

 **DRONE**
TEAM

Drone It Yourself!

MAKING AND DESIGNING A TOY DRONE
THROUGH MULTIDISCIPLINARY
COLLABORATIVE WORK
Project no. 2015-1-ES01-KA202-015925

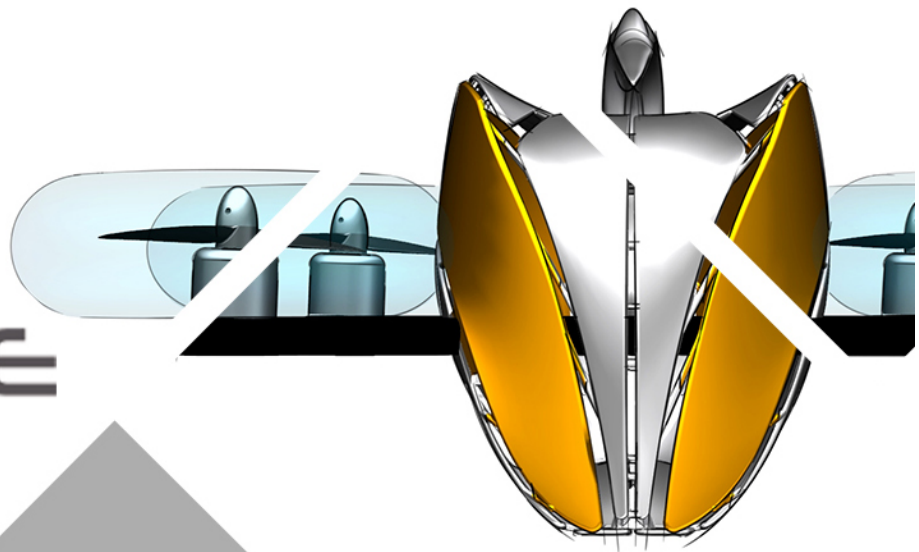


Co-funded by the
Erasmus+ Programme
of the European Union



Drone It Yourself! consists of the following modules:

0. INTRODUCTION TO THE DRONETEAM PROJECT
1. BASIC TOY DRONE FRAME
2. MODULE OF FLIGHT CONTROL
3. MODULE OF COMMUNICATION CONTROL
- 4. MODULE OF ADVANCED FRAME**
5. MODULE OF GPS-COMPASS CONTROL
6. MODULE OF PROBLEM MANAGEMENT
7. MODULE OF FLIGHT STABILIZATION SYSTEM
8. MODULE OF FIRST PERSON VIEW
9. DRONETEAM E-LEARNING PLATFORM
10. OTHER DEVELOPMENTS
11. GLOSSARY



This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



MODULE OF ADVANCED FRAME

2015-1-ES01-KA202-015925



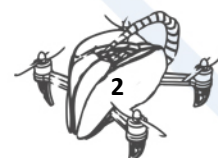
Co-funded by the
Erasmus+ Programme
of the European Union

Index

1.	DRONE ADVANCED COMPONENTS.....	3
1.1.	INTRODUCTION	3
1.2.	GPS	4
1.3.	POWER MODULE.....	4
1.4.	TELEMETRY.....	4
1.5.	FPV.....	5
2.	DRONE ADVANCED ASSEMBLY.....	6
2.1.	INTRODUCTION	6
2.2.	KIT CONTENTS	6
2.2.1.	KIT S250 SPEDIX.....	6
2.2.2.	EXTRA PROPELLERS BLACK 5X4.5 (CW / CCW).....	6
2.2.3.	TURNIGY 9X 9CH & MODULE 8CH RECEIVER MODULE.....	7
2.2.4.	BATTERY TURNIGY 2.2 AMPS 11.1V (3S) 1.5C.....	7
2.2.5.	BATTERY MULTISTAR 3.0 AMPS BATTERY 11.1V (3S) 20C	7
2.2.6.	HOBBYKING® B3AC COMPACT CHARGER.....	8
2.2.7.	APM KIT 2.6	8
3.	ASSEMBLY.....	8
3.1.	TOOLS FOR MOUNTING	8
3.2.	MECHANICAL ASSEMBLY.....	8
3.3.	ELECTRONIC ASSEMBLY.....	8
3.3.1.	APM 2.6 vs CC3D	8
3.3.2.	PRESET MOTORS	9
3.4.	CONNECTION DIAGRAM (APM 2.6).....	11
3.4.1.	INPUTS PORT APM 2.6 (RECEIVER RC)	11
3.4.2.	GPS	13
3.4.3.	TELEMETRY	14
3.4.4.	POWER MODULE.....	14
3.4.5.	OUTPUT PORTS APM 2.6 (MOTORS).....	15
3.5.	FINAL ASSEMBLY	16
4.	SETTING MISSION PLANNER.....	16
4.1.	BRIEF EXPLANATION ON THE FLIGHT MODES AND HOW THEY WORK.	22
5.	CHECKS.....	23



6.	PROPELLER COMPARATIVE	25
6.1.	CALCULATIONS:.....	29
6.2.	TESTS:	29
6.3.	PREMISES AND CONCLUSIONS:.....	29
6.4.	SPECIFICATIONS.....	30
6.5.	FIRST TESTS.....	31
6.6.	MAKING A LAB MACHINE AND TESTING.....	31
7.	PARTS OF A BASIC INJECTION MOULD AND HOW DOES IT WORK.	32
7.1.	PARTS OF A BASIC INJECTION MOULD.....	34
7.2.	THE MOST IMPORTANT PARTS	34
7.3.	OPERATION OF THE INJECTION OR FIXED PART.....	35
7.4.	OPERATION OF THE INJECTION OR FIXED PART.....	35
7.5.	OPERATION OF THE EJECTOR OR MOBILE PART	36
7.6.	OPERATION OF THE EJECTOR OR MOBILE PART	37
8.	CREATING DRONE PARTS ON A 3D PRINTER.....	37
8.1.	INTRODUCTION	37
8.2.	MODELING.....	37
8.3.	3D PRINTERS.....	37
8.4.	HOW TO ANALYZE A 3D PART?	38
8.5.	PRINT SETTINGS.....	38
8.6.	ADVANCED PRINT SETTINGS	38
8.7.	PREVIEW OF THE PART.....	39
8.8.	PART PRINTING.....	39
8.9.	LANDING GEAR.....	40
8.10.	CUSTOMIZATION.....	42
9.	FLOATING DESIGN.....	43
9.1.	BASED ON ARCHIMEDES' PRINCIPLE.....	43



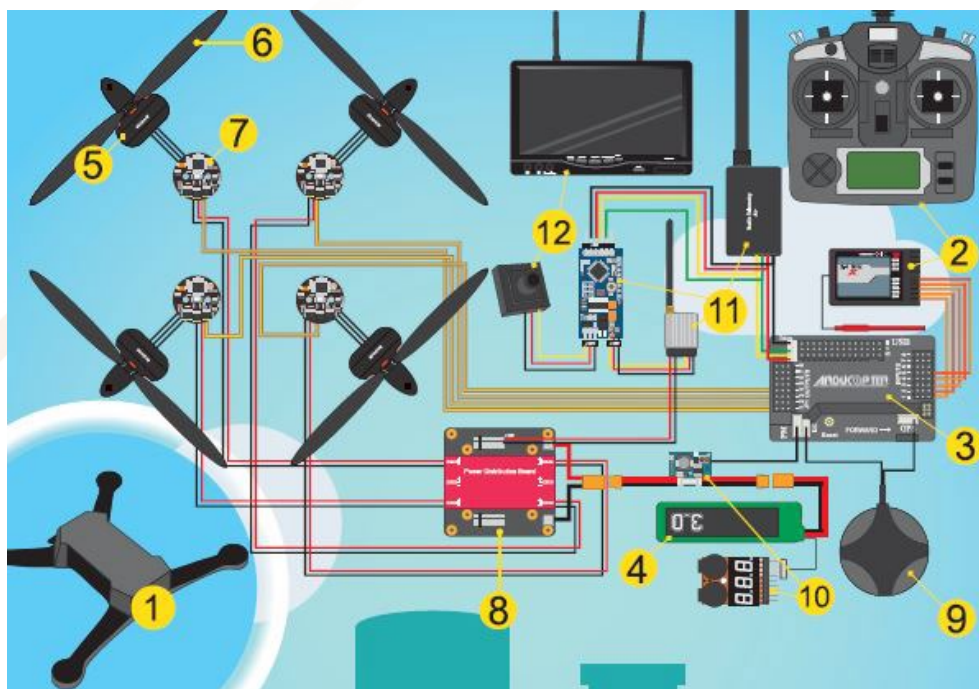
1. DRONE ADVANCED COMPONENTS

1.1. INTRODUCTION

Learning about all drone components. You can find all the information about advanced components.

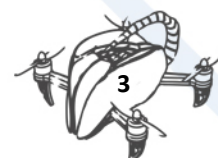
The advanced components are those components that aren't necessary for a drone to fly, but they make the flight experience better, as well as enabling the drone to perform scheduled routes. That is why, for a basic drone, they don't usually incorporate these components, but for advanced drones they are necessary. The advanced components that are usually incorporated are: GPS, Magnetometer, Gyroscope and Barometer.

First eight components are necessary to have a Basic Drone that can fly. The last four components are necessary to have an Advanced Drone with greater stability and greater flight possibilities:



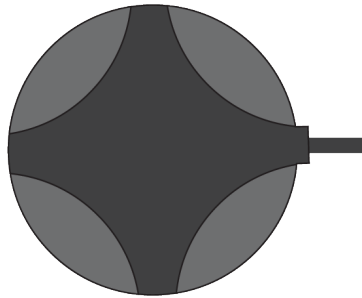
Download Poster. Link: <http://www.droneteamproject.eu/results/download-area2/231-posters-on-drone-components>

(Available in DIN A0 and DIN A2)



1.2. GPS

GPS provides latitude, longitude. Combined with a **Magnetometer** (direction), **Barometer** (elevation) **Accelerometer** (inertia), **Gyroscope** (position). It is needed for waypoint flying mode.



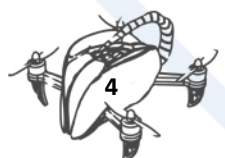
1.3. POWER MODULE.

Power module permit measure current consumption and provides a stable voltage. It allows triggering a warning when battery is near of its capacity or there is a power problem.



1.4. TELEMETRY

Telemetry, is used to collect data from mounted sensors. The data flow is bidirectional: it can send data about the flight to a Ground Station and send commands to the FC.





1.5. FPV

First Person View (FPV), allows viewing on a screen (e.g. smartphone) the view of the camera mounted. The camera may be mounted on a gimbal system to move and stabilise it.



The First Person View FPV system or real-time vision from a screen that receives the images from the drone camera is a system that consists of several components: the camera, the transmission system, the video receiver and the vision screen. In addition to the main elements, a drone can have a stabilising system of the camera, known as Gimbal. This system has the function of stabilising the camera, avoiding that the own inclination of the drone in its movements or the vibration of the motors can affect the quality of the images. In the most advanced drones, it is possible for an operator to independently operate the camera by moving the Gimbal system according to the needs. These cases are very interesting in the height inspection, where the pilot drives the drone and the camera operator manages the Gimbal camera.

2. DRONE ADVANCED ASSEMBLY

2.1. INTRODUCTION

The propellers could cause injuries, therefore the Quadcopter never should be used around people or in situations where you can lose control and cause an accident that could hit a person or cause material damages.

Never place the propellers in the Quadcopter to be sure of the direction of rotation of these have been mounted and should to be controlled safely.

Never leave charging batteries unattended or exposed to direct sunlight.

Never allow the cell voltage of the battery drops below 3.3V in shock.

2.2. KIT CONTENTS

2.2.1. KIT S250 SPEDIX



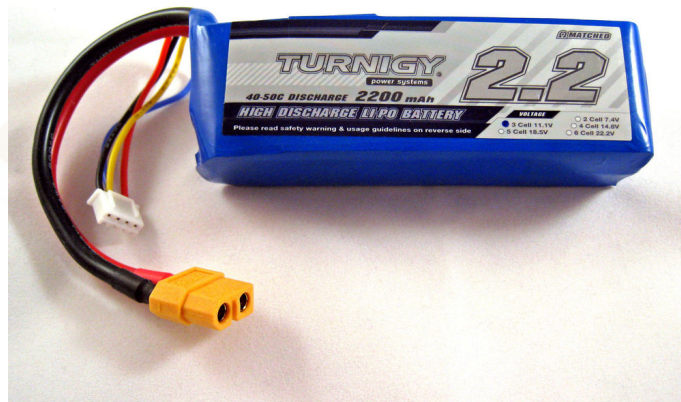
2.2.2. EXTRA PROPELLERS BLACK 5X4.5 (CW / CCW)



2.2.3. TURNIGY 9X 9CH & MODULE 8CH RECEIVER MODULE



2.2.4. BATTERY TURNIGY 2.2 AMPS 11.1V (3S) 1.5C



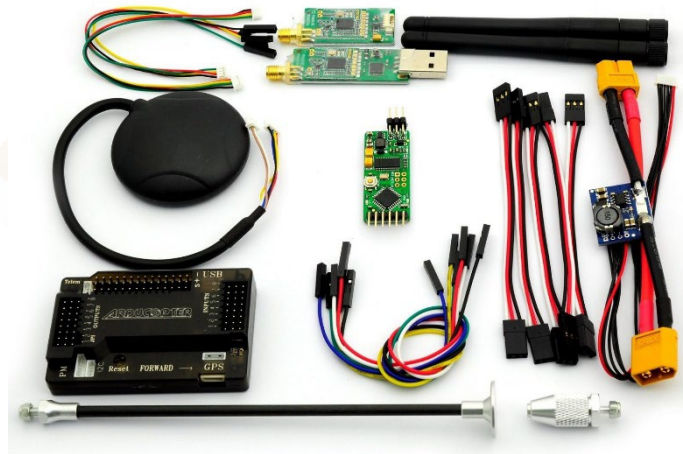
2.2.5. BATTERY MULTISTAR 3.0 AMPS BATTERY 11.1V (3S) 20C



2.2.6. HOBBYKING® B3AC COMPACT CHARGER



2.2.7. APM KIT 2.6



3. ASSEMBLY

3.1. TOOLS FOR MOUNTING

- Allen Wrenches.
- Phillips screwdriver.
- Tweezers
- Double-sided adhesive foam sticker

3.2. MECHANICAL ASSEMBLY

For chassis assembling, we should follow the manual accompanying the kit SPEDIX.

3.3. ELECTRONIC ASSEMBLY

3.3.1. APM 2.6 vs CC3D

The main differences between these autopilots are:



	<u>CC3D</u>	<u>APM 2.6</u>
Accelerometer	YES	YES
Gyroscope	YES	YES
Magnetometer	NO	YES
Barometer	NO	YES
GPS	NO	YES
Barometer	YES	YES
Battery Monitoring	NO	YES
Maximun motors No.	6	8

At first glance it can be seen that APM 2.6 is a higher version to CC3D both hardware and software. Thanks to the magnetometer and a barometer built 2.6 AMP control of two degrees of freedom to our drone (Altitude and YAW), degrees of freedom that could not be controlled with precision CC3D model are added. For the above and adding the GPS can say that this new model allows flight in automatic mode, the CC3D big change that allowed only a manual flight.

3.3.2. PRESET MOTORS

IMPORTANT: Make sure the propellers are not placed before performing the following steps.

Unlike CC3D, must be pre-set motors for greater motor performance. To do this, connect each motor with RC receiver channel 3 as shown in the following figure:

- **Why channel 3 of the receiver?**

This channel is transmitting the value of the transmitter stick corresponding to the throttle or also known as gas, which is the value that allows us to give power to the motors.

A solution to streamline this process, may be the implementation of the next plate of simple and quick installation:

Thus the final assembly would be:

It should be very careful with the wiring, all cables must be connected in the same sense of colours, as shown in the image.

You can also make individually calibrated as shown in the picture, repeating the action in all esc.



- **Why does this procedure do?**

The motors used for Spedix are called brushless motors. These motors work in conjunction with an ESC (Electronic Speed Controller) and APM to control them.

The APM processes the value that sends the station and he sends it to the ESC to vary the speed of the motors. As the value sent to the ESC is directly the value of the station, the motors must be prepared to don't start rolling just start moving the stick of the transmitter, so you change the minimum value that begin move motors with this procedure.

Once we make these steps, the procedure is as follows (for connecting both ways):

- Connect a tricolored cable channel 8 RC receiver to the port channel 8 OUTPUTS APM 2.6. This will cause the receiver to work when the battery is connected.
- With the transmitter battery still connected and disconnected, the throttle stick will move to its maximum position.

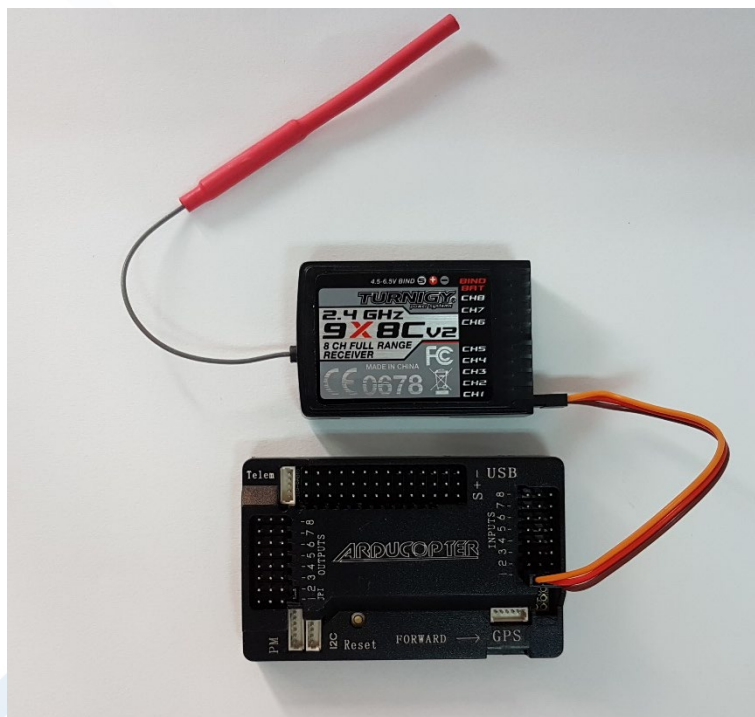
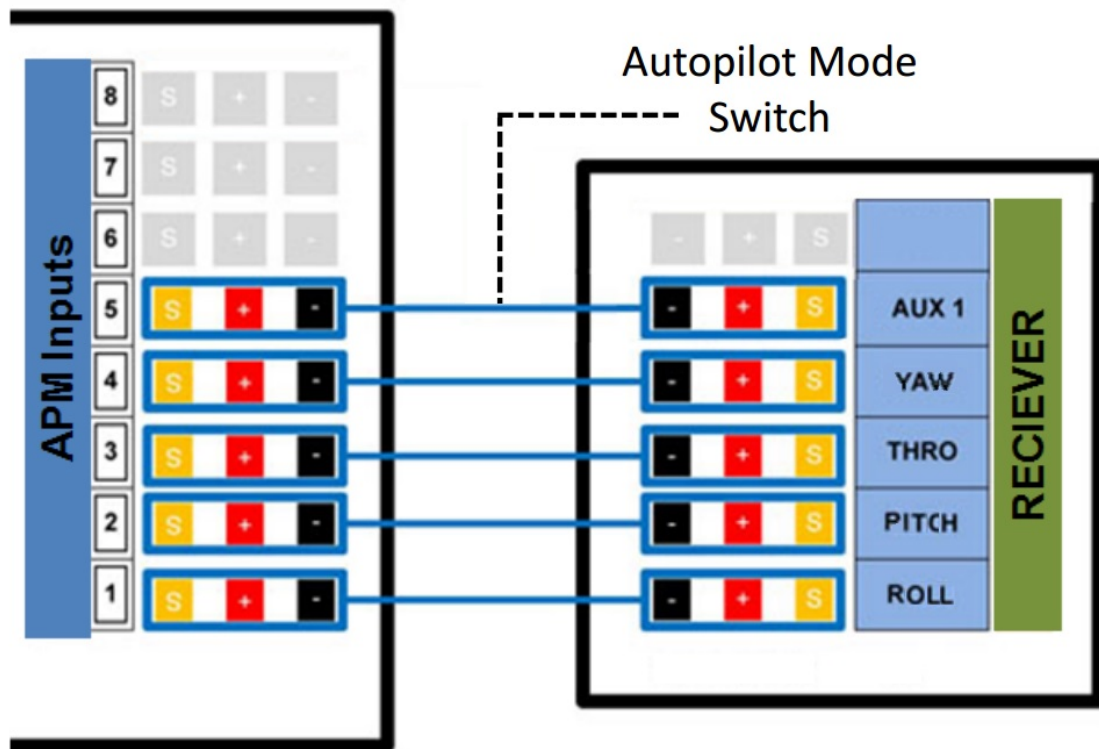
IMPORTANT: Be sure the propellers are not placed before the next step.

- Connect the battery, starting a small tune, followed by a short beep sounds.
- Move the throttle stick to a position about 25% of full throttle and leave it alone, two short beeps and long will be heard, this indicates that the procedure was successful.
- Place the throttle stick to the minimum and carefully check the throttle stick moving the motors begin to move about 25% of the value of the maximum throttle.



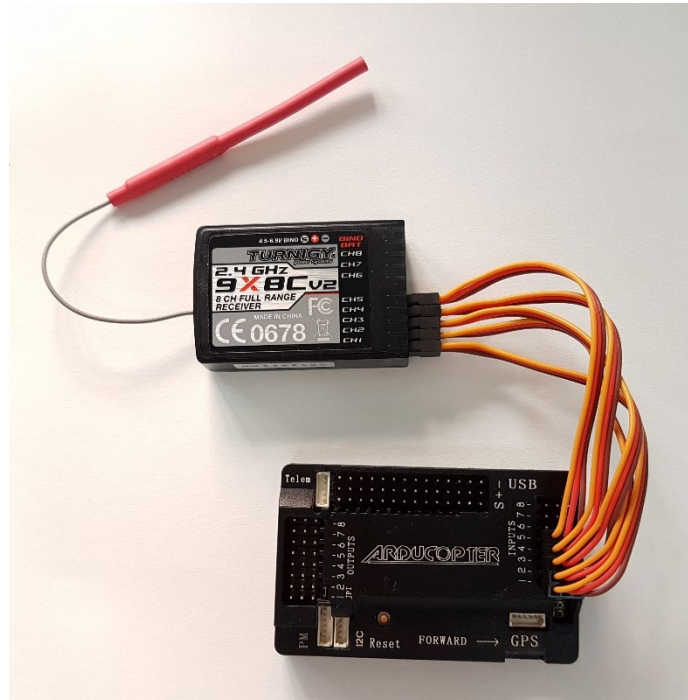
3.4. CONNECTION DIAGRAM (APM 2.6)

3.4.1. INPUTS PORT APM 2.6 (RECEIVER RC)

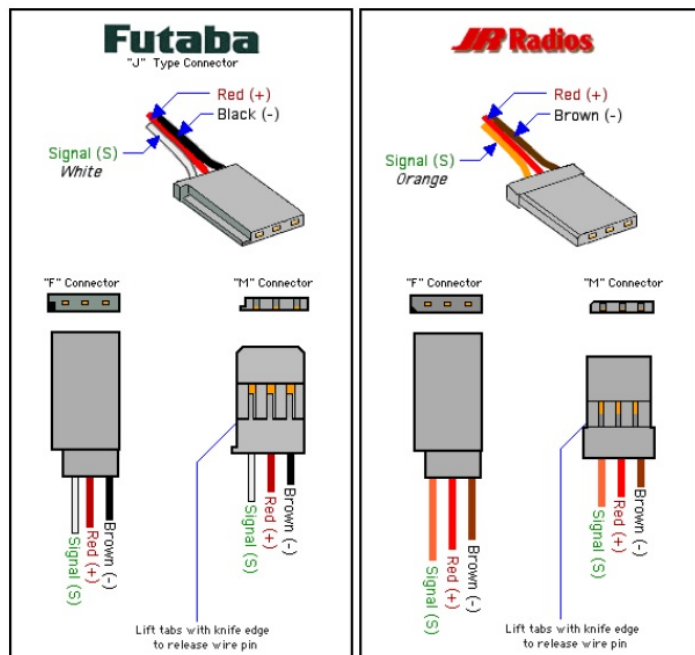
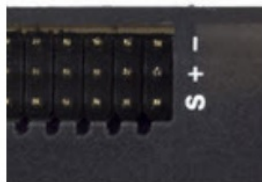


Connections between ArduPilot advanced controller (APM) and Drone Receiver:

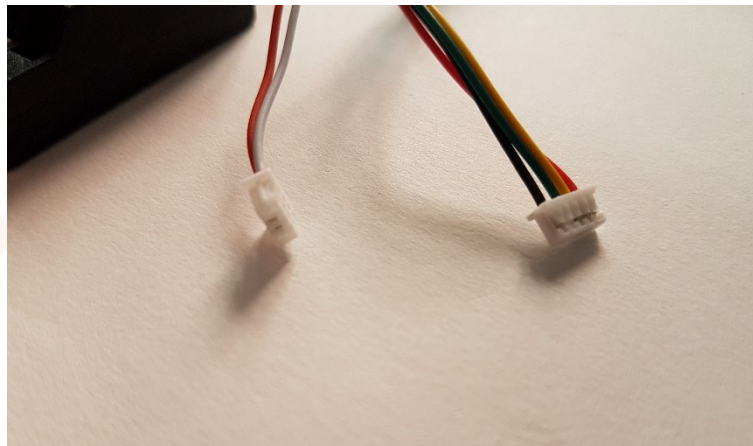
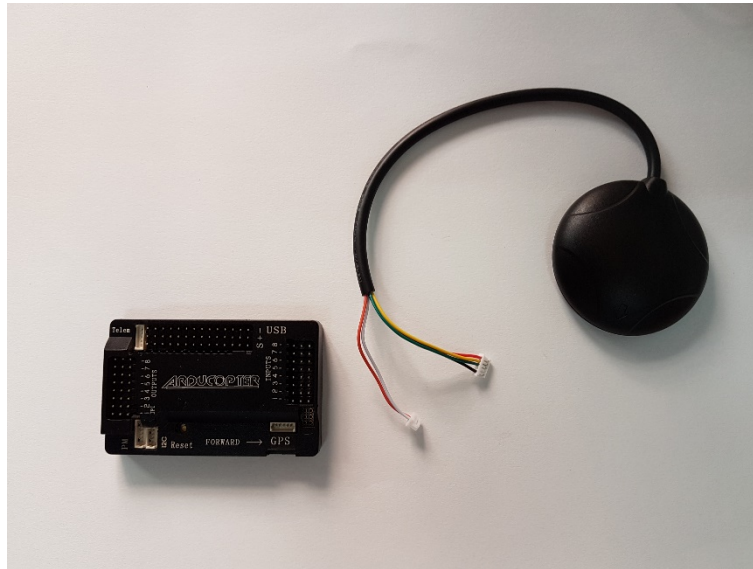




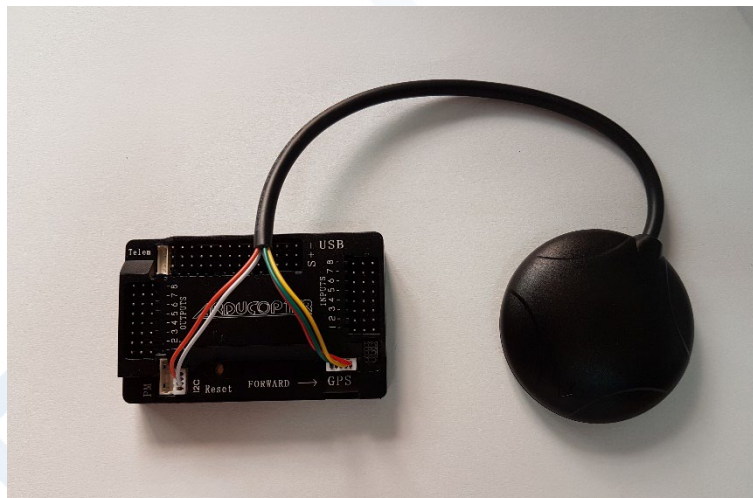
Look for markings like this -



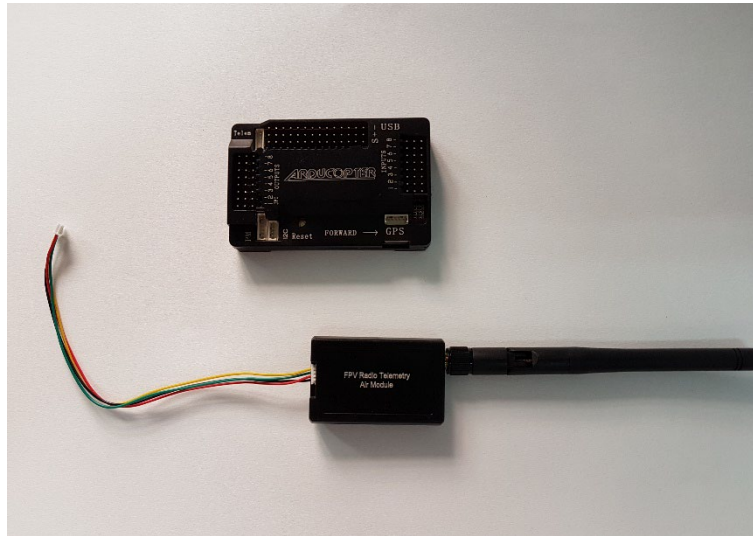
3.4.2. GPS



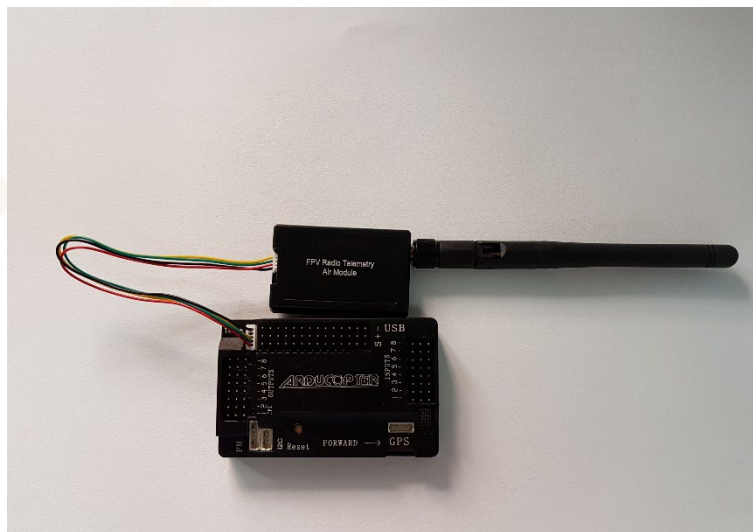
The connector with 2 wires must be connected to the I2C port (Magnetometer) and formed by 4 in the GPS connector, as shown in the following figure:



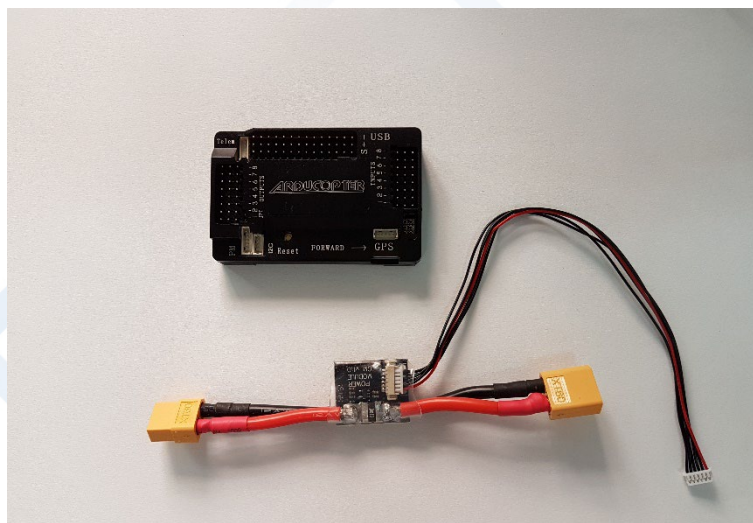
3.4.3. TELEMETRY



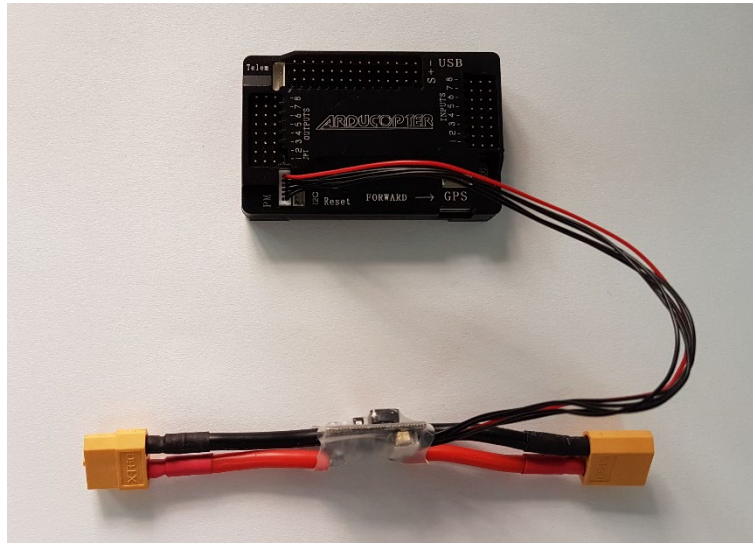
Telemetry must be connected to the TELEM connector, as shown in the following figure:



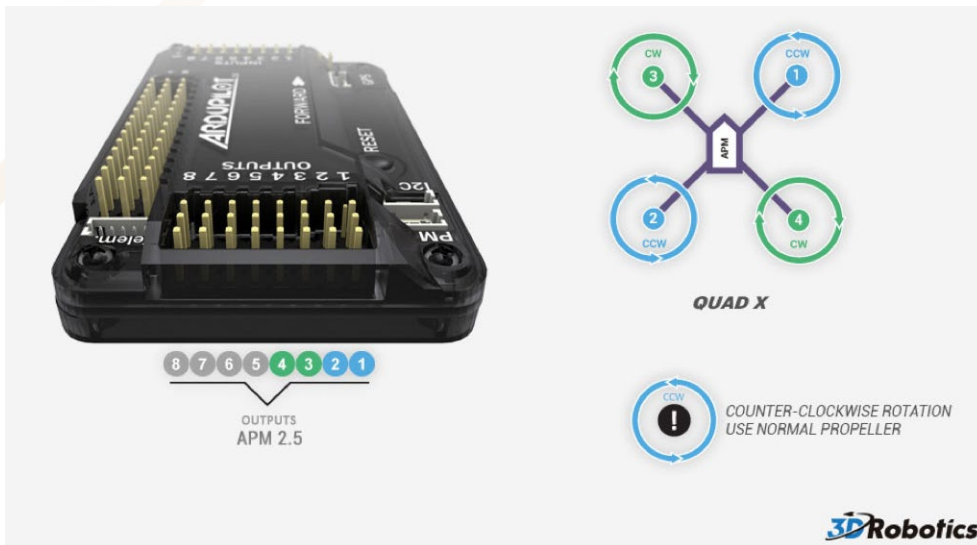
3.4.4. POWER MODULE



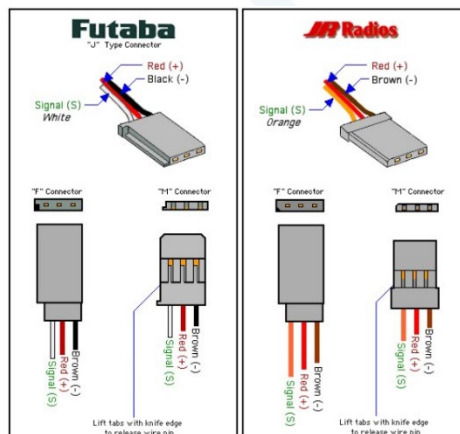
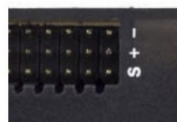
The "Power module" must be connected to the PM connector as shown in the figure below, this will allow us to know the battery voltage and ampere consumption of the motors.



3.4.5. OUTPUT PORTS APM 2.6 (MOTORS)



Look for markings like this -



3.5. FINAL ASSEMBLY

For correct mounting Spedix APM is it important to define the position in which certain components are placed.

(TAKE CARE TO THE RIGHT ADDRESSES AND MAGNETOMETER APM)

Once finished both electronic/mechanic assembly, it is suggested for the flight as follows:

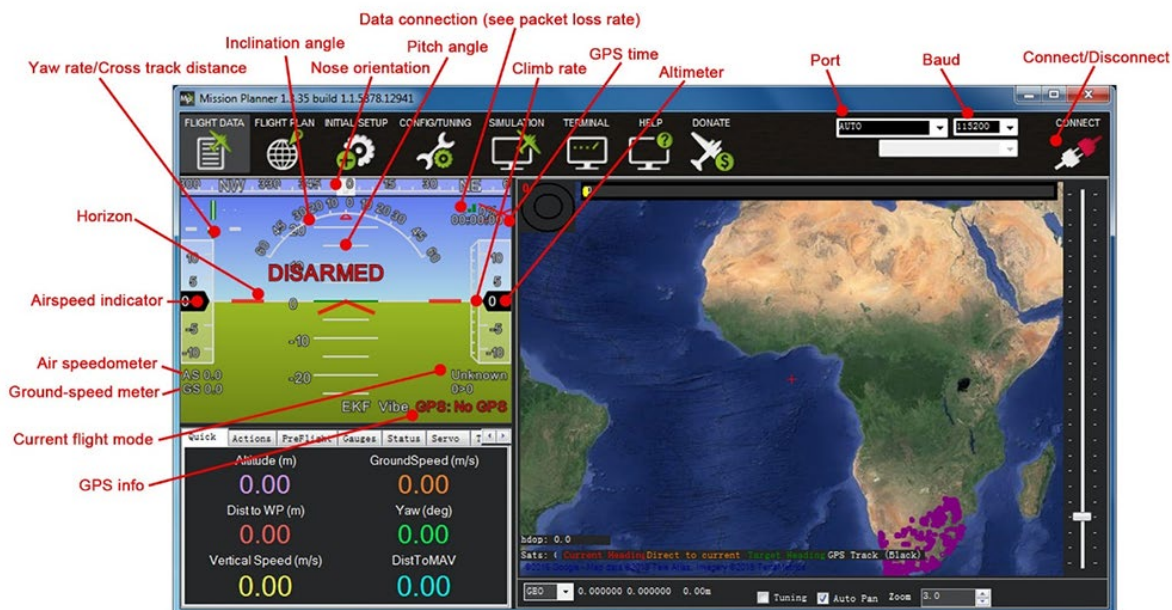


4. SETTING MISSION PLANNER

For optimal configuration of your drone, you can download the files from DroneTeam eLearning Platform (access from DroneTeam Webpage: <http://www.droneteamproject.eu/>)

Mission Planner is a platform created for configuring certain autopilots (ArduPilot, PixHawk ...) open source and free. Allow the configuration and monitoring for our autopilot data received from this.

- Connect your APM to the PC.
- Start the program, it is important do not update the program, although it is recommended, but this is a stable and fault-free software.



IMPORTANT: Make sure the blades are not placed before performing the following steps.

- In the upper right corner, a tab like the one shown below is appreciated. You must select the device to be connected (or Telemetry APM):

or If the device to be connected is your APM, you must select the option that reads "Arduino Mega 2560" and the secondary option "115200".

or If the device to be connected is the telemetry AutoPilot, you must select the appropriate port, in our case "Silicon Labs USB to UART CP210x" and the secondary option, select "57600".

- Press the "CONNECT" button.

A tab as the following, which first if everything is correct "DONE" will appear and then load a set of returning parameters. Wait until the tab disappears.

If an error occurs, it will start a countdown, to solve this problem, try the following solutions:

- or Reconnect the device and try again.
- or Make sure that the connection settings are correct.
- or restart the program.

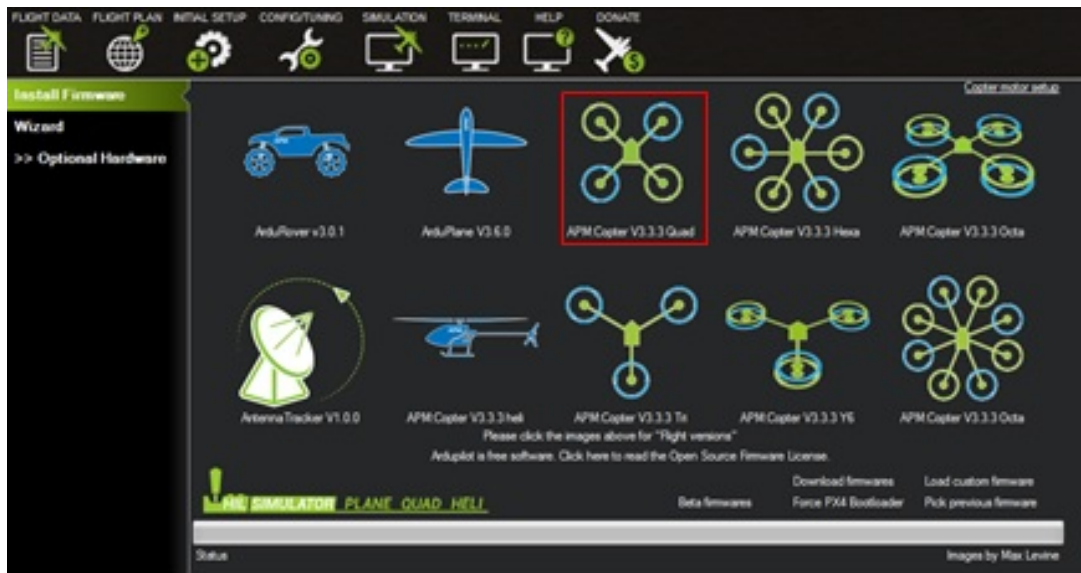
If everything is correct it will show the main screen again, this time showing real-time data AutoPilot.

- In the left upper, click "INITIAL SETUP". the screen will refresh and a small menu with 4 options appear. Click on "Install Firmware".



- As shown in the picture, it requests disconnection via MAVLink of the APM for upgrade. Click "DISCONNECT" on the top right of the screen.

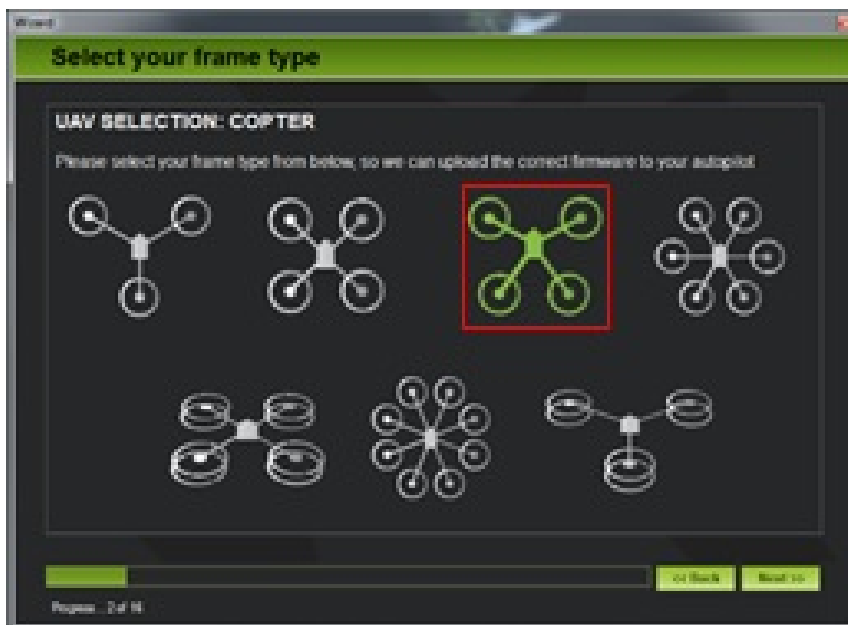
A small tab appears updating and checking the available versions for autopilots. Once complete that process a new screen like the one shown in the following image appears:



- Click on "APM: V3.3.3 Copter Quad", a tab will appear asking for upgrade confirmation, press "YES" and hope to finish the upgrade process.
- Click on the left side part of the "Wizard" option a tab such as that seen in the following image and proceeds to APM settings will be displayed.

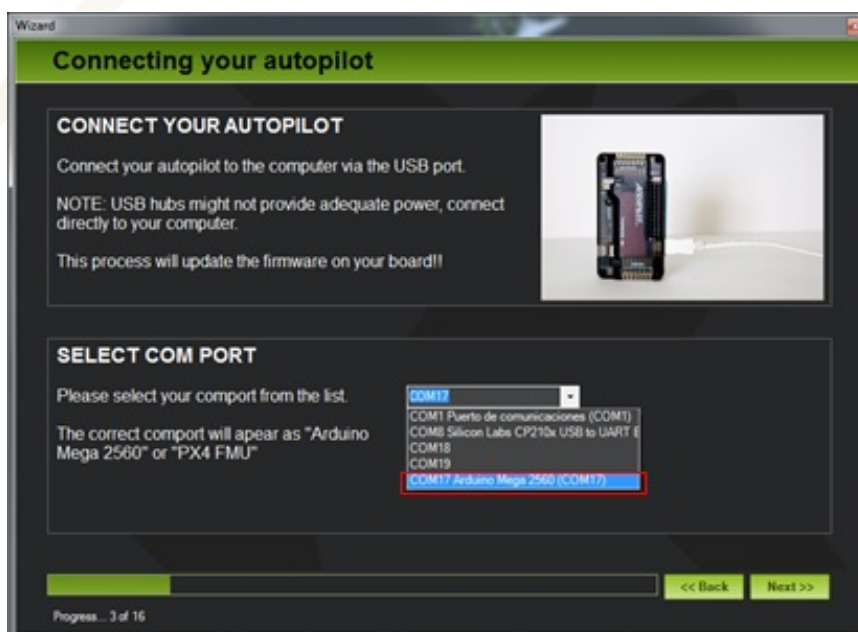


- Click on "Multirotor" and then on "Next".
- Selection of frames will be displayed. Click the Frame to configure, in this case in the "V" form, as shown in the following image and then press "Next".



IMPORTANT: For the next step is necessary that the APM is connected directly via USB to PC, invalid realize through telemetry.

Proceed to connect for update, select the port to APM (Arduino Mega 2560) and press "Next".



A small tab appears with the upgrade process.

IMPORTANT: Don't disconnect your APM during the firmware update or APM can be damaged.

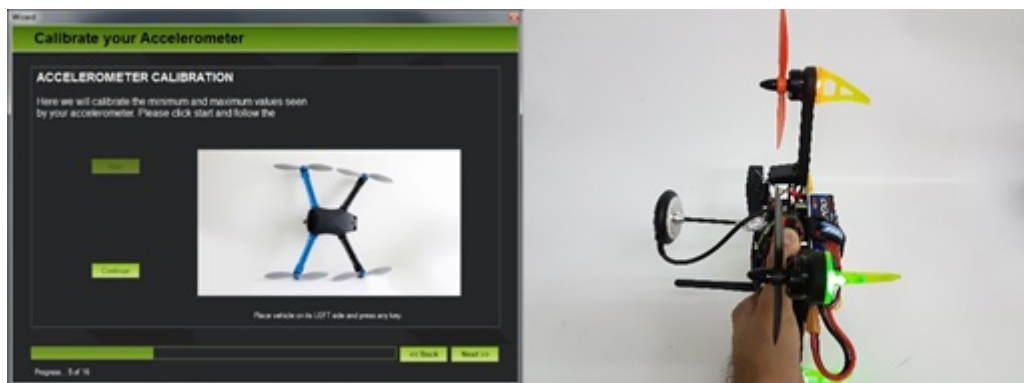
- Select Frame again in "V" as in the previous steps and click "Next".
- Then we proceed to calibrate the accelerometer APM, the following steps should be followed as quickly as possible, since the calibration has time between steps and if not met fail calibration:



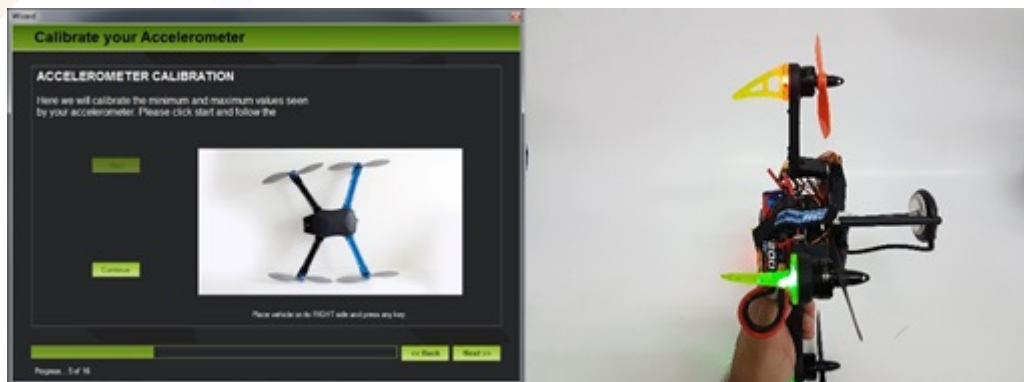
Press "START" and place the drone horizontally on a flat surface, as shown in the figure below. Once done, click "Continue".



Place the drone turned left 90 degrees as shown in the picture below and press "Continue".



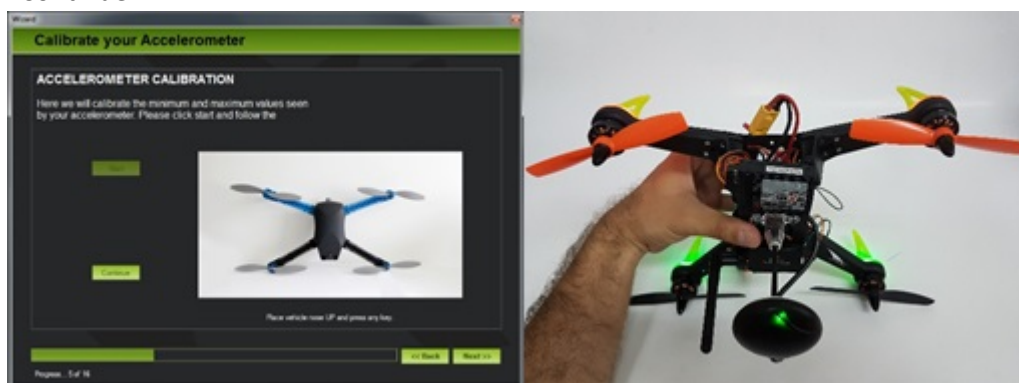
Place the drone turned right 90 degrees as shown in the picture below and press "Continue".



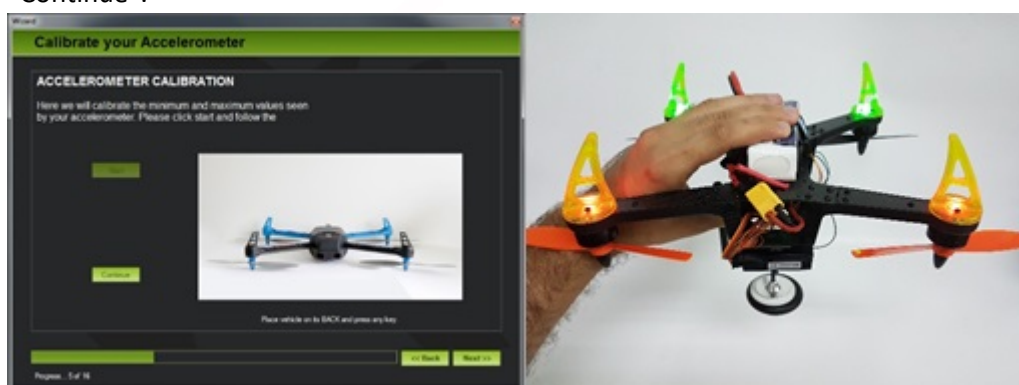
Place the drone tilting or 90 forward as shown in the picture below and press "Continue".



Place the drone or tilting 90 degrees backwards as shown in the picture below and press "Continue".



Place the drone tilting or 180 forward as shown in the picture below and press "Continue".



- If the process is completed correctly will show "Calibration successful" confirming that the process has completed successfully, as shown in the figure below.
- Then we proceed to the calibration of the magnetometer APM. For this test you need a compass to know where it is oriented north previously. Once known, the drone facing north and "Live Calibration" is pressed is placed.

The procedure is simple, we must approach each of the axes of the drone north, once faced you must turn the drone 360 ° around the axis.

Check that the option "Use auto accept" is marked in this way when they have received enough data automatically finish the whole process, returning to the previous display. Click "Next".

- Then the tab for configuring the power module is shown for it in the first option should be selected "2: APM2.5 - 3DR Power Module" in the second option should be selected "3DR Power Module" and the third section should be written the capacity of the batteries that are being used (in the case of using this tutorial, you should write "3000" mAh). Once finished click "Next".
- Then Sonar settings will appear, as have none connected, simply press "Next".
- Then the station settings will appear. Click "Continue".
- A new screen as shown in the following picture:

IMPORTANT: Make sure the blades are not placed before performing the following steps.

- Press "Calibrate Radio". The procedure is, move the sticks of the transmitter to extremes in all directions, including 3-position switch to select the flight mode.
- Once done the screen should be something like the following image:
- Press "Click when done" and wait a few seconds until a small sign confirming that the values have been stored.
- Once stored, press "Next". a new tab called "Flight Modes" appears, apply the values set out in the following image:
- Select flight mode 1 "Stabilize".
- Select flight mode 4 "AltHold".
- Select flight mode 6 "Land".

4.1. BRIEF EXPLANATION ON THE FLIGHT MODES AND HOW THEY WORK.

Flight mode

- **Stabilize:** The 'Stabilized' mode allows the vehicle to fly manually, auto levelling levels 'roll' and 'pitch'.
- **Altitude hold:** constant altitude mode allows the vehicle to maintain a constant altitude, allowing to modify the levels of 'roll', 'pitch' and 'yaw'.
- **Loiter:** It is a way to loiter, it tries to maintain the position and attitude ('roll', 'pitch', 'yaw' and altitude) of the vehicle. Pilots use the 'Loiter' mode like 'manual'.
- **RTL Mode:** In the 'Back to the launch site (Return To Land)' mode, the vehicle navigates from the current position in which it is to go flying around the area of initial release.
- **Auto Mode:** In automatic mode, the vehicle follows a previously scheduled flight plan stored in the autopilot which includes both the route such as where to take a picture.
- **Acro:** The acro mode (aerobatic mode) uses the sticks of the transmitter to control the vehicle turns. If the sticks are released, the vehicle maintains the altitude at which it is located. This mode is useful as its name suggests for aerobatics.
- **Sport:** The sport mode was designed to fly FPV and recording in difficult areas, since the vehicle can be positioned at an angle and hold it.
- **Drift:** The mode 'float' allows the user to fly the multicopter like a plane, automatic coordinated times.
- **Guided Mode:** The guided mode is a feature of APM. The guide wirelessly vehicle to a location using a wireless telemetry module and an application on the ground station.
- **Circle Mode:** The vehicle will sail in circles on the point of interest, with the front of the vehicle pointing to the centre.
- **Position Mode:** This is a mode similar to 'Loiter' mode but with manual control of the 'throttle' flight. This means that the vehicle maintains the attitude ('roll', 'pitch', 'yaw') and the position while allowing the operator to control the 'throttle' manually.
- **Land Mode:** The object of this mode is the automatic landing on the ground.
- **Follow me mode:** This mode is designed for the vehicle to follow the movements of the pilot, using telemetry and within a ground station.

Simple and Super Simple Modes: The 'Simple' and 'Super Simple' modes are used in combination with the Stabilize, Sport, Drift and Land modes to allow the pilot to control the movement of the vehicle from their own point of view, regardless of where they set the stand.



- Then press "Next". the "Verify" tab appears as shown in the following image, which will verify that all previous steps have been correctly performed.
- The first verification, "Verify GPS" may not appear in green, does not indicate that the GPS is not running, simply that it is not able to capture enough satellites to locate your position. This occurs when you set the GPS indoors where the GPS signal is severely attenuated.
- The last check "Verify Pre-Arm Test" appear in red, check that the transmitter and APM communicate properly and is able to arm themselves to fly.

IMPORTANT: Make sure the blades are not placed before performing the following steps.

- Connect the transmitter and slide the stick 'Throttle' down and then to the right for 5 seconds.
- If the process is successfully completed, the "Pre-Arm Test Verify" box will change colour to green.
- Press "Next". the "Failsafe" tab appears. This set of options protect the vehicle during flight to certain mishaps, such as loss of ground station battery level or below the recommended minimum.

It is important to note that with a battery down the drone will return to the take-off point, so it can cause problems inside, so we must have the fail safe mode off when we fly indoors.

- Press "Next". the "GeoFence Settings" tab appears. This set of options allows you to define a flight zone which the vehicle may not exceed.

It is recommended to turn on outdoor test flights so that aircraft do not leave your virtual frame. It can cause failures in indoor flights, so it is recommended to disable the option in indoor flights.

- Press "Next" and the last tab of the "Wizard" Mission Planner, in which certain pages to read and expand knowledge about APM Mission Planner and recommended appear.

5. CHECKS

Before the first flight, it is advisable to always check certain steps. A series of checks and possible solutions are as follows:

If this does not happen:

- Check if the computer recognizes the telemetry device correctly.
- Check that the connection with the APM telemetry is correct and the device is being fed properly.
- Check that the stick 'Throttle' is at the minimum value when the battery is connected and starts the APM.
- Check that the 'Roll', 'Pitch' and 'Yaw' are correctly oriented, that is, the APM revolves representation of the main screen and the controls correctly responds in the right direction.
 - If the orientation of the 'Roll', 'Pitch' and 'Yaw' in their representation does not correspond to what should, must check if the APM incorrectly placed inside the



vehicle. If you placed rotated, you can be changed without changing the assembly. For that:

- Access to the "CONFIG / TUNING" tab on the "Full Parameter Tree" option. Within this tab are all data records APM. We must seek "AHRS" family and then choose the "AHRS_ORIENTATION" parameter taking into account the direction of APM. The most common mistake is to place the APM turned "Yaw 180".
- Press the "Write Params" button so that the changes are made.
- Recheck the main tab apm response is correct.
 - If the APM does not respond in accordance with the instructions that are sent from the station, you have to check first instance that the sticks are not reversed. To do this go to the "INITIAL SETUP" tab to the "mandatary HARDWARE" option and select it "Radio Calibration".

Testing is simple, move the sticks and display the answer.

Example: Move Roll to the right, the screen should display as the green bar Roll call must be filled to the right. Do the same on all sticks all except the pitch. This bar should run inverted to stick to the station, that is, if you move the stick up, the bar must be filled down.

If any of the controls are reversed follow these steps:

- Access the "CONFIG / TUNING" tab on the "Full Parameter Tree" option.

Depending on the channel that has to invest must access a different record:

- If the pitch is reversed access the "RC1" family and in the "RC1_REV" choose the inverted value.
- If the Roll is inverted access the "RC2" family and in the "RC2_REV" choose the inverted value.
- If the Throttle is inverted access the "RC3" family and in the "RC3_REV" choose the inverted value.
- If the Yaw is inverted access the "RC4" family and in the "RC4_REV" choose the inverted value.
- Press the "Write Params" button so that the changes are made.
- Return to the "Radio Calibration" option and check again that everything works correctly after the change.



6. PROPELLER COMPARATIVE



Parameters controlled:

- Consumption in amps
- Revolutions per minute
- Volts on the battery
- Thrust in real grams on the structure of the drone

Propellers used on test:

- Propeller Nr1 ref. 6045



- Propeller Nr2 ref. 6030



- Propeller Nr3 ref. 5045 3B



- Propeller Nr4 ref. 5045 BN 3B



- Propeller Nr5 ref. 5045 Drone



- Propeller Nr6 ref. 5045 High Efficiency



- Propeller Nr7 ref. 5030



6.1. CALCULATIONS:

- Calculations

Volts \rightarrow
 Amps \rightarrow Power consumption (w) = Volts * Amps

Thrust (g).

Efficiency = Thrust (g)/Power consumption (w)

When r.p.m. is constant \rightarrow 10.000 r.p.m.
 \rightarrow 15.000 r.p.m.

6.2. TESTS:

Propellers	Diameter	Pitch	Colour	Amps	Thrust (g)	rpm	Volts	Power (w)	Efficency gr/w	Average Ef	Average Ef	Average T(g)
6045L	152.4	114.3	Green	4.6	270	10000	12	55.2	4.9	4.3	4.7	273.5
				11.5	500	15000	12	138.0	3.6			
6030	152.4	76.2	Black	1.4	99	10000	12.2	17.1	5.8	5.1		
				4.1	225	15000	12.2	50.0	4.5			
5045 3B	127	114.3	Green	2.1	108	10000	12	25.2	4.3	4.1		
				6.9	320	15000	12	82.8	3.9			
5045 BN 3B	127	114.3		2.9	204	10000	11.9	34.5	5.9	4.9	4.5	260
				8.8	408	15000	11.9	104.7	3.9			
5045 Drone	127	114.3	Green	1.2	75	10000	12.6	15.1	5.0	4.6		
				3.9	208	15000	12.6	49.1	4.2			
5045 BN	127	114.3	Black	1.6	114	10000	12.5	20.0	5.7	5.1	4.9	155.2
				5.1	293	15000	12.5	63.8	4.6			
5030	127	76.2	Green	1.1	66	10000	12.5	13.8	4.8	4.9		
				2.8	175	15000	12.5	35.0	5.0			

6.3. PREMISES AND CONCLUSIONS:

The thrust on the structure of the drone and the measurements are absolutely real

	rpm	Blades	Thrust	Efficency
Lower speed higher efficiency	10000 \rightarrow 15000 (50% \uparrow)			5.2 \rightarrow 4.2 (20% \downarrow)
Two blades are more efficient		2B \rightarrow 3B		4.9 \rightarrow 4.5 (8% \downarrow)
Three blades are more powerful		2B \rightarrow 3B	155.2 \rightarrow 260 (68% \uparrow)	
Higher diameter more powerful		ϕ 5" \rightarrow ϕ 6"	155.2 \rightarrow 273.5 (76% \uparrow)	



6.4. SPECIFICATIONS

WHAT DOES THE NUMBERS MEAN IN THE HELIX OF A RACE DRONE?

L (long) x **P** (pitch) x **N** (number of blades)

- The first number is the size of the helix in inches.
- The second set of numbers indicates the pitch of the helix in inches.
- The last number will specify the number of propeller blades.

In addition, you can also add letters;

- **BN**, Bullnose, type of trimmed propeller.

The Bullnose type are not very efficient but they get a greater boost and their consumption is high. This is due to the fact that they have a greater surface area than you finish them in tip.

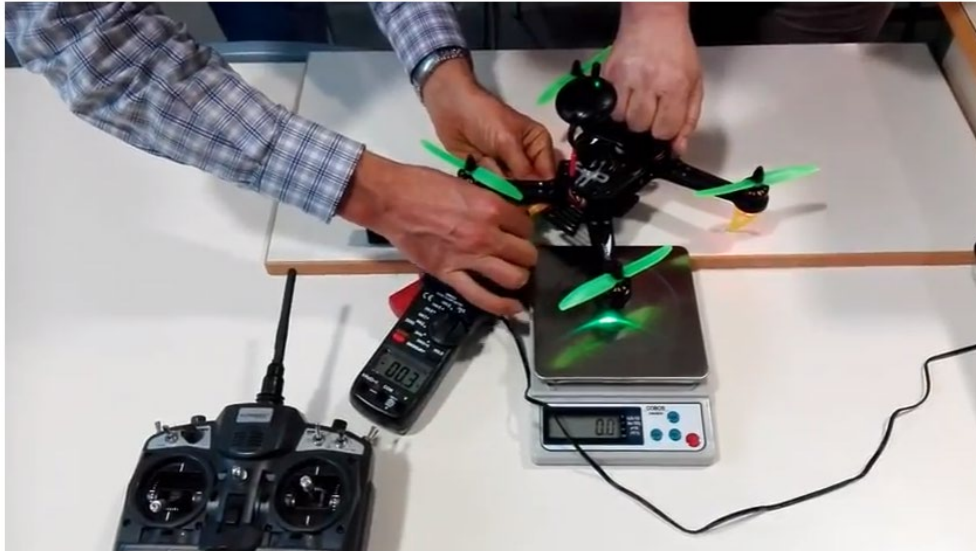
- **R**, Propellers that must be mounted on the motor clockwise.
- **L**, Propellers that must be mounted on the motor counter clockwise.



WHAT IS THE SENSE OF TURNING ON A DRON'S HELIX?

In each drone, there are two engines that rotate clockwise **CW** and two counter clockwise, **CCW** (counter clockwise).

6.5. FIRST TESTS



First Test Video: <https://youtu.be/t6jLUsmHzDI>

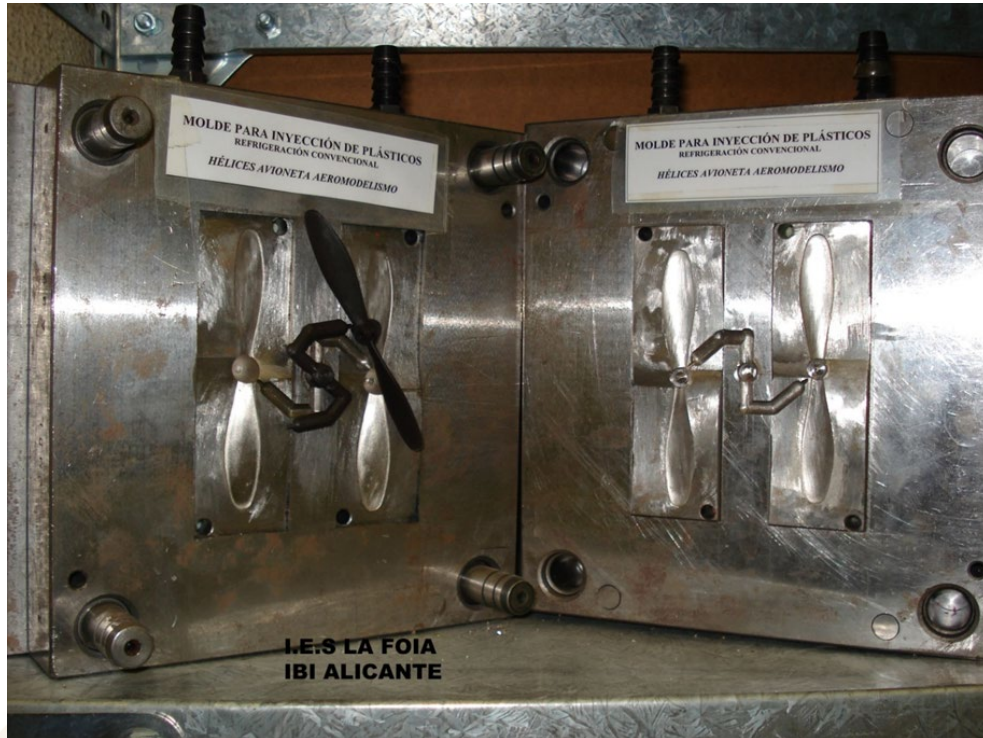
6.6. MAKING A LAB MACHINE AND TESTING



Video Link: <https://youtu.be/pgUqAcB3Y5s>

7. PARTS OF A BASIC INJECTION MOULD AND HOW DOES IT WORK.

Propellers mould explaining step by step:



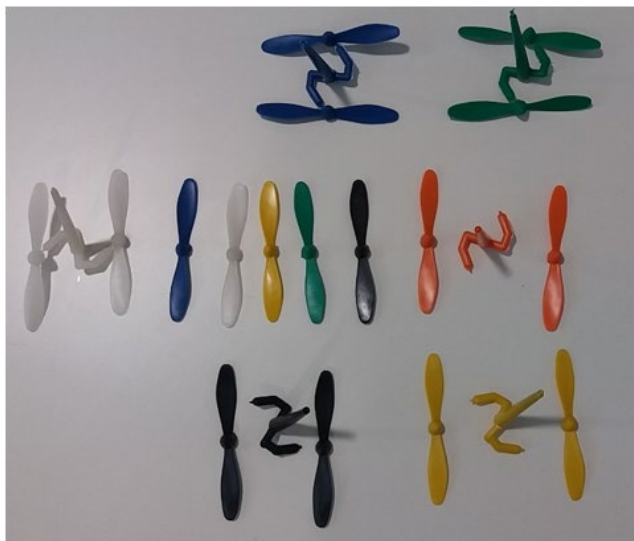
In February 2018, we injected some pieces using this mould in our injection moulding machine.



For this, we installed our mould in the injection moulding machine.

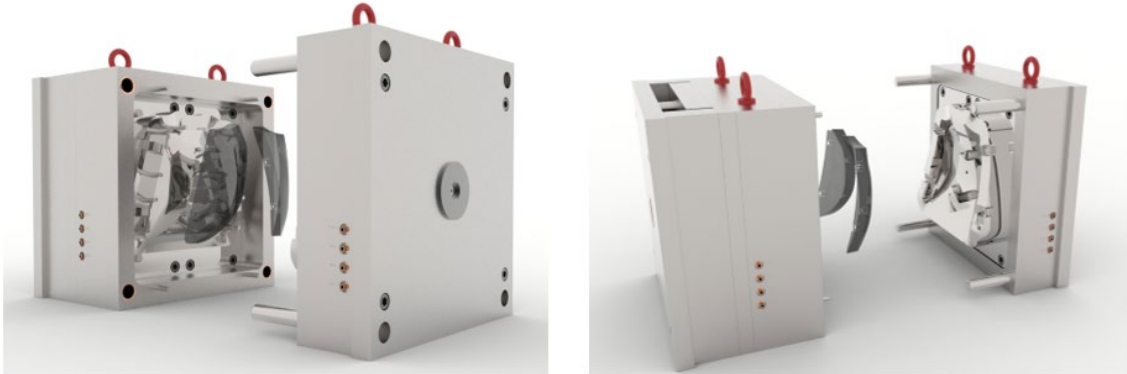


We made pieces with several materials and different colours.

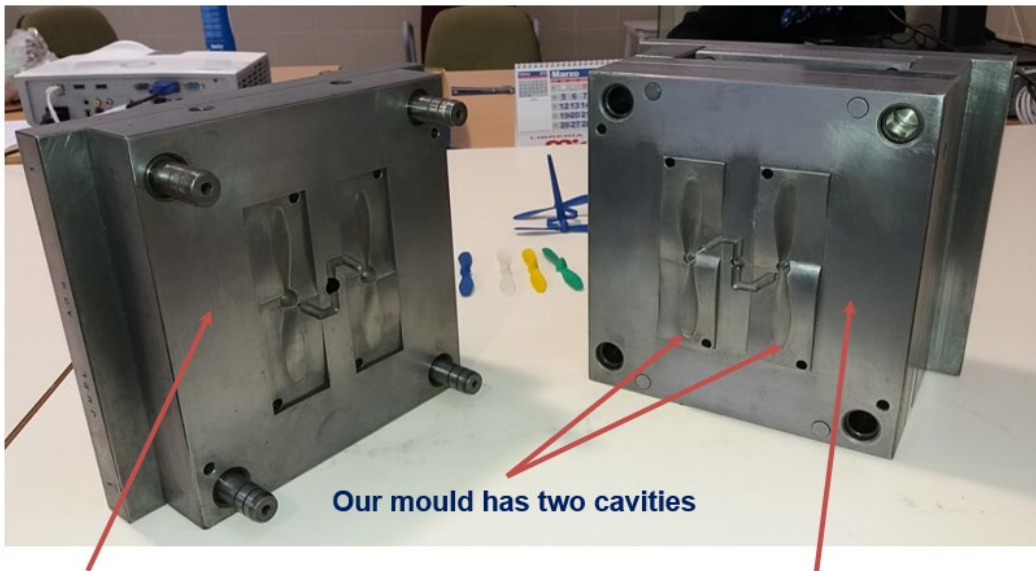


7.1. PARTS OF A BASIC INJECTION MOULD

Which are the parts of a basic injection mould and how does it work?



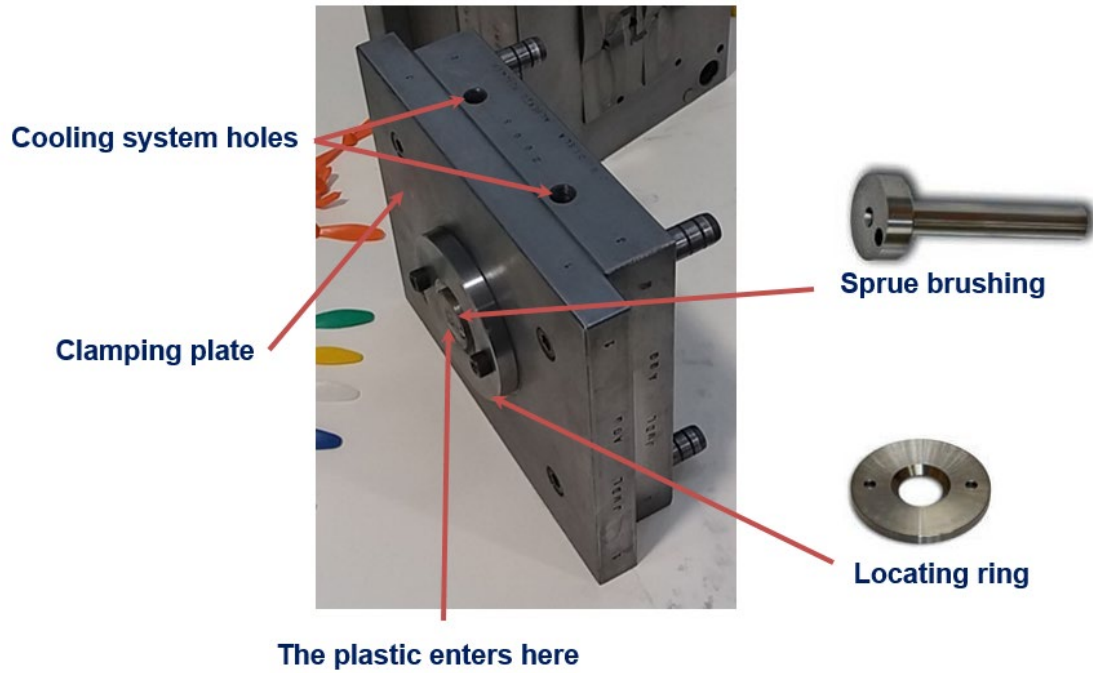
7.2. THE MOST IMPORTANT PARTS



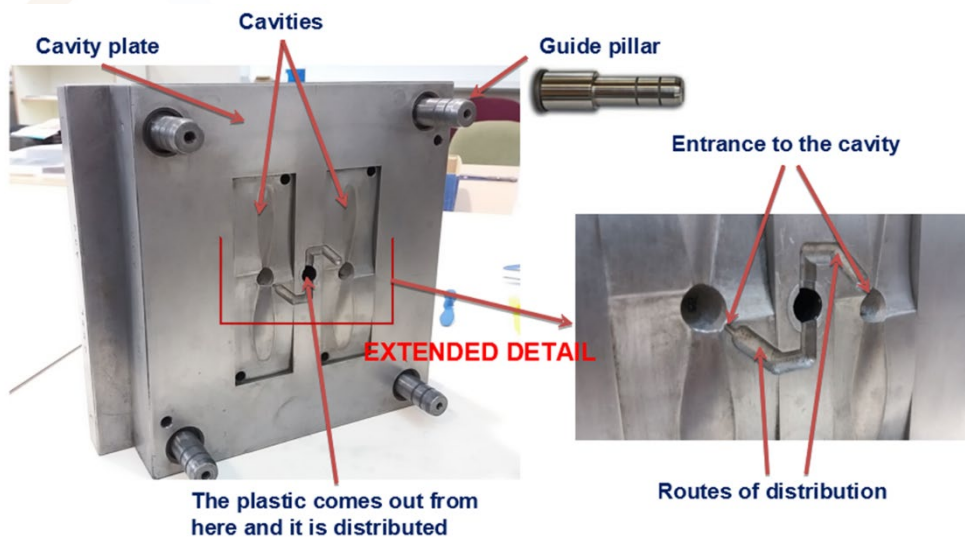
Injection or fixed part

Ejector or mobile part

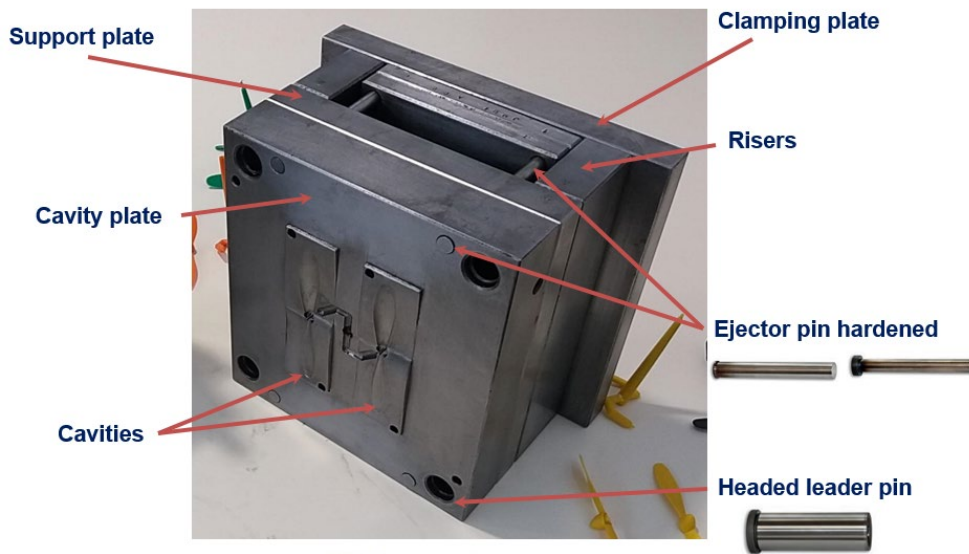
7.3. OPERATION OF THE INJECTION OR FIXED PART



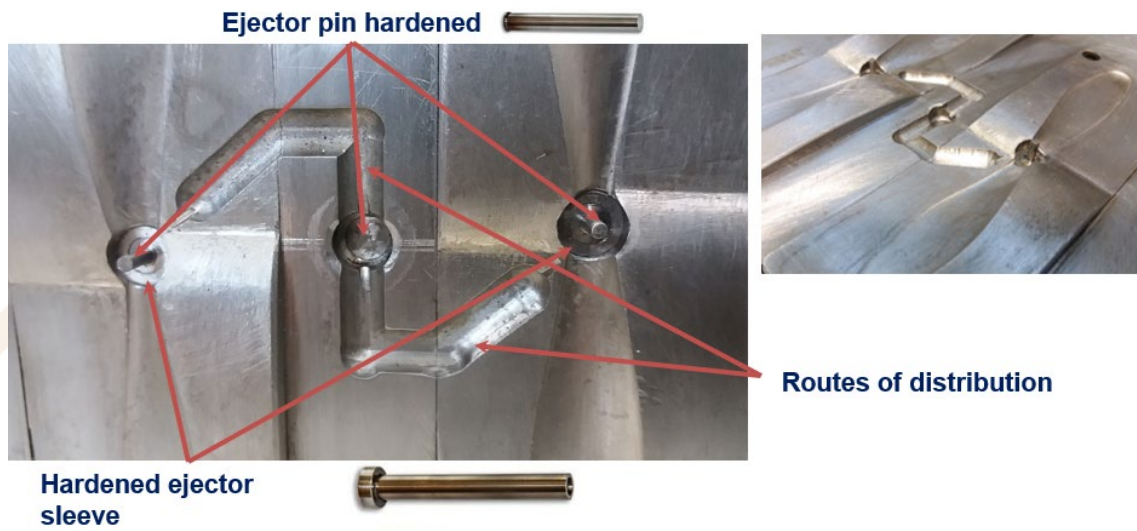
7.4. OPERATION OF THE INJECTION OR FIXED PART



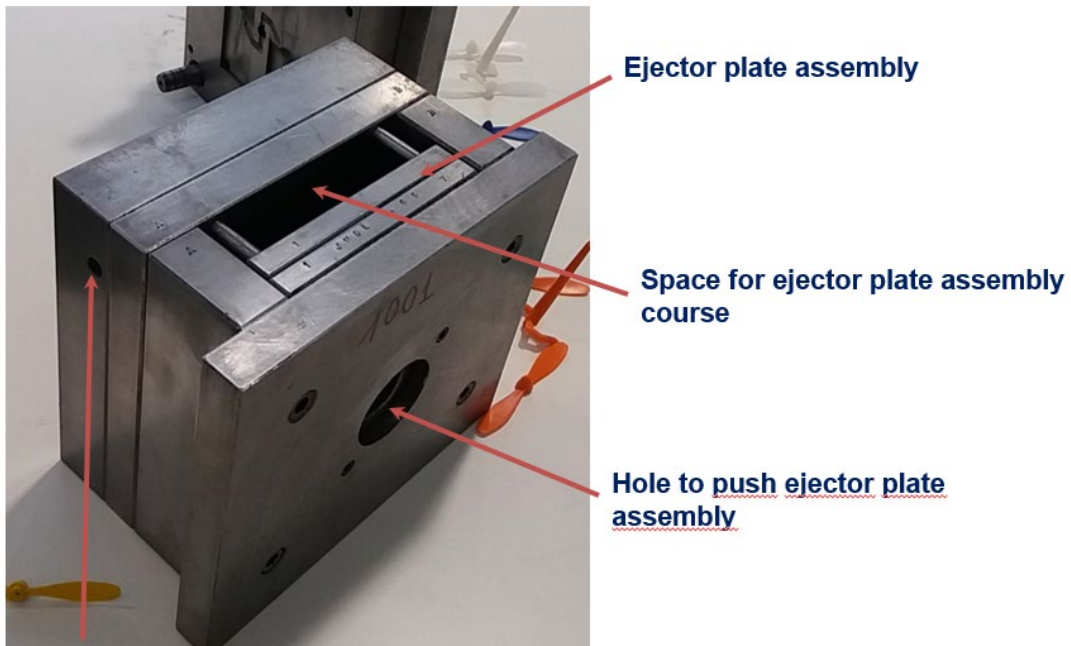
7.5. OPERATION OF THE EJECTOR OR MOBILE PART



IMAGES EXTENDED DETAIL WITH THE EJECTOR SYSTEM



7.6. OPERATION OF THE EJECTOR OR MOBILE PART



Cooling system hole

8. CREATING DRONE PARTS ON A 3D PRINTER

8.1. INTRODUCTION

To create drone parts on a 3D printer, you first need to create a 3D model of parts that will be printed. This time we used the CATIA V5 R19 software package. In addition to this 3D modelling software package, any other software package designed for 3D modelling (Solid Works, Soled Edge, AutoCad etc.) can be used. In the CATIA software package we have developed a complete drone model consisting of antenna, battery, propeller, engine, controller, leg, engine mount, guard, lower and upper plate.

8.2. MODELING

Each part is modelled separately and then merged into the frame. We selected the support leg and the engine and propeller shield to be created on a 3D printer.

When 3D models are created and saved, we have to make the output file needed for printing on 3D printers. The output document must be in STL format.

8.3. 3D PRINTERS

The following 3D printers are available for printing parts:

- Printer Name: xyz da Vinci 1.0
- Maximum print area: 200 x 200 x 200 mm
- Resolution: 0.1 - 0.5 mm
- Printer name: German RepRap X400

- Maximum print area: 400 x 400 x 350 mm
- Resolution: minimum 0.01 mm
- Printer Name: ZORTRAX M300
- Maximum print area: 300 x 300 x 300 mm
- Resolution: 90 - 290 μ m

8.4. HOW TO ANALYZE A 3D PART?

The Zortrax M300 was selected for printing parts. The printer driver is Z-SUITE. After the program is started, we select the printer we are using. We choose the M300 printer.

After that, we load the file in STL format

In the lower right corner of the toolbar, we choose/press ANALYSIS to perform a 3D model analysis. In this case, the surface of the model is analysed and once the analysis is completed and the 3D model can be printed, the object will be green.

Then, in the lower right corner, press the SUPPORT button. Here, we determine printing support for those surfaces that are in the air and cannot be printed without physical contact with the base.

8.5. PRINT SETTINGS

The next step is to press the PRINT SETTINGS button (in the lower right corner).

We choose "Material Group" under printing options – here we choose whether the printing materials are Zortrax materials or External materials (the materials must be from Zortrax or other manufacturer). If Zortrax materials are selected, we choose from Z-HIPS, Z-GLASS, Z-PETG, Z-ESD, Z-PLA PRO, Z-ASA PRO.

After selecting the material, we select the print mode in the "PROFILE" menu. We can choose between SMALL PRINTS and LARGE PRINTS (for printing small and large parts), both of which can be HIGH QUALITY MODE and ECONOMY MODE (high quality printing and economy printing). In addition, SMOOTH FINISH can also be selected (curved transition between surfaces). When we choose a profile, we can save it with a "SAVE" button.

In the printing options we also choose "LAYER THICKNESS" (0.09 to 0.29 mm), "PRINT QUALITY" - HIGH, NORMAL, DRAFT (high, normal and low quality), "PATTERN" as a form of incomplete section and "INFIL DENSITY" to determine if the cross section is completely filled or if it has a given pattern at a certain percentage.

8.6. ADVANCED PRINT SETTINGS

If you select "ADVANCED" printing options, you will see a menu with advanced printing options

With the "ADVANCED" printing option, we can further choose the surface printing method: NORMAL, MESH, SOLID, SHELL.



With "**NORMAL**", we choose the type of printing in sequences with a certain distance depending on the selection of the fill size ("INFILL DENSITY").

With the "**MESH**" option the surface is printed from the outside in.

"**SOLID**" option is full.

"**SHELL**" prints only the outer shell of the object (we can choose the thickness of the outer shell with "WALL THICKNESS").

The "**SURFACE LAYERS**" option is used to select "TOP" (top) y "BOTTOM" (bottom) layers, "**OFFSETS**" is used to select an initial surface on which an object will be printed and we choose "**OUTER CONTOURS**" to determine how much the surface will be larger than the object contours, and "**HOLES**" as an additional option for printing holes.

8.7. PREVIEW OF THE PART

When we have set all printing options, we click on "**PREVIEW**". The window opens:

Here we see under "**REPORT**" all printing data: estimated print time 1h and 15 min, material usage 2.54 meters or 6 grams.

Selecting "**EXPORT FILE**" opens the window

8.8. PART PRINTING

We save a document prepared for printing on the SD card under a certain name (drone leg). We put the SD card in the printer and start printing.

In the same way, we will print other drone parts as well. As an example we also mention the propeller and motor shield.

The document was prepared: **propeller STL file**. We will print the shield by using the same procedure for setting the print parameters.

Download link: <http://www.droneteamproject.eu/results/download-area2/243-propeller-security-part-for-3d-printing>



8.9. LANDING GEAR

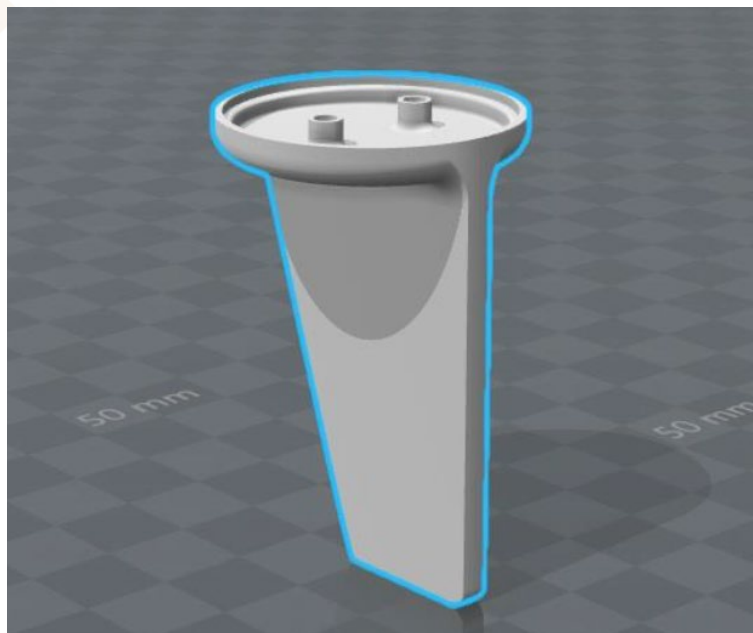
Main characteristics of the landing gear:

- It has to give space and protection to the ESC (Electronic Speed Controller),
- It has to be the lighter the better
- And it has to be strong to endure bumps, forces and efforts.

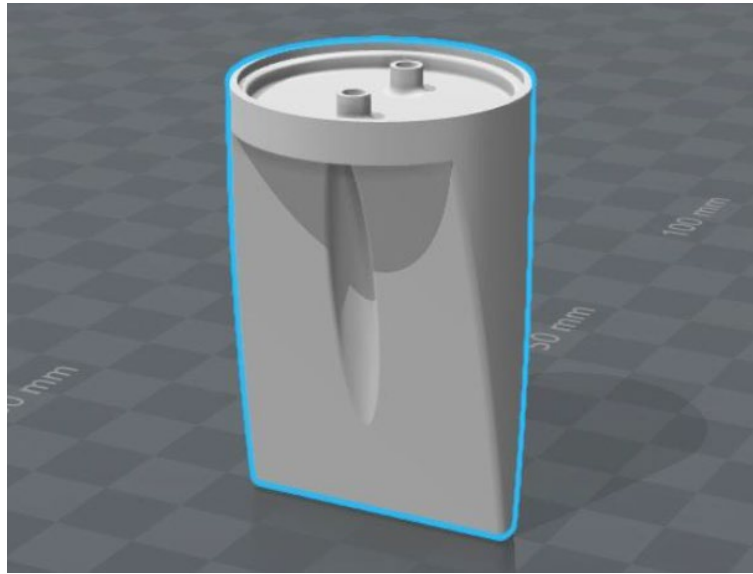
Original landing gear



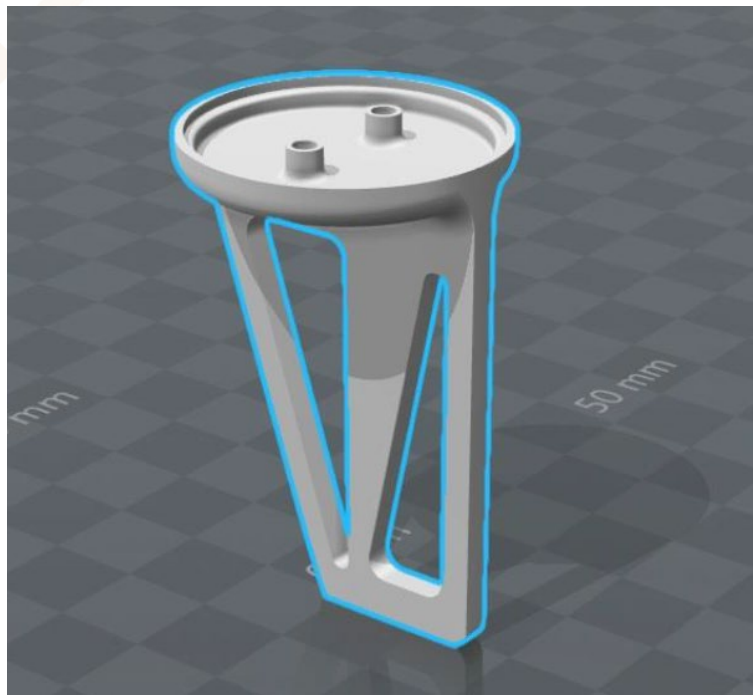
Simpler landing gear (5.6 grams):



Stronger landing gear design, it would be for beginners but the worst problem is that they weigh a lot (8.2 grams):



And lighter landing gear design, it would be for experts, because they break very easily (3.5 grams):



Download link: <http://www.droneteamproject.eu/results/download-area2>

8.10. CUSTOMIZATION.

Once the drone is assembled in all the components, it is possible to continue with the customization, designing a chassis. From the most complex to the simplest chassis, all are equally valid and it is a very interesting exercise for the students, who can design their chassis and print it in 3D.

For example, two chassis for advanced drone:

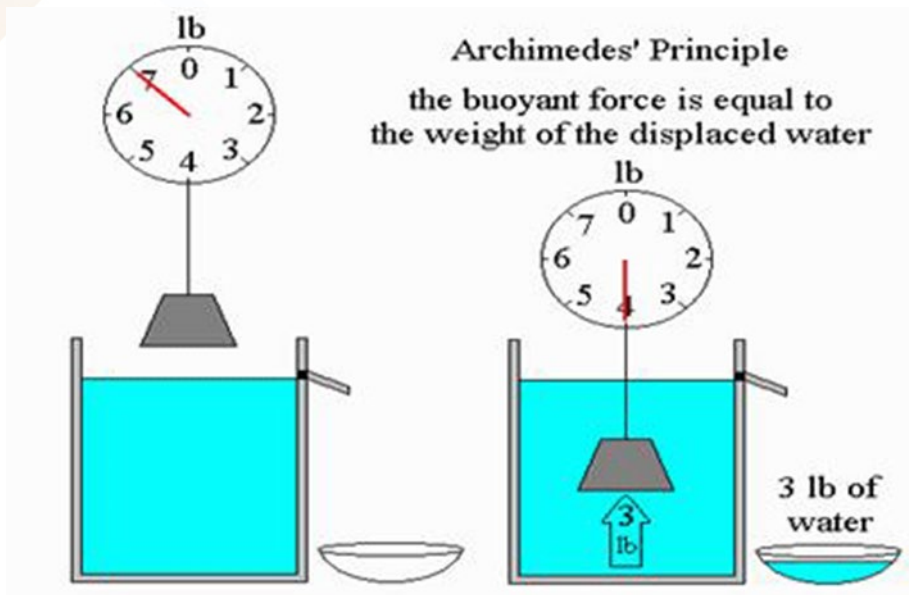


9. FLOATING DESIGN

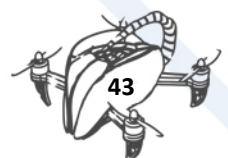
If we are going to fly a drone above the sea, a river or a lake, we need to be sure that it is going to float if it falls accidentally on them. The structure is made of ABS plastic with the 3D printer.



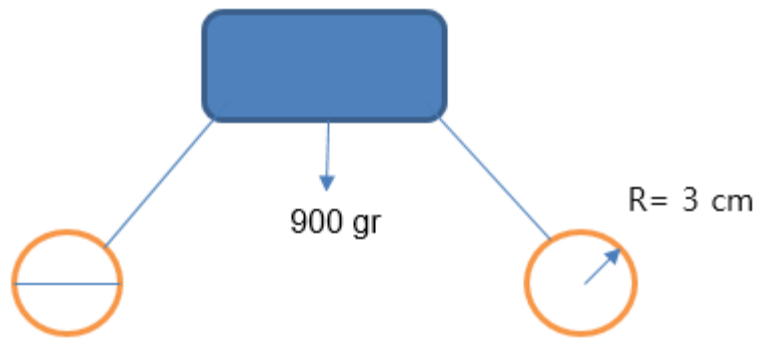
9.1. BASED ON ARCHIMEDES' PRINCIPLE



<https://physics.weber.edu/carroll/archimedes/principle.htm>



Applying to the drone, we need to install floats as big as necessary.



- V= Volume of floats
- R= Radio of floats
- L = Length of floats
- ρ = Density of water (1 g/cm^3)
- B= Buoyancy
- W = Weight (900 g)
- I need $B > \text{Weight} * 2$
- $B = 2 \text{ floats} * \pi * R^2 * L * \rho = 2 * \pi * 3^2 (\text{cm})^2 * 32 (\text{cm}) * 1 (\text{g/cm}^3) = 1800 \text{ g}$
- In this case the floats only sink half of them.

