QAV 250

Hardware Build

February 2026, Toulouse (FRANCE)

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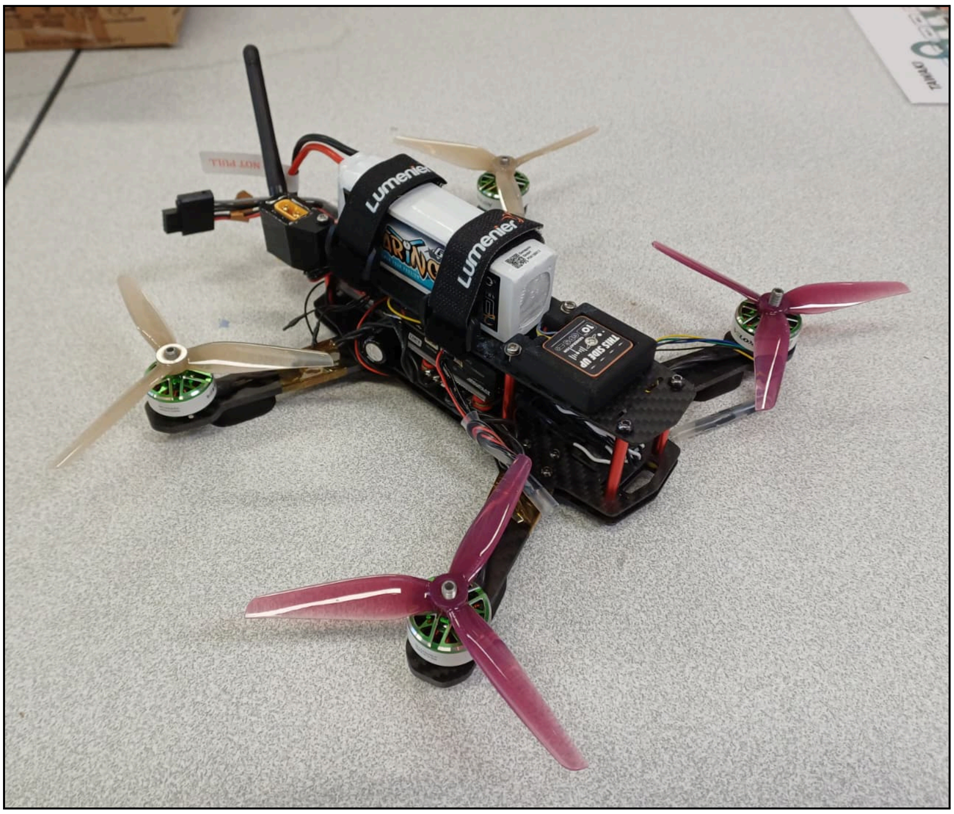
Part of the 03 First Drone Build GitHub public sub-folder



Assembled QAV250, without video equipment. Battery is not plugged; propellers are not tightened to the motors.

1) Introduction

1.1) Context

This document describes the practical hardware assembly of the QAV 250 drone described in the previous `01_QAV250_GoalAndSelection.pdf` document. As a reminder, the goal is to assemble a small quadcopter, 250mm motor-to-motor diagonal, to be used to gain drone experience.

For sake of complexity, current QAV250 does not include the camera, OSD and VTx components. The drone was assembled in ENAC laboratory in Toulouse, in February 2026 by me (Leonardo AVONI)

For more details on the goal of the project, read the previous document. The wiring scheme is described in the `02_First_Drone_Build_Wiring_Scheme.pdf`

1.2) Credits

I would like to express my sincere gratitude to Fabien BONNEVAL for all the support he provided while I was working on the soldering process. I would also like to thank Murat BRONZ once again for taking the time to double-check the final build.

My greatest thanks, however, go to my father, Giulio Avoni.

From multiplication tables to the inner workings of electronic devices, he has been my first and most enduring teacher. It is through his patient guidance that I learned to build, repair, and understand the world around me — and his influence is woven into every stage of this project. His practical advice on cable shielding, wire twisting, proper stripping techniques, and soldering was invaluable throughout the build, and his mastery of electronics made his support truly irreplaceable.

But beyond the technical, he gave me something more lasting: a deep respect for doing things the right way, and the perseverance to push through hard problems. He was the best guide I could have had growing up, and the best dad I could have wished for. I would not be an engineer today if it weren't for him. Thanks Dad

2) Method and Tools

2.1) Where to Build

Initially, the plan was to buy all components and assemble them myself at home. I quickly realized that was a stupid idea because of the following general random quotes of DIY and engineering creation:

“*If you get N objects, you will actually need N+1*”
“*The tool you don’t have is the one you end up needing the most*”
“*Having the correct tools to do the job saves a lot of time, and leads to better quality*”
“*Better to make one thing right the first time, than wrong 76’000 times*”
“*Time is money*” (I prefer “*time has value*”)
“*Measure twice and cut once*”

Because of all above lines, once I received all the components, I packed them and took a weekend to assemble them in ENAC workshop. After building the drone, I realized doing it at ENAC was way better because of the wider tool selection available.

2.2) Tools and Additional Components Used

Current paragraph lists the tools, miscellaneous and various 3D-printed additional components used for the build. For reference: all screws were M3; I preferred to use inox bolts for sturdiness reasons, instead of optimizing for minimal weight; coherent with previous document.

I am writing this list as to know what to buy to make my own drone building lab one day.

Generic Tools

- Flathead screwdriver/pick to move things around
- Phillips screwdriver
- Hex screwdriver
- Empty hex screwdriver
- Cutter
- FDM 3D printer
- Hacksaw
- Drill+M3 and M5 drillbits + cone head
- Measuring ruler
- Measuring caliper
- Punching tool
- Mallet
- Small pliers
- Metal file
- Sandpaper
- Bench vise

For the Wirings

- Crimping set: clamp + connectors
- Wire stripper
- Wire clamper
- SOldering iron
- Soldering paste
- Soldering flux
- Desoldering strip
- Soldering magnetic station+ wood
- Heat gun

Miscellaneous
- Crimping connectors
- Heat-shrinking tubes
- Kapton tape (used to secure things around)
- Thick double-sided tape
- Plastic washers (3mm)
- M3 Inox screws and nuts
- Rubbing Alcohol
- Epoxy glue
- Battery straps
- CyanoAcrylate (CA) glue
- Boxes (small elements can be lost)

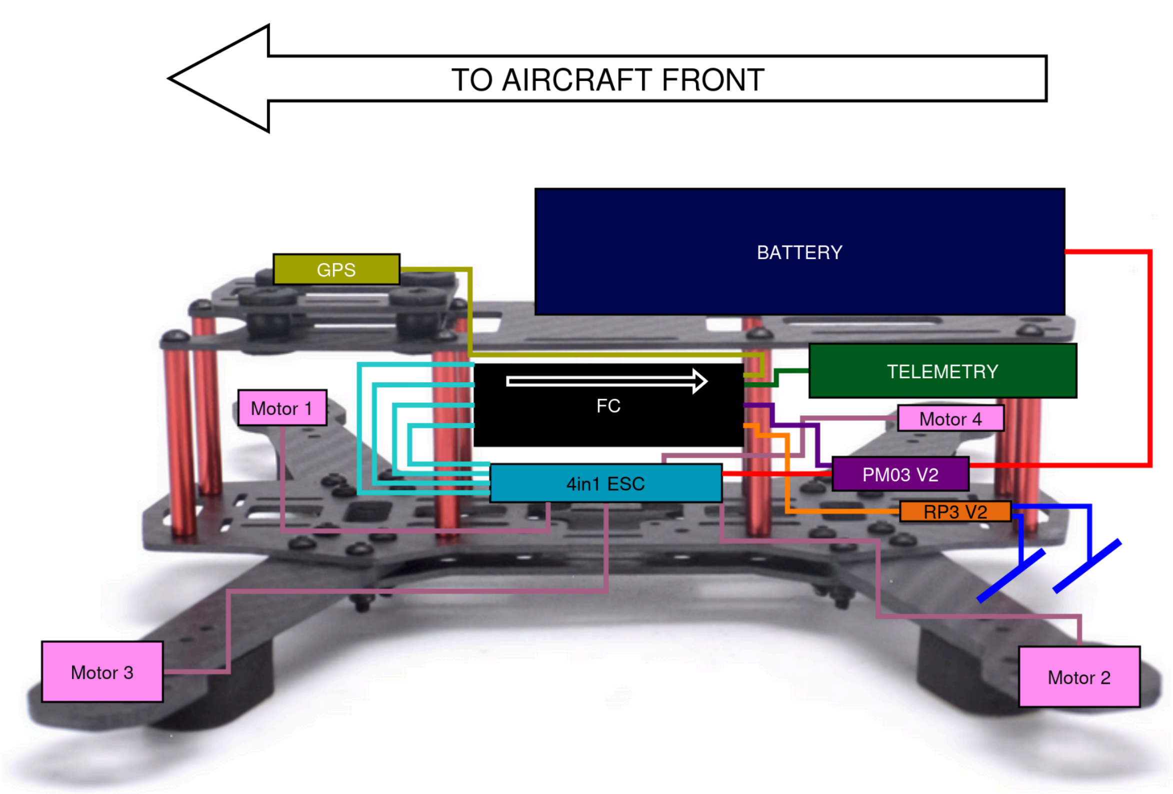
3D Printing Software (FDM)
- Bambulab slicer + OnShape

N**ot-planned additional components**:
- 3D printed parts:
  - GPS support
  - 4mm spacers (select the thickness based on the frame arms thickness you use)
  - XT60 plug holder; 3D-printed. XT plug was epoxy-glued to the support
- Battery straps; fixed to the frame using CA glue
- Pixhawk metal plate support (report the dimension used; holes on a 31.5mm square)
- Added plastic washers between screws and carbon, as to avoid scratching the carbon

3) Updated Assembly Plan

3.1) Physical Wiring

The autopilot was **mounted pointing towards the rear of the frame** to simplify cable routing, with the forward arrow effectively reversed relative to the physical orientation. This choice, shown below, was done after reviewing several possibilities in component placement.



Selected positioning of the various components on the QAV250. This is an update from the scheme initially defined in `01_QAV250_GoalAndSelection.pdf`. The FC orientation and general vehicle orientation are shown using large arrows. *Note that each connection (set of wires) between two components is shown as a single line in current graph. For instance: the red line connecting battery with PM02 V3 groups the + and - cables*

When deciding component placement, we had to pay attention to the following points:

1. The GPS and GPS-related cables should be located as far as possible from the FC, and from any radio-emitting device
2. As little cables and general wiring should be used

We defined the position of the following components (as shown above):

- Battery: I did not want to mount it on the bottom of the frame (although more stable in theory), and wanted to leave free space at the front of the drone for eventual accessories
- Motor 1 to 4 (because of frame geometry)
- From the battery position, we placed the PM03 V2 near it to limit power cable length (more cable leads to more losses). Similarly, the power input for the ESC was located facing the PM03 V2, and the component was aligned with the four 31.5mm holes. From there, we had to decide the placement of the following components:
    - **GPS**
    - **RC Receiver**
    - **Telemetry radio**

- **Flight controller orientation** (we already "knew" it had to stay on top of the ESC, for sake of space, and because it is a central position more or less

Because of point 1, the GPS and radios should be located at opposed ends (GPS at front and radios at the back, or vice versa). Since changing their position would have impacted only the cables used to connect them, we did not find great constraint related to this choice. We ended up picking GPS at front, but doing otherwise should not have been a bad guess. I In case one was expecting to have a camera (VTx emits radiowaves) the placement should be reconsidered of course.

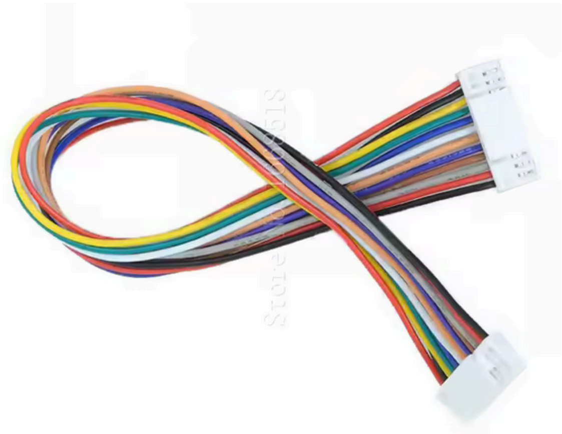
From a FC-orientation point-of-view, we realized that having the four "cyan" PWM lines from the ESC directly to the flight controller was convenient; and turning the FC in the default orientation would have added more wires and made the design more complex. Hence, the choice selected above was kept

3.2) Wiring and Connector Notes

On twisting: I2C cables were twisted following standard practice, motor cables were also twisted, but UART cables were left untwisted — consistent with the protocol notes above.

Regarding connectors, the Pixhawk requires GH1.25 connectors throughout. The five connections needed are: a **6P** for POWER (PM02 V3), a **6P** for TELEM1 (SiK Radio), a **6P** for GPS2 (ELRS RC Receiver), a **6P** for TELEM2 (ESC), and a **10P** for GPS1 (GPS module). PWM connectors for the four motor signals are assumed to be standard and should be available at the ENAC lab.

From the available stock — sourced from the PM02 V3 and SiK parcels — there are five double-ended and two single-ended 6P cables, plus four 4P cables from the Pixhawk parcel. The one confirmed gap is the **GH1.25 10P connector** required for the GPS1 port, which still needed to be sourced. We hence bought a pack of connector-cables-connector, as shown below (the image below is for a 12-pin cable).



GH-1.25 cables, 12-pin version. We purchased the 10-pin version
From Aliexpress

3.3) General Wiring Concerns

Before the build was fully underway, a number of wiring questions accumulated that I did not initially know how to answer. The first was where to place the capacitor (usually soldered to the ESC, and provided in the same package)— I was unsure whether an additional one was even needed, given that the PM02 V3 power module already includes one.

A related concern was whether the XT30 connector on both the battery and the PM02 V3 was adequate: the plug is nominally rated for 30A continuous current, which seemed dangerously low for a drone application.

Beyond power, I was uncertain about how to connect and configure the RC receiver, how to properly set up the ESCs, and whether they used a PWM or digital protocol. I also had broader conceptual gaps — I did not yet have a clear understanding of the communication protocols involved, namely **UART**, **I2C**, and **CAN**, and how each maps to the different peripherals on the Pixhawk. The official PX4 documentation on cable wiring, DShot ESC configuration, and DShot commands helped clarify some of these, but several questions remained open until I discussed them directly with Murat.

A note on communication protocols: UART (also called "serial") uses two lines — TX and RX — crossed between devices (one's TX connects to the other's RX). No twisting needed. **I2C** uses SDA (data) and SCL (clock), plus power and ground — all devices on the same bus share those two signal lines, each identified by a unique address. No twisting needed at short distances. **CAN** uses a differential pair — CANH and CANL — which *should be twisted*, as the noise rejection relies on both wires seeing the same interference. **PWM** is a single signal line plus ground — one pair per motor or servo, no twisting needed.

The main pins for each protocol are listed below:

Serial	**I2C**	**CAN**
VCC	VCC	VCC
TX	SCL	CAN_H
RX	SDA	CAN_L
GND	GND	GND

After discussing with Murat, most of the remaining uncertainty was resolved. On the capacitor question: it should be fine to have two capacitors in the circuit, so no change was needed. About the PWM ground wiring, Murat hinted that a single shared PWM ground is sufficient, though wiring more is welcome for redundancy. He also dismissed the XT30 amperage issue — while the datasheet rating is 30A, the connector is routinely used on batteries such as the *SMC Racing 6S 1600mAh 215C* which can deliver bursts well above 200A, so no connector swap was necessary. The ESC protocol question was also settled: the ESCs use **DShot600/1200**, a robust digital protocol. The AM32 configurator exists as an option to reflash or reconfigure the ESCs if ever needed, but in practice this is unnecessary for the vast majority of setups. Murat also clarified the ESC connector pinout: **Current** (3.3V analog signal proportional to drawn current), **VBAT** (raw battery voltage, ~12V nominal), **TX** (UART telemetry back to the flight controller — RPM, temperature, voltage), **GND**, and the **four motor signal lines** carrying DShot pulses from the flight controller.

3.4) GPS Concerns

One of the recurring uncertainties during this build was how to properly handle the GPS peripheral components. Standard HolyBro GPS modules conveniently bundle the GPS receiver, buzzer, safety switch, and UI LED into a single 10-pin GH1.25 connector, which sidesteps the issue entirely. Working with the Pixhawk–Goku GPS combination, however, meant dealing with these components separately. I spent time investigating how to wire an external buzzer (~16Ω) and safety switch using the leftover cables, but ultimately did not pursue it further — those wires remain unconnected for now. It is a concrete improvement worth revisiting in a future iteration.

On the cabling side, the PX4 GPS mounting guidelines recommend keeping GPS cables short and properly twisted (which I did), and shielded to minimize electromagnetic interference (which I did not, for simplicity reasons).

Finally, I did a brief foray into **Real Time Kinematics (RTK)**, which could significantly improve positioning accuracy for future use cases, but left it aside as it was beyond the current scope of the build.

The finalized and updated wiring scheme is present in the `02_First_Drone_Build_Wiring_Scheme.pdf` document

3.5) To do — Simulation with Gazebo.

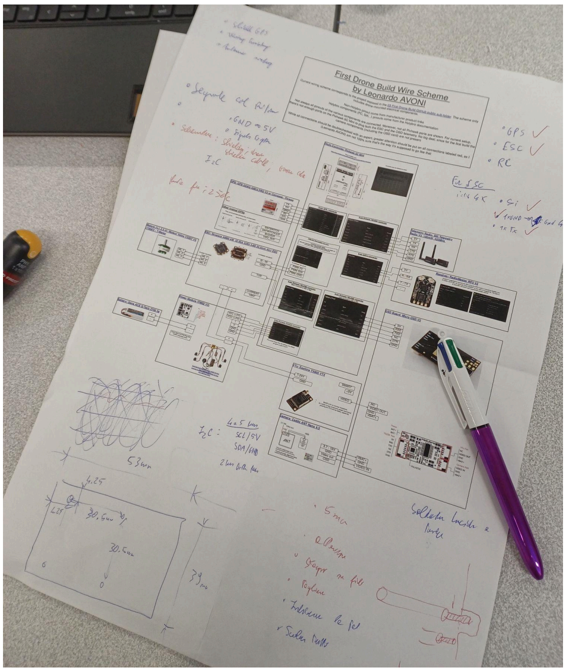
A separate open question concerned how to replicate or test this setup in the Gazebo simulation environment. Since this involves software configuration rather than physical wiring, it was deliberately set aside during the hardware phase. It will be addressed as part of the software and simulation setup in a later section.

4) Actual Build

Now that we had checked compatibility, and that we defined the position of each component, we started assembling the QAV250. Here we list pictures, as well as a few notes I realized throughout the build.

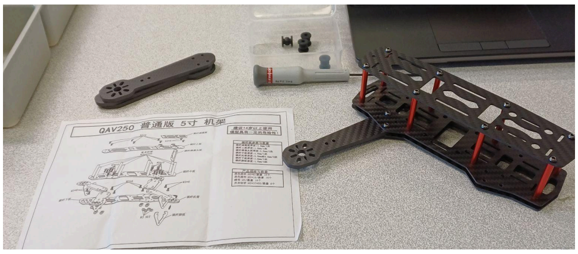
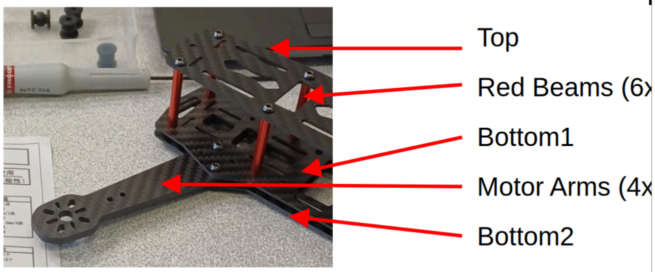
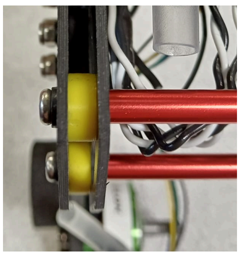
1: First I extract everything off the bags I have, to make sure all the components are there

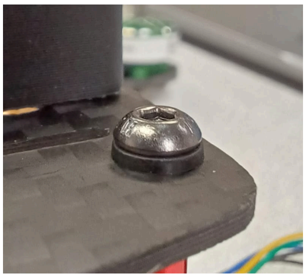
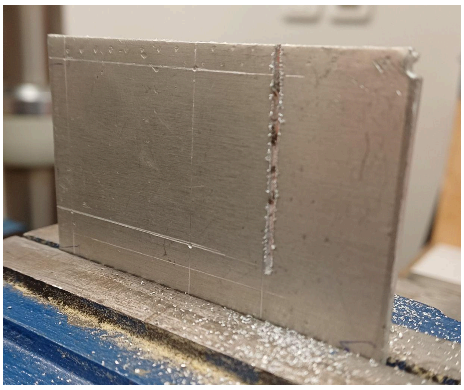
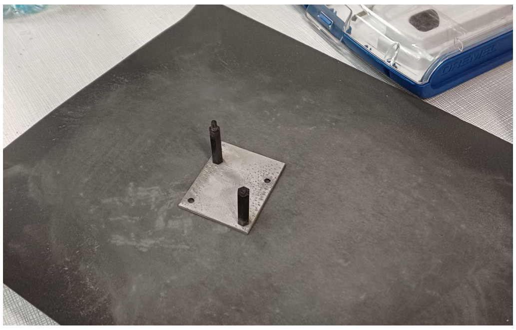
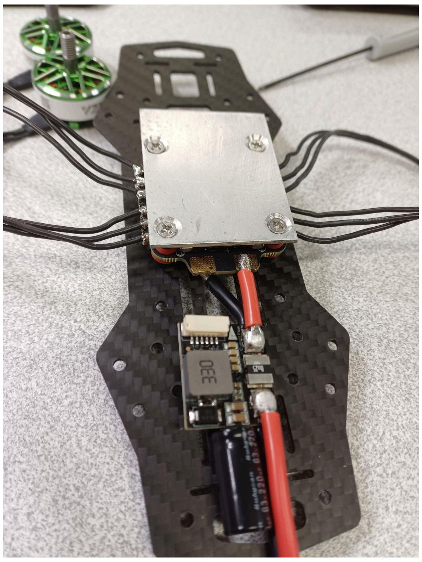
I make sure I place the components in boxes, as to avoid the classical “*A screw fell on the ground, let’s spend 3h looking for it…”* issue

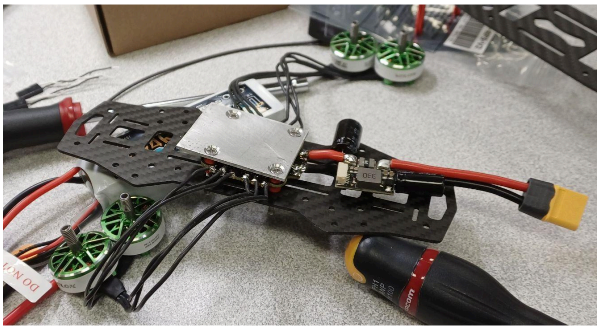
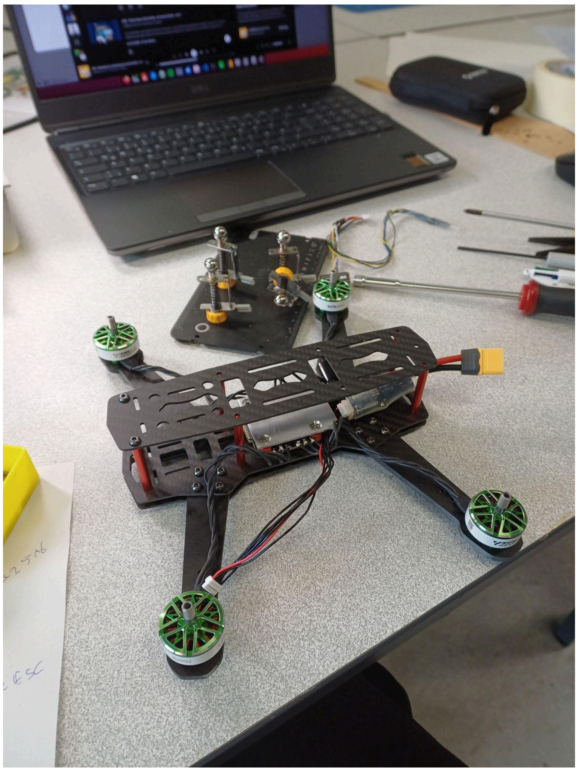
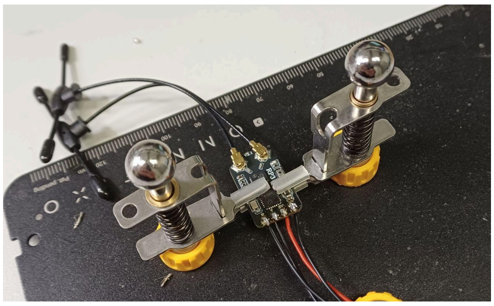


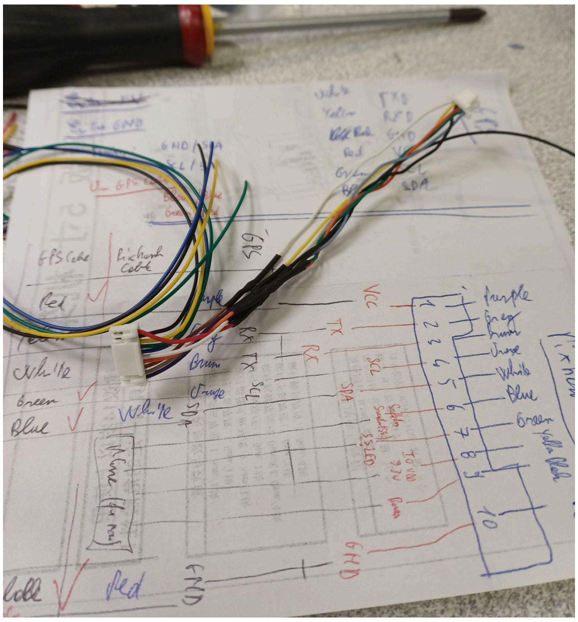
Before and during the build I took the time to A3-print the wiring scheme I wrote previously (`02_First_Drone_Build_Wiring_Scheme.pdf`).

This helped when issues came up, mostly to note which-cable-goes-where, and which-cable-is-which-color

	2: I started assembling the frame. I did not mean to fully assemble the drone at this point, but rather understand better how and where to fit the components. I realized (as expected) I could not place all 8 red beams in the structure, otherwise the FC could not fit. Coherently with previously-cited QAV250 similar designs, I removed two red poles.
	I also noticed that the frame was composed, top-down, of three frame parts (shown aside): ● Top ● Red Beams ● Bottom1 ● Motor Arms ● Bottom2 For assembly (screws): ● Top is fixed to beams, ● Beams are fixed to Bottom1 ● Screws hold Bottom2, Motor Arms and Bottom1 together I did not like that the Beams were only joined to Bottom1 and not Bottom2 as well. This would make assembly/disassembly tricker, and and less obvious to solve in case of unwinding screws.
 	I hence decided to create (3D-print) spacers (4mm-thick, just like the motor arms) between Bottom1 and Bottom2. I of course had to use longer screws to tighten together everything, but I ended up with a much sturdy and disassemblable design
	P.S. by “disassemblable” I mean it is easier to detach top form bottom, while leaving Bottom1-Arms-Bottom2 assembled. I like the new design, even though it is of course heavier; but as a testbench I am ok with it While not shown here, another 4mm spacer was located for the esc and pixhawk screws, to be able to

	re-tighten them if needed from under the QAV250
	Speaking of using screws on carbon frame, I decided to use some nylon washers because I did not like the idea of metal sliding on carbon.
	3) Turning now to how-to-fix-the-FC: Apparently most people tape it to a metal plate, and that plate is fixed to the frame. I decided to do the same, even though some threaded holes are available under the Pixhawk. I decided to use some double-faced tape as it should add a bit of vibration damping, compared to the all-screw design.
	On the side is an image of the metal plate getting manufactured (aluminium); maybe a 3D-printed stand could have been created but at the end I was ok with this plate method.
	The only thing (and it's a big one) I DID NOT LIKE is the fact that when placing the FC on top of the place, the screw heads get HIDDEN. So if they unscrew, it's hard to tighten them down. This is not dramating though, since the nuts under the QAV250 correspondent to those screws can kinda be turned even without touching the screw head. Not super happy with it, but the setup ended up pretty tight; will keep an eye on those screws though. By-the-way, here we can see the PM02 V3, ESC and FC plate mounted to Bottom1 only. one capacitor at the moment, this was a fit check.

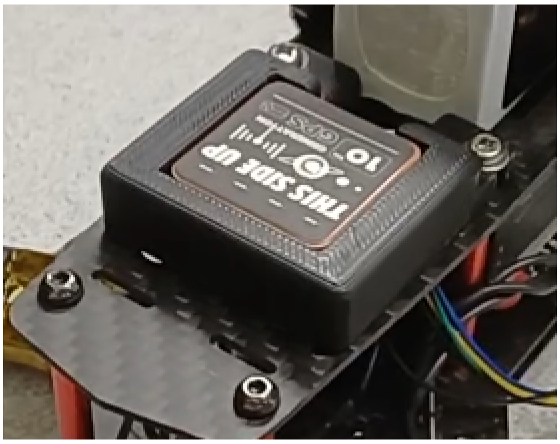
	4) I added elements to the ESC, namely the 4 motors and the capacitor. When fitting the ESC, I paid real care in making sure no carbon fiber, and no aluminium were touching the + and - poles of the red wires (those carry a lot of current, I don't want any shorts here. Same goes for the soldering for each motor.
	5) This is a dry assembly, with all the spacers between Bottom1 and Bottom2, and with the four motors in place. At that point I was still a bit unsure on where to place the various components, and getting to that allowed more clear understanding of what could fit and what could not. **Note:** between now and the next step I spent a good 10h time in *just* soldering, to have the GPS, ESC and RC receiver ready for assembly. I feel some talented person could have done it in way less time, but hey, skill issues, I'm here to learn. Plus I very rarely do soldering.
	6) RP02 V3 wire soldering, just to show the setup used. I had a hard time making clean professional soldering on the first try, since the PVC coating on the wires was melting quickly, leaving wire segments of up to 5mm exposed. While they were not touching, this is not a professional wiring method, and hence decided to repeat until similar to what is shown in this picture. Thanks Giulio for the heads up.



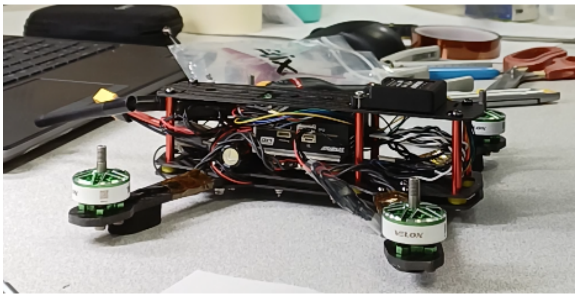
7) Additional wiring. This is the GPS cable, connecting it to the FC. I had to pay attention to the cable colours, since I was using pre-crimped GH1.25 10p cable, that did not have matching colors with either the Pixhawk standard, or the GPS standards.

Hence I triple-checked everything with a hand drawn wiring scheme, and only then soldered everything.

Thanks again to my dad Giulio for the tips on how to do a good job without burning the lab down.

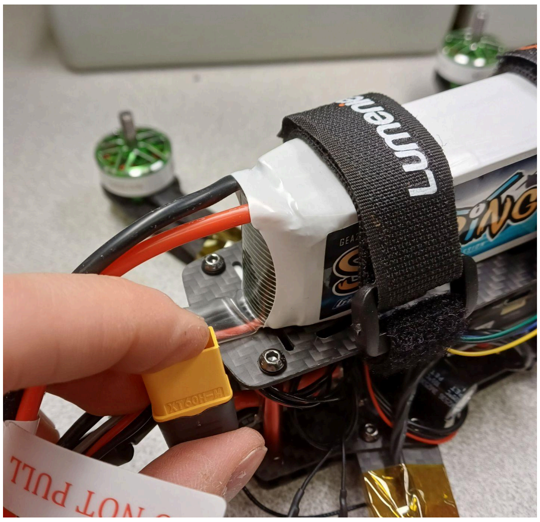
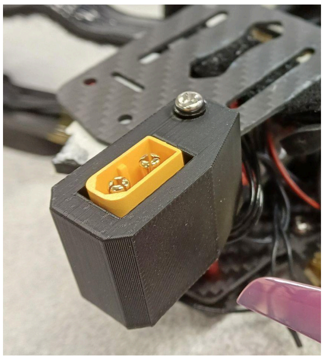
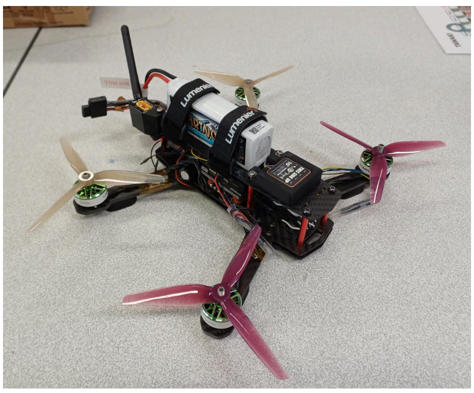


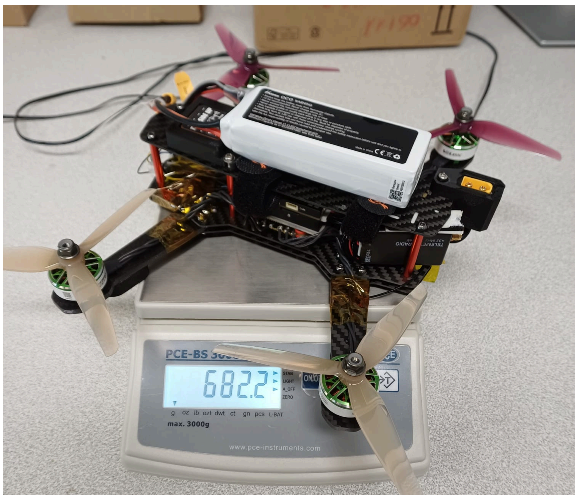
8) Until that moment I did not realize that taping the GPS to the frame would have been really ugly, so I quickly designed a GPS stand, and 3D printed it



9) I managed to make everything fit in the drone frame, without too many issues.

I of course made sure no components were in propeller reach, even though here propellers are not shown.

	10) The fact that the XT30 plug was left unattached to anything was making me sad; so I decided where I wanted it to be, and started thinking about how to fix it there. I wanted it to be in a place • far from the propellers • easily accessible if I need to quickly disconnect the battery I settled in the back of the drone, attached to one red pole screw.
	To do so, I 3D-printed this XT30 stand. No, it is not meant to be light, (even though it is not super heavy) but rather to be resistant
	Here is a dry assembly of the XT30-stand-drone. It does not rotate around the screw because of a slot that incorporates the carbon fiber Top element inside. I then proceeded to glue the XT30 to the stand using epoxy. Yes, the whole thing is a bit overkill but I DO NOT WANT IT TO TOUCH THE PROPELLERS.
	11) Finally, I glued (with CA glue) two battery straps to the frame Top part, and placed the battery there. I also tied all cables down using Kapton tape, and placed the small foam elements under the rotor arms: they serve as landing gear (and I like having a horizontal drone) I DID NOT PLUG IN THE BATTERY YET. I would like o first connect the FC to the computer, and check if everything is ok.

	12) I proceeded to weight the drone (yes, the battery is in the reverse direction here); The QAV250 mass, including battery, with no video equipment, is 682.2g. This measurement will be useful, also in view of current european drone regulation

5) Conclusion

With QAV250 hardware now completed, I learned the following things:

- Soldering and wiring takes a lot of time; and the total drone build time was around 26 hours (1 VERY full weekend). Time would have been longer with worse/inappropriate tools
- The mass of the QAV250 is 682.2g

Now I need to understand the software needed to make it fly