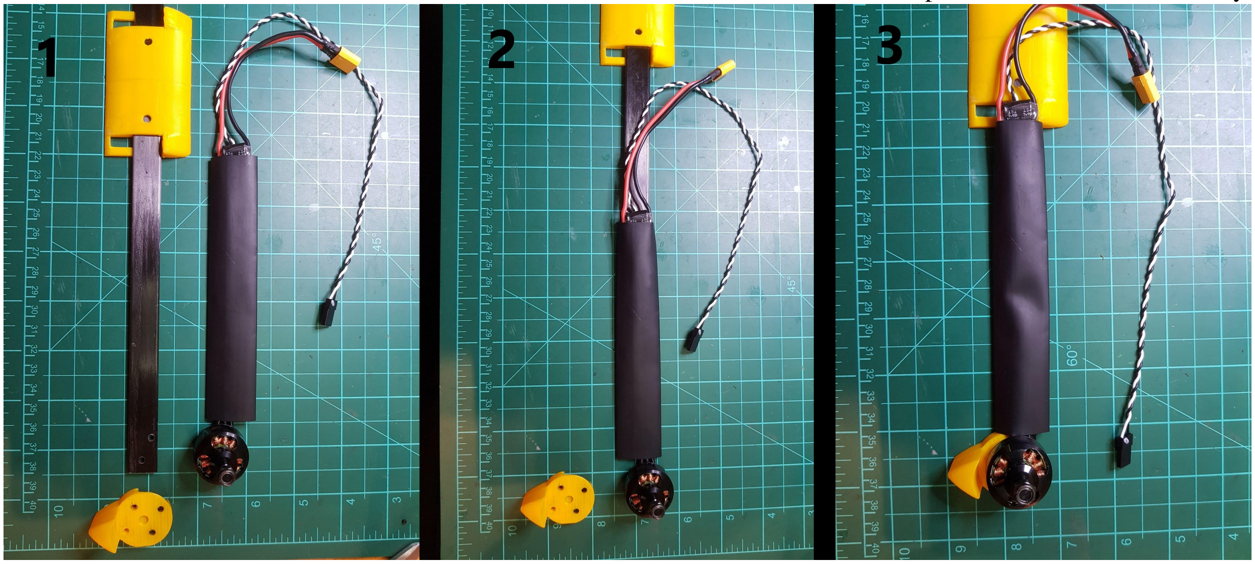
Slide all the 3D printed parts onto the CF bar as shown in Step 2, into the desired location with the correct orientation and placement. Use a sacrificial 3D printed motor mount or timber wedge with the right angle as follows to get the correct drill angle, and then, very slowly, drill 3mm holes using a drill press if possible.



Ensure the 3D printed middle parts are centered and carefully drill two 4mm holes through the CF bar using the 3D print as a guide. After cleaning and deburring all the newly drilled holes, carefully screw the motors onto the mounts and CF bar, and check to see if the motors can spin freely whilst attached to the mount.

Step 4 - Quad Arm Assembly

Once all the motor tolerances are checked, take off the motors and check all the components before final assembly.



Cut two 135mm long pieces of 16mm diameter heatshrink and slide the heatshrink over the XT30 and servo cables of the ESC up to the motor. Then slide the heatshrink and the ESC over the CF bar.

Use loctite on the correct screws to mount the motors onto the Motor Mounts and CF bar. Make sure the motor can still spin freely.

Align the cables and ESC along the CF bar and try to keep the cables to the front edge of the CF bar and then use a hot air gun to heatshrink them in place.

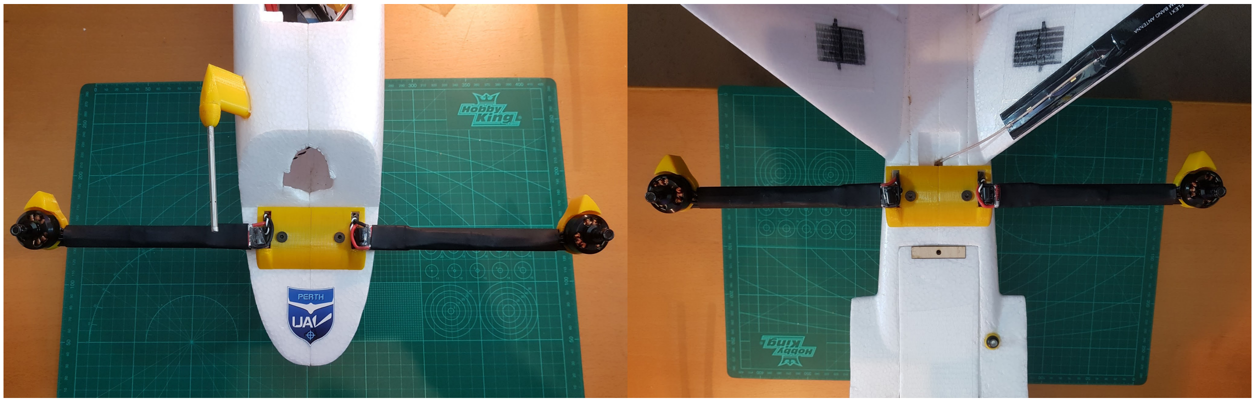
The finished quad arm should look like this: images/Propulsion/QuadArmFinish_SM.jpg

Tip: The hot air gun can be very hot, be careful not to hold in one place for very long and gradually go along the length of the heatshrink until it becomes taught around the Quad arm. Avoid heating the ESC and motors directly for prolonged periods. Keep hands and flammable items well clear!

Step 5 - Attaching the Quad Arms to the Fuselage

The final step for the quad arms section is to attach them correctly to the completed Mozzie fuselage.

Place a mark on the fuselage 12mm behind the fuselage hatch. Then dry fit the quad arm on the rear mark and into the front nose crease, as per the picture below. Mark the screw holes and rectangular cable penetrations on the 3D printed middle mounts onto the foam fuselage. Carefully cut the foam all the way through to the inside of the fuselage so that the cables can be routed internally to the power loom, and that the servo cables can be routed to the Pixhawk from the quad arms. Only drill small holes through the foam for the screws so that the screws are not loose in the foam.



Use the 20mm long M4 screws for the front quad arm and the 30mm M4 screws for attaching the rear quad arm.

Insert and glue the M4 locking nuts into Undermount recess provided. Place the 3D printed Undermount into the fuselage directly under the quadarms and then loosely screw it together until the screws are attached to the nuts.

Tip: Use the left over piece of CF bar and attach it to the Undermount using some velcro tape to place it under the screws in the fuselage.

Then route all the ESC cables through their respective penetrations and carefully screw the quadarms in place without damaging the cables.

Make sure to align the quadarms and only tighten the arms so they cannot move around loosely on the foam fuselage. Be careful not to overtighten the screws as this will over fatigue the foam and make it structurally unstable.

Tip: Check that the quad arms do not have excessive movement and tighten as required at every pre-flight check, and in particular after any hard landing (crash).

CHAPTER 8

Sensors and Accessories

Pitot Tube and Airspeed Sensor

For any quadplane, the placement and performance of the pitot tube and air speed sensor is important for smooth transitions and flight control. The airspeed sensor is mounted in the avionics enclosure and connected via the I2C bus to the flight controller.

The pitot tube 3D mount can be found on Thingiverse here: https://www.thingiverse.com/thing:169317

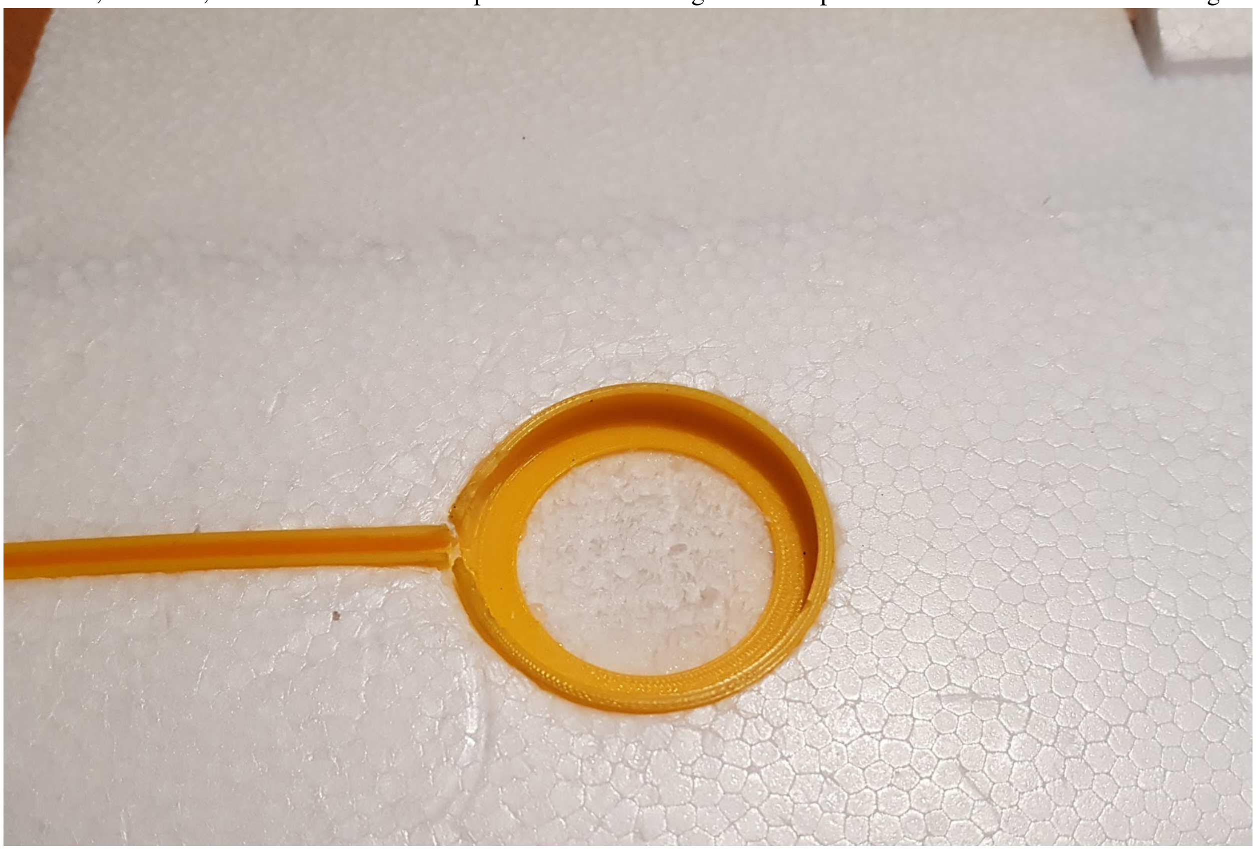
Tip: Prior to mounting the pitot tube, ensure the 3D printed parts screw together and there is enough clearance for the pitot tube and rubber hoses to fit through the print.

In order to work accurately, the pitot tube must be mounted in a position where it is exposed to laminar and not turbulent airflow. It should not be placed behind or too close to any wings or other parts of the aircraft. Also make sure the air hoses can be routed cleanly, without being bent or clamped, to the airspeed sensor on the inside of the fuselage. Use the pitot riser or the template to mark and cutout the foam in the location that the pitot will be attached to the fuselage.

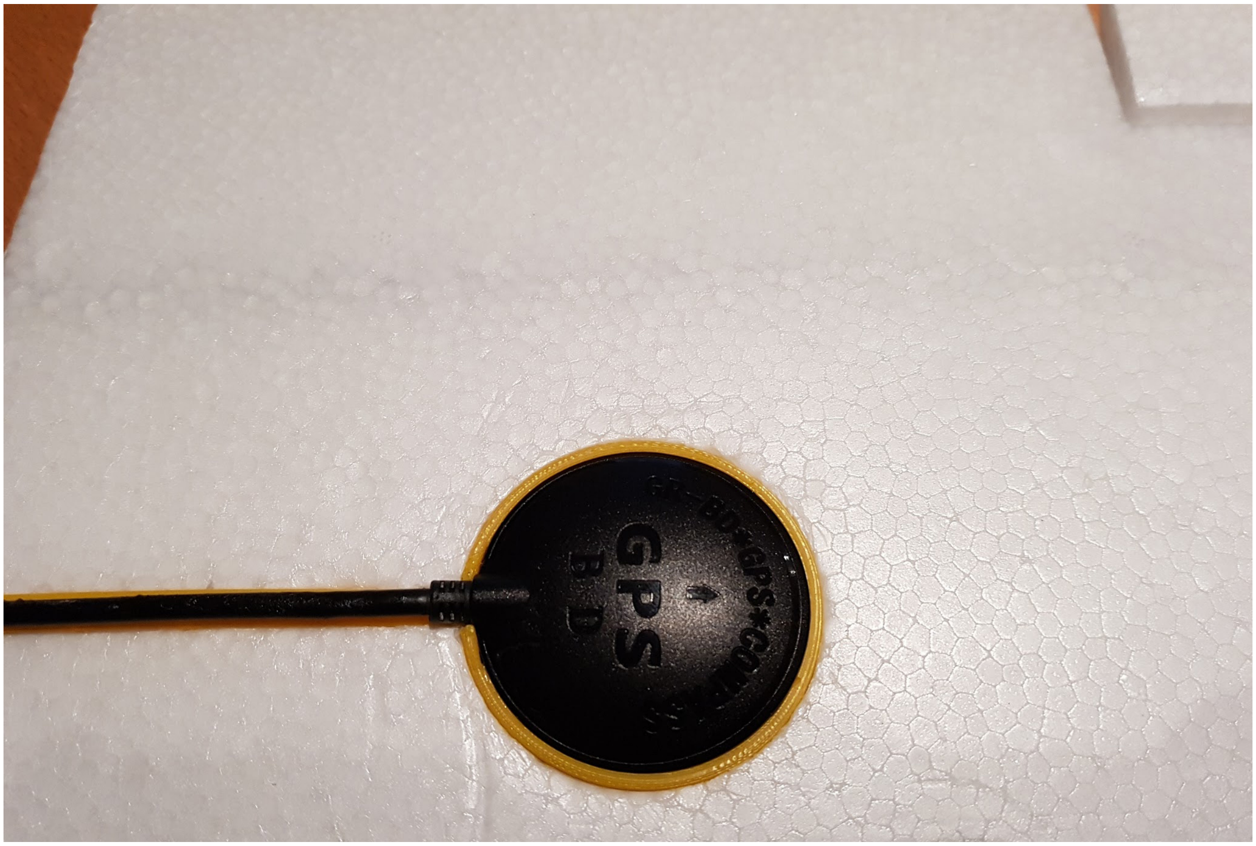
First, insert the pitot tube into the 3D printed screw cap and then connect the air hoses to the pitot tube and route, then through the pitot mount riser. Carefully insert the pitot tube and air hoses into the 3D printed pitot riser, making sure that they are not damaged or kinked, and then screw the cap onto the riser. Check to see that the pitot tube and hoses work correctly by blowing into the hose ends and seeing if air comes out of the pitot tube holes. Insert the air hoses through the cutout in the foam and glue the riser in place, ensuring the pitot tube is oriented directly forwards into the airflow.

GPS

The GPS is a very sensitive RF antenna that is prone to radio and electromagnetic interference of nearby electronics and transmitters. Because the Mozzie is a fairly small airframe, it is somewhat difficult to keep the GPS isolated from such interference by maintaining enough separation from the source. For this reason, we have opted to mount the GPS on the left wing, which requires it to be removed and attached with the main wing. The GPS can be unclipped from the 3D printed mount and the cable can remain connected to the FC for transport with the wing removed, however, make sure the GPS is placed in the fuselage for transport so the GPS cable is not damaged.



To mount the GPS, first use the GPS M8 Mount and Conduit 3D print to mark the position of them on the wing, making sure the GPS cable is long enough to reach that location with no tension on the connector, and avoiding any other structures in the wing like cables and spars. Then cut out the foam to recess the GPS mount and cable conduit into the wing so the top of the 3D GPS Mount and Conduit is flush with the top of the wing foam. Dry fit all the parts, including the GPS module and cable, to make sure they fit and then glue into the wing.



When assembling the aircraft, clip the GPS module and cable into the relevant 3D printed parts in the wing and make sure they are not loose when fitted, and that the cable does not get damaged when inserting or removing the GPS module. Trim and adjust the parts as required. It is also possible to use copper tape underneath the GPS on the wing or inside the fuselage to reduce interference further.

Antennas

Depending on the final configuration and the hardware used, there are various placement options for the antennas on the aircraft.

RC Receiver

When the FrSky RC receiver is mounted in the avionics enclosure, the antennas can be mounted on the enclosure itself by inserting the antenna cables through the two angled slots on the front of the avionics enclosure RFD/Air (top). In this location, the Frsky range is typically enough for line of sight operations up to 1-2km, which should suffice for most operations. It's unlikely that any extra range is required as it is not possible to physically see the orientation and fly the Mozzie from that distance.

Wifi (WLAN)

The Pi Zero W wifi antenna is mounted on the Pi PCB so its position can't be changed. Its range is unlikely to exceed 100-150m outdoors so it is not very useful for in flight wifi connectivity. Connecting an external USB wifi module will perform better, and ranges of multiple kilometers are possible using the right hardware and antennas. Having in flight wifi connectivity might also be useful to use to download images or for short range telemetry, should any of the other primary connectivity systems like 3G/4G mobile data or RFD900 telemetry fail in flight, as it allows connectivity without requiring the landing of the aircraft.

Tip: It is possible that the wifi will interfere with the FrSky RC signal as they can operate on the same 2.4Ghz frequencies. If possible, use a 5.8Ghz wifi USB module.

RFD900x Telemetry

The RFD900 is the primary RF telemetry connection on the Mozzie platform and, in the case of the RFD900x, can also provide manual RC control of the Mozzie as well. Accordingly, the RFD900x is the second most important RF hardware on the aircraft, following closely after the GPS module, so antenna placement can be critical in achieving the required range and performance. Being a small airframe, positioning the antennas with enough separation and the correct orientation can be difficult.

We have opted to mount both the foil antennas on the foam V-tail of the Mozzie as these surfaces are mostly RF transparent and the antenna cables can be conveniently connected directly to the RFD900x on the avionics enclosure. The antenna orientation also allows for good ground coverage, which is not typically sensitive to aircraft heading changes.

Tip: It is advisable to test the long range performance of the RFD900x by using a separate ground team at a remote location, while another local ground crew can fly and observe the Mozzie directly overhead and be ready to use the RC to take control should the aircraft loose telemetry. Note: For this to work reliably the FrSky receiver must be installed in the Mozzie.

3G/4G Mobile External Antenna

If using a USB mobile data modem, placement of the antenna in flight is likely to be less critical than when it is operating on the ground. 3G/4G mobile reception on the ground is not very good if the antenna is less than 500mm from the ground. Due to the compact nature of the Mozzie, it is only some 250mm high overall, so it's not possible to mount a mobile antenna on the Mozzie that will work effectively on the ground; however, it should perform quite well whilst in flight if it is placed in the front nose of the aircraft, in front of the battery.

LED Status Strip

It is connected via the Pi LED servo connector.

Caution: The Front Pi LED servo connector that comes from the Pi Zero header should never be inserted into the Pixhawk or any standard servo connector as it is not compatible and can only be used with the LED strip as specified. Do not use this connector for anything else otherwise the Pi IO might be damaged.

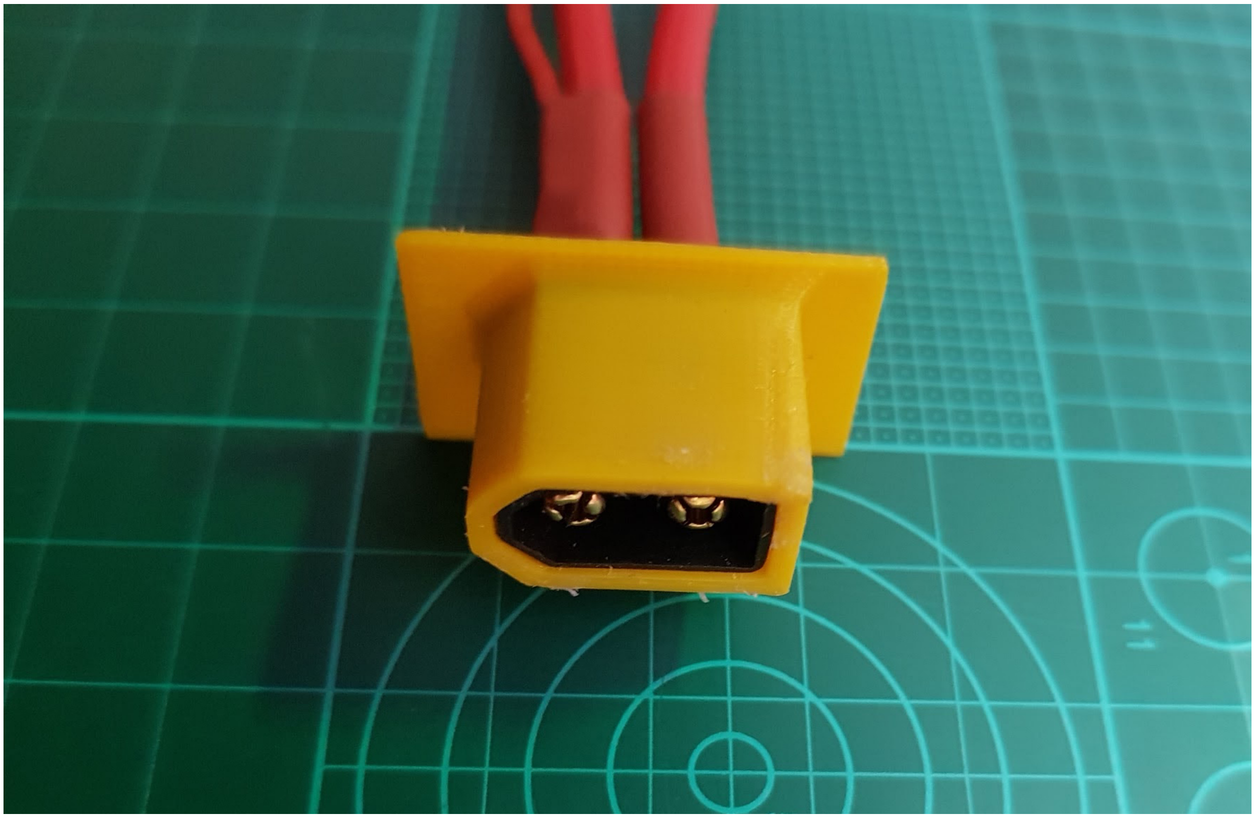
The LED bar shows the current status of the Flight Controller (Pixhawk) as follows: * Green is disarmed * Red is armed * Slow pulsing shows the flight controller heartbeat (which also indicates that the CC has booted correctly and that mavproxy is forwarding mavlink messages from the PXH).

The LED strip should to be mounted on the top side of the fuselage for easy visibility. It can be mounted using the 3D Printed LED Holder part.

Power Key

One of the rule requirements is to provide a method to remove all power to the propulsion system. For this we are using a simple XT60 plug that is inserted into Power Loom to close the circuit and power up the propulsion.

Tip: If the wiring is configured as per the Power Loom diagram, only the power for the propulsion is disabled if the power key is removed and the avionics and UBEC's will continue to be powered by the battery. Disconnecting the battery will completely un-power all the aircraft systems, but it is advisable to unplug the power key every time work is to be done on the aircraft for safety reasons, because the propellers and motors will be disabled. Running the aircraft without the power key is also convenient for bench testing and configuring the avionics before flight.



To install the Power Key 3D print, use it to score and mark the position you would like to install the key on the fuselage, making sure that the power loom cable can reach that location and the 3D print can fit against the foam smoothly. Cut out the foam smaller than the 3D print so that the print fits snugly into the fuselage. Find the correct XT60 connector of the power loom, where the power key is meant to be inserted, and glue that XT60 into the Power Key 3D print, making sure the glue does not block the connector. Wait until the glue sets and then glue the 3D print into the foam fuselage cutout.

Note: To comply with the rules, note colour standards required for showing the propulsion power state on the power key connector.

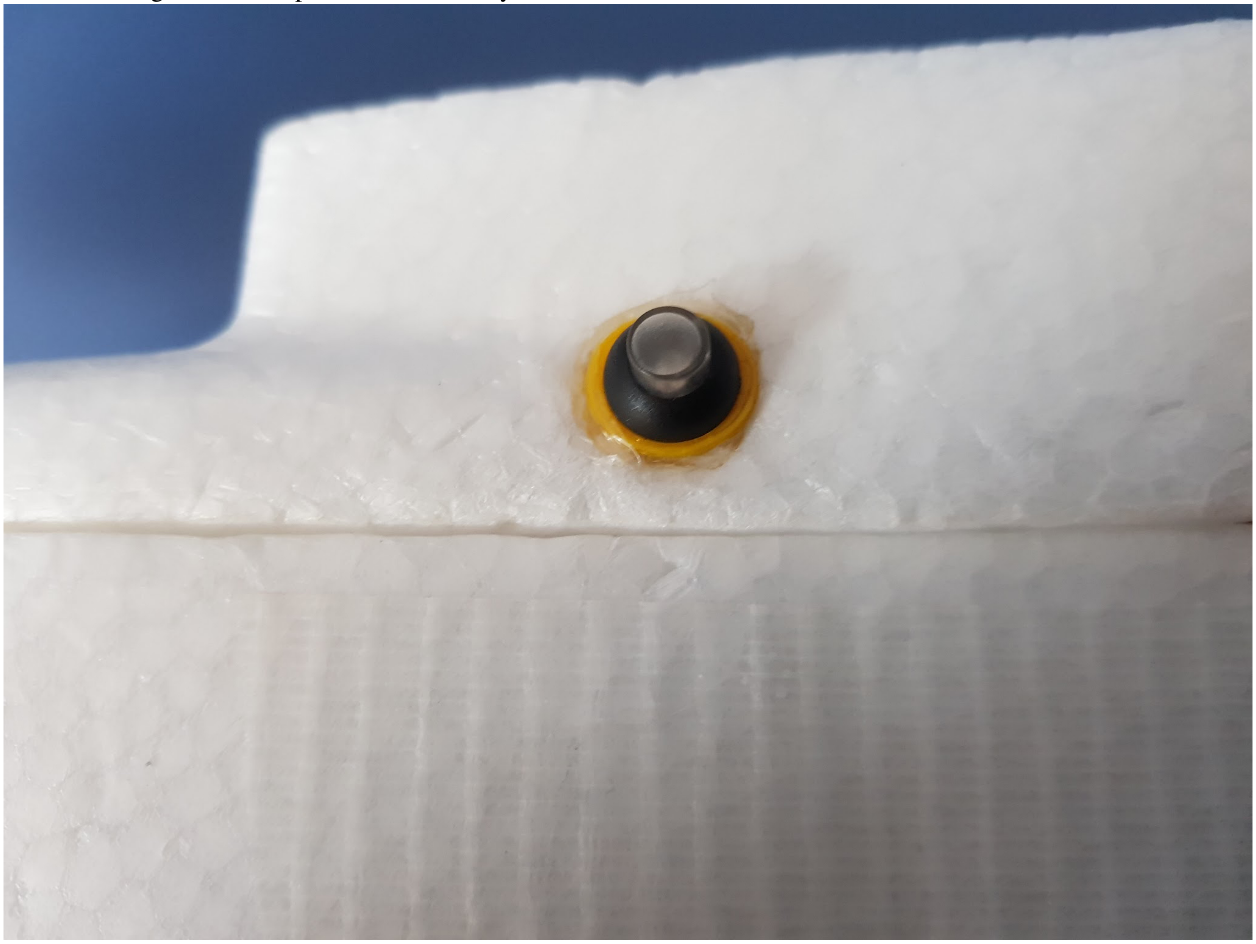
Safety Switch

To install the Safety Switch into the fuselage, find a location on the fuselage that gives you safe access to the safety switch away from the propellers and is also within reach of the cable length of the safety switch. Then carefully mark that location and cut out the fuselage foam with a hobby knife to a diameter that is smaller than the Safety Switch 3D print, so it fits snugly into the foam.

Tip: It is advisable to avoid mounting the switch in the foam lid, as the safety switch wire will fatigue and break over time, and also impair access to the inside of the airframe for placing the battery etc. Like with the sample vial tube, it is possible to cut a section and permanently attach some of the foam lid to the fuselage and attach it on that instead.

Glue the Safety Switch 3D print into the hole and wait for it to set. Insert the cable of the Safety

Switch through the 3D print and carefully route it to the FC and connect it to the Switch connector.



Sample Vial

For the blood sample, the challenge rules require a tube 100mm long and 20mm wide. The blood sample itself is in fact much smaller than this, and can withstand some impact in itself without breaking. We used a Berocca tube (similar to a Smarties tube) with about the right dimensions, but any lightweight tube of similar dimensions should suffice to contain the sample. Adding extra padding to reduce the likelihood of breaking the vial is optional.

First cut the Berocca tube to the right length so that it just clears the height of the foam lid whilst standing on the 3D printed cap. This should be about XXmm long. It can also be partially recessed into the foam lid to make it more streamlined; however, ensure that it is easy to both remove the Berocca tube cap and that it secures properly, to avoid the sample falling out. Then insert the cut end of the Berocca tube through the center hole of the Talon Box Bridge and score and cut the fuselage foam so that the Berocca tube will sit level on the fuselage floor when mounted.

Then, whilst the tube is still inserted through the Talon Box Bridge, glue the 3D printed cap to the cut end of the Berocca tube and, subsequently, to the floor of the fuselage. If required, it is possible to segment the foam fuselage lid and permanently attach those foam parts with glue or tape to the fuselage to accommodate the vial holder tube better.

Cable Management

It's good practice to ensure that all the cables, connectors and any penetrations where cables go through hard materials are managed by ensuring they are not tensioned, cut, clamped, bent or excessively fatigued through movement. By adding some cable ties, cable clips and spiral cable wrap, the overall presentation and routing of cables can be improved and protected. This also helps greatly when trying to diagnose hardware or wiring issues, as well as making sure that everything is connected the way it should be when doing pre-flight checks.