PIX6

User Manual for Plane/Quadplane

(Compatible with Fixed wing/2-8 copter/Helicopter/VTOL/Car/Boat/Robot/Mower)

14+

SAFETY PRECAUTIONS

- Never operate models during adverse weather conditions. Poor visibility can cause disorientation and loss of control of pilots' model.
- Never use this product in a crowd or illegal areas.
- Always check all servos and their connections prior to each run.
- Always be sure about turning off the receiver before the transmitter.
- To ensure the best radio communication, please enjoy the flight/driving at the space without interference such as high voltage cable, communication base station or launching tower.

WARNING

This product is not a toy and is **NOT** suitable for children under the age of 18. Adults should keep the product out of the reach of children and exercise caution when operating this product in the presence of children.
Water or moisture may enter the transmitter inside through gaps in the antenna or joystick and cause model instability, even out of control. If running in the wet weather (such as game) is inevitable, always use plastic bags or waterproof cloth to cover the transmitter.

FCC Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
-- Reorient or relocate the receiving antenna.
-- Increase the separation between the equipment and receiver.
-- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
-- Consult the dealer or an experienced radio/TV technician for help.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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1. PIX6 Introduction

1.1 Spare Parts

Flight Controller ×1

Buzzer ×1

Safety Switch ×1

Power Module (2-12S) ×1

4G TF (MicroSD) Card ×1

CAN1/2 Port Connect Cable ×2

DSM RC Port Connect Cable ×1

TELEM1/2 Port Connect Cable ×2

ADC 6V6 Port Connect Cable ×1

ADC 3V3 Port Connect Cable ×1

OSD Port Connect Cable ×1

GPS1/2 Port Connect Cable ×2

SWITCH Port Connect Cable ×1

I2C Port Connect Cable ×1

SPI Port Connect Cable ×1

POWER1 Port Connect Cable ×1

POWER2 Port Connect Cable ×1

Debug Port Connect Cable ×1

Receiver Connect Cable ×1

USB Port Connect Cable ×1

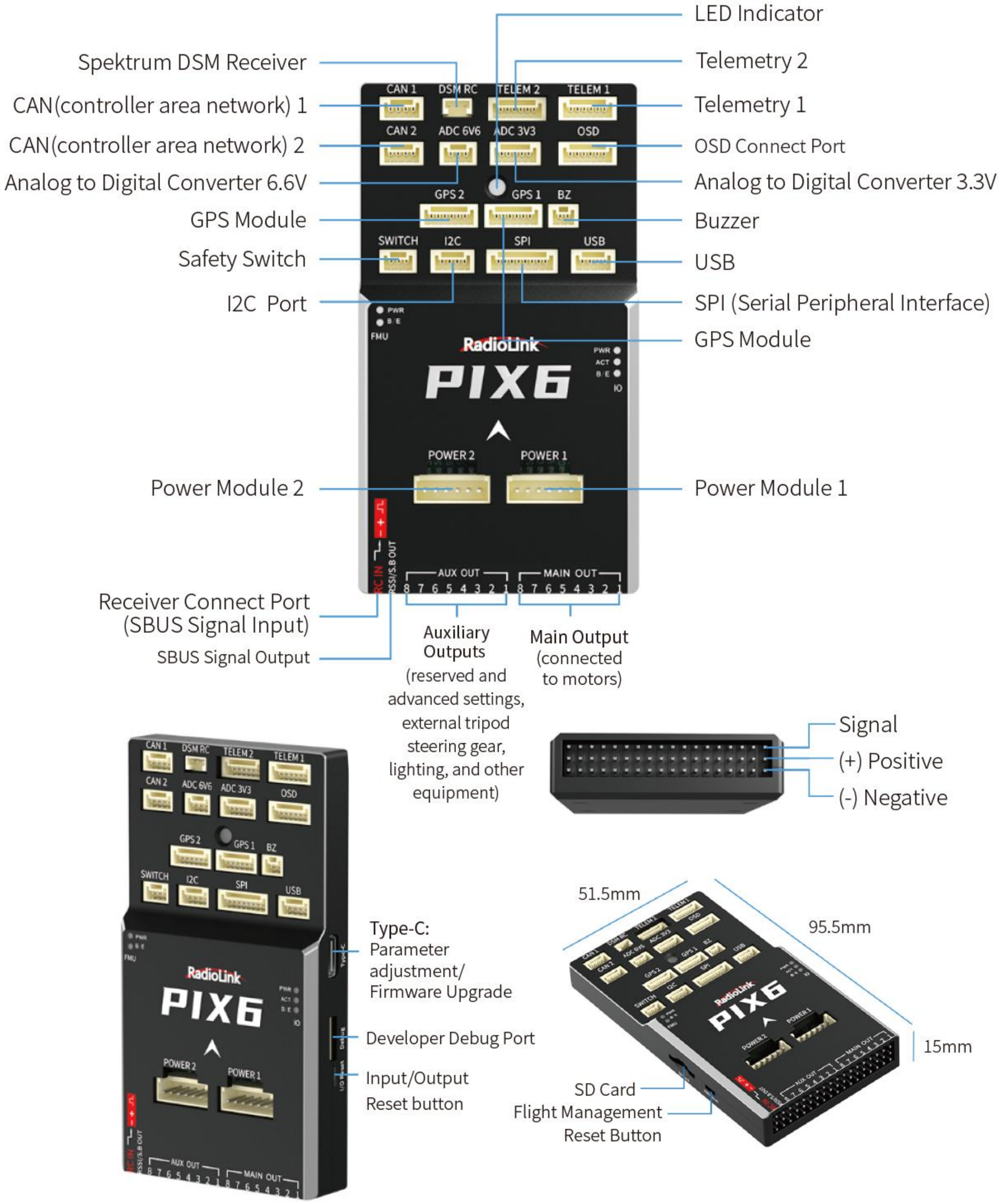
Type-C Cable ×1

Double-sided Adhesive Tape ×2

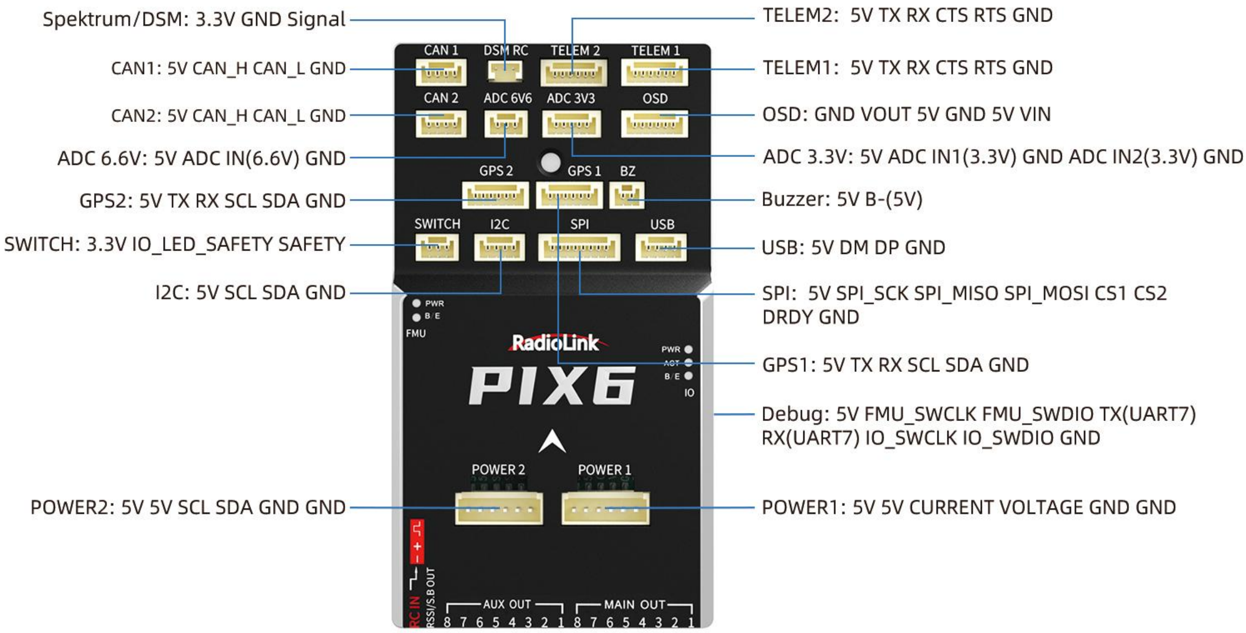
Quick Start Guide ×1

Packaging Color Box ×1

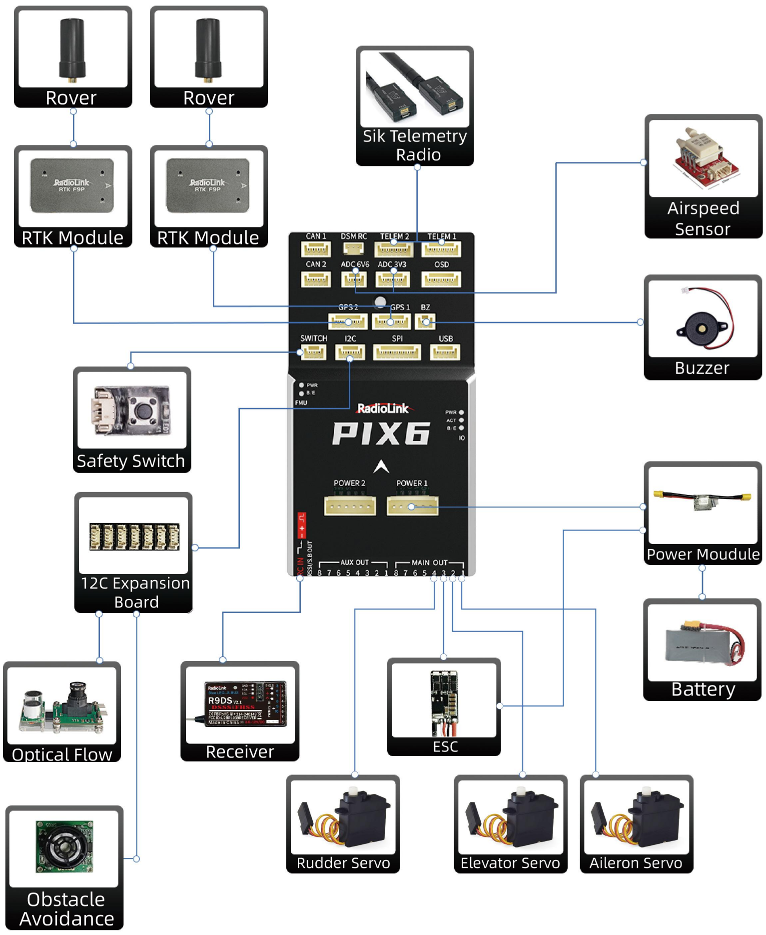
1.2 Connectors & Specifications



Pinouts



Connection Diagram of PIX6



Specifications		
Hardware	Main Processor	STM32F765VIT6
	Co-processor	STM32F100
Sensor	Gyro & Accelerometer	BMI088, ICM-42688
	E-compass	IST8310
	Barometer	SPA06-003
	RAM Memory	512KB
	Flash Memory	2MB
	FRAM	32KB, FM25V02A
Connector	Channel Output	16 Channels Output (Main Outputs:8 channel; Auxiliary Outputs: 8 channel)
	Connector	POWER1,2 Port: HY-6P; DSM RC Port: XH1.25-3P; Debug Port: 1.0-8P; Other Port: GH1.25
	CAN Port	2
	DSM RC	1
	Mavlink USART	2 (with RTS/CTS)
	ADC	3.3V*1&6.6V*1
	OSD	1
	GPS	2 (GPS1：USART；GPS2：UART)
	Buzzer	1
	Safety Switch	1
	I2C Port	1
	SPI Port	1
	USB Port	1
	POWER Port	2, Power1: voltage and current monitor inputs(Analog) Power2: SMBUS/I2C Power Module Inputs(I2C)
	Type-C Port	1
	SD Card Port	1
	FMU Reset	1
	Debug Port	1

	I/O Reset Button	1
	Signal (RC In)	PPM/SBUS
	Video Transmission	HD Digital and Analog Video Transmission Supported
	RSSI Signal Input	PWM/3.3V
	RSSI Signal Output	Support
	OneShot/DShot	Support
	OSD Module	Support, OSD Module Integrated
	ESC Protocol	PWM/OneShot/DShot
	Neopix Led Connection	Support
	RTK	Support
Power Module Specifications	Weight	24.5g (0.86oz) without wire
	Input Voltage	2-12S
	Maximum Detection Current	90A
	Output Voltage(BEC)	5.3V±0.2V
	Output Current(BEC)	2A
	Single ESC Maximum Detection Current	22.5A
Adaptable Firmware	Ardupilot	
Adaptable Models	Airplane/2-8 Copters/Helicopter/Car/Boat/VTOL/Submarine/Radartracker/Robot/Mower	
	Dimension	95.5*51.5*15mm
	Weight	50g(without wires)
	USB Voltage	5V±0.3V
	Operating Temperature	-30~85°C

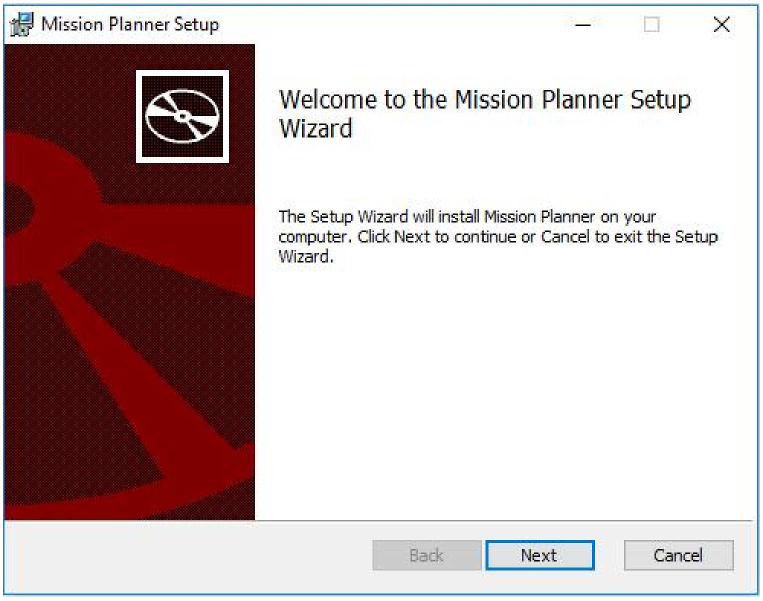
2. Mission Planner

2.1 Install Mission Planner

Mission Planner is designed for Windows installations originally. However, it can also be used under Linux (with occasional issues), and there is a beta version for Android OS.

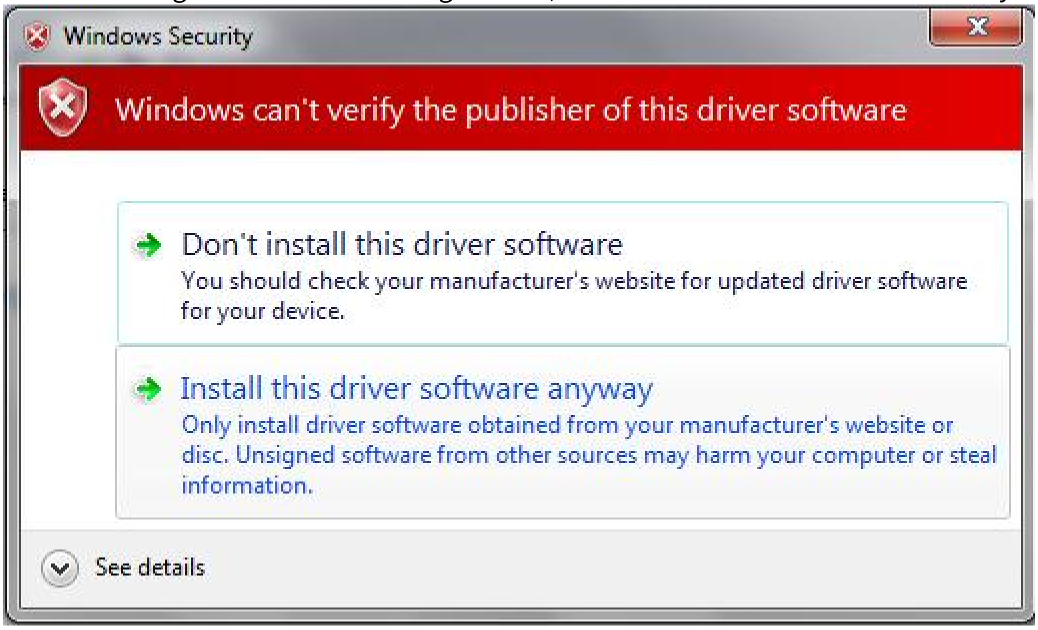
2.1.1 Install Mission Planner on Windows

The following instructions show how to install Mission Planner on Windows computer.
Download the latest Mission Planner installer from here, double-click the downloaded .msi file to install.



Follow the instructions to complete the installation. The installation utility will automatically install any necessary software drivers. If you receive a DirectX installation error, please update your DirectX plug-in from the Windows Download Center.

If you receive a warning as shown in the image below, select Install this driver software anyway.



Mission Planner is usually installed in the C:\Program Files (x86)\Mission Planner folder. And create a shortcut icon for opening Mission Planner according to your instructions during installation. After the installation is complete, click the icon to open Mission Planner.

2.1.2 Install Mission Planner on Android

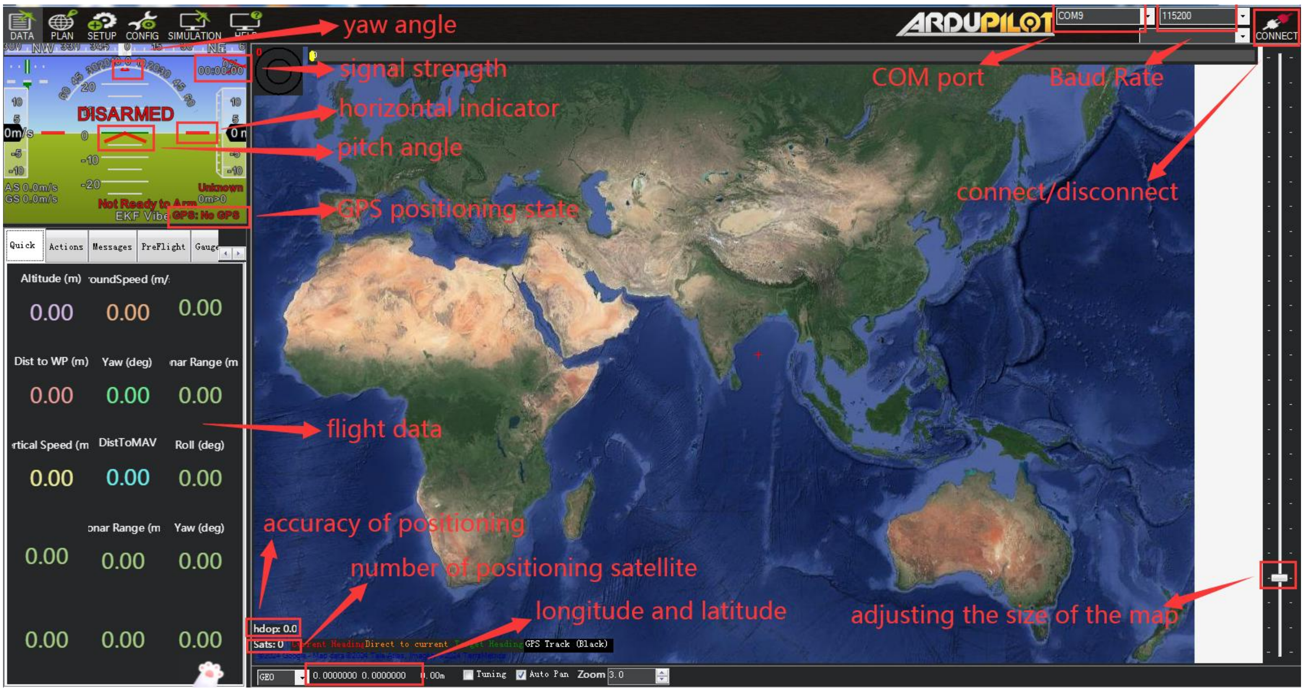
An Android version is under development and can be downloaded from the Google Play Store. The latest version is also available here. Download to your device and double-click to install.

2.1.3 Install Mission Planner on Linux

You can use MONO to run most Windows-based programs on many Linux distributions. Mission Planner does run under MONO, but occasionally issues and/or crashes occur. QGC and MAVProxy are stable alternatives that run in Linux, but if you really need Mission Planner, you can follow these steps:
Download and install the latest version of MONO here.
Download the Mission Planner zip file here and unzip it to a directory.
Enter the directory and execute: mono MissionPlanner.exe

2.2 Mission Planner Introduction

Once installation is complete, open Mission Planner by clicking on its system icon.
Once the installation of Mission Planner and driver is done, there will several pop-ups when you open the MP at the first time. The first pop-up clicks Yes and the others click NO.
There are six Menu Button in main menu.
FLIGHTDATA: flight attitude and data will show in real time on MP.
FLIGHTPLAN: planning the flight mission.
INTIAL SETUP: for firmware installation and update, Mandatory Hardware and Optional Hardware setup.
CONFIG/TUNING: including detailed PID setup and parameters change.
SIMULATION: make PIX6 work as a simulator after upgrade a special simulation firmware .
HELP: you can get help when you have questions about MP.



3. Initial Setup

3.1 Download and Install Firmware

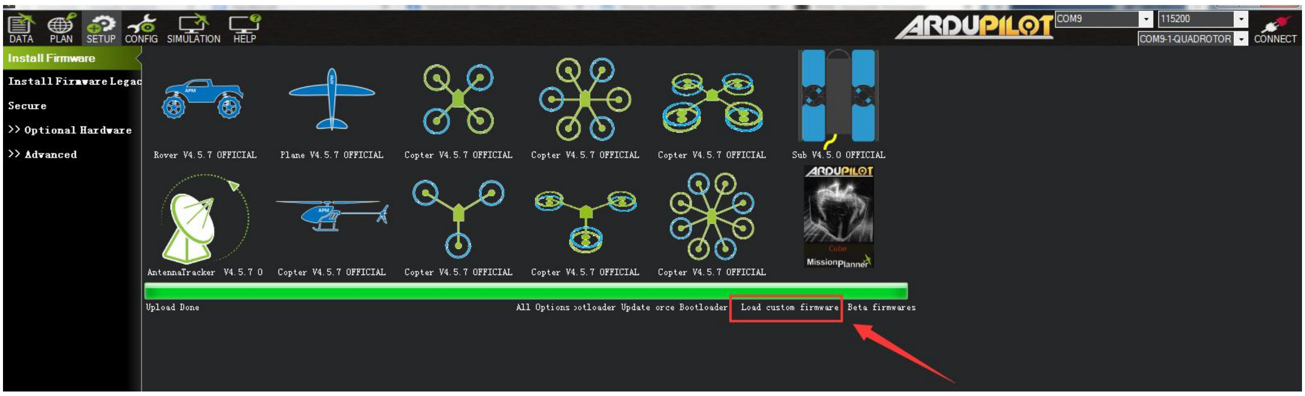
Radiolink PIX6 is default with quadcopter firmware, you have to install the right firmware if you use the other frame drone.

Before installing the firmware, please connect PIX6 to the computer with a USB cable. After the computer has recognized the COM port of PIX6, open the Mission Planner Mission Planner (hereinafter referred to as MP) and select the corresponding COM port in the drop-down box of the upper right corner of the MP main interface, and then select 115200 baud rate.

Attention:

1. Do not click CONNECT before you upload the new firmware, please click DISCONNECT if you have connected successful before. Upload new firmware will be not success if you have connected already.
2. Please do not upload new firmware by wireless data transmission because it has missed the reset signal.
3. If there’ s without firmware version number, it means failed upload new firmware. It may cause of network problem, please re-upgrade firmware until shows the version.
4. Autopilots with F7 or H7 processors that have a CAN interface use firmware that provides two USB interfaces: one for a normal MAVLink connection and other one for a SLCAN serial connection to the CAN interface for configuration and firmware updates. This is called a composite USB device. By default, the MAVLink USB interface is SERIAL0 and the SLCAN USB interface is the highest SERIALx port on the motherboard. The Windows driver currently installed with Mission Planner has the option to use one or the other, and since both are set up by default in the ArduPilot firmware for the MAVLINK protocol, it will work fine regardless of which one is selected as the COM port.

First, download the firmware from the RadioLink official website, click to load custom firmware, and select the firmware. It will be installed.



There may also be a suspended animation interface showing that the flight controller has been connected. The firmware is being flashed at this time. After the firmware is installed, a warning prompt box may pop up , which reminds you that after the arming is successful, the motor will run at idle speed. After the firmware installation prompts Done successfully, you can click the connect button in the upper right corner to connect to the flight controller and perform settings and calibration.

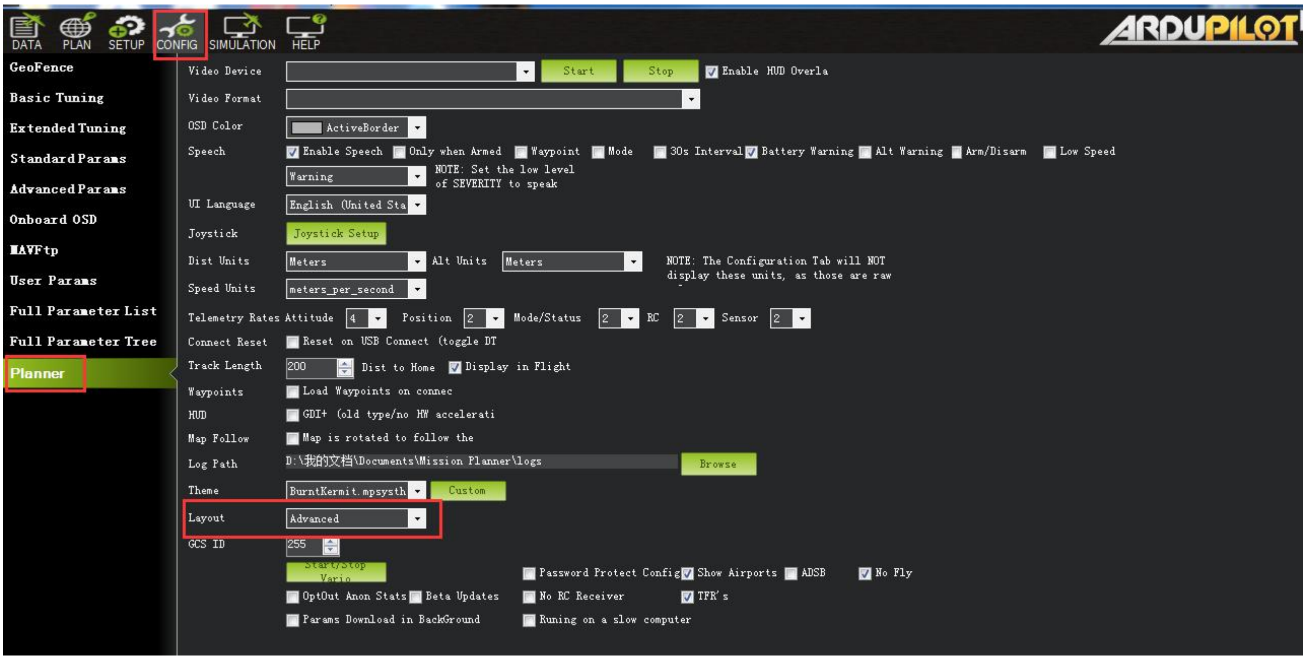
Pay attention:

Please set Layout from “Basic” to “Advanced” in CONFIG/TUNING menu if any of the three questions as below encontered when you installing the Mission Planner.

(1) It takes a long time to read the parameters.

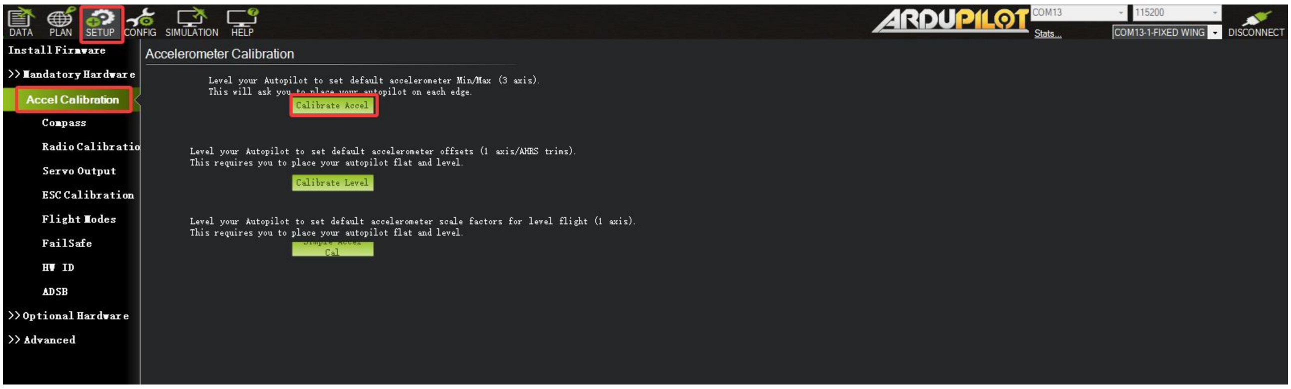
(2) There is no option of “Load custom firmware” .

(3) There’ s no Full Parameter List in INITIAL SETUP.



3.2 Accelerometer Calibration

Make sure the PIX6 is keeping horizontal when do the accel calibration.

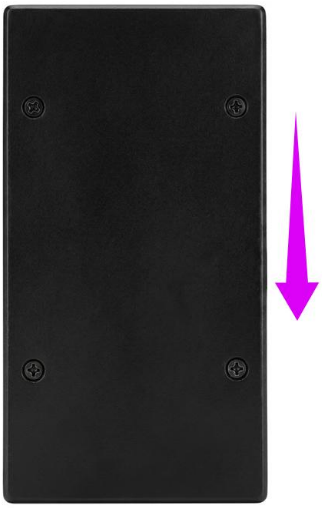


1. Place vehicle level and press any key to save setting.

2. Place vehicle on its LEFT side and press any key to save setting.

3. Place vehicle on its RIGHT side and press any key to save setting.

4. Place vehicle DOWN and press any key to save setting.



5. Place vehicle UP and press any key to save setting.

6. Place vehicle on its BACK and press any key to save setting.

3.3 Radio Calibration

This article shows how to perform radio control calibration in Mission Planner.

RC transmitters are used to control vehicle movement and orientation. Copter and Plane minimally control throttle, pitch, roll and yaw, while on Rover we just control throttle and roll. Each of these control signals are mapped to transmitter stick/switch(s) and in turn to autopilot channels from the connected receiver.

Calibrating each of the transmitter controls/channels is a straightforward process - simply move each of the enabled sticks/switches through their full range and record the maximum and minimum positions.

There are two main transmitter configurations:

Mode 1: left stick controls pitch and yaw, the right stick will control throttle and roll.

Mode 2: left stick controls throttle and yaw; the right stick will control pitch and roll.

Copter default channel mappings are:

Channel 1: Roll

Channel 2: Pitch

Channel 3: Throttle

Channel 4: Yaw

Channel 5: Flight modes

Channel 6: (Optional) In flight tuning or camera mount (mapped to transmitter tuning knob)

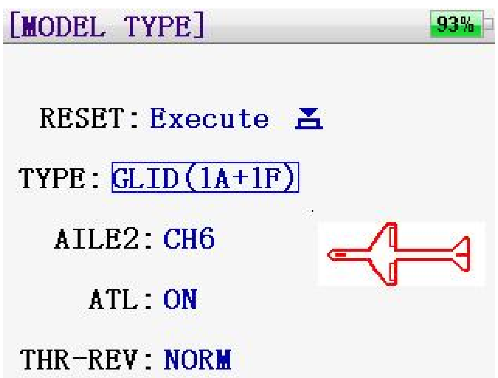
Unused channels can be mapped to control additional peripherals.

For safety, you should disconnect the battery and/or remove propellers before preforming radio calibration.

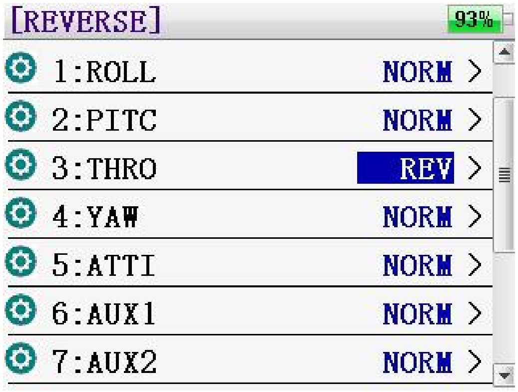
Bind your transmitter and receiver before calibrate radio, connect CrossFlight-CE to computer via USB cable and then turn on transmitter. The RC receiver ask to connect to the RC port of CrossFlight-CE.

The transmitter will make AT9S Pro as an example in this manual. Here are the settings on the transmitter:

1. Press Mode button to select MODEL MENU--MODE TYPE and select the glider model.



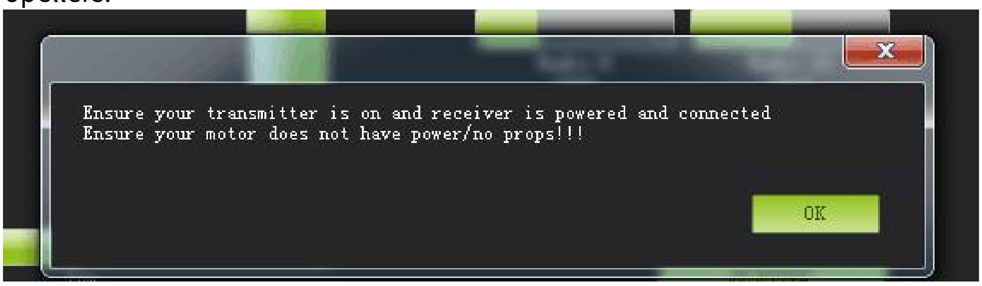
2. Setup CH3: THRO REV in REVERSE menu. Press Mode button to select MODEL MENU--REVERSE. Set the throttle channel to REV.

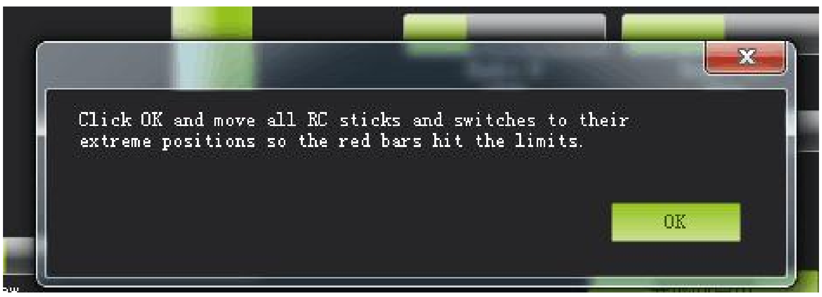


Radio Calibration Steps:

1. Open Mission Planner.
2. Choose the right COM and Baud rate.
3. Click the CONNECT.
4. Choose SETUP—Mandatory Hardware—Radio Calibration.
5. Click “Calibrate Radio” .

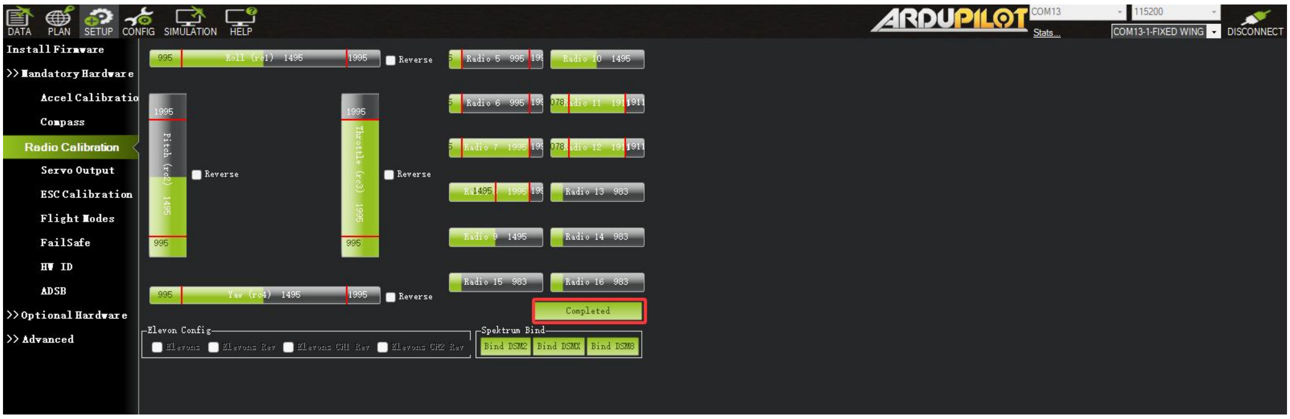
There are two tool pop-ups after you click “OK” , one for make sure both your transmitter and receiver are powered on and connected, and the motor of your drone does not have power and without propellers.





And then click “OK” and move all RC sticks and switches to their extreme positions so the red bars hit the limits.
If the red bars have not any change when you move the sticks, please check the receiver have connect success or not, make sure the receiver (maybe R9DS) is output SBUS signal (the blue LED of R9DS means work as SBUS signal). You can check if every corresponding red bar for every channel is work as below:
CH1: low position = roll (towards the left), up position= roll (towards the right).
CH2: low position =pitch(forward), up position =pitch(backwards).
CH3: low position =reduced speed, up position =speed up.
CH4: low position = yaw (towards the left), up position = yaw (towards the right).

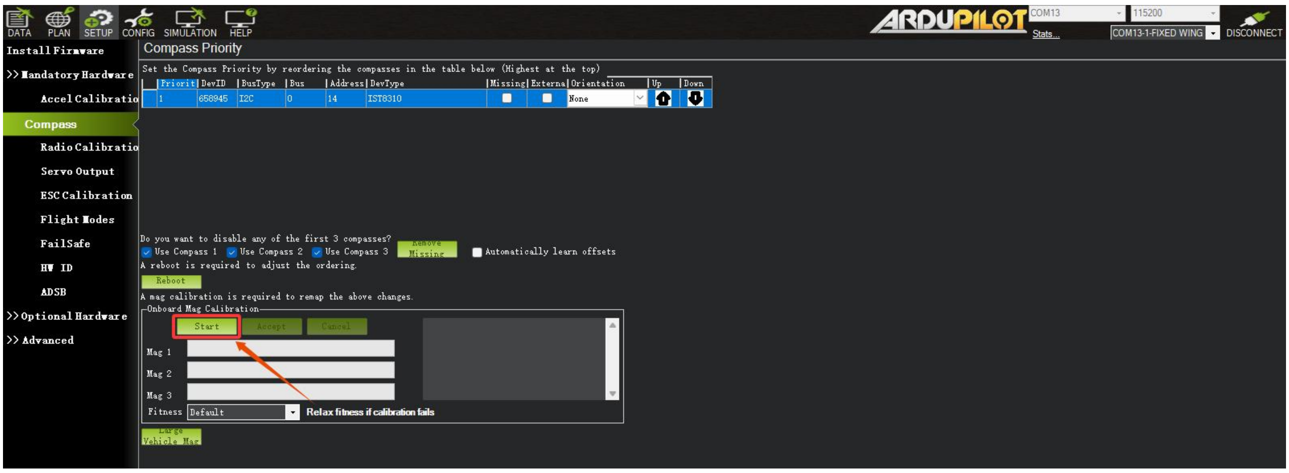
Click to save the radio calibration data when done.



3.4 Compass Calibration

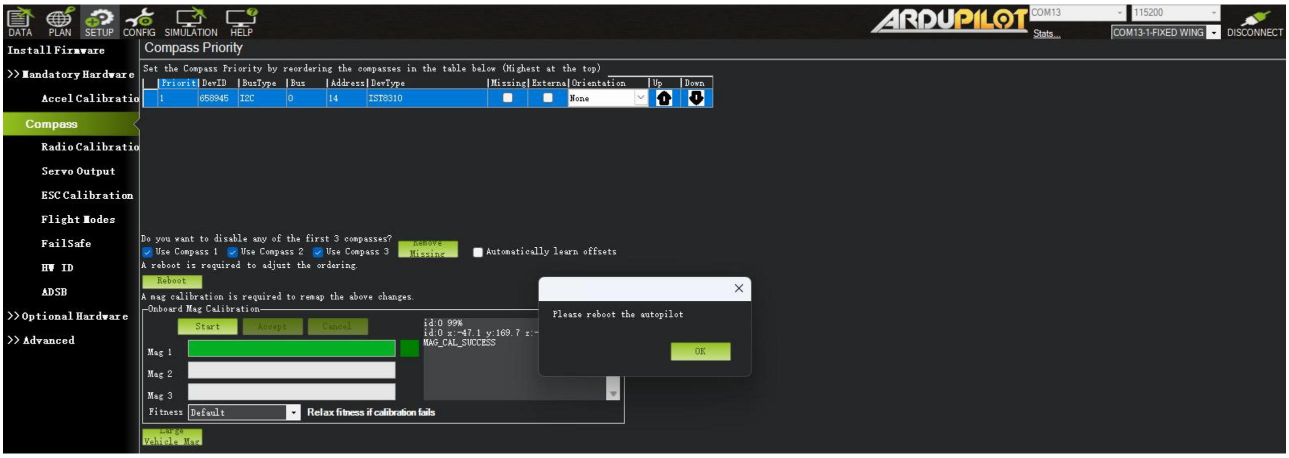
There are two situations about compass calibration:
1. Without GPS, use internal compass.
2. With GPS, use external and internal compass.
You can also check the video tutorials on how to calibrate the compass:
https://www.youtube.com/watch?v=XR_4e18F5W0

Enter Compass calibration, the interface will shows as picture below. Click “Start” and turn PIX6.



The mission planner will keep recording the data that collected by the compass sensor and the progress bar and the percentage will keep change when you calibrate the compass, if the percentage have not changed, please check if the compass is connect success.

The mission planner will prompt a notice: Please reboot the autopilot when the compass calibration is successful.

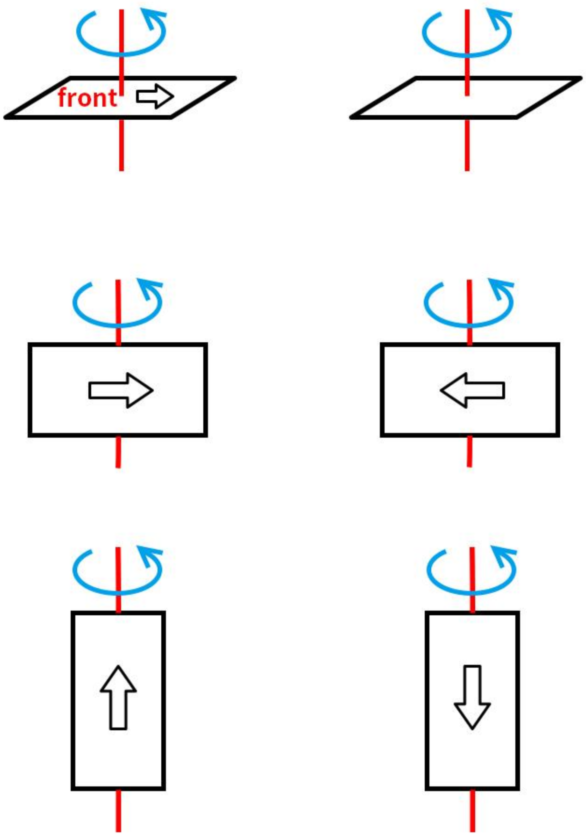


Click OK and then reconnect PIX6 to computer, compass calibrate success after restart the PIX6.

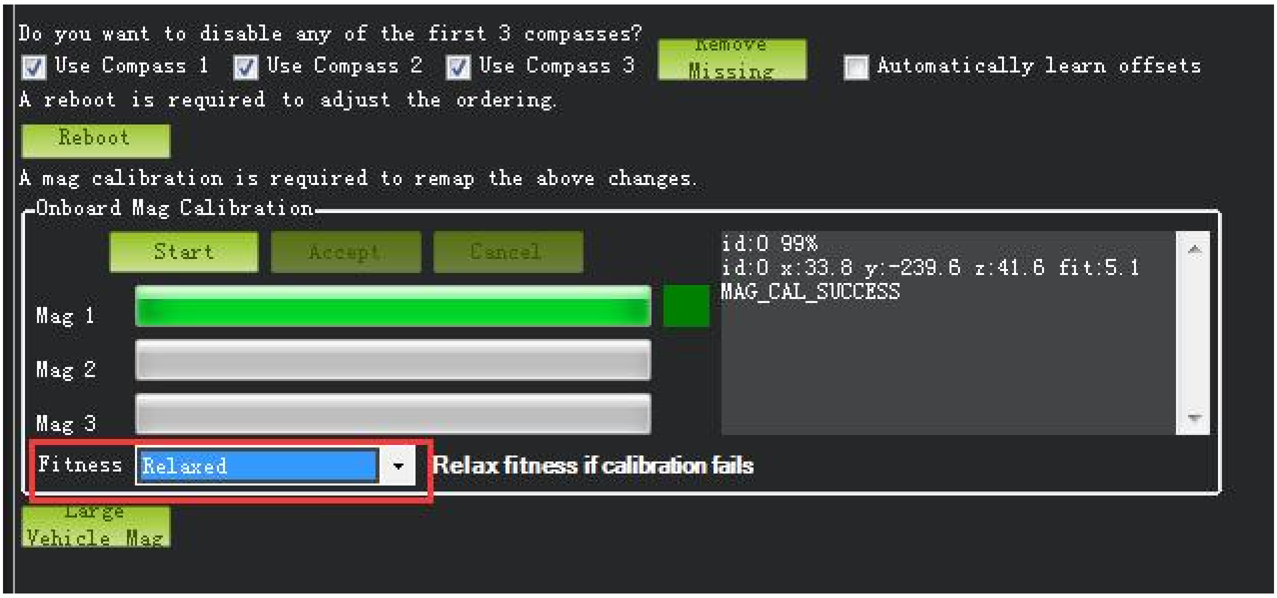
If the GPS mounted with the same direction with flight controller, then it need not to setup the direction of GPS in MP but if you mounted the GPS with the different direction of PIX6, you have to setup in the MP. Please set the parameter AHRS_ORIENTATION.

Calibrate the compass as these steps below:

Hold the vehicle in the air and rotate it slowly so that each side (front, back, left, right, top and bottom) points down towards the earth for a few seconds in turn.



Attention:
When the progress bar moves to 100 and then restart from 0, it may because of the wrong calibrate action or interference. You can have a try to calibrate again till compass calibrate success, or setup the Fitness is Relaxed and re-calibrate.



3.5 Flight Modes Setting

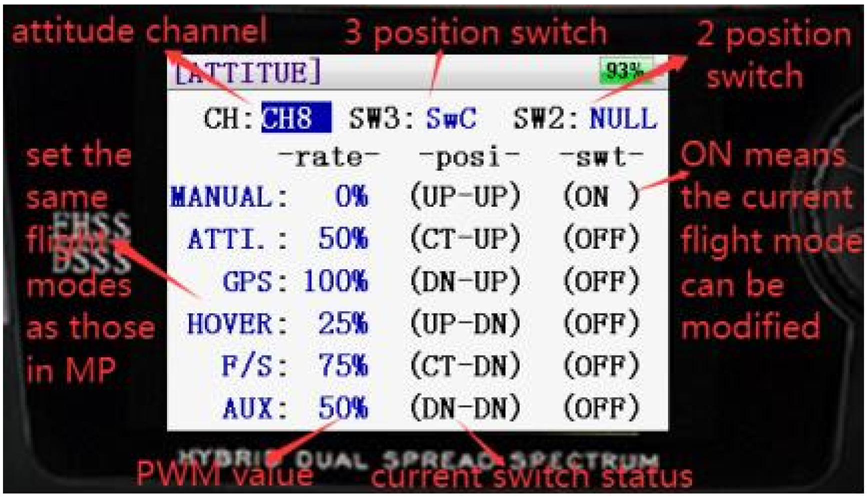
PIX6 has multiple flight modes, 6 of which are regularly used. You can setup six flight modes once and max setup eight modes combine with AUX-CH (CH7 and CH8).

Flight modes setting steps:

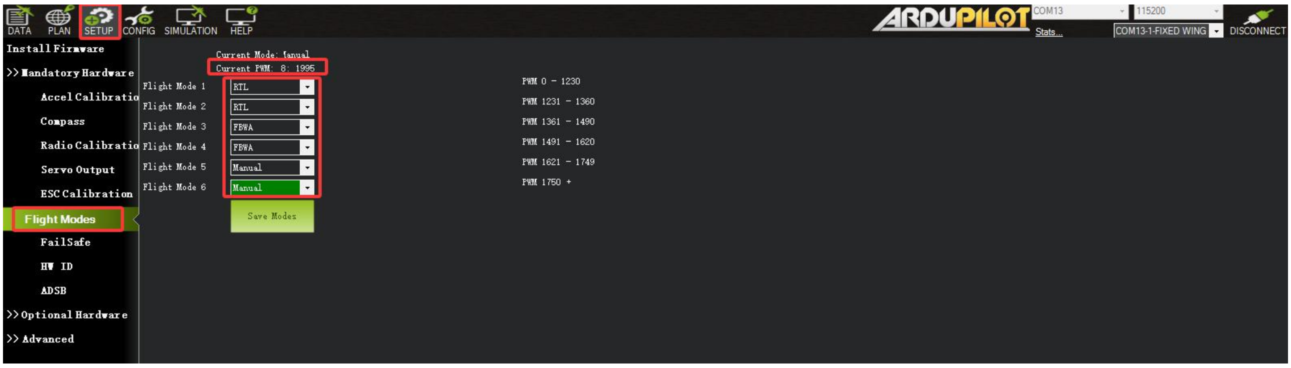
First, you have to setup flight mode in transmitter. The setting steps as below:

(1) Power on and turn on your transmitter.

(2) Press Mode button twice to into ADVANCE MENU, press Push button into ATTITUDE setting menu. Set CH to CH8 (Note: CH8 is the default channel to control the flight modes of the fixed-wing. If you want to modify the channel, please set the parameter FLTMODE_CH in Mission Planner) , and please choose a 3 Posi-SW and a 2 Posi-SW to control the attitude.



3. Setup Flight Mode 1 is Stabilize both in Mission Planner and transmitter.
Make sure the -swt- is ON (by press the 3 Posi-SW or 2 Posi-SW to make it ON or OFF) and then you can setup the PWM data.
Setup the PWM value according to the default numerical interval (change the value by turn the dial, press the Push button when you choose the right value.)



3.6 Flight Modes Introduction

3.6.1 Manual Mode

Direct input control via remote controller; joysticks will not automatically return to horizontal when centered. Regular RC control, no stabilization. All RC inputs are passed through to the servo outputs set by their SERVOx_FUNCTION.

3.6.2 Stabilize Mode

RC provides simple stabilization via flight control, but if you release the controls, the aircraft will automatically level off. However, this makes tilting and maneuvering more difficult. It's best to use FBWA mode instead of stabilization .

3.6.3 FBWA Mode

This is the most popular mode for assisted flying in Plane, and is the best mode for inexperienced flyers. In this mode Plane will hold the roll and pitch specified by the control sticks. So if you hold the aileron stick hard right then the plane will hold its pitch level and will bank right by the angle specified in the ROLL_LIMIT_DEG parameter (in degrees). It is not possible to roll the plane past the roll limit specified in ROLL_LIMIT_DEG, and it is not possible to pitch the plane beyond the PTCH_LIM_MIN_DEG or PTCH_LIM_MAX_DEG settings.
In FBWA mode throttle is manually controlled, but is constrained by the settings of THR_MIN and THR_MAX.

3.6.4 FBWB Mode

FBWB mode is similar to FBWA, but the aircraft maintains altitude much better. Roll control is the same as FBWA , altitude is controlled via climb and descent, and airspeed is controlled via throttle.
Altitude is controlled via the pitch upgrade channel. After returning to center, the aircraft maintains its current altitude. The extent of altitude change depends on the FBWB_CLIMB_RATE, which controls the rate of change. The default value is 2 meters per second, representing a relatively slow speed. For a faster altitude change rate, modify the FBWB_CLIMB_RATE value; a larger value indicates a faster altitude change rate.

Adjusting the FBWB_ELEV_REV to move the joystick forward and backward controls climb and descent. The default is to pull back to control the aircraft's climb, which is the general control mode for fixed-wing models. If you want to reverse it, you can set FBWB_ELEV_REV to 1 for reverse.
If an airspeed meter is installed, adjust the airspeed range from ARSPD_MIN to ARSPD_MAX . At the lowest throttle setting, the aircraft will attempt to fly at ARSPD_MIN . At the highest throttle setting, it will attempt to fly at ARSPD_MAX .
If no airspeed meter is installed, the throttle will adjust the output to achieve the required altitude hold. It's best to apply more throttle than the calculated value, which will also result in faster flight. The rudder, like FBWA, is a coordinated control system.

3.6.5 Cruise Mode

The cruise mode is similar to FBWB, in which it locks onto the heading and is best suited for long-distance FPV flights. You can point the aircraft at a distant object, and it will accurately track that object and automatically control altitude, airspeed, and heading.
It works as follows:

- If you operate the ailerons, the rudder changes are similar to FBWB; it will maintain altitude unless you operate the elevator. Speed is controlled via the throttle.
- When you release the joystick for more than 0.5 seconds , the current point will be set as the starting point, maintaining the current heading for 1 kilometer (note that heading lock is only activated when GPS is locked and the ground speed exceeds 3 meters per second).
- The flight path continuously updates the target point, which remains 1 kilometer away from the current point. If you manipulate the ailerons or rudder, the flight path will exit the current target point.
- As long as you don't touch the ailerons or the azimuth, it can accurately maintain its course on the ground, even in constantly changing wind conditions.

One advantage of cruise mode is how it controls the rudder. If you adjust the direction, the flight controller will keep the wings level and turn the aircraft via the rudder.
At this point, make a "horizontal" turn, allowing you to rotate your flight point to point towards any geographical feature you want to face. When you release the rudder, it will proceed directly in that direction.

3.6.6 Autotune Mode

roll /pitch adjustment parameters for your aircraft is crucial for stable and accurate flight. To address this, we strongly recommend using the automatic parameter adjustment mode described below.
Autotune mode is a flight mode with the same flight operation as FBWA, but it uses user- inputted flight attitude changes to learn key values for roll and pitch adjustments. Therefore, users switch to autotune mode using their remote controller's mode switch and then fly for a few minutes. During this time, the user needs to maneuver the aircraft as quickly and sharply as possible , and the flight controller will automatically learn and tune the parameters.
AUTOTUNE_LEVEL parameter allows you to select the tuning level. The default is level 6, which produces a medium tuning level suitable for beginners to intermediate pilots. Higher levels allow for more aggressive and rapid aircraft adjustments, suitable for experienced pilots.
Automatic parameter adjustment flight : You can take off in automatic parameter adjustment mode or other modes. After reaching a certain altitude, switch to automatic parameter adjustment mode.
After entering autotune mode:

- The flight controller will set the roll and pitch I and D values, with the maximum rate set to default. These values depend on your parameter tuning level.

- The flight controller will automatically detect the roll and pitch rates requested by the pilot (depending on your remote controller operation). When the requested roll and pitch rates exceed 80 % of the maximum rate , it will trigger automatic learning and adjust to the required values.
- The system saves the adjustment parameters from 10 seconds ago every 10 seconds . This means that if the aircraft becomes unstable due to adjustments, you have 10 seconds to switch to another mode. When you exit the parameter adjustment mode, the last saved parameters will be saved.
- When you fly with default parameters, you'll find the aircraft quite slow, but it will improve as you fine-tune the parameters. Also, ensure there's enough flight space to allow for slow turns.

The key to success lies in fast input. For roll and pitch, you should only perform one directional action at a time and quickly reach the maximum value in that direction.

In the roll direction, you should first fully engage the left aileron, then fully engage the right aileron. You don't need to wait to level off the plane; after each maneuver, wait 2 seconds before reversing the operation. Each sudden reversal will substitute 5% of the adjustment progress, so you'll need 20 such adjustments .

In the pitch direction, you should imagine the plane is like a roller coaster, rapidly ascending and then rapidly descending, repeating this 20 times .

When your initial adjustment value is too low, you may find that your subsequent adjustments become increasingly sensitive, causing the aircraft to become unstable. At this point, you should exit the automatic parameter adjustment mode.

Don't finish too early. 20 adjustments is just a suggestion. You should adjust the adjustment time appropriately based on the aircraft's flight attitude and the feel of the controls.

3.6.7 RTL Mode

In return-to-launch mode, the aircraft will return to its home location (the unlocked location under GPS) and remain there in circles until further instructions are given or the battery runs out.

The target altitude for RTL mode is set using the RTL_ALTITUDE parameter in meters. When initiated below RTL_ALTITUDE, Plane will immediately climb at maximum allowable rate to reach that altitude, if above, it will descend in a linear manner versus distance to home, reaching that altitude at the home loiter point.

3.6.8 Loiter Mode

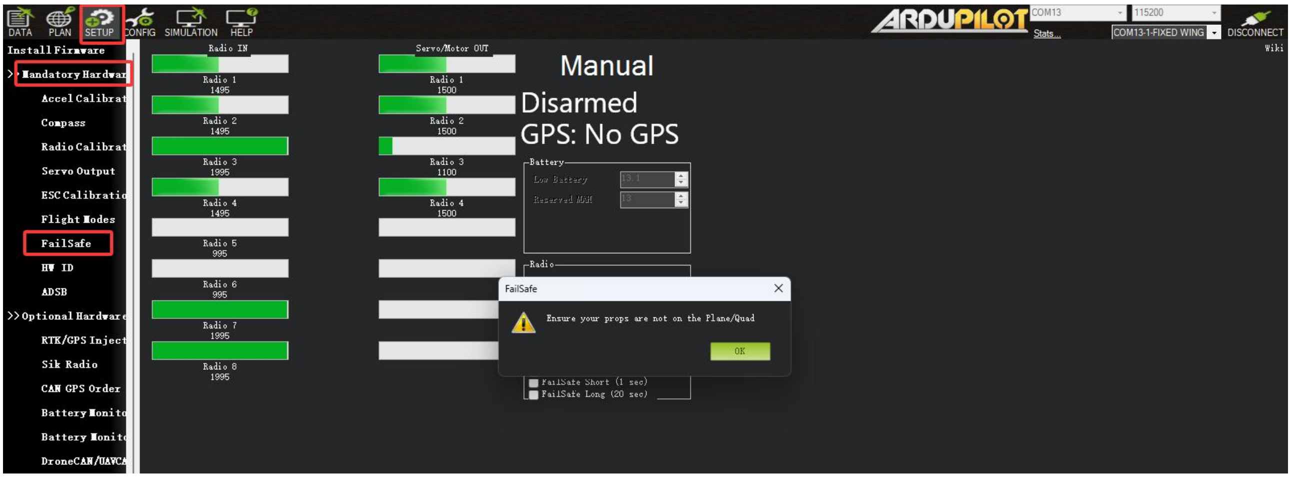
In loiter mode, the aircraft will circle at the position and altitude at which it entered loiter mode. The radius is based on the WP_LOITER_RAD setting, but also requires adjustment of the NAVL1_PERIOD. This mode also requires good GPS positioning, and slight operations can be performed using the remote controller in this mode.

3.6.9 More Flight Modes

CIRCLE
TRAINING
ACRO
AUTO
GUIDED etc.
For more details of the flight mode, please refer to https://ardupilot.org/plane/docs/flight-modes.html

4. F/S(Fail Safe) Setting

PIX6 supports Return-To-Launch in cases where contact between the Pilot’s RC transmitter and the flight controller’s receiver is lost. This page explains this failsafe’s setup and testing. Note the “Radio failsafe” was previously called “Throttle failsafe” because of the way in which some receivers use the throttle channel to signal the loss of contact.



Click OK to into the failsafe setting menu.

If enabled and set-up correctly the radio Failsafe will trigger if:
(1) The pilot turns off the RC transmitter.
(2) The vehicle travels outside of RC range.
(3) The receiver loses power (unlikely).
(4) The wires connecting the receiver to the flight controller are broken (unlikely).

1. Set battery fail safe.
Set battery fail safe according to the aircraft power consumption, battery voltage, and flight distance. When the battery voltage is lower than this value, there will be enough battery voltage to return the aircraft. Set the low battery value (This value is set according to the battery voltage. When you fly long distances, Please set the single cell to 3.8V, the voltage value is 3.8V*S, the 3S battery is 3.8*3=11.4V; when at a close distance, you can set 3.6V for each cell), and set the action to RTL (return to home).

2. Set the radio fail safe（throttle fail safe）.

Set the action to RTL , and set the fail safe PWM (generally no need to change). Set the fail-safe setting in the transmitter, because we set the fail safe to start after the throttle is lower than 975, so we need to set the throttle fail safe value. Push the throttle trim button in the transmitter and check the input value of channel 3 in the transmitter in fail safe, so that the value is less than 10 or more than 975. Take RadioLink AT9S Pro as an example. Press the Mode button to enter the basic menu and select FAIL SAFE. Press Push to select Channel 3: Throttle. Turn the dial to select F/S and press Push button. When a value appears, the setting is successful. Remember to turn trim button to restore.

When a radio Failsafe is triggered one of the following will happen:

- Nothing if the vehicle is already disarmed.
- Motors will be immediately disarmed if the vehicle is landed OR in stabilize or acro mode and the pilot’s throttle is at zero.
- Return-to-Launch (RTL) if the vehicle has a GPS lock and is more than 2 meters from the home position.
- LAND if the vehicle has no GPS lock OR is within 2 meters of home OR the FS_THR_ENABLE parameter is set to “Enabled Always Land”.
- Continue the task if in automatic mode and the failsafe option is Enabled_continue_in_auto_mode.
- If the failsafe is cleared (the throttle is above 975), the aircraft will continue to fly in the flight mode corresponding to the previously set failsafe, and will not automatically return to the previous flight mode of normal flight.

For example: the RTL mode is set for the fail safe, and the aircraft is flying normally in stabilize mode. Suddenly the fail safe is triggered due to signal loss, causing the aircraft's flight mode to automatically change from the stabilize mode to the previously set RTL mode. Even if the transmitter and receiver signals are reconnected during the return journey and the fail safe is released, the aircraft will still fly in the RTL mode. If you need to fly in stabilize mode again, you need to move the flight mode switch to another position and then back to the position of stabilize mode.

3. Set attitude fail safe in the transmitter. The prerequisite for setting attitude fail safe is that there is a fail safe mode in the flight mode settings. Taking RadioLink AT9S Pro as an example. Turn on the transmitter, flip the setting switch to RTL mode or the fail-safe mode you want to set, press Mode to enter the basic menu, select fail-safe, press Push to select 5: Attitude, Toggle to select F/S, hold Push, and the numbers below will change. Open Mission Planner to verify it. Turn off the transmitter and check that it is RTL in Mission Planner.

5. Introduction and Connection to Plane

5.1 Four Channel Planes

It has 4 output channels, and they control the roll, pitch, yaw, and throttle independently.

Confirm RC Transmitter Input

Keep the plane level in FBWA mode and command the following inputs by moving the sticks on your transmitter:

Input	Action
Roll Right	Right aileron moves up and left aileron moves down
Roll Left	Left aileron moves up and right aileron moves down

Pitch up	Elevator moves up
Pitch down	Elevator moves down
Yaw right	Rudder moves right
Yaw left	Rudder moves left

If the control surfaces do not respond correctly, change the RCn_reversed parameter (from 0 to 1, or from 1 to 0). Do NOT reverse the output on your transmitter. It must be changed in the autopilot! Double check MANUAL mode for the same inputs. If everything is setup correctly, the plane should be almost ready to fly.
If in MANUAL mode the surfaces move backward with stick movements now, the corresponding RC input should be reversed. To do this, in Mission Planner RCn_REVERSED can be easily set on the SETUP/Mandatory Hardware/Radio Calibration page. There is a check box “Reverse” next to each input bar. You can reverse the correct parameter by checking the box. However, if Radio Control Calibration was followed correctly, changing RC input reversal will not be necessary.

Servo Trim
Switch to MANUAL mode in order to adjust the servo trim values. The servo trim is in the SERVOn_TRIM parameters.
Adjust the trim values so that the servo is centered when the transmitter sticks are centered. If the trim value is not between 1450 and 1550 PWM, mechanical trim adjustment is recommended.

5.2 Elevon Planes

Elevon planes (also known as delta-wings) are popular for their simplicity and robustness.
A typical elevon plane will have 2 servo outputs and one throttle output.

Setting Up Your Plane
The recommended setup for APM:Plane with elevon planes is:

Parameter	Value	Meaning
SERVO1_FUNCTION	77	Left elevon
SERVO2_FUNCTION	78	Right elevon
SERVO3_FUNCTION	70	Throttle

Servo Setup & Reversal
The next step is to get the servo reversals right. You should connect the battery (with propeller removed) and turn on your RC transmitter. Now switch to FBWA mode and press the safety switch (if fitted) to enable servo outputs.
At this point both the autopilot and RC transmitter should have control of the elevons. You now should adjust the reversal and function of the two servos so that you get correct movement.
Correct FBWA (automatic stabilization)movement for an elevon plane WITHOUT PROVIDING RC INPUT is:

Input	Action
Roll right	Left elevon goes up and right elevon goes down
Roll left	Right elevon goes up and left elevon goes down
Pitch down	Both elevons go up
Pitch up	Both elevons go down

If your movements are incorrect then you need to adjust which servo output is left/right and the reversals of each elevon.
The parameters you should adjust are SERVO1_REVERSED, SERVO2_REVERSED, SERVO1_FUNCTION and SERVO2_FUNCTION.
If your left elevon on servo 1 is moving the wrong way for both pitch and roll corrections, set SERVO1_REVERSED to 1.
If your left elevon on servo 1 responds correctly to pitch, but incorrectly to roll, change the SERVO1_FUNCTION.
Repeat the servo reversal or function change for the right elevon.

Servo Trim

Now stay in MANUAL mode in order to adjust the servo trim values. The servo trim is in the SERVOn_TRIM parameters.
You should adjust the trim values so that the servo is centered when your transmitter sticks are centered. If you find you need to adjust the trim value by more than 50 PWM from the default of 1500 then it is recommended that you instead adjust the trim mechanically.

Mixing Gain

The MIXING_GAIN parameter is critical for elevon aircraft. It is the gain used in mixing between roll and pitch input and your elevon movement.
For example, if your MIXING_GAIN is 0.5, then the following outputs are used:

- LEFT ELEVON = (roll+pitch)*0.5
- RIGHT ELEVON = (roll-pitch)*0.5

5.3 V-Tail Planes

A common alternative to a traditional elevator and rudder is a V-Tail, or an ATail (an upside down V-Tail).
A V-Tail aircraft has the same functionality as a standard aircraft, but it requires special configuration of the servo outputs. Do not use V-Tail mixing on the transmitter. Although you may choose custom channels, the typical V-Tail setup uses channel 2 and 4 for the servo outputs.

Configuration & Setup

Parameter	Value	Meaning
SERVO1_FUNCTION	4	aileron
SERVO2_FUNCTION	79	left V-tail
SERVO3_FUNCTION	70	throttle
SERVO4_FUNCTION	80	right V-tail

Confirm RC Transmitter Input

Keep the plane level in FBWA mode and command the following inputs:

Input	Action
Roll Right	Right aileron moves up and left aileron moves down
Roll Left	Left aileron moves up and right aileron moves down
Pitch up	Both tail surfaces moveup
Pitch down	Both tail surfaces move down
Yaw right	Both tail surfaces move right
Yaw left	Both tail surfaces move left

Double check MANUAL mode for the inputs as well. If everything is setup correctly, the plane should be almost ready to fly.

If the ailerons do not respond correctly, reverse the output by changing the corresponding SERVOn_REVERSED setting (from 0 to 1, or from 1 to 0).

ATail Planes

With "A-Tail" planes (an inverted V-Tail), the control surface movements referenced above should still be the same directions. It is likely that the servo reversal or function will be opposite from a similar V-Tail setup.

Servo Trim

Switch back to MANUAL mode in order to adjust the servo trim values. The servo trim is in the SERVOn_TRIM parameters.

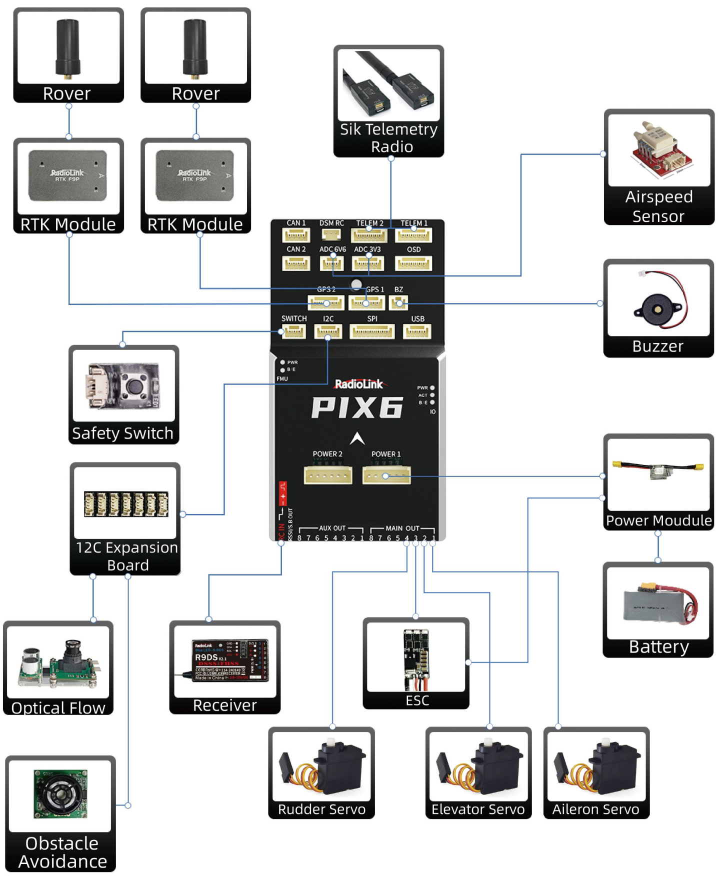
Adjust the trim values so that the servo is centered when the transmitter sticks are centered. If the trim value is not between 1450 and 1550 PWM, mechanical trim adjustment is recommended.

Mixing Gain

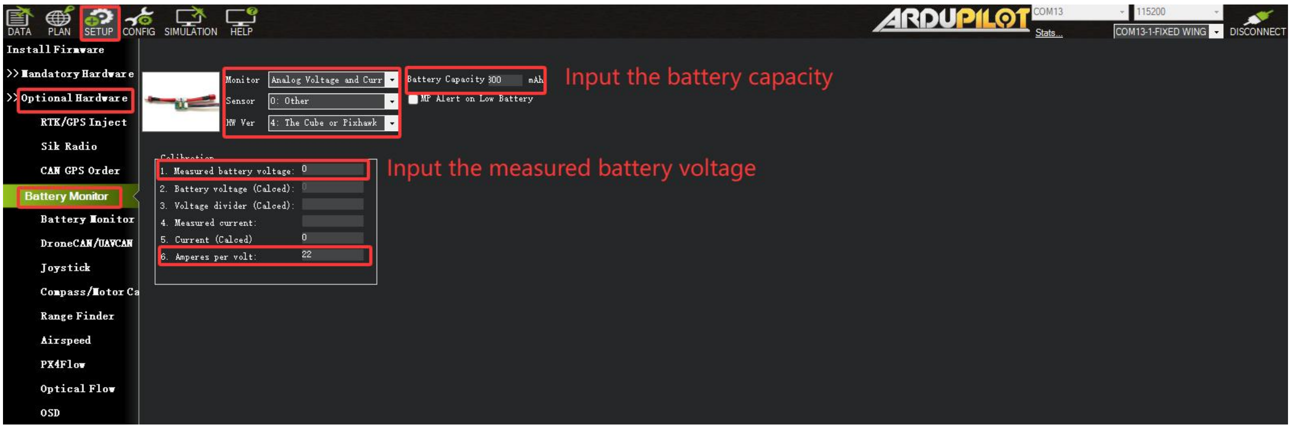
The MIXING_GAIN parameter is critical for vtail aircraft. It is the gain used in mixing between yaw and pitch output and the vtail movement. For example, if MIXING_GAIN is 0.5, then the following outputs are used:

- LEFT_VTAIL = (yaw+pitch)*0.5
- RIGHT_VTAIL = (-yaw+pitch)*0.5

5.4 Connection to Planes



5.5 Battery Monitor Setup



PIX6 has two dedicated power monitoring ports, which is compatible with 6-pin connect cables. One is for an analog power monitor (Power1), and the other one is for an I2C power monitor (Power2).

1. When using Power1, enable Battery Monitor 1 by following the below settings:
Monitor: Analog Voltage and Current
Then restart the flight controller and modify the below settings:
Sensor: 0: Other
HW Ver: 4: The Cube or Pixhawk
6. Amperes per volt: 22
And search for BATT_CURR_PIN in Full Parameters List and change it to 5

2. When using Power2, enable Battery Monitor 2 by following the below settings:
Monitor: INA2XX
Restart the flight controller and search for the below parameters in Full Parameters List and modify them:
Search for BATT2_I2C_BUS and change it to 1
Search for BATT2_I2C_ADDR and change it to 65

After all the modifications, disconnect the flight controller, power it on again, and then reopen this interface. Input the 1. measured battery voltage. When the value of the 2. Battery Voltage (calced) shows the same as the 1. measured battery voltage and the value no longer fluctuates, the setting is normal.

Note: Inaccurate settings may result in the inability to arm, or a rapid beeping of the buzzer after arming. It indicates an incorrect power setting. Please reset it correctly. If continuous fault protection occurs, it may be due to low battery protection being enabled, causing inaccurate battery monitoring.

Disable Battery Monitor:
Monitor: 0: disable

5.6 LED Indicator, Arming and Troubleshooting

5.6.1 LED Indicator

Blue and red flashing: Initializing

Yellow flashing twice: Error, Arming rejected

Blue flashing: Stabilize, can be armed. Faile to RTL or PosHold

Green flashing: GPS locked, can be armed and take off, RTL

Green always on + a long D sound: Armed and ready to take off

Yellow flashing: Transmitter failsafe activated

Yellow flashing+repeated sounds: Battery failsafe activated

Yellow and blue flashing+High/High/Low sounds: GPS data error or GPS failsafe activated

5.6.2 Arming and Disarming

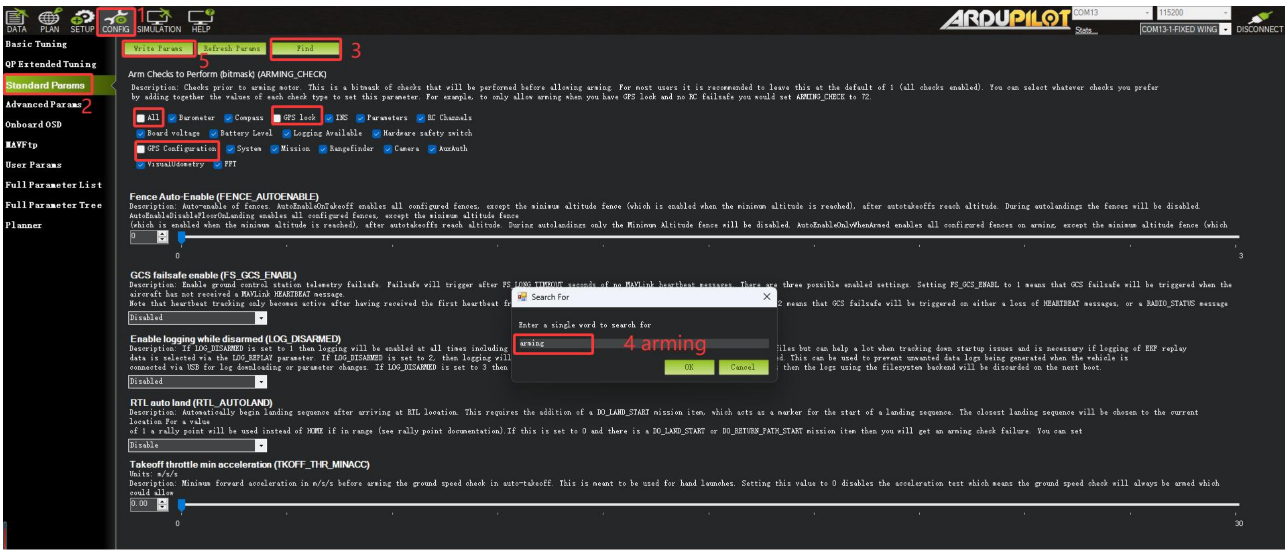
Please note the following before arming:

- Fixed-wing aircraft require GPS positioning before they can be armed in any mode by default. When you fly the plane indoors or there is no GPS signal, you can disable the GPS check in Mission Planner . Please follow the steps below:

  Uncheck the boxes for "All", "GPS lock", and "GPS Configuration" , and check all other boxes to disable GPS checks. When flying normally, check "All ". Remember to click "Write Parameters " to save the settings after the modifications .

  If no memory card is inserted , please uncheck the "Logging Available" and "All" boxes.)

  Besides, you can also set the parameter ARMING_CHECK in Full Parameter List to disable the GPS check.



- After powering on, please keep the flight controller stationary and do not shake it. Wait for the flight controller status light to flash blue or green .
- In fixed-wing mode , if there is no terrain data on the SD card, the Mission Planner will display a "Bad or No terrain Data" message. This message does not affect normal flight and can be ignored .
- After pressing and holding the safety switch, you can control all channels or check the aircraft's flight status; at this time, please be careful not to put your hands near the propeller.

There are two ways to arm a fixed-wing aircraft :

- Arm in Mission Planner.
- Arm by using the transmitter.

The transmitter arm action is controlled by the parameters ARMING_REQUIRE and ARMING_RUDDER .
ARMING_REQUIRE :

- ARMING_REQUIRE = 0: This cancels the transmitter arm action. Pressing the safety switch will put the aircraft into arm state
- ARMING_REQUIRE = 1: When the flight controller is armed by the transmitter, the throttle motor channel outputs the minimum channel value (default value) used during radio calibration when the throttle is at its lowest setting.
- ARMING_REQUIRE = 2: When the flight controller is armed by the transmitter, there will be no output from the throttle motor channel when the throttle is at its lowest setting. At this time, the ESC will emit a beeping warning.

ARMING_RUDDER :

- ARMING_RUDDER = 0: This cancels the transmitter arm action.
- ARMING_RUDDER = 1: At this time, the flight controller can be armed by the transmitter arm action, but cannot be armed by the transmitter arm action (default value; it is recommended to disarm using the safety switch after landing).
- ARMING_RUDDER = 2: At this time, the device can be armed or disarmed by the transmitter arm action.

Arm steps by default:

1. Press and hold the safety switch until the red light stays on.
2. Perform the transmitter arm action .

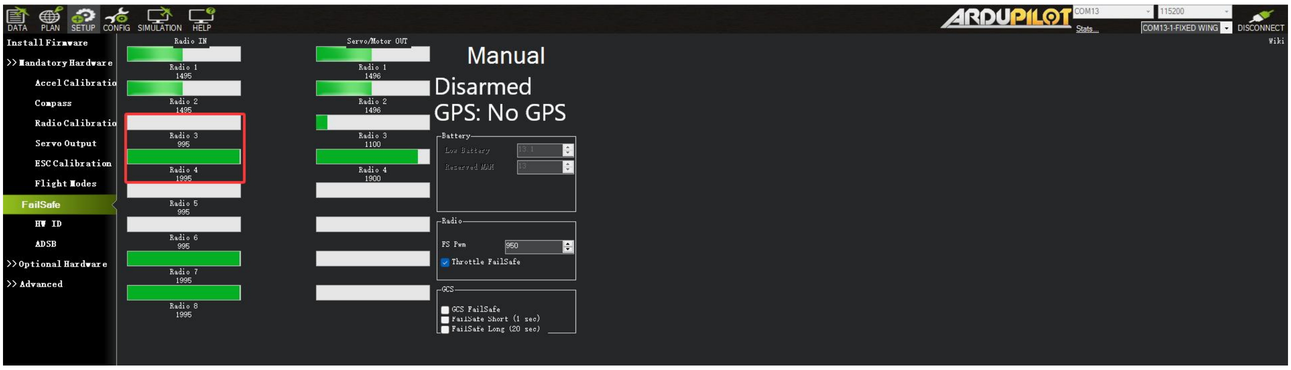
Arm action:

1. Press and hold the safety switch until the red light stays on.
2. Use the left joystick to perform the arm action shown below (The stick mode is mode 2):

3. Hold it for 5 seconds;
3. When you hear the buzzer beeping for a long time and the flight controller indicator light is always on, the arming is successful.

Note:

1. When the stick mode of the transmitter is not mode 2, please make sure Channel 3 is at the lowest and channel 4 is at the highest to perform arming. You can check the action in Mission Planner.



In the above picture, Channel 3 is at the lowest and channel 4 is at the highest.

2. If the buzzer beeps when the arming action is performed, the arming fails. Please connect the flight controller to Mission Planner to check the arm failure message, and solve the problem according to the below chapter.

Disarm steps by default: Press and hold the safety switch until the red light flashes, and the plane will not respond to any commands from the transmitter.

Disarm action:

Hold the left joystick to perform the arm action shown below for 5 seconds. (The stick mode is mode 2). When the LED of flight controller flashes and propellers stop rotating, the disarming is successful.

Note: When the stick mode of the transmitter is not mode 2, please make sure Channel 3 is at the lowest and channel 4 is at the lowest to perform disarming.

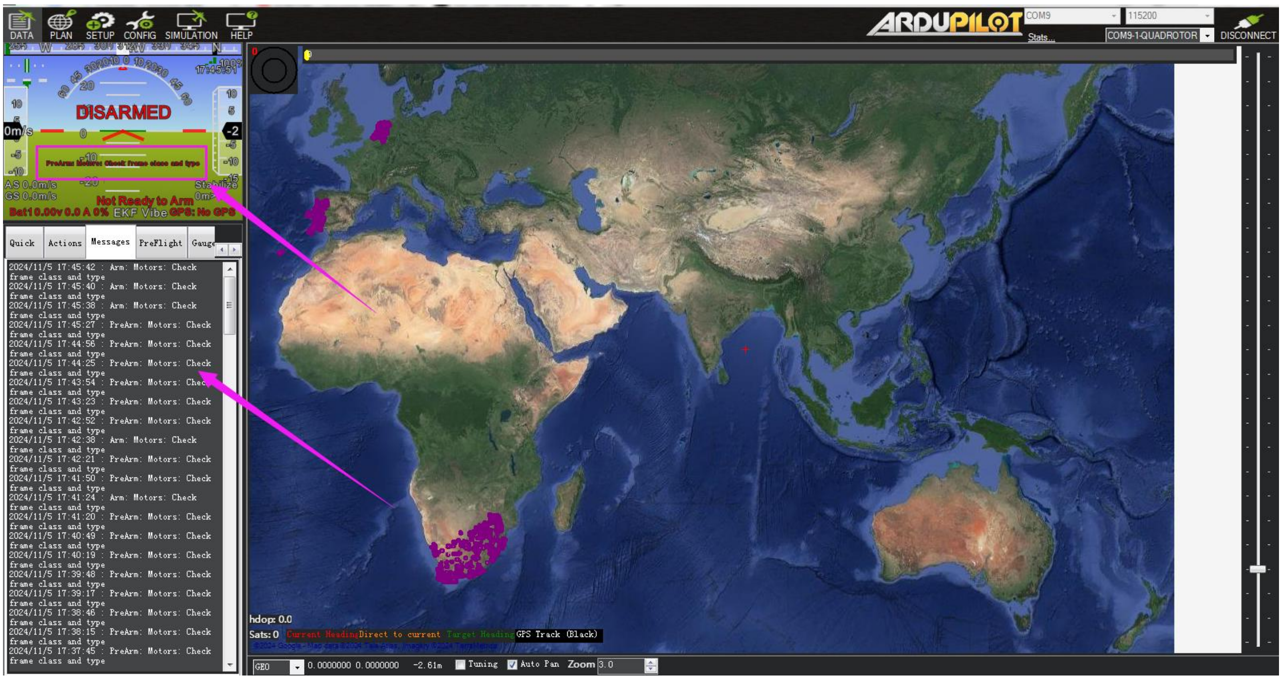
5.6.3 Troubleshooting for Arm Failure

Pre-Arm Safety Checks:

1. Radio calibrated
2. Accelerometers calibrated
3. Compass healthy
4. Compass offsets
5. Compass calibrated
6. Compass Field length
7. Barometer healthy
8. Geofencing & GPS lock
9. Board Voltage

For more details of Pre-arm safety check, please refer to the link:
https://ardupilot.org/copter/docs/common-prearm-safety-checks.html

When the arming fails, the flight controller LED indicator flashes yellow, perform arming action, and the buzzer prompts. Connect the flight contrroller to Mission Planner to view the fault prompt. After connecting, view the following interface:



When a prompt starting with PreArm appears in red font, this represents the cause of the fault at this time. For details, you can check the translation and comparison of the prompts below to solve them;
When there is no red font displayed, you can perform the arming action, which will be displayed, or view the top line of text in the message bar;
After solving the fault, power on the flight controller again. After the flight control starts normally, the status indicator light will turn blue and flash, which means it can be armed;

Some failure messages:
safe switch: The safety switch is not closed. Check the value of BRD_SAFETYENABLE in all parameter list. If it is 1, modify it to 0.

safe switch: The safety switch is not closed. Check the value of BRD_SAFETYENABLE in all parameter list. If it is 1, modify it to 0.

RC not calibrated: the radio calibration has not been performed. RC3_MIN and RC3_MAX must have been changed from their default values (1100 and 1900), and for channels 1 to 4, MIN value must be 1300 or less, and MAX value 1700 or more.

Barometer failures:
Baro not healthy: the barometer sensor is reporting that it is unhealthy which is normally a sign of a hardware failure.
Alt disparity: the barometer altitude disagrees with the inertial navigation (i.e. Baro + Accelerometer) altitude estimate by more than 2 meters. This message is normally short-lived and can occur when the

flight controller is first plugged in or if it receives a hard jolt (i.e. dropped suddenly). If it does not clear the accelerometers may need to be calibrated or there may be a barometer hardware issue.

Compass failures:
Compass not healthy: the compass sensor is reporting that it is unhealthy which is a sign of a hardware failure.
Compass not calibrated : the compass(es) has not been calibrated. the COMPASS_OFS_X, Y, Z parameters are zero or the number or type of compasses connected has been changed since the last compass calibration was performed.
Compass offsets too high: the primary compass’ s offsets length (i.e. sqrt(x^2+y^2+z^2)) are larger than 500. This can be caused by metal objects being placed too close to the compass. If only an internal compass is being used (not recommended), it may simply be the metal in the board that is causing the large offsets and this may not actually be a problem in which case you may wish to disable the compass check.
Check mag field: the sensed magnetic field in the area is 35% higher or lower than the expected value. The expected length is 530 so it’ s > 874 or < 185. Magnetic field strength varies around the world but these wide limits mean it’ s more likely the compass calibration has not calculated good offsets and should be repeated.
Compasses inconsistent: the internal and external compasses are pointing in different directions (off by >45 degrees). This is normally caused by the external compasses orientation (i.e. COMPASS_ORIENT parameter) being set incorrectly.

GPS related failures:
GPS Glitch : the GPS is glitching and the vehicle is in a flight mode that requires GPS (i.e. Loiter, PosHold, etc) and/or the circular fence is enabled.
Need 3D Fix : the GPS does not have a 3D fix and the vehicle is in a flight mode that requires the GPS and/or the circular fence is enabled.
Bad Velocity: the vehicle’ s velocity (according to inertial navigation system) is above 50cm/s. Issues that could lead to this include the vehicle actually moving or being dropped, bad accelerometer calibration, GPS updating at below the expected 5hz.
High GPS HDOP : the GPS’ s HDOP value (a measure of the position accuracy) is above 2.0 and the vehicle is in a flight mode that requires GPS and/or the circular fence is enabled. This may be resolved by simply waiting a few minutes, moving to a location with a better view of the sky or checking sources of GPS interference (i.e. FPV equipment) are moved further from the GPS. Alternatively, the check can be relaxed by increasing the GPS_HDOP_GOOD parameter to 2.2 or 2.5. Worst case the pilot may disable the fence and take-off in a mode that does not require the GPS (i.e. Stabilize, AltHold) and switch into Loiter after arming but this is not recommended.
Note: the GPS HDOP can be readily viewed through the Mission Planner’ s Quick tab as shown below.

INS checks (i.e. Accelerometer and Gyro checks):
INS not calibrated: some or all of the accelerometer’ s offsets are zero. The accelerometers need to be calibrated.
Accels not healthy: one of the accelerometers is reporting it is not healthy which could be a hardware issue. This can also occur immediately after a firmware update before the board has been restarted.
Accels inconsistent: the accelerometers are reporting accelerations which are different by at least 1m/s/s. The accelerometers need to be re-calibrated or there is a hardware issue.
Gyros not healthy: one of the gyroscopes is reporting it is unhealthy which is likely a hardware issue. This can also occur immediately after a firmware update before the board has been restarted.

Gyro cal failed: the gyro calibration failed to capture offsets. This is most often caused by the vehicle being moved during the gyro calibration (when red and blue lights are flashing) in which case unplugging the battery and plugging it in again while being careful not to jostle the vehicle will likely resolve the issue. Sensors hardware failures (i.e. spikes) can also cause this failure.
Gyros inconsistent: two gyroscopes are reporting vehicle rotation rates that differ by more than 20deg/sec. This is likely a hardware failure or caused by a bad gyro calibration.

Board Voltage checks:
Check Board Voltage: the board’ s internal voltage is below 4.3 Volts or above 5.8 Volts.
If powered through a USB cable (i.e. while on the bench) this can be caused by the desktop computer being unable to provide sufficient current to the flight controller - try replacing the USB cable.
If powered from a battery this is a serious problem and the power system (i.e. Power Module, battery, etc) should be carefully checked before flying.

Parameter checks:
Ch7&Ch8 Opt cannot be same: Auxiliary Function Switches are set to the same option which is not permitted because it could lead to confusion.
Check FS_THR_VALUE: the radio failsafe pwm value has been set too close to the throttle channels (i.e. ch3) minimum.
Check ANGLE_MAX: the ANGLE_MAX parameter which controls the vehicle’ s maximum lean angle has been set below 10 degrees (i.e. 1000) or above 80 degrees (i.e. 8000).

5.7 ESC Calibration

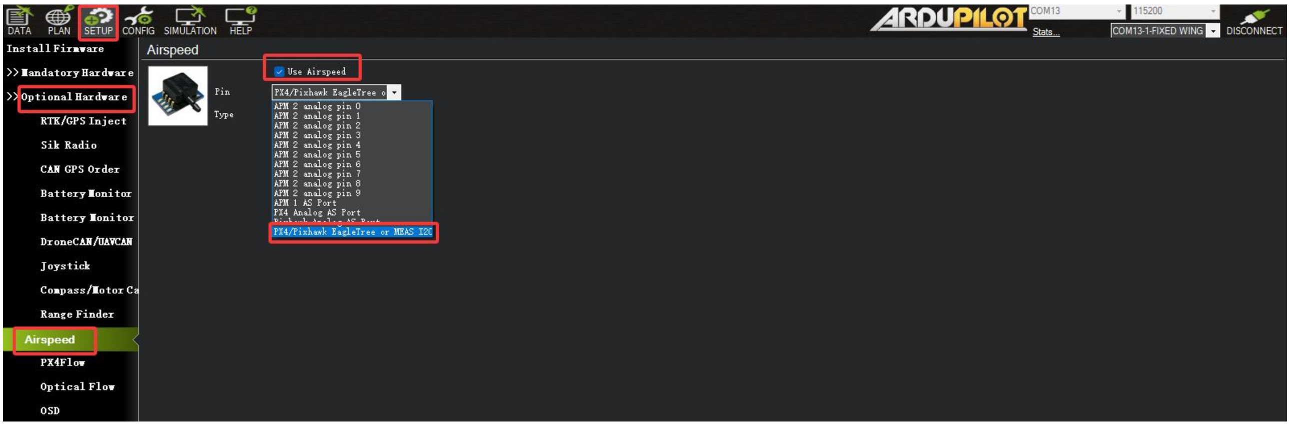
Please first ensure that the aircraft is connected properly, the calibration is completed, and can be armed successfully, and then remove the aircraft propellers.
1. Push the throttle channel of the transmitter to the highest position. Power on the aircraft, and when you see LED flashing in multiple colors, disconnect the power.
2. Power on again. Do not move the transmitter until you hear the beeping sound.
3. Push the throttle channel of the transmitter to the lowest position. After hearing the beeping sound, push the throttle slightly. If the motor rotates, the calibration is done. If not, please try the above steps again.

5.8 Air Speed

A properly configured airspeed sensor can significantly enhance an aircraft's ability to maintain altitude while in autothrottle modes (such as AUTO, CRUISE, and FBWB), as well as greatly improve the performance of automatic landings. It can also reduce the risk of stalling.

Connect the airspeed meter device to the I2C port of the PIX6. (If you want to connect it to the other ports, please refer to the link https://ardupilot.org/plane/docs/airspeed.html)

After connecting the flight controller to the Mission Planner, follow the steps below to configure it. Select "Air airspeed" and then choose PX4/Pixhawk EagleTree or MEAS I2C.



Post-setting detection

After blowing air into the air inlet of the airspeed sensor, check if there is any change in the airspeed data in the Mission Planner diagram below. If there is a change, it means that the setting is correct .

Takeoff calibration

After powering on, wait one minute or longer for the data to stabilize before performing data zeroing calibration. Follow the below steps:

1. Slightly block the air inlet of the airspeed sensor to prevent wind from affecting the calibration ;
2. Connect to the Mission Planner, open the interface shown in the image below, select **PREFLIGHT_CALIBRATION** , click "Execute Action", and wait a few seconds for the process to complete. This operation will recalibrate the barometer and airspeed sensor, allowing the altitude to return to zero.

Automatic calibrating airspeed meter

(1) Set the parameter ARSPD_AUTOCAL to 1;

(2) Take off and circle for 5 minutes. This can be done in any mode. If your automatic flight is already well-adjusted, you can use hold or RTL flight for 5 minutes. The calibration value will be updated and saved every 2 minutes during the flight. It will only be changed and saved if the difference between two values is greater than 5% .

(3) Landing, change ARSPD_AUTOCAL to 0;

(4) Check the value of ARSPD_RATIO, which is usually between 1.5 and 3. If it is outside this range, check for air leaks in the installation .

Notice:

(1) The calculation automatically compensates for the effect of altitude on air density.

(2) After calibration, please modify the ARSPD_AUTOCAL to turn off the automatic calibration function; otherwise, it will keep entering calibration and affect flight during wind speed changes.

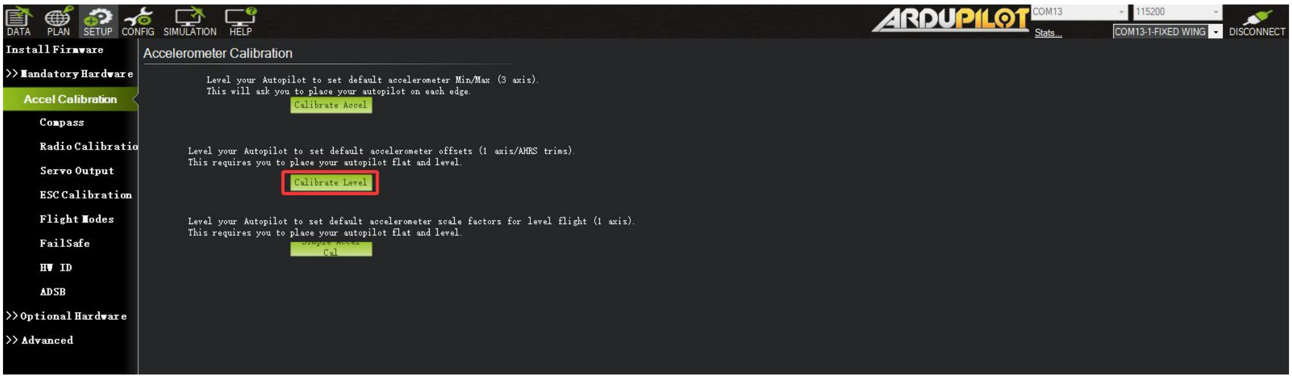
(3) To improve accuracy, you can measure the current air temperature and set GND_TEMP to the current air temperature.

(4) When you do not want to use the airspeed sensor until it is fully calibrated, you can set the parameter ARSPD_USE to 0 to disable its use, but you must set ARSPD_ENABLE to 1 to enable the airspeed indicator .

5.9 Level Calibration

If the Mission Planner shows the drone not level when you put it horizontal as this picture, You can setup as below to solve the problem.

Under Initial Setup--Mandatory Hardware--select Accel Calibration from the left-side menu--Click Calibrate Level to start the calibration.



5.10 GeoFence

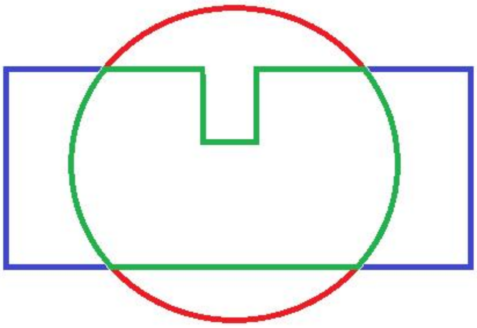
This is a safety protection mechanism that protects the aircraft from flying out of the range you set. When the function is turned on, it will detect whether the GPS is positioned. If there is no positioning, it cannot be enabled. Please enter Full Parameter List, and set the FENCE_ENABLE from 0 to 1 to enable the geofence function.

Setting parameters introduction:

When setting GeoFence parameters, please search for the following parameters in Full Parameter List and set them.

FENCE_TYPE (GeoFence type):

- Altitude is the height protection, above which the protection action will be performed.
- Circle is circular protection. Take the take-off point as the center of the circle, set the radius to draw a circle, and perform protection actions beyond this range.
- Altitude and Circle is cylindrical row protection. The take-off point is the center of the circle, set the radius, height, and the surrounding cylinder, and perform protection actions beyond this range.
- Polygon is polygon protection. After drawing the polygon on the map in the flight plan, with the maximum point of 84 points, the protection action will be performed if it exceeds this drawing range.
- Altitude and Polygon is height and polygon protection, which adds altitude protection based on polygon protection.
- Circle and Polygon is circle and polygon protection, which adds circle protection on the basis of polygon, so that the limited range is the green area, and when the green area is exceeded, the protection is performed.

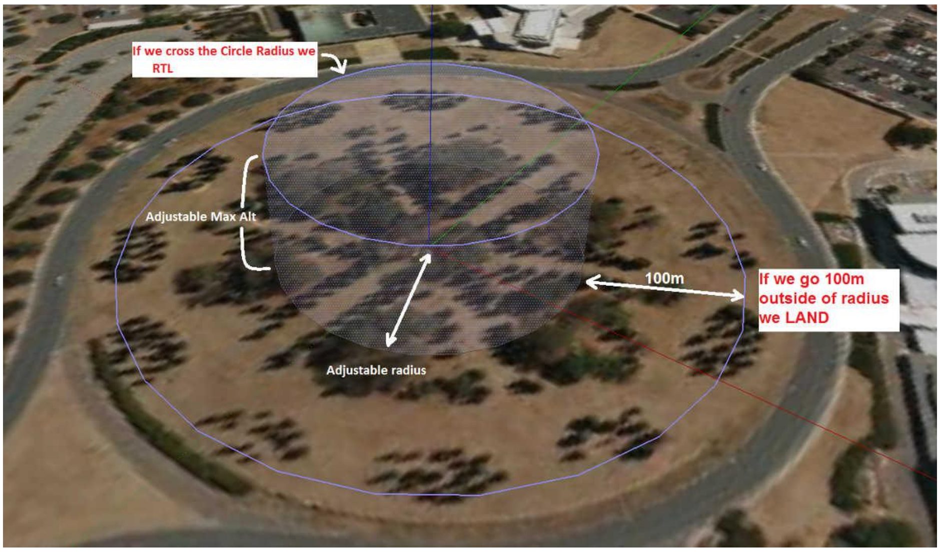


FENCE_ACTION:

All: The above 3 types of protection are involved.

Report Only: When the restricted area is exceeded, only Mission Planner message prompts and no other operations are performed.

RTL or Land: Return or land.



FENCE_ALT_MAX (maximum altitude): protection limit maximum flight altitude (10-1000m).
FENCE_RADIUS (maximum radius): Protection limits maximum flight radius (30-10000m).
FENCE_ALT_MIN (minimum altitude): Protection limit minimum flight altitude (-100-100m).

5.11 Onboard OSD

OSD is the abbreviation of On Screen Display in English. It is a kind of screen display technology, which is used to display characters, graphics and images on the display terminal. The status of the aircraft can be displayed in the returned video, and the data of each module can be integrated into the OSD module, and then the OSD module can return the monitored data to the terminal (FPV glasses or screen) and superimpose it on the video transmission image. PIX6 flight controller integrates an OSD chip. Users do not need to connect an external OSD module. They only need to connect the signal lines corresponding to the image transmission and camera to the OSD port of PIX6 to use the OSD function.

5.11.1 Setting Introduction

OSD Parameters

OSD_W_RESTVOLT: RESTVOLT warn level. Set level at which RESTVOLT item will flash Range is from 0 to 100.

OSD_CELL_COUNT: Battery cell count. Used for average cell voltage display. -1 disables, 0 uses cell count autodetection for well charged LIPO/LIION batteries at connection, other values manually select cell count used.

OSD_CHAN: Screen switch transmitter channel. This sets the channel used to switch different OSD screens. The value includes 0, 5-16.

OSD_SW_METHOD: Screen switch method. This sets the method used to switch different OSD screens.

0 = switch to next screen if channel value was changed.

1 = select screen based on pwm ranges specified for each screen.

2 = switch to next screen after low to high transition and every 1s while channel value is high.

OSD_OPTIONS: OSD Options. This sets options that change the display, including Decimal pack, Inverted Wind, Inverted AH Roll.

OSD_FONT: OSD Font. This sets which OSD font to use. It is an integer from 0 to the number of fonts available.

OSD_V_OFFSET: OSD vertical offset. Sets vertical offset of the osd inside image.

OSD_H_OFFSET: OSD horizontal offset. Sets horizontal offset of the osd inside image.

OSD_W_RSSI: RSSI warn level. Set level at which RSSI item will flash. The range is from 0 to 99.

OSD_W_NSAT: NSAT warn level. Set level at which NSAT item will flash. The range is from 0 to 30.

OSD_W_BATVOLT: BAT_VOLT warn level. Set level at which BAT_VOLT item will flash. The range is from 0 to 100V.

OSD_UNITS: Display Units. Sets the units to use in displaying items.

0 = Metric (m, km, m/s, km/h)

1 = Imperial (feet, miles, feet per second, miles per hour)

2 = ArduPilot Native (m, km, m/s)

3 = Aviation (feet, nautical miles, feet per minute, knots)

OSD_MSG_TIME: Message display duration in seconds. Sets message duration seconds.

OSD_ARM_SCR: Arm screen. Screen to be shown on Arm event. Zero to disable the feature.

OSD_DSARM_SCR: Disarm screen. Screen to be shown on disarm event. Zero to disable the feature.

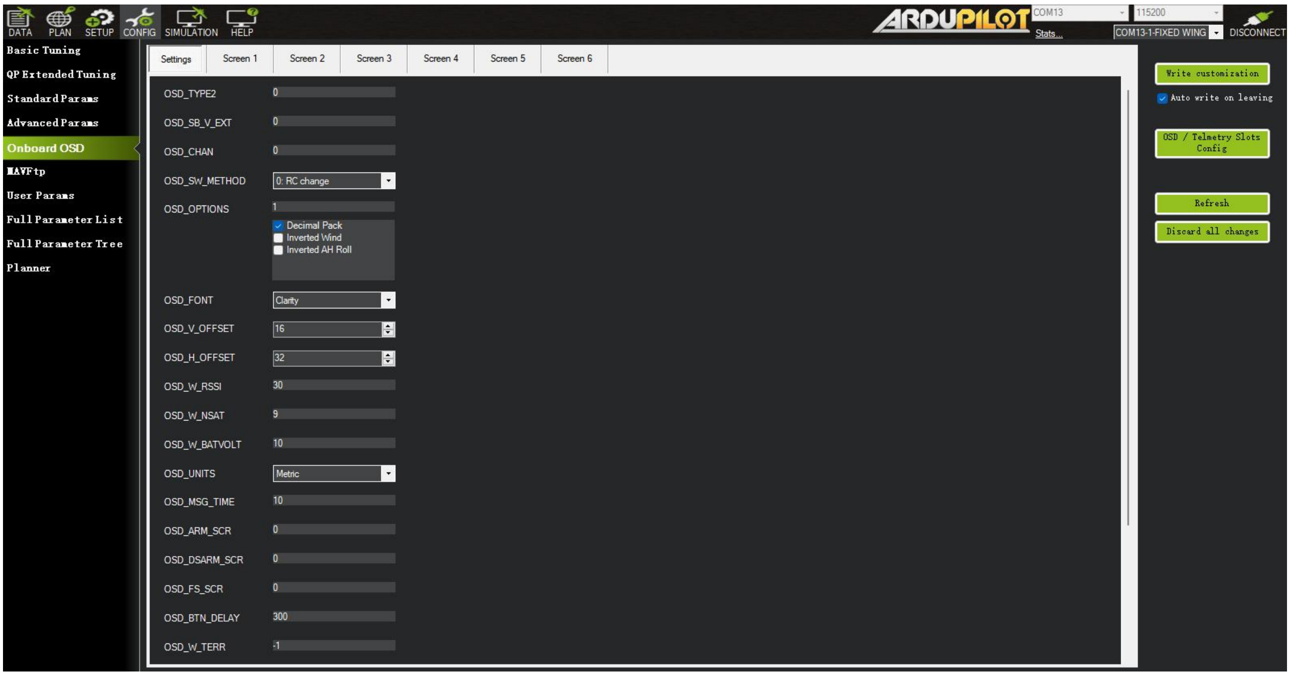
OSD_FS_SCR: Failsafe screen. Screen to be shown on failsafe event. Zero to disable the feature.

OSD_BTN_DELAY: Button delay. Debounce time in ms for stick commanded parameter navigation.

OSD_W_TERR: Terrain warn level. Set level below which TER_HGT item will flash. -1 disables.

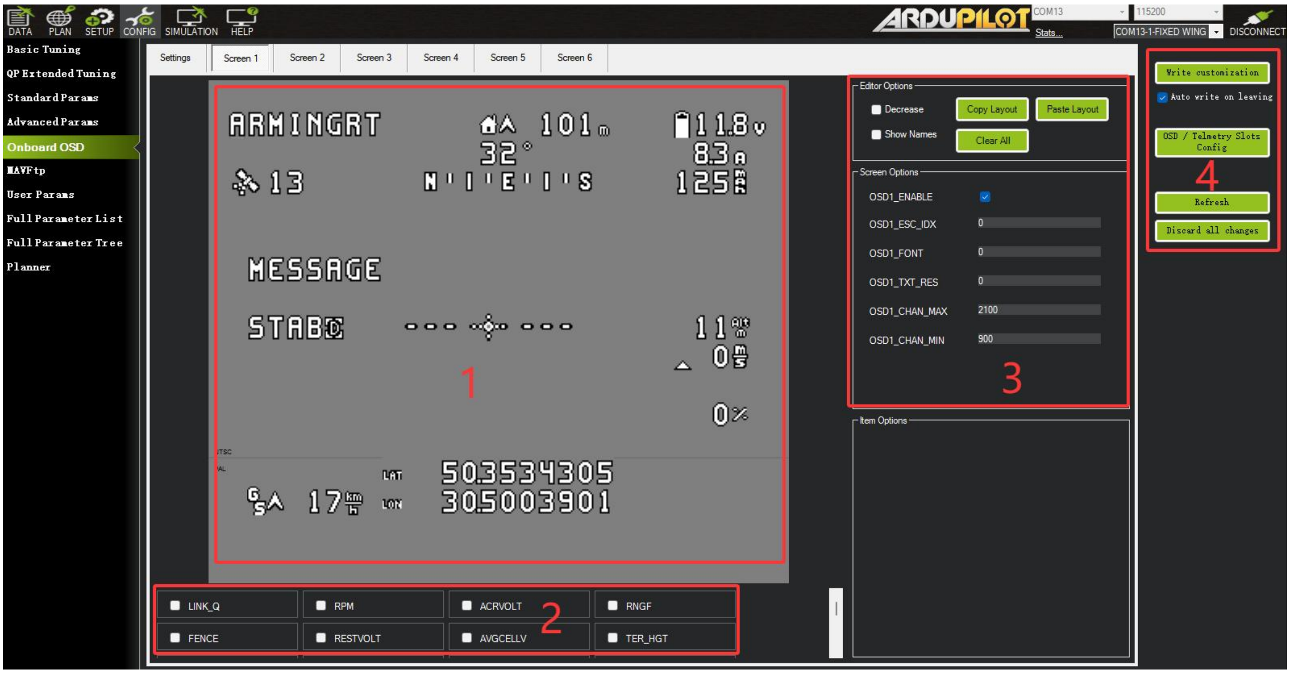
OSD_W_AVGCELLV: AVGCELLV warn level. Set level at which AVGCELLV item will flash.

OSD_TYPE: 1 means the chip of OSD is MAX7456.



5.11.2 Screen Introduction

The Screen interface is the interface displayed on the user's screen, where the user can independently design the interface layout, display options, etc.



① The area is the layout displayed on the screen. Users can freely drag and drop the options inside to customize and adjust the layout of the screen.

② The area is the content displayed on the screen. Users can tick the content they need and display it on the screen.

③ The area can copy the layout of the current screen or paste the layout of other screens to this screen.

④ Write all the current settings in the area.

6. QuadPlane Setup and Operation

6.1 Overview

A QuadPlane is a combined fixed wing and MultiCopter aircraft. This sort of aircraft brings the benefit of vertical takeoff and landing, significantly greater speed and range of travel, and the ability to hover and perform copter-like tasks at the destination.

QuadPlane is built upon Plane, but adds copter like stability control for one or more motors. In some configurations 4 or more additional motors are added. Additional modes and commands allow a QuadPlane to take off, land and fly like a copter, and to smoothly transition between the Plane and Copter-like (VTOL) modes in both automatic and autopilot-assisted modes. The additional rotors can also provide lift and stability in normal Plane modes.

Note: When you install the plane firmware and look in the parameter list you will see a Q_ENABLE parameter. That defaults to zero, which disables QuadPlane support. Setting Q_ENABLE to 1 will enable QuadPlane support. You then need to refresh your parameter list to see all the other QuadPlane options. All QuadPlane specific parameters start with Q_

6.1.1 Types and Configurations

The wide variety of configurations are possible. Motors can be under tilt control or not, the number of motors can vary from one to 8 or more, and the VTOL stance of the QuadPlane can either be horizontal, like a plane in normal fixed wing flight, or vertical (called Tailsitters).

6.2 Building a QuadPlane

6.2.1 General Rules

A wide range of fixed wing aircraft can be converted to have VTOL capabilities. QuadPlane is the name for these aircraft, you are not restricted to just QuadCopter motor layouts. Almost any multicopter motor arrangement can be used with a QuadPlane, including quad, hexa, tricoper, octa and octaquad. In addition, tilting motors to allow their use in both VTOL and Fixed Wing flight is possible. Finally, versions which use a vertical stance (nose vertical) for VTOL operations are possible.

Some of the key factors to success are:

- a fixed wing frame that can carry the weight of the additional lifting motors and power system, along with any payload needed
- sufficient power in the lifting motors not just for the total airframe weight, but also for the additional load that may be induced by downforce on the wings for configurations using a horizontal VTOL stance.
- complete clearance above and below the whole disk area of the lifting motors, to ensure they achieve full aerodynamic thrust
- minimum wing, frame, and mount twist and flex so the motors provide thrust vertically at all times
- a sufficiently robust mounting system for the lifting motors
- minimizing aerodynamic drag from the lifting motors and frame

6.2.2 QuadPlane Range

Perhaps surprisingly, it is sometimes possible to increase the potential range of an aircraft using a QuadPlane conversion. This may seem counter intuitive as a QuadPlane conversion will both add weight and increase aerodynamic drag to an airframe.

The reason why range can be increased is the extra carrying capacity of a QuadPlane. Many fixed wing aircraft are limited in the amount of battery they can carry due to the requirements for reliable launch. During launch, and especially when using a flying launch such as a catapult or bungee, the aircraft needs to rapidly accelerate to an airspeed above its stall speed. If it fails to reach that speed suffiently quickly then it will crash. A QuadPlane avoids this problem by taking off vertically, and can spend longer on the acceleration needed to sufficient speed for forward flight.
This means it is often possible to pack a lot more battery into a QuadPlane than is possible in the same airframe without VTOL motors. The extra battery capacity can more than make up for the increased weight and drag of the VTOL motors.
To make the most of this advantage you need to do very rapid VTOL takeoffs and landings to minimise the battery consumption in VTOL flight.
A second factor that can help with QuadPlane range is the flexibility available in choosing the propeller and power train for the forward motor. As conventional takeoff is not needed the forward motor does not need to be optimised for the high level of thrust needed for takeoff. This can allow larger propellers and geared motors to be used that are highly efficient for forward cruise flight.
Finally, for really long range with a QuadPlane you can use an internal combustion engine for the forward motor. A gas engine can run for a lot longer than an electric motor with the same weight of fuel.

6.3 Flying a QuadPlane

6.3.1 Transitions: VTOL/FW

QuadPlane transition is where the aircraft is changing between flying primarily as a VTOL (copter-like) aircraft and flying as a conventional fixed wing aircraft. Transition happens in both directions, and can either be commanded by the pilot or happen automatically based on airspeed/attitude/altitude(Assisted Fixed-Wing Flight) or flight mode changes during a mission.
The primary way to initiate a transition is to change flight mode, either using the flight mode channel on your transmitter or using a Mission Planner to command a mode change.
During a transition, depending on type of QuadPlane and various Q_OPTIONS settings, pilot control of the vehicle’s attitude, climb rate, etc. may be modified or restricted to assure successful transition as detailed below.

Transition to Fixed Wing Mode from VTOL
If you transition to MANUAL or ACRO, then the VTOL motors will immediately stop. In the case of a tilt-rotor, the motors will also immediately rotate to forward flight orientation.

Warning
If you do not have sufficient airspeed, an immediate stall will occur! Since MANUAL mode is often setup as a reflex driven “bail-out”, some users move, or remove this mode, and substitute QSTABLIZE or QLOITER as an alternative “bail-out” for a QuadPlane. Also if the transition is made downwind, the transition time is short, and no airspeed sensor is used in non-tailsitters, a stall could occur also since insufficient airspeed has been obtained when VTOL assistance has terminated.

If you transition to any other fixed wing mode then the VTOL motors will continue to supply lift and stability until you have reached the AIRSPEED_MIN airspeed (or airspeed estimate if no airspeed sensor). This phase is called “Transition airspeed wait”.

In non-tilt rotor configurations, the forward motor(s) thrust is controlled by the throttle stick in a manner similar to whatever fixed wing mode was entered.

- Transitioning to FBWB/CRUISE, throttle stick controls forward thrust as in that mode, as a speed or throttle value, depending on whether or not an airspeed sensor is in use. A minimum pusher throttle value is applied during the transition. If TKOFF_THR_MIN is nonzero, then it will be the minimum throttle. If it is zero, TRIM_THROTTLE will be used as the minimum throttle.
- In FBWA/STABILIZE transitions, the forward throttle is directly controlled, ie low stick is minimum/zero thrust and the QuadPlane will just hover, higher stick provides more forward throttle. The VTOL motors will behave similar to that in QHOVER and will try to maintain present altitude throughout the transition.
- During the transition, elevator input will act as climb/descent demand to the VTOL motors, roll input as roll attitude change, unless Q_OPTIONS bit 0 is set.

In the case of tilt-rotors, the motors will tilt to Q_TILT_MAX for throttle stick positions at or above mid-stick to begin building forward airspeed for the transition. In FBWA/STABILIZE transitions, throttle stick positions below mid-stick will proportionately rotate VTOL motors back towards vertical, since that controls the forward thrust component. Transitioning to FBWB/CRUISE in any configuration, throttle stick has no effect until transition is complete. Overall thrust to the motors will behave similar to that in QHOVER and will try to maintain present altitude throughout the transition. During the transition, elevator input will act as climb/descent demand to the VTOL motors, roll input as roll attitude change, unless Q_OPTIONS bit 0 is set.

Warning

Unless the Q_OPTIONS bit 0 is set, pulling back on elevator will not only pitch the nose up but also increase the VTOL motor output to assist in climbing during the transition airspeed wait phase. If bit 0 is set, only the pitch will change and altitude will not. In tilt-rotors, this can lead to delaying, or even preventing, the transition from ever completing! For tilt-rotors, do not pull back on pitch if this bit is set, until the transition is completed!

Once AIRSPEED_MIN is reached the VTOL only motors' contribution will slowly drop in power over Q_TRANSITION_MS milliseconds (default is 5000, so 5 seconds) and will switch off after that. And tilt-rotors will slowly rotate to full forward thrust configuration. Once transition is completed, normal control of throttle and attitude resumes for whatever fixed wing mode the vehicle is now in.

If Q_TRANS_FAIL is not zero, then exceeding this time before reaching AIRSPEED_MIN airspeed will cancel the transition and the aircraft will immediately execute the action specified by Q_TRANS_FAIL_ACT. The default is 0, which disables this timeout.

Note

for tiltrotors only: if bit 19 of Q_OPTIONS is set and Q_TRANS_FAIL is not zero, and if the groundspeed is greater than 1/2 of AIRSPEED_MIN, then the transition to fixed wing will immediately complete. This is useful if no airspeed sensor is being used, and the transition is into a headwind, which could prevent an accurate airspeed estimate from being obtained until a turn is made. Without using the Q_TRANS_FAIL timeout and this Q_OPTION, the transition could be indefinitely long since airspeed might be reported as below AIRSPEED_MIN due to low groundspeed.

Note

The airspeed used during transition can be found in dataflash logs as CTUN.As. This is a canonical value which will include the airspeed sensor if enabled, or use the synthetic airspeed if not.

Transition to a VTOL mode from Fixed Wing

If you transition from a fixed wing mode to a QuadPlane VTOL mode then the forward motor/thrust will immediately stop, and the control surfaces will continue to provide stability while the plane slows down. This allows for transitions to QuadPlane modes while flying at high speed. Tilt-rotors will, therefore, immediately move to VTOL position.

- VTOL attitude control will be provided as needed as the vehicle slows.
- Transition to altitude holding VTOL modes will manage power to the VTOL motors as necessary to hold altitude as the vehicle slows from forward fixed wing flight.
- Transition to non-altitude holding VTOL modes will provide vertical thrust as commanded by the throttle.
- Transition to position holding modes will project a stopping position to maintain based on deceleration of the vehicle and then hold it once reached.
- When transitioning to a position holding mode, like QLIOTER, QuadPlane will try to decelerate, which can result in the nose pitching up rapidly if traveling at high speeds (which will result in considerable altitude gain in most cases). In order to prevent this, the pitch is initially limited to 0 degrees, relaxing this limit to the smaller of Q_ANGLE_MAX or PTCH_LIM_MAX_DEG over the period of Q_BACKTRANS_MS. Even with these limits altitude gain can result during the deceleration while transitioning.

The one exception to the forward motor stopping in QuadPlane VTOL modes is if you have the Q_VFWD_GAIN parameter set to a non-zero value. In that case the forward motor will be used to hold the aircraft position in a wind.

Warning

During transitions from VTOL to fixed wing mode, all motors can be running at very high levels. Battery sag below minimum levels (3.0V/cell for LiPo batteries) and resulting battery damage is possible. Extreme cases may even result in a crash due to VTOL motor output being too low. This is especially true when using high capacity, low C rating flight batteries common for long duration setups. This can be managed somewhat with manual throttle control when manually transitioning, but in AUTO mode, a VTOL to fixed wing transition is currently done with TKOFF_THR_MAX on the forward motor until transition is complete, so very high currents can be experienced. Whether or not this will be an issue can be determined by examining the battery voltage during a manually initiated transition from the flight log. If too much voltage sag is seen, the best solutions are to use a higher C rating flight battery, or use separate batteries for forward motors and the VTOL motors, or to use BATT_WATT_MAX and other parameters to limit excessive current draw during transitions.

6.3.2 Assisted Fixed-Wing Flight

The QuadPlane code can also be configured to provide assistance to the fixed wing code in any flight mode except MANUAL or ACRO. VTOL motor assistance is enabled if Q_ASSIST_SPEED is non-zero. If left at its default value (0), a pre-arm warning will occur telling the user to set this parameter. a value of -1 disables assistance features and suppresses the pre-arm warning.

When Q_ASSIST_SPEED is non-zero and positive then the quad motors will assist with both stability and lift whenever the airspeed drops below that threshold. This can be used to allow flying at very low speeds in FBWA mode for example, or for assisted automatic fixed wing takeoffs.

Warning

If you are not using an airspeed sensor, airspeed will be determined by the synthetic airspeed generated internally as a backup in case of airspeed sensor failure. This estimate can be very inaccurate at times. You may want to consider not enabling Assisted Fixed Wing Flight if not using an airspeed sensor to prevent false activations when airspeed really is above the threshold but is being misrepresented by the internal airspeed. Setting Q_ASSIST_SPEED to -1 will disable the pre-arm warning and assistance except in transitions.

It is suggested that you do initial flights with Q_ASSIST_SPEED disabled just to test the basic functionality and tune the airframe. Then try with Q_ASSIST_SPEED above plane stall speed if you want that functionality.
A second assistance type is available if Q_ASSIST_SPEED is a positive value based on attitude error. If Q_ASSIST_ANGLE is non-zero then this parameter gives an attitude error in degrees above which assistance will be enabled even if the airspeed is above Q_ASSIST_SPEED.
A third trigger to provide assistance. if Q_ASSIST_SPEED is positive, is Q_ASSIST_ALT. This is the altitude below which QuadPlane assistance will be triggered. This acts the same way as Q_ASSIST_ANGLE and Q_ASSIST_SPEED, but triggers if the aircraft drops below the given altitude while the VTOL motors are not running. A value of zero disables this feature. The altitude is calculated as being above ground level. The height above ground is given from a Lidar used if available and RNGFND_LANDING bit 0 or 1 is set, or from terrain data if TERRAIN_FOLLOW =1, or comes from the height above home otherwise.
Assistance will be activated Q_ASSIST_DELAY after any of the above enabling thresholds are reached.
Assistance can also be enabled, disabled, or forced by setting an RC switch to RCx_OPTION = 82. If that channel is below 1200us (LOW), then assistance is unconditionally disabled, if above 1800us, (HIGH) then assistance is always enabled. For other RC values, assistance will be enabled as explained above.
Assistance can also be forced active all the time by setting Q_OPTIONS bit 7 to “1”. For Tailsitters, assistance for tailsitters can be limited only to VTOL motors by by setting Q_OPTIONS bit 8 to “1”. This can increase stability during assistance by not using the copter style pid gains on the flying surfaces as well as the VTOL motors, or for use with copter tailsitters without servo-controlled flying surfaces.

Note
Assistance is available for all QuadPlane frame types except the single motor and non-tilt dual motor tailsitter frames.

What assistance the quad motors provides depends on the fixed wing flight mode. If you are flying in an autonomous or semi-autonomous mode then the quad motors will try to assist with whatever climb rate and turn rate the autonomous flight mode wants when assistance is enabled (ie. airspeed is below Q_ASSIST_SPEED or attitude error is above Q_ASSIST_ANGLE, or altitude is below Q_ASSIST_ALT). In a manually navigated mode the quad will try to provide assistance that fits with the pilot inputs.
The specific handling is:
- In AUTO mode the quad will provide lift to get to the altitude of the next waypoint, and will help turn the aircraft at the rate the navigation controller is demanding.
- In fixed wing LOITER, RTL or GUIDED modes the quad motors will try to assist with whatever climb rate and turn rate the navigation controller is asking for.
- In CRUISE or FBWB mode the quad will provide lift according to the pilot’s demanded climb rate (controlled with pitch stick). The quad motors will try to turn at the pilot demanded turn rate (combining aileron and rudder input).

- In FBWA mode the quad will assume that pitch stick input is proportional to the climb rate the user wants. So if the user pulls back on the pitch stick the quad motors will try to climb, and if the user pushes forward on the pitch stick the quad motors will try to provide a stable descent.
- In AUTOTUNE mode the quad will provide the same assistance as in FBWA, but it is not a good idea to use AUTOTUNE mode with a high value of Q_ASSIST_SPEED as the quad assistance will interfere with the learning of the fixed wing gains.
- In MANUAL, ACRO and TRAINING modes the quad motors will completely turn off. In those modes the aircraft will fly purely as a fixed wing.
- In STABILIZE mode the quad motors will try to provide lift if assistance is turned on.

6.3.3 Return to Launch

Returning to Launch (either HOME or a Rally point) can be executed by either switching to RTL mode or QRTL mode. In each case a key concept is the return point. This is defined as the closest rally point, or if a rally point is not defined, then the HOME location. See the Rally Points page for more information on rally points.

RTL mode has four different options for its behavior but basically uses fixed wing flight for at least the majority of the return. Behavior also depends on how close to the return point the vehicle is when entered and from what mode, fixed wing or VTOL/QAssist. RTL mode behavior is determined by the Q_RTL_MODE parameter and explained in the sections below.

QRTL mode, by default, will return either in fixed wing mode and land in VTOL mode the same way as the RTL mode selected by Q_RTL_MODE = 3, or by using Q_OPTIONS bit (16), as a pure VTOL return and land.

Note

RC failsafe when in a VTOL mode will only result in either a switch to QLAND, RTL, or QRTL, depending on the Q_OPTIONS bit 5 (QRTL) and bit 20 (RTL) settings (bit 20 overrides bit 5), independent of what the FS_SHORT_ACTN or FS_LONG_ACTN setting is.

RTL Modes

Fixed Wing RTL

Q_RTL_MODE = 0

RETURN FIXED WING AND LOITER

The default behaviour (Q_RTL_MODE = 0)of the RTL mode is the same as for fixed wing. It will fly to the nearest rally point (or HOME if no rally point is defined) and circle as a fixed wing aircraft about that point. The VTOL motors will not be used unless the aircraft drops below the airspeed defined in Q_ASSIST_SPEED. The altitude the aircraft will circle at will be the altitude in the rally point, or the RTL_ALTITUDE altitude if a rally point is not being used.

If in a VTOL mode when RTL is selected (either by a failsafe action or the pilot), the Quadplane will immediately transition to fixed wing and fly back as if in normal fixed wing RTL mode.

Hybrid RTL

The another options for RTL in a QuadPlane are to fly as a fixed wing aircraft until it is close to the return point at which time it switches to VTOL QRTL mode and land vertically at the return point. To enable this type of hybrid RTL behavior you need to set the Q_RTL_MODE parameter to 1, 2, or 3.

Note

for the code to judge when to start the transition to VTOL in order to arrive at the point it should be totally VTOL, the Q_TRANS_DECEL parameter is used to calculate the when to start the transition. If the vehicle is overshooting, this value can be lowered, and vice-versa.

Q_RTL_MODE = 1

RETURN FIXED WING, SWITCH TO QRTL, and LAND

If in fixed wing mode when RTL is entered, the initial altitude that will be aimed for in the fixed wing portion of the hybrid RTL is the same as for a fixed wing RTL. You should set your rally point altitude and RTL_ALTITUDE parameters appropriately to ensure that the aircraft travels at a safe altitude.

The distance from the return point at which the aircraft switches from fixed wing to VTOL flight is set using the RTL_RADIUS parameter, or if that is not set then the WP_LOITER_RAD parameter is used. The aircraft will then slow down as it approaches the return point, aiming for an altitude set by Q_RTL_ALT. Once the return point is reached the aircraft begins to descend and land.

If in a VTOL mode when RTL is selected (either by a failsafe action or the pilot), the Quadplane will immediately transition to fixed wing and fly back as if it had been entered while in a fixed wing mode.

Q_RTL_MODE = 2

RETURN FIXED WING, LOITER TO ALT, SWITCH TO QRTL, LAND

Setting Q_RTL_MODE to 2 results in behavior similar to above, but with the vehicle returning like normal fixed wing RTL until it reaches Q_FW_LND_APR_RAD, then loitering in fixed wing mode down to Q_RTL_ALT altitude, and then exiting facing the wind and executing a QRTL to the home position. Be sure the loiter portion is set up to clear any obstacles.

If RTL is triggered within the larger of RTL_RADIUS and WP_LOITER_RAD, and below Q_RTL_ALT, in a VTOL mode or assisted fixed wing flight, the vehicle will proceed immediately toward Q_RTL_ALT and the landing position and then land (ie QRTL mode).

If in a VTOL mode or assisted fixed wing flight when RTL is selected (either by a failsafe action or the pilot) beyond those radii, the Quadplane will immediately transition to fixed wing and fly back as if it had been entered while in a fixed wing mode.

Q_RTL_MODE = 3

RETURN FIXED WING,APPROACH TO VTOL TRANSITION POINT, AIRBRAKE, SWITCH TO QRTL, LAND

Setting Q_RTL_MODE to 3 results in behavior similar to a normal QRTL. The vehicle will enter an “APPROACH” phase, and will return at RTL_ALTITUDE and at a calculated distance, start a descent towards Q_RTL_ALT. As it approaches the landing position, an “airbraking” phase is started in non-tailistters to slow the vehicle and once slowed enters full VTOL mode and proceeds to execute a VTOL landing. This behavior is also used by default for the QRTL mode unless Q_OPTIONS bit 16 is set to prevent the Hybrid operation above.

In effect, this enables the QRTL mode for any RTL actuation: failsafe actions, mode change to QRTL, or completion of a mission (unless the last mission item prevents RTL).

Note

This mode is also used by default in all mission VTOL_LANDINGs unless the Q_OPTIONS bit 16 is set to disable it.

This fixed wing “approach” allows VTOL landings to be used without needing to setting up approach waypoints to reduce altitude and get close enough to proceed in VTOL mode toward the landing point. If disabled by bit 16, the vehicle will instantly transition to VTOL mode upon that mission items execution, or upon mode changes to QRTL, and navigate to its landing point in VTOL before doing a QLAND. This means that you should be very close to the landing site if the FW approach mode is disabled in a mission since it will proceed in VTOL flight to the land point.

The phases of the approach are:

- in a fixed wing mode when further than 2 times the greater of either RTL_RADIUS or WP_LOITER_RADS (MAXRAD) plus a calculated distance needed to descend from RTL_ALTITUDE to Q_RTL_ALT, the plane will attempt to climb or descend to RTL_ALTITUDE. If within that range, it will attempt to climb/descend to a linear descent slope, meet it, and continue to descend, as shown above.
- if started further than 2X "MAXRAD" but closer than above, at 2x MAXRAD it will continue in fixed wing mode at Q_RTL_ALT.
- when it reaches a point that is within the VTOL stopping distance of the landing point (calculated using the VTOL deceleration parameter Q_TRANS_DECEL which gives the deceleration that will occur as the vehicle transitions to VTOL and the vehicle's current speed), it will transition to VTOL mode and send a message that it is in "VTOL Position1" and continue moving to the land point. If the vehicle is NOT a tailsitter, an "AIRBRAKING" phase may occur before the VTOL transition, spinning up the VTOL motors to create additional braking.

Note

if the vehicle is overshooting "VTOL Position1", try decreasing Q_TRANS_DECEL in steps. However, this increases the point before "VTOL Position1" that the vehicle will transition to VTOL.

- once the QuadPlane is within 5m of the land point and moving less than 2 m/s, it will send a GCS message declaring that it is in "VTOL Position 2", and final position itself over the land point and begin its landing descent, which will also be indicated by GCS messages
- if the approach is entered less than 1.5X MAXRAD, it will immediately move to "VTOL Position 1" state, whether entered from fixed wing or VTOL modes, and move toward the landing site attempting to obtain Q_RTL_ALT as it does so.
- if in VTOL mode at greater than 1.5X MAXRAD, the vehicle will climb to Q_RTL_ALT, if below, then transition to fixed wing and start a normal fixed wing RTL, and attempt to navigate to home, executing the approach. The climb and turn toward the landing point will occur at even low altitudes as determined by Q_RTL_ALT, so the FLIGHT_OPTIONS bit 4 for "Climb before turn in RTL" and/or Q_OPTIONS bit 0 for "Level Transitions" might be worth considering for the fixed wing initial phases.

Note

In cases where it is feared that using the approach feature may result in it being initiated too close to HOME due to the 1.5X MAXRAD distance being too close in VTOL modes, instead of using Q_OPTIONS bit 16 to disable the feature entirely, the Q_APPROACH_DIST to increase the distance from HOME that the vehicle needs to be to transition to fixed wing and execute an approach.

QRTL Mode

By default, switching to QRTL mode will act exactly as Q_RTL_MODE = 3, above. However, if you prefer to do return to launch as a pure VTOL aircraft (like a multirotor would do) then you can use the QRTL flight mode, but with Q_OPTIONS bit 16 set in order to disable QRTL's default behavior (which is like the hybrid RTL described above with Q_RTL_MODE = 3). The vehicle will transition to VTOL

flight, if not already in VTOL, and then fly at the Q_WP_SPEED speed towards the return point, at an altitude of Q_RTL_ALT.
Once the return point is reached the aircraft will start a vertical descent towards the ground for landing. The initial descent rate is set by Q_WP_SPEED_DN. Once the aircraft reaches an altitude of Q_LAND_FINAL_ALT the descent rate will change to Q_LAND_FINAL_SPD for the final landing phase.
In the final landing phase the aircraft will detect landing by looking for when the VTOL motor throttle drops below a minimum threshold for 5 seconds. When that happens the aircraft will disarm and the VTOL motors will stop.

6.3.4 VTOL vs Fixed-Wing Level Trim

Often fixed wing "level" trim, which is the pitch attitude stabilization modes attempt to maintain, is set to be several degrees positive with respect to the wing chord line in order to provide lift while cruising.
However, when in VTOL modes, this can result in the vehicle leaning "backward" a few degrees, building in a tendency to drift backwards. This can be eliminated by setting the Q_TRIM_PITCH parameter to correct this. This can also be used to correct minor CG imbalances caused by VTOL motor placement not being exactly balanced around the CG.

Manual Forward Throttle in VTOL Modes

By setting an RC channel option (RCx_OPTION) to "209", that channel can provide a separate throttle input to the forward motor(s) in QSTABILIZE, QACRO, and QHOVER VTOL modes. This allows forward movement without having to tilt the QuadPlane forward requiring throttle stick repositioning in QSTABILIZE and QACRO to maintain altitude, and present more forward flat plate resistance to forward movement in all modes. The maximum percentage throttle that will be applied by this channel is set by Q_FWD_MANTHR_MAX.

Radio or Throttle Failsafe

If flying in a plane mode or AUTO, behaviour is determined by the FS_SHORT_ACTN and FS_LONG_ACTN parameter settings. QuadPlanes can be set such that instead of normal plane behaviour on Failsafe induced RTLs, to transition to QRTL and land once at the rally point or home, if Q_RTL_MODE =1. If Q_RTL_MODE =2, then a fixed wing approach followed by a loiter to alt and QRTL will be executed, similar to that described in the "AUTO VTOL Landing" section of QuadPlane AUTO Missions.
If flying in any VTOL mode (QHOVER,QSTAB,etc.) and not flying a mission, failsafe will evoke QLAND , QRTL or RTL, depending on how Q_OPTIONS, bits 5 and 20, are set.

Note
if failsafe occurs during a VTOL takeoff, it will immediately switch to QLAND mode

VTOL Landing Repositioning

During the final descent phase of QRTL/QLAND or a mission VTOL LAND command, repositioning the vehicle or pausing the descent is usually not possible unless switching to a pilot controlled mode like QLOITER. However, there are two options that can be enabled to give the pilot control:

Throttle Descent Control

If Q_OPTIONS bit 15(+32768 to param value), is set, it will allow pilot to control descent during VTOL AUTO-LAND phases, similar to throttle stick action during QHOVER or QLOITER. However, this will not become active until the throttle stick is raised above 70% momentarily during the descent at least once.

Horizontal Repositioning

If Q_OPTIONS bit 17(+131072 to param value), is set, it will enable pilot horizontal re-positioning during VTOL auto LAND phases using the pitch and roll sticks like QLOITER, momentarily pausing the descent while doing so.

What Will Happen?

Understanding hybrid aircraft can be difficult at first, so below are some scenarios and how the code will handle them.

I am hovering in QHOVER/QLOITER and switch to FBWA mode

The aircraft will continue to hover, setting forward thrust/throttle at whatever the throttle stick position dictates and gaining speed. If you zero throttle during the transition, the aircraft will continue to hold the current height and hold itself level, slowing to a halt. It will drift with the wind as it is not doing position hold.

If you advance the throttle stick then the forward motor will throttle-up and the aircraft will start to move forward. The quad motors will continue to provide both lift and stability while the aircraft is moving slowly. You can control the attitude of the aircraft with roll and pitch stick input. When you use the pitch stick (elevator) that will affect the climb rate of the quad motors. If you pull back on the elevator the quad motors will assist with the aircraft climb. If you push forward on the pitch stick the power to the quad motors will decrease and the aircraft will descend.

The roll and pitch input also controls the attitude of the aircraft, so a right roll at low speed will cause the aircraft to move to the right. It will also cause the aircraft to yaw to the right (as the QuadPlane code interprets right aileron in fixed wing mode as a commanded turn).

Once the aircraft reaches an airspeed of AIRSPEED_MIN (or Q_ASSIST_SPEED if that is set and is greater than AIRSPEED_MIN) the amount of assistance the quad motors provide will decrease over 5 seconds. After that time the aircraft will be flying purely as a fixed wing.

I am flying fast in FBWA mode and switch to QHOVER mode

The quad motors will immediately engage and will start by holding the aircraft at the current height. The climb/descent rate is now set by the throttle stick, with a higher throttle stick meaning climb and a lower throttle stick meaning descend. At mid-stick the aircraft will hold altitude.

The forward motor will stop, but the aircraft will continue to move forward due to its momentum. The drag of the air will slowly bring it to a stop. The attitude of the aircraft can be controlled with roll and pitch sticks (aileron and elevator). You can yaw the aircraft with rudder.

I switch to RTL mode while hovering

The aircraft will generally transition to fixed wing flight. The quad motors will provide assistance with lift and attitude while the forward motor starts to pull the aircraft forward. Depending on the Q_RTL_MODE, different behaviors can be selected as it returns to the return point (rally or home). See Return to Launch for details.

If you have RTL_AUTOLAND setup then the aircraft will follow the mission configuration.

I switch into QRTL close to HOME

If closer than 1.5X the larger of either RTL_RADIUS or WP_LOITER_RAD, then the vehicle will proceed toward home in VTOL mode and land. If greater, it will transition to fixed wing, climbing toward RTL_ALTITUDE and executing a normal QRTL. Depending on how far from home, the vehicle may only briefly climb and then switch back to approach or airbrake phases. The further away, the higher the climb as it flies back toward home. If the approach behavior has ben disabled with Q_OPTIONS bit 16, then it will just switch to VTOL (if not already in that mode, navigate to home and land).

I have an EKF Failsafe
A failsafe mechanism is provided to protect VTOL operation in case the EKF becomes unhealthy. In normal fixed wing operation, it "falls back" to another inertial guidance filter, DCM, if the EKF becomes unhealthy. However, if operating in AUTO mode in a VTOL mode when an EKF failure occurs, QuadPlanes will switch modes to QLAND, and to QHOVER in all other position control VTOL modes (QLOITER, QRTL, QLAND, QAUTOTUNE).

Typical Flight
A typical test flight would be:

- VTOL takeoff in QLOITER or QHOVER
- switch to FBWA mode and advance throttle over 50% and start flying fixed wing
- switch to QHOVER mode to go back to quad mode and reduce throttle back to 50% for hover.

6.4 First Time Setup

6.4.1 Frame Setup

The QuadPlane code supports several frame arrangements of quadcopter, hexacopter, octacopter and octaquad multicopter frames which use lifting motors in addition to the normal forward motor(s). Also configurations in which the VTOL motors tilt for transitions or control, as well as choice between horizontal VTOL stance or vertical (Tailsitters).

Tailsitters
Frame setup for Tailsitters is in this section: Tailsitter Planes. Once the frame is configured, proceed with the other QuadPlane Setup instructions.

Plane VTOL Motor Configurations
These configurations add multicopter style lifting motors to a conventional fixed wing configuration. Some or all of these motors may also be configured as tilting motors to be used in fixed wing flight instead of the normal fixed forward motor(s).

Frame Types and Classes
To use a different frame type you can set Q_FRAME_CLASS and Q_FRAME_TYPE.

Frame Class
Q_FRAME_CLASS designates the number of motors used, and can be:

- 1 for quad
- 2 for hexa
- 3 for octa
- 4 for octaquad
- 5 for Y6 (ignores all following frame types except 10 and 11, all others result in Y6A configuration)
- 7 for tri (ignores all following frame types except 6 for reversed tricopter)
- 10 for tailsitter using single/dual motors (ignores all following frame types)

Frame Type

Within each of these frame classes the Q_FRAME_TYPE chooses the motor layout and rotation directions.

- 0 for plus frame
- 1 for X frame
- 2 for V frame
- 3 for H frame
- 6 for reversed X frame
- 10 for Y6B only
- 11 for FireFly6Y6 (Y6F only)

VTOL Motor Ordering

The motor order and output channel is the same as for copter (see Copter motor layout) except that the default output channel numbers usualy start at 5 instead of 1, since the basic plane control surfaces are usually setup by default already on outputs 1 thru 4 when Q_ENABLE is set to 1 and the autopilot rebooted to setup QuadPlane.

Note

Tailsitter Planes configuration is a special case. See Tailsitter notes below

For example, with the default Quad-X frame the motors are on outputs 5 to 8. The arrangement is:

- Output 5: Motor 1 - Front right motor, counter-clockwise
- Output 6: Motor 2 - Rear left motor, counter-clockwise
- Output 7: Motor 3 - Front left motor, clockwise
- Output 8: Motor 4 - Rear right motor, clockwise

You can remember the clockwise/counter-clockwise rule by “motors turn in towards the fuselage”, except for the H configuration, there all directions are inverted!

Another common setup is an OctoQuad X8, which uses the following ordering

- Output 5: Motor 1 - Front right top motor, counter-clockwise
- Output 6: Motor 2 - Front left top motor, clockwise
- Output 7: Motor 3 - Rear left top motor, counter-clockwise
- Output 8: Motor 4 - Rear right top motor, clockwise
- Output 9: Motor 5 - Front left bottom motor, counter-clockwise
- Output 10: Motor 6 - Front right bottom motor, clockwise
- Output 11: Motor 7 - Rear right bottom motor, counter-clockwise
- Output 12: Motor 8 - Rear left bottom motor, clockwise

You can remember the clockwise/counter-clockwise rule for an octa-quad by “top motors turn in towards the fuselage, bottom motors turn out away from the fuselage”.

For a Tricopter configuration, the default output assignment is:

- Output 5: Motor 1 - Front right motor, looking from above
- Output 6: Motor 2 - Front left motor
- Output 8: Motor 4 - Rear motor
- Output 11: Motor 7 - Tail Tilt Servo (see below)

The normal plane outputs are assumed to be on 1 to 4 as usual. Only vertical lift outputs (5 to 8 on a quad setup) normally should be run at high PWM rate (400Hz). When using these default configurations, you can assigne other outputs to whatever functions you desire.
You can optionally move the motors to be on any other channel, using the procedure outlined in the section further below.

Tricopter
Frame Type 7 is Tricopter and can be either non-Tiltrotor, or a Tiltrotor configuration for the front motors, but using a separate servo to sideways tilt the rear motor for yaw control, or a Tiltrotor using Vectored Yaw control via the front tilting motors.
If using a tilting yaw control, an output is setup as Motor 7 (SERVOn_FUNCTION = 39) for a servo-controlled sideways tilt mechanism for the yaw motor, Motor 4. You should set up the yaw servo’s maximum lean angle in degrees with Q_M_YAW_SV_ANGLE to prevent prop strikes to the ground or frame. This lean angle assumes that SERVOn_MIN and SERVOn_MAX, represent +/- 90 degrees, with SERVOn_TRIM representing 0 degrees lean.

Note
the rear motor tilt servo is not affected by Q_TILT_MASK or any other Tiltrotor related parameters since it is not involved with vertical or horizontal propulsion, only yaw control.

Using different channel mappings
You can remap what output channels the lifting motors are on by setting values for SERVOn_FUNCTION. This follows the same approach as other output functions.

Note
Note that you do not need to set any of the SERVOn_FUNCTION values unless you have a non-standard motor ordering, using vectored thrust, or are a Tailsitter. It is highly recommended that you use the standard ordering and do not set the SERVOn_FUNCTION parameters, leaving them at zero. They will be automatically set to the right values for your frame on boot.

The output function numbers are:

- 33: motor1
- 34: motor2
- 35: motor3
- 36: motor4
- 37: motor5
- 38: motor6
- 39: motor7
- 40: motor8

So to put your quad motors on outputs 9 to 12 (the auxiliary channels on a Pixhawk) you would use these settings in the advanced parameter list:

- SERVO9_FUNCTION = 33
- SERVO10_FUNCTION = 34
- SERVO11_FUNCTION = 35
- SERVO12_FUNCTION = 36

6.4.2 Tilt Rotor Planes

Tilt rotors are treated as a special type of QuadPlane. You should start off by reading the QuadPlane documentation before moving onto this tilt-rotor specific documentation.
A tilt-rotor is a type of VTOL aircraft where transition between hover and forward flight is accomplished by tilting one or more rotors so that it provides forward thrust instead of upward thrust.

Note
This is distinct from tailsitters where the autopilot and main fuselage change orientation when moving between hover and forward flight. Do not use the information below for a Tailsitter, some parameters are shared, but use the instructions in the Tailsitter Planes.

Types of Tilt-Rotors
A very wide range of tilt-rotor configurations are supported. Common configurations include:

- tilt-quadplanes with the front two motors tilting
- tilt-quadplanes with all four motors tilting
- tilt-tricopters with the front two motors tilting and rear tilt for yaw
- tilt-tricopters with the front two motors tilting and vectored yaw
- tilt-hexacopters with the front four motors tilting
- tilt-wings where the main wing tilts along with two motors
- binary-tiltrotors where the tilt mechanism can only be in one of two positions
- continuous-tiltrotors where the tilt mechanism can be controlled to any angle in a range from straight up to straight forward
- vectored tilt-rotors where the tilt of the rotors on the left can be controlled independently from the tilt of the right motors

Combined with these variants are versions that use ailerons, elevons, vtails and other control surfaces for fixed wing flight. There are an amazing number of combinations possible, and experimentation with VTOL designs is common.

Setting Up A Tilt-Rotor
The first thing you need to do is enable QuadPlane support by setting Q_ENABLE to 1 and Tilt Rotor support by setting Q_TILT_ENABLE = “1”, and then choose the right quadplane frame class and frame type.
The quadplane frame class is in Q_FRAME_CLASS. The frame class is chosen based on your vehicles rotor configuration while hovering. Currently supported tilt-rotor frame classes are:

Frame Class	Q_FRAME_CLASS
Quadcopter	1
Hexacopter	2
Octacopter	3
Octaquad	4
Y6	5

Tricopter	7
Bicopter	10

Once you have chosen your frame class you will need to get the Q_FRAME_TYPE right. The Q_FRAME_TYPE is the sub-type of frame. For example, for a Quadcopter, a frame type of 1 is for a “X” frame and a frame type of 3 is for a “H” frame. For Tri and Y6, this parameter is ignored.
Please see the ArduCopter setup guide for multi-copters for more information on choosing your frame type.
After setting up Q_ENABLE, Q_FRAME_CLASS and Q_FRAME_TYPE you will need to reboot.

The Tilt Mask

The most important parameter for a tilt-rotor is the tilt-mask, in the Q_TILT_MASK parameter.
The Q_TILT_MASK is a bitmask of what motors can tilt on your vehicle. The bits you need to enable correspond to the motor ordering of the standard ArduCopter motor map for your chosen frame class and frame type, ie. bit 0 corresponds to Motor 1.
For example, if you have a tilt-tricopter where the front two motors tilt, then you should set Q_TILT_MASK to 3, which is 2+1.
If you have a tilt-quadplane where all 4 motors tilt, then you should set Q_TILT_MASK to 15, which is 8+4+2+1.

The Tilt Type

Most tilt-rotors use normal servos for tilting their rotors. This allows the autopilot to control the angle of tilt continuously in a range from straight up to straight forward.
Some tilt-rotors instead have a binary mechanism, typically using retract servos, where the autopilot can command the servo into either a fully up or fully forward position, but can’t ask for the tilt to stop at some angle in between.
Finally some tilt-rotors have vectored control of yaw, where they can control yaw by tilting the left rotors independently of the right rotors.
You need to set the type of tilt you have using the Q_TILT_TYPE parameter. Valid values are:

Tilt Type	Q_TILT_TYPE
Continuous	0
Binary	1
Vectored	2
BiCopter	3

Tilt Servos

Next you need to configure which servo outputs will control tilt of the tiltable rotors.
You control that with the following servo function values.

Tilt Control	SERVOn_FUNCTION
TiltMotorsFront	41
TiltMotorFrontLeft	75
TiltMotorFrontRight	76
TiltMotorsRear	45
TiltMotorRearLeft	46
TiltMotorRearRight	47

Note
For Vectored Yaw applications, the right and left tilt servos would be used for front and/or back. You should choose normal TiltMotorsFront and/or TiltMotorsRear otherwise.

Tilt Reversal and Range
You will need to set the SERVOn_REVERSED parameter on your tilt servos according to the direction of your servos. You should adjust so that in MANUAL mode the rotors are tilted forward and in QSTABILIZE mode they point straight up.
You will probably also need to adjust the SERVOn_MIN an SERVOn_MAX values to adjust the range of movement and the exact angle of each servo for forward flight and hover.

Tilt Angle
The Q_TILT_MAX parameter controls the tilt angle during transitions for continuous tilt vehicles. It is the angle in degrees that the rotors will move to while waiting for the transition airspeed to be reached.
The right value for Q_TILT_MAX depends on how much tilt you need to achieve sufficient airspeed for the wings to provide most of the lift. For most tilt-rotors the default of 45 degrees is good.

Tilt Rate
A critical parameter for tilt rotors is how quickly they move the tilt servos when transitioning between hover and forward flight.
The two parameters that control tilt rate are:

- Q_TILT_RATE_UP is the tilt rate upwards in degrees per second
- Q_TILT_RATE_DN is the tilt rate downwards in degrees per second

If Q_TILT_RATE_DN is zero then Q_TILT_RATE_UP is used for both directions.

How fast you should move the tilt servos depends on a number of factors, particularly on how well tuned your vehicle is for multi-rotor flight. In general it is recommended to err on the side of slow transitions for initial testing, then slowly speed it up as needed.
A typical value would be 15 degrees per second for both up and down.
Note that there are some automatic exceptions to the tilt rate in the tilt-rotor code:

- the tilt rate when changing to MANUAL mode is 90 degrees per second. This gives you rapid forward flight control in case MANUAL mode is needed.
- once a forward transition is completed then the motors will cover any remaining angle at 90 degrees per second.

Note
For Binary type tilt servos these rates should be set at the actual measured rate of the servo since it’s independent of the control.

Tilt Stabilization Assist in Fixed Wing Flight

It is possible to use the tilt motors (if not the BINARY tilt type) to aid in fixed wing roll and pitch control. This is activated if the Q_TILT_FIX_GAIN is greater than zero, which determines how much control demand results in tilting of the motors. The maximum tilt angle achievable is determined by the Q_TILT_FIX_ANGLE parameter. It is recommended to start with 0.1 for the Q_TILT_FIX_GAIN and work your way up to desired the response.
In order to setup the ranges of the servo movement, see Tilt Rotor Servo Setup.

Vectored Yaw

Vectored yaw aircraft tilt the left and right rotors (front and/or rear, if used) separately to control yaw in hover. This reduces mechanical complexity in tilt-tricopters as it avoids the need for a tilt servo for the rear motor for yaw control.
To setup a vectored yaw aircraft you need to set Q_TILT_TYPE =2, and also set Q_TILT_YAW_ANGLE to the angle in degrees that the tilt motors can go up past 90 degrees.
For example, if you have a tilt-tricopter with vectored yaw, and your front motors can tilt through a total of 110 degrees from forward flight, then your Q_TILT_YAW_ANGLE would be 20, as that is the angle past 90 degrees that the tilt mechanism can go.
You also need to setup your two tilt servos with SERVOn_FUNCTION =75 for left front tilt and SERVOn_FUNCTION =76 for right front tilt.
In order to setup the ranges of the servo movement, see Tilt Rotor Servo Setup.

Non-Vectored Yaw

Non-Vectored yaw aircraft (Q_TILT_TYPE = 0 or 1) needs a tilt servo for yaw control.
You need to setup your front tilt servos with SERVOn_FUNCTION=41 and also your servo for yaw control with SERVOn_FUNCTION=39, if the frame is a Tricopter. You should set up the yaw servo’s maximum lean angle in degrees with Q_M_YAW_SV_ANGLE. This lean angle assumes that SERVOn_MIN and SERVOn_MAX, represent +/- 90 degrees, with SERVOn_TRIM representing 0 degrees lean.
Note: SERVO_FUNCTION=39 is normally the output function for motor 7, but in a non-vectored yaw tilt-rotor Tricopter, the yaw servo is controlled via SERVOn_FUNCTION = 39.
If you wish to setup BLEHeli esc telemetry, you need to set Q_M_PWM_TYPE to 4 (DShot 150), connect the telemetry signal to a SERIAL port, and set its SERIALn_PROTOCOL to 23.
Note that if you want to use BLHeli passthru setup or telemetry in a non-vectored yaw Tricopter, you must not set SERVO_BLH_AUTO to 1. Instead, set SERVO_BLH_MASK to the output-bitmask of the servo-channels actually connected BLHELI-ESCs.
For example if your motors are connected to servo 9,10,11 (the first three aux-outputs of a pixhawk1), set SERVO_BLH_MASK to 1792.

BiCopter Tilt-Rotor

This is a special case of tilt-rotor QuadPlane. Setup is a bit different, but the configuration is actually a normal QuadPlane and performs QuadPlane transitions. In order to setup this vehicle configuration:

- Q_FRAME_CLASS = 10 (Tailsitter, even though this is not a tailsitter!)
- Q_TILT_TYPE = 3 (BiCopter)

Motor and Tilt Setup

For motors and tilt servos,you should set the SERVOn_FUNCTION values for your two tilt servos for the left and right motors, and for the left and right motor throttles.

The tilt servo limits are setup a bit differently than other Tilt Rotors. To setup, a normal tilt rotor range, you would set the Q_TILT_YAW_ANGLE, then the tilt servo’s MIN and MAX output range to get vertical in QSTABLIZE and horizontal in MANUAL on the bench.The TRIM value is ignored.

With this frame type, the tilt servo’s MIN sets horizontal position, TRIM the vertical position, and MAX the full rearward (max VTOL yaw). In this case, the user must set the Q_TILT_YAW_ANGLE for the amount of forward yaw from vertical (should match the rearward angle to prevent asymmetric yaw authority in one direction).

Note

MIN and MAX may be swapped if the tilt servo had to be reversed to get proper directions.

Otherwise, this frame type conforms to the normal vectored yaw tilt-rotor QuadPlane transitions, and parameters.

Tilt Wing Flap Emulation

Tilt Wing Tilt Rotors are where the entire wing rotates, instead of the motors. These frames use the “TiltMotorsFront” SERVOx_FUNCTION (41) to tilt the entire wing for fixed-wing or VTOL operation.

You can also set up the wing to tilt just like (or in addition to) normal manually controlled or automaticflaps, and the wing will tilt in fixed wing modes just as a flap would activate. The amount of wing tilt when flaps are fully extended is set by the Q_TILT_WING_FLAP parameter to tilt the wing up to 15 degrees when full flaps are activated.

Pre Flight Checks

In addition to the normal pre-flight checks for a QuadPlane, you should check your tilt-rotor transition by changing between MANUAL and QSTABILIZE modes on the ground. Make sure that your tilt moves smoothly and that the servos are trimmed correctly for the right rotor angles.

6.4.3 Tailsitter Planes

Tailsitters are any VTOL aircraft type that rotates the fuselage (and autopilot) when moving between forward flight and hover.

Despite the name, not all tailsitters land on their tails. Some are “belly landers”, where they lie down flat for landing to improve takeoff and landing stability in wind. Some may have an undercarriage for wheeled takeoff and others may have a stand or other landing aid.

All tailsitters are considered types of QuadPlanes. You should start off by reading the QuadPlane documentation before moving onto this tailsitter specific documentation.

Tailsitters and their parameters are enabled by setting Q_TAILSIT_ENABLE to either “1” ,for most tailsitters, or “2” for the special case of Copter Motor Only Tailsitters (those without control surfaces like elevons or ailerons/elevators).

Vectored and non-Vectored

Tailsitters are divided into two broad categories:

- Vectored tailsitters can tilt their rotors independently of the movement of the fuselage, giving them vectored thrust

- Non-vectored tailsitters have fixed rotor orientation relative to the fuselage, and rely on large control surfaces for hover authority (although dual motor versions can use differential thrust for body frame yaw control also)

Within Non-vectored are two sub-categories, Single/Dual Motor and CopterMotor:

- Single/Dual Motor uses one or two motors and can employ only differential thrust if dual motor. Single motor tailsitters are similar to normal 3D planes that can hover using large control surfaces exposed to the single motor prop wash for control, but with the control stability for hovering, loitering, and VTOL mission navigation provided. Dual Motor add differential thrust to assist in body frame yaw control, while copter motor tailsitters are almost the same as a multicopter when in VTOL stance with flying surfaces, if present, adding to the control.
- CopterMotor uses three, four, or more motors and operates in a more copter-like fashion. These may or may not have control surfaces usable in fixed wing flight for control. ** CopterMotor tailsitters without them (ie. only have a lifting wing with no control surfaces) must always use their motors to provide control while in fixed wing flight modes. Setting Q_TAILSIT_ENABLE = 2 automatically does this.

Tailsitter Configuration

firmware versions 4.1 and earlier

The key to make a QuadPlane a tailsitter is to either set Q_FRAME_CLASS =10 or Q_TAILSIT_MOTMX non-zero. That tells the QuadPlane code to use the tailsitter VTOL backend.

firmware version 4.2 and later:

To make a QuadPlane a tailsitter is to set Q_TAILSIT_ENABLE to “1” or “2” to tell the QuadPlane code to use the tailsitter VTOL backend.

If Q_TAILSIT_MOTMX is zero (the default), meaning no multicopter-like motors, it provides roll, pitch, yaw and thrust (Throttle, Throttle Left, Throttle Right) values to the fixed wing control code. These values then control your ailerons, elevons, elevators, rudder and forward motors.

This has a nice benefit when setting up the tailsitter that you can follow the normal fixed wing setup guide in MANUAL and FBWA modes, and then when you switch to hover all of your control directions will be correct.

It also means that you can fly any fixed wing aircraft that is capable of 3D flight as a single or dual motor tailsitter, and fly it in modes like QSTABILIZE, QHOVER and QLOITER.

However, it can also have copter-like motors, like a conventional QuadPlane if Q_TAILSIT_MOTMX is non-zero. Then this parameter determines which motors remain active in normal forward flight (plane modes). If non-zero, then use the Q_FRAME_CLASS and Q_FRAME_TYPE parameter to configure the multicopter motor style, and the appropriate MOTORx outputs will be activated.

Q_FRAME_CLASS determines the number and layout of VTOL motors and Q_TAILSIT_MOTMX determines which motors are active when in fixed wing modes, except in the special case of the Copter Motor Only Tailsitter which keeps running the motors like a Copter mode even when flying in a fixed wing mode for control surface-less Copter tailsitters (ie always running the motors to provide attitude control, even at low throttle).

Tailsitter Style	ENABLE	CLASS	TYPE	MOTORMASK	Motor Output Functions
3D Single Motor	1	10(Single/Dual)	NA	0	Throttle
Twin Motor and Twin Motor Vectored	1	10(Single/Dual)	NA	0	Left Throttle, Right Throttle
Copter Tailsitters with fixed wing control surfaces	1	to match number of VTOL motors	to match motor mixing	active motors in fixed wing modes	Motor 1-Motor x
Copter Tailsitters with no fixed wing control surfaces	2	to match number of VTOL motors	to match motor mixing	active motors in fixed wing modes	Motor 1-Motor x

The ENABLE column refers to the Q_TAILSIT_ENABLE parameter, while CLASS,TYPE, and MOTORMASK refer to Q_FRAME_CLASS, Q_FRAME_TYPE, and Q_TAILSIT_MOTMX, respectively.

Motor Layout

Copter Tailsitters

All the copter motor layouts are supported as CopterMotor tailsitters if Q_TAILSIT_MOTMX is non-zero . See Copter ’ s Motor Layout Section. If non-zero, then use the Q_FRAME_CLASS and Q_FRAME_TYPE parameter to configure the multicopter motor style, and the appropriate MOTORx outputs will be activated.

Note

in firmware versions previous to 4.1, CopterMotor Tailsitters did not use any yaw torque control. Roll (with respect to plane body) is only controlled by the flying surface (ailerons or elevons). Now QUAD PLUS and X frames have yaw control via motors, and frame types 16 and 17 are added that have no torque yaw control, as previous versions of PLUS and X did.

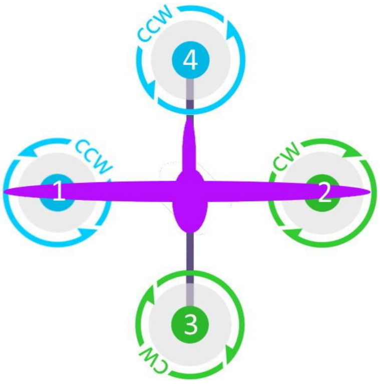
Note

(firmware 4.1 and earlier)it is possible to have a CopterMotor Tailsitter using no fixed wing control surfaces, ie basically a quadcopter with a wing. For that configuration, all Copter motors would be set to be active in fixed wing modes via Q_TAILSIT_MOTMX and Q_OPTIONS bitmask would have bit 7 (Force QASSIST) set to have QASSIST active in all modes. With firmware 4.2 and later, for this configuration, use Q_TAILSIT_ENABLE = 2 which forces QASSIT all the time. Q_TAILSIT_MOTMX is ignored in that case.

In addition, two Copter tailsitter specific configurations are available which provide No Yaw Torque (NYT) control to the copter style motors: Q_FRAME_TYPE = 16 (Plus) and =17 (X).
(looking down on nose from above)

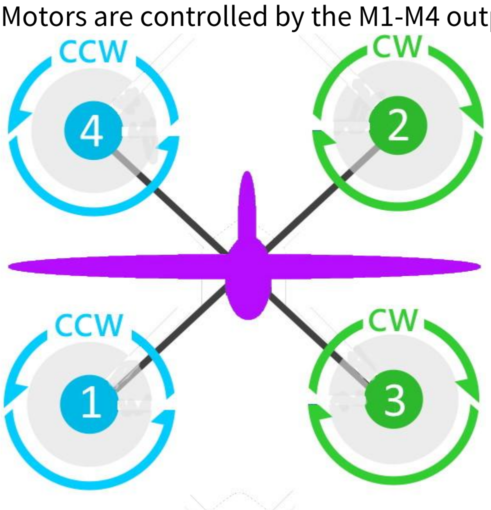
NYT QUAD PLUS Motor Tailsitter

Motors are controlled by the M1-M4 outputs:



NYT QUAD X Motor Tailsitter

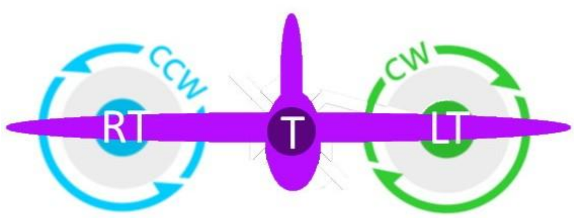
Motors are controlled by the M1-M4 outputs:



Single/Dual Motor Tailsitter

If Q_TAILSIT_MOTMX is zero and Q_FRAME_CLASS =10, then the Single/Dual Motor configuration is used. Motors may also be vectored using tilt servos, which gives much higher control authority. If not vectored, these frames rely on large control surfaces, exposed to the prop flow, in order to maintain control. The motor layouts are shown below:

Motors are controlled by the Throttle, Throttle Left, Throttle Right outputs:



Autopilot Orientation
The AHRS_ORIENTATION, the accelerometer calibration and Level trim should all be done for fixed wing flight. Fixed wing flight is considered "normal" orientation for a tailsitter.

- when in VTOL flight the nose of the aircraft will try to point vertically for "level" flight
- when in fixed wing flight the nose of the aircraft will try to point horizontally for "level" flight

Key parameters
The key differences between fixed wing flight and VTOL for a tailsitter are:

- when in VTOL the copter style PID gains will be used (the ones starting with Q_A_RAT_x)
- when in fixed wing flight the fixed wing PID gains will be used (the RLL_RATE_x and PTCH_RATE_x gains)
- Q_TAILSIT_RLL_MX allows the roll limit angle limit to be set differently from Q_ANGLE_MAX. If left at zero, both pitch and roll are limited by Q_ANGLE_MAX. If Q_TAILSIT_RLL_MX is nonzero roll angle will be limited and pitch max angle will still be Q_ANGLE_MAX. This should be set if your tailsitter can achieve much larger pitch angle than would be safe for roll (some airframes can't recover from high-speed knife-edge flight using only yaw control).
- Q_TRIM_PITCH can be used to account for any offset in hovering pitch angle due to the thrust line not being through the CG, or to counter fixed wing AHRS trim used to set angle of attack in cruise, instead of using PTCH_TRIM_DEG for adjusting the trim since it is only in fixed modes and AHRS trim affects all modes. Set this such that the vehicle does not drift forwards or backwards in QSTABILIZE or QHOVER with no pilot inputs.

Tip
After calibrating the accelerometers, using the "LEVEL" calibration position as normal fixed wing flying attitude, you may find that the VTOL nose up hover drifts to one side (ie earth frame roll), as well as front to back. While there is a Q_TRIM_PITCH adjustment for pitch trim, there is not for roll. You may use the "LEVEL" only calibrate button in Mission Planner (the "ahrstrim" command in MAVProxy) to set the pitch and roll trim while in Nose Up VTOL hover attitude, if you change the mode to QSTABILIZE or QHOVER while doing so. This may change the fixed wing pitch trim, but not the fixed wing roll trim. Therefore, you may have to re-adjust the PTCH_TRIM_DEG parameter to get the desired pitch attitude in fixed wing flight, as well as the Q_TRIM_PITCH value, but this should correct the side drift.

Vectored Thrust
If your tailsitter has vectored thrust then you should set the SERVOn_FUNCTION values for your two tilt servos for the left and right motors and for the left and right motor throttles.

Note
All tailsitters ignore the Q_TILT_TYPE parameter, and require continuous output servos, and will drive the tilt servos appropriately.

For example, if your left tilt servo is channel 5 and your right tilt servo is channel 6, then set:

- SERVO5_FUNCTION =75
- SERVO6_FUNCTION =76

and you need to assign left throttle to the left motor and right throttle to the right motor, for example using the SERVO 7 and SERVO 8 outputs, for left and right motor escs, respectively:

- SERVO7_FUNCTION =73
- SERVO8_FUNCTION =74

You also need to set the right SERVOn_REVERSED values, and the correct SERVOn_TRIM, SERVOn_MIN and SERVOn_MAX values, as appropriate.
Q_A_ANGLE_BOOST should be disabled for vectored thrust tailsitters. Failure to disable this will cause the throttle to decrease as the nose dips, making the nose dip even further and resulting in a crash.

Caution
When disarmed, switching to QHOVER or QLOITER will force the motors forward into fixed wing orientation. If armed in this position, a prop strike could occur for Belly Sitter configurations. Tilt will be raised to VTOL position when throttle is raised above idle, but the strike will have already occurred. The solution is to momentarily raise the throttle above idle, allowing the tilts to raise, return throttle stick to idle, then arm. This needs to be done also for AUTO mode takeoffs, which should be started from QSTABILIZE with motors raised, armed, and then change to AUTO for the takeoff.

Tilt Rotor Movement Setup
See Tilt Rotor Setup Tips and Tilt Rotor Servo Setup

TVBS (Thrust Vectored Belly Sitter)
TVBS are just dual motor vectored thrust tailsitters that don’t sit on their tails, but rather their belly. Aside from making sure props clear (ie sufficient throw on tilt servos) when in the horizontal stance, nothing special is required to make it take off from a horizontal stance.
At least 45 degree throw, either side of neutral (fixed wing flight position) is required, with 60 degrees being most desirable. Otherwise, the vehicle will “skid” along the ground a bit when you raise the throttle to bring it vertical on takeoff. Takeoffs, required a decisive move of throttle to hover or above to reduce the “skid”.
For landing in fixed wing, manual throttle controlled modes, there is an RCx_OPTION (89) that will force the tilt servos upright at idle throttle, and optionally force the pitch to target LAND_PITCH_DEG for flaring to the normal fixed wing landing. This allows intentional or emergency fixed wing landings in MANUAL, ACRO, STABILIZE, and FBWA modes without the risk of a prop strike in configurations where this could occur otherwise.

Vectored Gains
There are two vectoring gains available. One controls the amount of vectored thrust movement in hover, and the other controls the amount of vectored thrust movement in forward flight.
The Q_TAILSIT_VHGAIN parameter controls vectored thrust in hover. A typical value is around 0.8, which gives a lot of control to vectored thrust in hover. This control is combined with control from your elevon mixing gain (controlled by MIXING_GAIN).
The Q_TAILSIT_VFGAIN parameter controls vectored thrust in forward flight. A typical value is around 0.2, which gives a small amount of control to vectored thrust in forward flight. This control is combined with control from your elevon mixing gain (controlled by MIXING_GAIN).
By adjusting the relative values of Q_TAILSIT_VHGAIN, Q_TAILSIT_VFGAIN and MIXING_GAIN you can adjust how much control you have from elevons and thrust vectoring in each flight mode.

CopterMotor PID Gain Scaling
There are a number of options for scaling control surface movement versus speed. Control surface effectiveness is dependent on airspeed they see, in tailsitter configurations this is heavily driven by the motor layout and prop wash. A copter tailsitter with lots of control authority from thrust and small control surfaces will be much less sensitive to these gain scheduling parameters. For a vehicle with large control surfaces care must be taken to setup gain scaling to best suit the configuration.

The gain scaling scheme is selected with Q_TAILSIT_GSCMSK, it is a bitmask, some options can be used in combination, others must be used in isolation.
The maximum and minimum scaling that can be applied by any scheme is set by Q_TAILSIT_GSCMIN and Q_TAILSIT_GSCMAX. If a scheme is working well at all but the extremes these endpoints can be adjusted.

Tip
Scaling is done relative the hover throttle point, ensure this is set correctly before proceeding, see: Flight Modes, QHOVER mode.

Disk theory gain scaling is the most advanced method available and should result in the best results, if setup correctly.

Throttle scaling (Bit 0)
Control surfaces will be scaled directly with throttle. High throttle will result in less control surface movement, low throttle will result in more. This method is always used for thrust vectoring scaling in non-CopterMotor tailsitters independent of Q_TAILSIT_GSCMSK.

Reduce gain at high throttle/tilt (Bit 1)
Attitude/throttle based gain attenuation, with this option control surface deflection is reduced at high tilt angles and high throttle levels to prevent oscillation at high airspeeds. This can be used in combination with throttle scaling.

Disk theory (Bit 2)
Disk theory gain scaling attempts to calculate the airspeed seen on the control surfaces as a result of both prop wash and forward airspeed. In order for this calculation to be done Q_TAILSIT_DSKLD must be set. This is the aircraft weight in KG divided by the total disk area of the propellers. The disk area for each propeller is calculated from the radius, the disk area of all propellers should then be summed. This can calculate the airspeed directly behind the propeller, however on a real vehicle 100% of the control surface is not in the direct prop wash.
For example if half of the control surfaces are in the prop wash the calculated disk loading value should also be halved. Some tuning will be required for best performance, If oscillations are seen at high throttle Q_TAILSIT_DSKLD should be reduced.
For best results an airspeed sensor should be fitted.

Altitude correction (Bit 3)
Gain is scaled with altitude, this should be considered when operating over a wide range of altitudes, this method can be enabled in combination with any other method.

Transitions
Tailsitter transitions are a little different than other QuadPlane transitions.
Q_TAILSIT_ANGLE specifies how far the nose must pitch down in a VTOL mode before transition to forward flight is complete. So a value of e.g. 60 degrees results in switching from copter to plane controller (forward transition) when the nose reaches 30 degrees above the horizon (60 degrees down from vertical). The pitch rate used when pitching down to forward flight is given by Q_TAILSIT_RAT_FW, this rate will be held until Q_TAILSIT_ANGLE is reached.
For the back transition from forward flight to VTOL, the plane controller will be used until the nose reaches Q_TAILSIT_ANG_VT above the horizon. If Q_TAILSIT_ANG_VT is 0 Q_TAILSIT_ANGLE will be

used for both forward and back transitions. The pitch rate used when pitching up to VTOL flight is given by Q_TAILSIT_RAT_VT, this rate will be held until Q_TAILSIT_ANG_VT is reached.

Note
if you back transition while on the ground, ie sitting in a FW mode at zero throttle, armed, and then switch to a VTOL mode, the motors will immediately start spinning until the “transition” completes and the motors tilt up. This can result in ground movement. To help prevent this, you can set Q_OPTIONS bit 18 to prevent arming unless already in a VTOL mode.

Depending on the entry speed and time required to transition, the vehicle may gain altitude, sometimes significantly, since the throttle is set to the current Q_M_THRST_HOVER hover thrust value throughout the transition to VTOL. This can be overridden with a lower value by setting Q_TAILSIT_THR_VT. With experimentation, changing the rates, angle, and this parameter for fixed wing to VTOL transitions, it is possible to obtain almost level altitude transitions. Especially with copter style tailsitters with no control surfaces using Q_TAILSIT_ENABLE = 2, keeping attitude control active even at low or zero throttle values.

Note
During transitions, pilot input is disabled and vehicle attitude and throttle is controlled totally by the autopilot.

Tip
Message is sent to the GCS when transition is complete, these can be found in the Mission Planner messages tab. If the transition does not complete normally the transition parameters and vehicle tune should be checked. A example message is `Transition FW done, timeout`, the timeout time is one and a half times the expected transition time as calculated from the angle and rate parameters.

Control Surfaces
Although usually not recommended, it is possible to fly a tailsitter aircraft with no control surfaces. Care should be taken to get the vehicle flying well in the hover modes first.

- Q_OPTIONS bit 7:Force Qassist will force the vehicle to use the copter controller in all flight modes.
- Q_OPTIONS bit 8:Mtrs_Only_Qassist allows use of the copter controller for the motors but leave any controls surfaces under plane control, this allows the control surfaces to act as ‘trim tabs’ for the motors.

See Assisted Fixed-Wing Flight for more details on how Qassist can be automatically enabled and disabled with airspeed, altitude, attitude, and/or by RCx_OPTION switch.

Tailsitter Input
You can change how control inputs while hovering a tailsitter will be interpreted using the Q_TAILSIT_INPUT parameter. The choices are:

- Q_TAILSIT_INPUT =0 means that in hover the aircraft responds like a multi-rotor, with the yaw stick controlling earth-frame yaw, and roll stick controlling earth-frame roll. This is a good choice for pilots who are used to flying multi-rotor aircraft.
- Q_TAILSIT_INPUT =1 means that in hover the aircraft responds like a 3D aircraft, with the yaw stick controlling earth-frame roll, and roll stick controlling earth-frame yaw. This is a good choice

for pilots who are used to flying 3D aircraft in prop-hang, but is not very useful when flying around, due to the earth-frame multicopter control inputs.

- Q_TAILSIT_INPUT =2 and 3 mean that the aircraft responds like a 3D aircraft with the yaw stick controlling earth-frame yaw and the roll stick controlling body-frame roll when flying level. When hovering, these options behave the same as types 0 and 1, respectively. This is accomplished by splitting the roll and yaw command inputs into bodyframe roll and yaw components as a function of Euler pitch.

Note

Due to the rotation of the tailsitter body frame with respect to the multicopter body frame, the roll limits are set by parameter Q_YAW_RATE_MAX (in degrees), and the yaw rate limits are set by parameter Q_TAILSIT_RLL_MX (in deg/sec). The pitch limit is set by parameter Q_ANGLE_MAX (in degrees), and this also serves as the yaw rate limit if Q_TAILSIT_RLL_MX is zero. If any rate limit is too high for the airframe, you may experience glitches in attitude control at high rates.

Note

Q_TAILSIT_INPUT is ignored in QACRO modes. All inputs are body-frame referenced.

Center of Gravity

The center of gravity for a tailsitter is important in an extra dimension. When hovering it is important that there is not too much weight in the belly of the plane or on its back, so that it leans forward or back. This is particularly important for non-vectored tailsitters.

Pre-Arm Issues

Due to an issue in DCM related to compass fusion for yaw when pointing straight up, sometimes the AHRS subsystems will disagree when powering up, nose up. Slight errors in compass calibration, while resulting in a successful calibration, may worsen this effect.

The result is that some setups will give a pre-arm failure. Typically it is “Pre-Arm:DCM roll/pitch inconsistent by “x” degrees” or similar. If this happens consistently, then one of two solutions can be used:

- Power up horizontally, and allow the autopilot to begin initialization in this position. After the IMUs tilt initialization is completed (usually in the first ten to fifteen seconds or so), the Tailsitter can be set vertically for the remainder of the initialization (ie after GPS lock and EKF is using the GPS) and then armed.
- Or, if you get the Pre-Arm failure above, lay the Tailsitter down horizontally for 10-30 seconds to allow the various AHRS subsystems to synchronize. After that it can be raised and arming should proceed normally.

6.4.4 ESC calibration

Most models of PWM based ESC need to be calibrated to ensure that all the ESCs respond to the same input with the same speed. To calibrate them they need to receive maximum PWM input when initially powered on, then receive minimum PWM input when they have beeped to indicate that the maximum has registered.

Warning

You must remove all propellers from your vehicle before doing any ESC calibration. Calibrating with propellers installed is dangerous.

ESC Calibration Procedure

This process uses the Q_ESC_CAL parameter to enable ESC calibration in QSTABILIZE mode. There are two modes of operation available:

- with Q_ESC_CAL=1 the output to the motors will come directly from the throttle stick in QSTABILIZE mode when the vehicle is armed
- with Q_ESC_CAL=2 the output to the motors will be full throttle when the motors are armed

The process when using Q_ESC_CAL=1 is

(1) remove your propellers for safety
(2) power up just the flight board and not your motors. If you don’t have the ability to isolate power to the ESCs when on battery power then power up your flight board on USB power
(3) set the Q_ESC_CAL parameter to 1
(4) change to QSTABILIZE mode
(5) set the safety switch off to activate the outputs
(6) arm your aircraft. The PWM output on all quad motors will now be controlled by your throttle stick
(7) move the throttle stick to maximum
(8) add power to your ESCs by connecting the battery
(9) wait for the ESCs to beep to indicate they have registered the maximum PWM
(10) lower the throttle stick to zero and disarm your aircraft
(11) you should hear a beep from your ESCs to indicate they have registered the throttle range

The process when using Q_ESC_CAL=2 is

(1) remove your propellers for safety
(2) power up just the flight board and not your motors. If you don’t have the ability to isolate power to the ESCs when on battery power then power up your flight board on USB power
(3) set the Q_ESC_CAL parameter to 2
(4) change to QSTABILIZE mode
(5) set the safety switch off to activate the outputs
(6) arm your aircraft. The PWM output on all quad motors will now be at maximum
(7) add power to your ESCs by connecting the battery
(8) wait for the ESCs to beep to indicate they have registered the maximum PWM
(9) disarm your aircraft
(10) you should hear a beep from your ESCs to indicate they have registered the throttle range

Note that using Q_ESC_CAL=1 can be useful for testing your motors response. This is the only mode when you are able to directly control the throttle level on all your motors at once. While in this mode you can use a laser tachometer to test your motor speeds at different throttle levels if you have one.

Warning

Be sure to set Q_ESC_CAL back to zero after calibrating for normal operation

6.4.5 QuadPlane Parameter setup

All QuadPlane specific parameters start with a “Q_” prefix. The parameters are very similar to the equivalent Copter parameters so if you are familiar with those you should find setting up a QuadPlane is easy.

Key Parameters

- To enable QuadPlane functionality you need to set the Q_ENABLE parameter to 1 and then refresh the parameter list
- The Q_M_PWM_MIN and Q_M_PWM_MAX parameters used to set the PWM range of the VTOL motors (MOTORx) and the SERVOx_MIN/MAX for the outputs driving these motors is ignored. These need to be set to the range your ESCs expect.
- The most critical tuning parameters are Q_A_RAT_RLL_P and Q_A_RAT_PIT_P. These default to 0.25 but you may find significantly higher values are needed for a QuadPlane.
- The Q_M_SPIN_ARM parameter is important for getting the right level of motor output when armed in a quad mode
- It is recommended that you set ARMING_RUDDER to 2 to allow for rudder disarm. Alternatively you could have MANUAL as one of your available flight modes (as that will shut down the quad motors). Please be careful not to use hard left rudder and zero throttle while flying or you risk disarming your motors.
- The default SCHED_LOOP_RATE for a QuadPlane is to 300 (Hz). Most QuadPlanes do not need this to be rasied. Some very small vehicles (< 1Kg) might benefit from setting it to 400. In heavier vehicles, their higher inertia results in lower effective control response rates, so they do not benefit from a higher loop rate. Raising above 300 only leads to larger log files in these vehicles.

Attitude Limiting Parameters

The pitch and roll limits in VTOL modes are controlled by the lesser of Q_ANGLE_MAX, or the fixed wing limits (PTCH_LIM_MAX_DEG, PTCH_LIM_MIN_DEG, and :ref:` ROLL_LIMIT_DEG<ROLL_LIMIT_DEG>`), but conformance to only Q_ANGLE_MAX can be controlled with Q_OPTIONS bit 14.

In addition, Q_BCK_PIT_LIM sets the maximum number of degrees of back or pitch up in Q modes when the airspeed is at AIRSPEED_MIN, and is used to prevent excessive structural loads when pitching up to decelerate. The backwards/up pitch limit controlled by this parameter is in addition to limiting applied by the params above. The Q_BCK_PIT_LIM limit is only applied when Q_FWD_THR_USE is set to 1 or 2 and the vehicle is flying in a mode that uses forward throttle instead of forward tilt to generate forward speed. A value 0 to deactivates this limit.

Return Behavior Setup Guide:

While there are many parameters setting distances and heights for the various home return modes/behaviors (read about failsafes in Flying a QuadPlane and QRTL and RTL modes), this is a quick setup guide for basic behaviors.

RTL mode

Is a fixed wing return mode which normally flys back to the home point and loiters, but can optionally do an automatic mission sequence, usually set by the user to land the vehicle at home in fixed wing mode.

If entered from VTOL flight several other behavior options can be selected by the Q_RTL_MODE parameter.

QRTL mode

When operating close to home is a VTOL return and the land at home, but further away will switch to fixed wing flight until back closer to home, and then transition back to VTOL and land at home. QRTL mode always results in a VTOL landing at home unless the pilot interrupts it.

RC Failsafe

Loss of RC link can switch to a return flight mode or several other behaviors.

Setup

(1) If you lose RC link for greater than FS_LONG_TIMEOUT in fixed wing flight set FS_LONG_ACTN value below to obtain various behavior options:

- "0" : do nothing if in AUTO mode, otherwise switch to RTL mode (see #3,4 below)
- "1" : switch to RTL mode (see #3,4 below)
- "2" : cut throttle and glide in FWBA mode
- "3" : deploy parachute (assuming you have one setup)
- "4" : switch to AUTO mode and execute mission at current mission sequence pointer

(2) If you lose RC link for greater than FS_LONG_TIMEOUT in VTOL flight, you will immediately QLAND, unless you select the following optional behavior:

- set Q_OPTIONS bit 5 to switch to QRTL mode instead. (see #5 below)
- set Q_OPTIONS bit 20 to switch to RTL mode instead (see #3,4 below). If bit 5 is set above, it will be ignored in lieu of this option bit.

(3) Anytime you switch to RTL (due either to manual mode change or failsafe action), do you want to execute an autoland sequence (does not need to actually have a land command, if some other action is desired), rather than just return and loiter around home?

- If yes,then set up a DO_LAND_START mission sequence and enable the RTL_AUTOLAND parameter. See Using DO_LAND_START for details of setup.

(4) If in a VTOL mode, and you switch to RTL (due either to manual mode change or failsafe action), then set the Q_RTL_MODE parameter value as follows to determine the behavior:

- "0" : Switch to normal RTL mode, transitioning to fixed wing (see #3 above)
- "1" : Transition to fixed wing, fly towards home, transition back to VTOL mode when close to home, move to over home, switch to QLAND and land at home in VTOL.
- "2" : Transition to fixed wing, fly towards home, loiter down to altitude around home, turn into the wind, transition back to VTOL mode and move to over home, switch to QLAND and land at home in VTOL
- "3" : Switch to QRTL :Transition to fixed wing, and do a special approach to home including "airbraking", transition back to VTOL mode, move to over home, switch to QLAND and land at home in VTOL.

(5) When switching to QRTL default behavior is to transition to fixed wing if in VTOL (assuming you are not close to home already in VTOL Flight), flying back to home, then switching back to VTOL as you approach home, switching to QLAND over home, and landing at home (see QRTL Mode for more information). You can disable the fixed wing approach, and return home and land only using VTOL mode if Q_OPTIONS bit 16 set.

Q_OPTIONS

In addition, the behavior of QuadPlane can be modified by the setting of the Q_OPTIONS bitmask parameter (no bits are set, by default):

- bit 0 (+1), if set, will force the transition from VTOL to Plane mode to keep the wings level and not begin climbing with the VTOL motors (as in a mission to a higher waypoint after VTOL takeoff) during the transition.
- bit 1 (+2), if set, will use a fixed wing takeoff instead of a VTOL takeoff for Mission Planner that can only send TAKEOFF instead of a separate VTOL_TAKEOFF mission command. Otherwise, QuadPlane will use VTOL takeoffs for a TAKEOFF mission command.
- bit 2 (+4), if set, will use a fixed wing landing instead of a VTOL landing for Mission Planner that can only send LAND instead of a separate VTOL_LAND mission command. Otherwise, QuadPlane will use VTOL_LAND for a LAND mission command.
- bit 3 (+8), if set, will interpret the takeoff altitude of a mission VTOL_TAKEOFF as specified when setup in Mission Planner (ie Relative to Home/Absolute {ASL}/Terrain {AGL}). Otherwise, it is relative to the takeoff point's altitude (AGL).
- bit 4(+16), if set, for "Always use FW spiral approach" then during a VTOL_LAND mission command,instead of transitioning to VTOL flight and doing a VTOL landing, it will remain in plane mode, and proceed to the landing position, climbing or descending to the altitude set in the VTOL_LAND waypoint. When it reaches within Q_FW_LND_APR_RAD of the landing location, it will perform a LOITER_TO_ALT to finish the climb or descent to that altitude set in the waypoint, then, turning into the wind, transition to VTOL mode and proceed to the landing location and land. Otherwise, a standard VTOL_LAND will be executed. See QuadPlane AUTO Missions for more information.
- bit 5(+32), if set, it will replace QLAND with QRTL for failsafe actions when in VTOL modes. See the Radio and Throttle Failsafe section of Flying a QuadPlane for more information.
- bit 6(+64), if set, will enforce the ICE idle governor even in MANUAL mode.
- bit 7(+128), if set, will force QASSIST to be active at all times in VTOL modes. See Assisted Fixed-Wing Flight.
- bit 8(+256), if set, QASSIST will only affect VTOL motors. If not set, QAssist will also use flying surfaces to stabilize(Assisted Fixed-Wing Flight).
- bit 9(+512), if set, will enable AirMode (AirMode) if armed via an RC switch. See Auxiliary Functions option value 41. This function has been deprecated as of Version 4.2. See new arming switch options in Auxiliary Functions
- bit 10(+1024), if set, will allow the tilt servos to move with rudder input in vectored tilt setups while disarmed to determine range of motion.
- bit 11(+2048), if set, will delay VTOL motor spin up until 2 seconds after arming.
- bit 12(+4096), if set, disable speed based Qassist when using synthetic airspeed
- bit 13(+8192), if set, will disable Ground Effect Compensation of baro due to ground effect pressures
- bit 14(+16384), if set, ignore forward flight angle limits in Qmodes, otherwise PTCH_LIM_MAX_DEG, PTCH_LIM_MIN_DEG, and ROLL_LIMIT_DEG can constrain Q_ANGLE_MAX in VTOL modes.
- bit 15(+32768), if set, will allow pilot to control descent during VTOL AUTO-LAND phases, similar to throttle stick action during QHOVER or QLOITER. However, this will not become active until the throttle stick is raised above 70% during the descent at least once.
- bit 16(+65536), if set, will disable the fixed wing approach in QRTL mode and VTOL_LANDING mission items, see Hybrid RTL modes section of Flying a QuadPlane for details of this hybrid landing approach.

- bit 17(+131072), if set, will enable pilot horizontal re-positioning during VTOL auto LAND phases, momentarily pausing the descent while doing so.
- bit 18(+262144), if set, will only allow arming in VTOL and AUTO modes. This can be used for tailsitters to prevent arming in a fixed wing mode when sitting in VTOL stance to prevent tip-overs. For AUTO mode, WP must be a VTOL takeoff in order to arm with this option.
- bit 19(+524288), if set, will allow the forcing of VTOL to Fixed Wing transitions if Q_TRANS_FAIL is not zero and exceeded, and if the airspeed is greater than 1/2 of AIRSPEED_MIN, then the transition to fixed wing will immediately complete, rather than taking the Q_TRANS_FAIL_ACT action. See Transitions.
- bit 20(+1048576), if set overrides bit 5, if set, and forces an RTL on RC failsafe while in a VTOL mode. This is useful in over-water operations where either an QLAND or QRTL is undesirable.
- bit 21(+2097152), if set tilts tilt motors up when disarmed in FW modes (except manual) to prevent ground strikes.
- bit 22(+4194304), if set scale fixed wing FF pid gains by the ratio of VTOL/fixed wing angle P gains in VTOL modes rather than reducing VTOL angle P based on airspeed. Used only if experiencing oscillations in back transitions at high airspeeds.

Behavior can be modified as well as by the Q_RTL_MODE and Q_GUIDED_MODE parameters.

Warning
If you set INITIAL_MODE to a VTOL mode, then switch to a fixed wing (other than MANUAL/ACRO/TRAINING) before arming, you will effectively be in a VTOL transition and when armed, the motors will spin up, and move, if tilted, to vertical.

Note
The QuadPlane code requires GPS lock for proper operation. This is inherited from the plane code, which disables inertial estimation of attitude and position if GPS lock is not available. Do not try to fly a QuadPlane indoors. It will not fly well!

6.4.6 Flight Modes

QSTABILIZE Mode

QSTABILIZE mode allows you to fly your vehicle manually, but self-levels the roll and pitch axis.

Tip
If you’re learning to fly, try QHOVER or QLOITER instead of QSTABILIZE. You’ll have fewer crashes if you don’t need to concentrate on too many controls at once.

Warning
While QSTABILIZE mode does not necessarily require GPS, switching to QRTL or RTL in case of emergency does. Make sure you do have a reliable position estimate prior to arming, most commonly provided by 3D GPS fix with sufficient HDOP. This is required by default in the arming checks. It is highly recommended that these checks not be disabled.

Warning
Flying QuadPlane backwards at speed or backwards into high wind is not recommended, since the Plane control surfaces will act backwards and could increase instability.

Overview

- Pilot's roll and pitch input control the lean angle of the QuadPlane. When the pilot releases the roll and pitch sticks the vehicle automatically levels itself.
- Pilot will need to regularly input roll and pitch commands to keep the vehicle in place as it is pushed around by the wind.
- Pilot's yaw input controls the rate of change of the heading. When the pilot releases the yaw stick the vehicle will maintain its current heading.
- Pilot's throttle input controls the average motor speed meaning that constant adjustment of the throttle is required to maintain altitude. If the pilot puts the throttle completely down the motors will go to their minimum rate (Q_M_SPIN_ARMED) and if the vehicle is flying it will lose attitude control and tumble.
- The throttle sent to the motors is automatically adjusted based on the tilt angle of the vehicle (i.e. increased as the vehicle tilts over more) to reduce the compensation the pilot must do as the vehicle's attitude changes.

Note

Always switch into a manual mode such as QSTABILIZE if the autopilot fails to control the vehicle. Maintaining control of your copter is your responsibility.

Common Problems

- QuadPlane flips immediately upon take-off. This is usually caused by the motor order being incorrect or spinning in the wrong direction or using an incorrect propeller (clockwise vs counter-clockwise). Check the rc connections for your autopilot.
- QuadPlane wobbles on roll or pitch axis. This usually means the Rate P values are incorrect. See Copter Tuning section for some hints as to how to adjust the Q_A_xxx parameters.
- QuadPlane wobbles when descending quickly. This is caused by the copter falling through its own prop wash and is nearly impossible to tune out although raising the Rate Roll/Pitch P values may help.
- QuadPlane yaws right or left 15degrees on take-off. Some motors may not be straight or the escs need calibration QuadPlane ESC Calibration.
- QuadPlane does not maintain altitude or does not stay perfectly still in the air. As mentioned above this is a manual flight mode and requires constant control of the sticks to maintain altitude and position.
- occasional twitches in roll or pitch. Normally caused by some kind of interference on the receiver (for example FPV equipment placed too close to the receiver) or by ESC problems that may be resolved by QuadPlane ESC Calibration.
- sudden flips during flight. This is nearly always caused by mechanical failures of the motor or ESCs.

Hover Throttle

Usually, it is desired to hover in any mode at mid-stick on throttle, so that transitions between modes is easily accomplished without throttle position changes. This can be adjusted using the Q_M_THST_HOVER parameter, or automatically learned in QHOVER or QLOITER modes by enabling Q_M_HOVER_LEARN.

Note

If Q_THROTTLE_EXPO = 0 in QACRO and QSTABILIZE modes, then Q_M_THST_HOVER, whether set manually or learned via Q_M_HOVER_LEARN, is not applied, and the throttle is determined directly from the RC input.

QHOVER Mode

In QHOVER mode, QuadPlane maintains a consistent altitude while allowing roll, pitch, and yaw to be controlled normally. This page contains important information about using and tuning alt hold.

Overview

When altitude hold mode (aka QHOVER) is selected, the throttle position is used to control the climb or descent rate, maintaining current altitude when at mid-stick. Roll, Pitch and Yaw operate the same as in QSTABILIZE mode meaning that the pilot directly controls the roll and pitch lean angles and the heading.

Automatic altitude hold is a feature of many other flight modes (QLOITER, etc.) so the information here pertains to those modes as well.

Note

The autopilot uses a barometer which measures air pressure as the primary means for determining altitude (“Pressure Altitude”) and if the air pressure is changing in your flight area due to extreme weather, the QuadPlane will follow the air pressure change rather than actual altitude.

Controls

The pilot can control the climb or descent rate of the vehicle with the throttle stick.

- If the throttle stick is in the middle deadzone set by RCn_DZ (where n is the channel mapped to throttle input) the vehicle will maintain the current altitude. The default for throttle channel deadzone is 60 (+/- 6%).
- Outside of the mid-throttle deadzone the vehicle will descend or climb depending upon the deflection of the stick. When the stick is completely down the QuadPlane will descend at Q_PILOT_SPD_DN and if at the very top it will climb by Q_PILOT_SPD_UP.

Tuning

The Q_P_POSZ_P is used to convert the altitude error (the difference between the desired altitude and the actual altitude) to a desired climb or descent rate. A higher rate will make it more aggressively attempt to maintain it’s altitude but if set too high leads to a jerky throttle response.

The Q_P_VELZ_P (which normally requires no tuning) converts the desired climb or descent rate into a desired acceleration up or down.

The Q_P_ACCZ_P, Q_P_ACCZ_I, Q_P_ACCZ_D gains convert the acceleration error (i.e the difference between the desired acceleration and the actual acceleration) into a motor output. The 1:2 ratio of P to I (i.e. I is twice the size of P) should be maintained if you modify these parameters. These values should never be increased but for very powerful QuadPlanes you may get better response by reducing both by 50% (i.e P to 0.5, I to 1.0).

Verifying altitude hold performance with dataflash logs

Viewing the altitude hold performance is best done by downloading a dataflash log from your flight, then open it with the mission planner and graph the barometer altitude, desired altitude and inertial navigation based altitude estimate: QTUN’s BarAlt (baro alt), DAlt (desired alt) and Alt (inertial nav alt estimate)

Common Problems

(1) High vibrations can lead to the QuadPlane rapidly climbing as soon as altitude hold is engaged. Check the Measuring Vibration and Vibration Dampening wiki pages for details on how to measure and reduce vibrations.

(2) The motors seem to stop for a moment just as an altitude hold mode is engaged but then it soon recovers. This normally occurs when the pilot enters altitude hold modes while climbing rapidly. The target altitude is set at the moment the pilot switches into alt hold but because the vehicle is rising quickly it flies above the target. The aggressive altitude hold controller then responds by momentarily reducing the motors to near minimum until the QuadPlane begins falling back to the target altitude. The workaround is to enter these modes while the QuadPlane is flying at a stable altitude.
(3) Air pressure changes cause the vehicle to drift up or down by a couple of meters over longer period of time or for the altitude shown on the GCS to be inaccurate by a couple of meters including occasional negative altitudes (meaning altitudes below the home altitude).
(4) Momentary altitude loss of 1m ~ 2m when the QuadPlane levels out after a high speed forward flight. This is caused by an aerodynamic effect which leads to a momentary low pressure bubble forming on the top of the QuadPlane where the autopilot is mounted which leads the QHOVER controller to believe it is climbing so it responds by descending. There is no cure for this behaviour at the moment although increasing the EKx_ALT_M_NSE parameter reduces the effect but increases the change of Common Problem #1 listed above. The EKx_ALT_M_NSE parameter has a range from 0.1 to 10.0 and allows increments of 0.1.
(5) Altitude hold becomes erratic when the vehicle is close to the ground or during landing. This can be caused by the barometer being affected by pressure changes created by prop-wash. The solution is to move the autopilot out of the prop wash effect or shield it within an appropriately ventilated enclosure.
(6) Sudden altitude changes caused by light striking the barometer. Assuring sunlight cannot hit the baro will cure this.
(7) QuadPlane slowly descends or climbs until the pilot retakes control in stabilize. Normally this is caused by not having the throttle stick in the mid position. This commonly happens when the pilot is switching into an altitude holding mode from a manual flight mode (like QSTABILIZE) on a QuadPlane that does not hover at mid throttle. Usually it is desired to hover in any mode at mid-stick on throttle, so that transitions between modes is easily accomplished without throttle position changes. This can be adjusted using the Q_M_THST_HOVER parameter, or by having its value automatically learned in QHOVER or QLOITER modes when hovering hands- off at mid-throttle stick if Q_M_HOVER_LEARN is enabled.

Adequate Power

It is very important that the vehicle has enough power available. Without this the altitude hold and attitude controllers can require more power than is available from one or more motors and will be forced to sacrifice some control which could lead to a loss of attitude or altitude.
Ideally the vehicle should be able to hover at about 50% throttle (mid stick) and anything higher than 70% is dangerous.

Warning
If you incorporate expo on your transmitter, that directly increases the effective size of the throttle dead band.

QLOITER Mode

QLOITER Mode automatically attempts to maintain the current location, heading and altitude. The pilot may fly the QuadPlane in QLOITER mode as if it were in a more manual flight mode but when the sticks are released, the vehicle will slow to a stop and hold position.

A good GPS lock, low magnetic interference on the compass and low vibrations are all important in achieving good QLOITER performance.

Controls

The pilot can control the QuadPlane's position with the control sticks.

- Horizontal location can be adjusted with the Roll and Pitch control sticks with the default maximum horizontal speed being 5m/s (see Tuning section below on how to adjust this). When the pilot releases the sticks the QuadPlane will slow to a stop.
- Altitude can be controlled with the Throttle control stick just as in QHOVER mode.
- The heading can be set with the Yaw control stick

The vehicle can be armed in QLOITER mode in the same manner as any other mode, but only once the GPS has 3D lock, and the HDOP has dropped below 2.0, just as with any other mode, unless the default arming checks have been modified to avoid checking GPS (not recommended!). More details on LED patterns here.

Tuning

QLOITER mode incorporates the altitude controller from QHOVER mode. Details for tuning are in QHOVER mode description.

- Q_LOIT_SPEED: max horizontal speed in cm/s (i.e. 1250 = 12.5m/s)
- Q_LOIT_ACC_MAX: max acceleration in cm/s/s. Higher values cause the QuadPlane to accelerate and stop more quickly
- Q_LOIT_ANG_MAX: max lean angle in centi-degrees (i.e. 3000 = 30deg). By default this value is zero which causes the ANGLE_MAX parameter's value to be used
- Q_LOIT_BRK_ACCEL: max acceleration in cm/s/s while braking (i.e. pilot has moved sticks to center). Higher values will stop the vehicle more quickly
- Q_LOIT_BRK_DELAY: the delay in seconds before braking starts once the pilot has centered the sticks
- Q_LOIT_BRK_JERK: max change in acceleration in cm/s/s/s while braking. Higher numbers will make the vehicle reach the maximum braking angle more quickly, lower numbers will cause smoother braking
- Q_P_NE_POS_P: converts the horizontal position error (i.e difference between the desired position and the actual position) to a desired speed towards the target position. It is generally not required to adjust this
- Q_P_VELXY_P converts the desired speed towards the target to a desired acceleration. The resulting desired acceleration becomes a lean angle which is then passed to the same angular controller used by QSTABILIZE. It is generally not required to adjust this

Common Problems

(1) The vehicle circles (aka "toiletbowls"). This is normally caused by a compass problem the most likely being magnetic interference from the power cables under the autopilot. Other possibilities include bad compass offsets set during the live calibration process or incorrect compass orientation.

(2) The vehicle takes off in the wrong direction as soon as QLOITER is engaged. The cause is the same as #1 except that the compass error is greater than 90deg. Please try the suggestions above to resolve this.

(3) The vehicle is QLOITERing normally and then suddenly takes off in the wrong direction. This is generally caused by a GPS Glitch. There is no 100% reliable protection against these which means

the pilot should always be ready to take-over manual control. Beyond that ensuring a good GPS HDOP before take-off is always good and it may help to reduce the EK2_GLITCH_RAD and/or EK3_GLITCH_RAD parameters (see GPS glitch wiki page for details) to tighten up on the glitch detection.

(4) QuadPlane slowly descends or climbs until the pilot retakes control in stabilize. Normally this is caused by not having the throttle stick in the mid position. This commonly happens when the pilot is switching into an altitude holding mode from a manual flight mode (like QSTABILIZE) on a QuadPlane that does not hover at mid throttle. Usually it is desired to hover in any mode at mid-stick on throttle, so that transitions between modes is easily accomplished without throttle position changes. This can be adjusted using the Q_M_THST_HOVER parameter, or automatically learned in QHOVER or QLOITER modes by enabling Q_M_HOVER_LEARN.

Verifying QLOITER performance with dataflash logs

Viewing the QLOITER's horizontal performance is best done by downloading a dataflash log from your flight, then open it with the mission planner and graph the NTUN message's DesVelX vs VelX and DesVelY vs VelY. In a good performing QuadPlane the actual velocities will track the desired velocities as shown below. X = latitude (so positive = moving North, negative = South), Y = longitude (positive = East, negative = West).

QLAND Mode

QLAND Mode attempts to bring the QuadPlane straight down at the position the vehicle is located when the mode is entered, descending to Q_LAND_FINAL_ALT at Q_WP_SPEED_DN until it reaches Q_LAND_FINAL_ALT, at which point it continues to descend at Q_LAND_FINAL_SPD until landing.

Note

QuadPlane will recognize that it has landed if the motors are at minimum for 5 seconds and its altitude has not changed more than 0.2m for 4 seconds. It does not use the altitude itself to decide whether to shut off the motors except that the QuadPlane must also be below Q_LAND_FINAL_ALT above home(ie in the LAND FINAL phase). The altitude change for the decision can be increased, in case the altitude determination from the EKF is excessively noisy by increasing the Q_LAND_ALTCHG value from its default value of 0.2m.

- If the QuadPlane appears to bounce or balloon back up a couple of times before settling down and turning the props off, try lowering the Q_LAND_FINAL_SPD parameter a bit.
- If the vehicle has GPS lock the landing controller will attempt to control its horizontal position but the pilot can adjust the target horizontal position just as in QLOITER mode.
- If the vehicle does not have GPS lock the horizontal control will be as in QSTABILIZE mode so the pilot can control the roll and pitch lean angle of the QuadPlane.

Warning

In any mode based on using the barometer: QLAND, QLOITER, QHOVER, QRTL, if your QuadPlanes operation becomes erratic when you are close to the ground or landing (and also if any auto landing procedure results in bouncing or failure to turn off motors properly after landing) you probably have the autopilot situated such that its barometer (altimeter) is being affected by the pressure created by the QuadPlanes prop-wash against the ground.

QRTL Mode

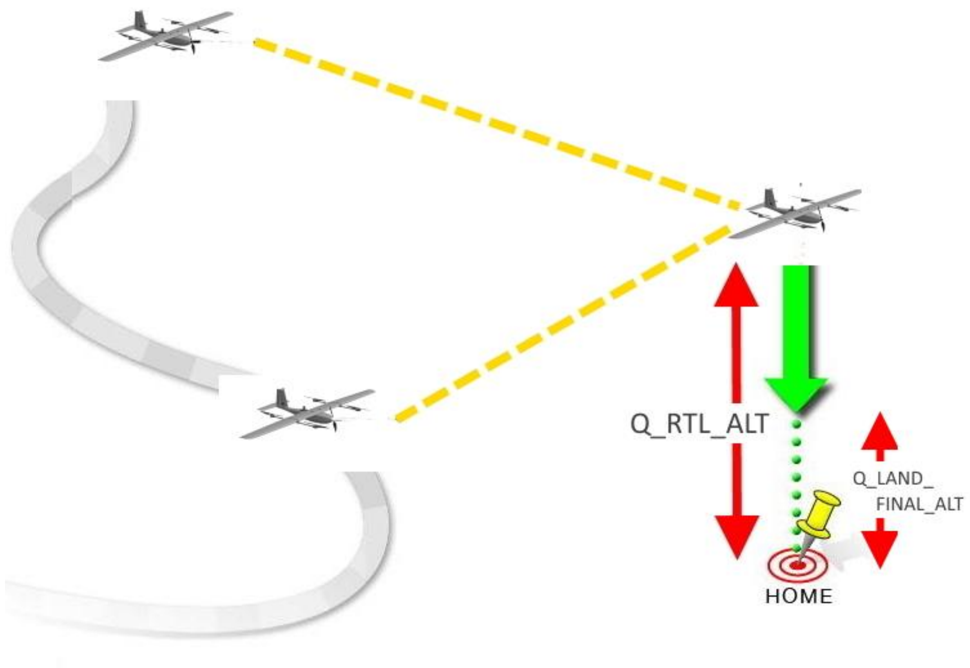
QRTL mode (QuadPlane Return To Launch mode) navigates QuadPlane from its current position to hover above the home position and then land. The behavior of QRTL mode can be controlled by several adjustable parameters. This page describes how to use and customize QRTL mode.

Overview

When QRTL mode is selected, the QuadPlane will return to the home location. By default, it will transition to fixed wing mode (if in a VTOL mode before entering, it will climb to Q_RTL_ALT if below that altitude, before transitioning), executing the first part of a normal RTL, and then make an approach as it nears the landing point and switch to VTOL mode and proceed to the landing point, then descend to a landing. See the description of this under the Hybrid RTL section for Q_RTL_MODE = 3.

If a pure VTOL QRTL is desired, then you must disable the fixed wing RTL and approach feature by setting Q_OPTIONS bit 16. Then the following actions will then occur on a QRTL:

The QuadPlane will immediately navigate towards the home location at Q_WP_SPEED, climbing or descending towards the Q_RTL_ALT altitude. Once arriving within Q_WP_RADIUS distance of home, it will begin descending at Q_WP_SPEED_DN rate, until it reaches Q_LAND_FINAL_ALT at which point it will descend at Q_LAND_FINAL_SPD until landing.



Note

QuadPlane will recognize that it has landed if the motors are at minimum for 5 seconds and its altitude has not changed more than 0.2m for 4 seconds. It does not use the altitude itself to decide whether to shut off the motors except that the QuadPlane must also be below Q_LAND_FINAL_ALT above home(ie in the LAND FINAL phase). The altitude change for the decision can be increased, in case the altitude determination from the EKF is excessively noisy by increasing the Q_LAND_ALTCHG value from its default value of 0.2m.

Alternatively, you may configure the plane to return to a Rally Point, rather than the home location.

Warning

"Home" position is always supposed to be your Plane's actual GPS takeoff location:

(1) It is very important to acquire GPS lock before arming in order for QRTL, QLOITER, AUTO or any GPS dependent mode to work properly. This requirement is provided in the default arming checks. It is highly recommended that this check is not disabled.

(2) For QuadPlane the home position is initially established at the time the plane acquires its GPS lock. It is then continuously updated as long as the autopilot is disarmed.

- This means if you execute an QRTL in QuadPlane, it will return to the location where it was when it was armed - assuming it had acquired GPS lock.
- Consider the use of Rally Points to avoid returning directly to your arming point on QRTL

Warning

In QRTL mode the autopilot uses a barometer which measures air pressure as the primary means for determining altitude ("Pressure Altitude") and if the air pressure is changing in your flight area, the copter will follow the air pressure change rather than actual altitude.

QAUTOTUNE

Autotuning PIDs in QuadPlane is supported with this flight mode. This uses the same system as the AUTOTUNE mode for copter. It should allow you to improve the tune without having to manually adjust PIDs. It is not recommended to use QAUTOTUNE for Tailsitter pitch or yaw axis, or any axis which requires feed forward pid contributions.

Configuration

- Set QAUTOTUNE mode (mode 22) on one of your mode switch positions. It may not show up as an available mode in your GCS, so you may need to set the FLTMODEn parameter in the full parameter list
- Select which axes you want to tune with Q_AUTOTUNE_AXES.

Operation

Note

QAUTOTUNE mode cannot be entered while disarmed, unlike many other QuadPlane modes.

As a QAUTOTUNE can take quite a long time (3 to 5 minutes per axis is common) you may wish to tune one axis at a time. Choose whether you want position hold support while tuning. If you enter QAUTOTUNE mode from QLOITER then it will use a loose position hold, preventing wind from carrying it away while tuning. If you start from QHOVER then it will not hold position, and you may need to reposition while tuning, but it will only do tuning ("twitching" to measure responses) while the sticks are centered.

You may need to increase the deadzone (RCx_DZ) on your input channels or re-calibrate your RC channels to ensure it can start the tune. Once you start the tune it will "twitch" on the axis it is tuning. So if it is tuning roll, then it does small sharp roll movements to measure response.

You can tell that QAUTOTUNE has finished when it stops twitching. You need to then land while staying in QAUTOTUNE mode and disarm without changing modes to save the tune. If you land in QAUTOTUNE and disarm after some axes have completed ,but the whole tune is not complete, then the PIDs for the axes that have completed will be saved.

You can reposition while tuning by moving your sticks. Once you re-center the sticks the tune will continue. If you change modes then the tune stops immediately.

QACRO Mode

QACRO (for acrobatic) is a quadplane mode for advanced users.
Training mode is not implemented and this mode will behave similarly to a fixed wing plane in MANUAL mode, with no limitations on earth frame roll, pitch and yaw.
Aileron and elevator stick scalings are set by parameters Q_ACRO_RLL_RATE and Q_ACRO_PIT_RATE, respectively, with default of 180 deg/sec. Yaw stick scaling is set by Q_ACRO_YAW_RATE with default of 90 deg/sec.
To avoid control surface oscillation, it is necessary to reduce control surface deflections at high airspeeds in VTOL modes. If the vehicle has no airspeed sensor, this reduction is based on attitude (tilt angle from vertical) and throttle setting, since these are generally correlated with airspeed. If an airspeed sensor is available, the reduction is based on the measured airspeed. There are 2 parameters which control gain scaling: Q_TAILSIT_GSCMSK and Q_TAILSIT_GSCMIN
Q_TAILSIT_GSCMSK is a bitmask with two bits: BOOST (bit 0): boost gain at low throttle and ATT THR (bit 1): reduce gain at high throttle/tilt If BOOST is set, parameter Q_TAILSIT_THSCMX determines whether gain boost (default 2) is applied below hover throttle (used for hovering a conventional 3D plane) If ATT THR is set, attenuation is applied at high throttle and tilt angles (used for “copter” tailsitters). Q_TAILSIT_GSC_MIN (default 0.4) sets the minimum gain scaling at high throttle/tilt angle when ATT THR is active.

Parameter summary:

(1) If gain boost at low throttle values is desired:

- Set bit 0 of Q_TAILSIT_GSCMSK (value 1).
- Set Q_TAILSIT_THSCMX to the maximum boost value desired.

(2) If attitude/throttle based gain attenuation is desired to reduce oscillation at higher airspeeds in VTOL modes:

- Set bit 1 of Q_TAILSIT_GSC_MSK (value 2).
- Set Q_TAILSIT_GSC_MIN to minimum desired scale (greater than zero and less than 1) for gain attenuation based on attitude and throttle. Reduce this value if oscillation occurs at high airspeeds.

(3) If both gain scaling functions are desired:

- Set Q_TAILSIT_GSC_MSK to 3.
- Set Q_TAILSIT_THSCMX and Q_TAILSIT_GSC_MIN as desired.

QACRO flying tips:
Transitions from QACRO mode to any other Q-mode are not aided by the autopilot: no throttle boost is automatically applied. This is critical when airspeed (or high throttle) is needed for attitude control, as with non-vectored dual motor tailsitters. The safest way to transition is to make sure you have sufficient airspeed for elevon authority if flying level, or to establish a stable nose-up hover before switching out of QACRO.

Hover Throttle

Usually, it is desired to hover in any mode, at mid-stick on throttle, so that transitions between modes is easily accomplished without throttle position changes. This can be adjusted using the Q_M_THST_HOVER parameter, or automatically learned in QHOVER or QLOITER modes by enabling Q_M_HOVER_LEARN.

Note

If Q_THROTTLE_EXPO = 0 in QACRO and QSTABILIZE modes , then Q_M_THST_HOVER, whether set manually or learned via Q_M_HOVER_LEARN, is not applied, and the throttle is determined directly from the RC input.

More Flight Modes

LOITER to Altitude and QLAND Mode

If the previous mode was a fixed wing mode, this mode will perform a descending fixed wing LOITER down to Q_RTL_ALT and then switch to QLAND mode. If the aircraft was already performing a loiter when switching to this mode the LOITER center does not change, otherwise the LOITER center will become the same location it is at when entering the mode.

AirMode

This is not an actual flight mode, but rather, an important feature of QACRO and QSTABILIZE modes. Other flight control software refer to it as a flight mode, so for consistency, its included in the QuadPlane flight modes documentation.

VTOL QUICKTUNE

Quick means of obtaining a good tune for Quadplanes in VTOL modes are provided . The process slowly increases the relevant gains until it detects an oscillation. It then reduces the gains by 60% and moves onto the next gain. Once all the gains have been tuned the tune completes and the user can decide to save or discard the new gains.

Flight modes to avoid

The linked nature of the vertical lift and fixed wing control in quadplanes means the autopilot always needs to know what the pilot is trying to do in terms of speed and attitude. For this reason you should avoid the following flight modes in a quadplane:

- ACRO
- STABILIZE
- TRAINING

these modes are problematic as the stick input from the pilot is not sufficient to tell the autopilot what attitude the aircraft wants or what climb rate is wanted, so the quadplane logic does not engage the quad motors when in these modes. These modes also make log analysis difficult. Please use FBWA mode instead of STABILIZE for manual flight.

In the future we may add ways to use the quad motors in these modes, but for now please avoid them.

The other mode where the quad motors are disabled is MANUAL mode. That mode still can be useful for checking aircraft trim in fixed wing flight or for taxiing your aircraft.

6.4.7 QuadPlane Setup Tips

There are a few helpful hints and tips for first-time QuadPlane users.

Motor Alignment

Motor alignment is always critical for any Plane’ s performance, but it is especially so for QuadPlanes. Miss-aligned VTOL motors can greatly affect basic VTOL performance, especially yaw trim and effectiveness, as well as fixed-wing flight performance.

Checking motor alignment on the bench can be done by blocking the vehicle in a level position and measuring prop to table distances for all motors with props in fore-aft and side-to-side positions.

Measurement differences easily reveal miss-alignments. The arc-sine of the prop tip end differences divided by the prop diameter will give the tilt angles. A degree or two miss-alignment, while not disastrous for pitch or roll, can be significant in non-vectored yaw configurations with regards to extreme yaw miss-trim.
Miss-alignment can also be seen in the dataflash log RCOUT values in a hover for the VTOL motors. Yaw problems appear as large separations between diagonal motor pairs.
For vectored thrust frames, fixed-wing mode alignment is also critical. Very small differences between motor thrust angles in forward flight will generate undesirable, and sometimes uncontrollable, roll trim tendencies. Careful bench checking and adjustment of forward fixed-wing mode positions with respect to airframe and one another is required.

X vs H Quad Mixing

If the airframe is perfectly rigid, the performance difference between X and H mixing schemes is negligible. However, quadplanes structures are often less rigid than traditional multirotors and torsional effects must be considered. When a yaw input results in most of a quadplane's weight being supported by a diagonal pair of motors, the fuselage or wing of a quadplane may twist and distort the thrust vectors of some or all motors. This distortion often induces a yaw moment that can reduce or even completely disable yaw effectiveness unless the appropriate mixing scheme is used. While this effect is airframe dependent, it usually can be summarized in one of two ways:

- Airframes with quad motors mounted to arms extending forward and aft of the wings, aligned with the chord direction. X mixing scheme should be used such that any induced twist complements the desired yaw. If the H mixing scheme is used with this configuration, yaw inputs may induce wing twist that counteracts the desired yaw.
- Airframes with quad motors mounted to arms extending left and right from the fuselage, usually attached near the nose and tail. H mixing scheme should be used such that any induced twist complements the desired yaw. If the X mixing scheme is used with this configuration, yaw inputs can induce fuselage twist that counteracts the desired yaw.

Increasing YAW Authority

In non-vectored yaw configurations, where torque deltas between motors is the only means of inducing/maintaining yaw, you may find that the yaw authority is too weak. In some cases, it may be so weak as to be inadequate even to maintain yaw directional stability in a hover due to imperfections in motor alignment or frame twist, even after careful trimming of motor alignment.
However, by intentionally inducing the appropriate motor tilt into each mount, YAW authority can be greatly increased at very small cost to total vertical lifting capability of the VTOL motors.
For H mixing, simply tilt all the motors inward toward the plane by 2-3 degrees, either by shimming or intentional design of the motor mounts. This provides a rotational thrust boost in addition to the torque differential, as the diagonal motor pairs are sped up/slowed down. With additional YAW authority, small motor angle imperfections can be automatically overcome by the autopilot, as well as giving the pilot additional YAW authority.

Note

Be aware that QuadPlanes rarely have the same yaw authority as multicopters due to the greater mass and surface area to wind that a plane presents. Expect to be only able to face into the wind if it's not relatively calm.

“LEVEL” Trim

When you setup a QuadPlane, the “level” calibration should be done with the plane in its normal cruising attitude (ie angle of attack of the wings). In a non-tailsitter quadplane, if the vertical position of the VTOL motors is not 90 degrees to this attitude, then the QuadPlane will tend to move forward or backward when hovering, requiring stick input to modify pitch. Or, in a tailsitter, if the “trim” position of the motors, and/or vertical CG is not through the thrust line when vertical, it will also drift.
Fortunately, there is a parameter which allows the independent adjustment of the VTOL AHRS “level” attitude. This is Q_TRIM_PITCH in degrees to be added, negative or positive, to the AHRS “level”.
However, there is a better way for non-tailsitter QuadPlanes. If mechanically possible, trim each motor to be vertical when the QuadPlane is in fixed wing “level” mode, so that using Q_TRIM_PITCH is not required. Usually, this requires 3-5 degrees of forward tilt. This has the advantage of having the wings generate lift while hovering in the wind, reducing the load on the VTOL motors and preventing sudden pitch changes during transitions back to VTOL mode from fixed-wing flight.

Note

Those fabricating their mounts via a 3D printer, this is very easy to do, as well as tilt for yaw enhancement discussed above.

Note

Fixed wing pitch “level” trim is set by the AHRS “level” done during accelerometer calibration, which adjusts the AHRS_TRIM_Y values, PLUS any PTCH_TRIM_DEG (in degrees). See Accelerometer Calibration and Tuning Cruise Configuration for more details.

Trimming VTOL “Level” thru Accelerometer LeveL only Calibration

There is another, slightly more complex, way to set the VTOL stance pitch trim without using Q_TRIM_PITCH, in tailsitters only:

- Do the normal fixed wing accelerometer calibration. But read and save the AHRS_TRIM_Y value after the calibration.
- Place the vehicle in VTOL stance (nose pointing veritically) and set the mode to QSTABILIZE. Be sure that Q_TRIM_PITCH = “0” or the next step will fail.
- Do a “LEVEL only” accelerometer calibration. In Mission Planner there is a button for this under the Accelerometer calibration. In MAVProxy, its the “ahrstrim” command.
- Restore the previously noted and saved AHRS_TRIM_Y value to restore the fixed wing attitude pitch trim.

In some cases, Q_TRIM_PITCH may still need to be adjusted if the calibration stance used is not the true hovering attitude.

Copter Motors vs Servos

If you are using a configuration where there are copter motors involved (almost all QuadPlanes do except single/dual motor tailsitters), the motor outputs are assigned as PWM protocol unless changed (see PWM, OneShot and OneShot125 ESCs). But the PWM is at a 400Hz update rate, not 50Hz. If a servo is used in an output group sharing the same timer as one of the motor outputs, then it too will be operating at 400HZ and must be able to tolerate that. Most analog servos will overheat or burn up. Most digital servos can tolerate that rate. Check your autopilot’s hardware description page for the DShot output groups, which indicates which outputs share the same timer.

Battery Sag

Many QuadPlanes are targeted for duration and therefore may utilize high capacity to weight ratio, but low "C", batteries. Battery sag in the initial phase of VTOL to fixed-wing transitions can be a real issue. Be sure to read the warning in Flying a QuadPlane and to set BATT_WATT_MAX, Q_M_BAT_CURR_MAX, and the Q_M_BAT_VOLT_MIN parameters appropriately.

6.5 First Flight and VTOL Tuning

6.5.1 QuadPlane VTOL Tuning Overview

This section provides an overview of how to tune various QuadPlane VTOL parameters.

Overview

The default parameters controlling the VTOL motors PID loops should allow most frames to initially hover controllably, if the motors' mechanics are setup and aligned correctly and escs calibrated.
The most important parameters controlling stability are the Roll/Pitch/Yaw PIDS. For altitude control, the vertical position controller's parameters and Motor Thrust Scaling parameters, and for navigation/loiter the Loiter controllers's parameters
Normally, it's best to start by tuning the Rate Roll/Pitch P in QSTABILIZE mode then move onto tuning altitude hold in QHOVER mode, then QLOITER (which often needs no tuning) and finally the waypoint navigation performance in Auto mode.

Note
for Tailsitter QuadPlanes, some axes need a slightly different PID tuning approach depending on the exact frame configuration used. Be sure to also read TailSitter Tuning.

Filter tuning

QuadPlanes are often affected by vibration and tuning the various software filters available is critical to achieving an optimum overall tune. A guide on tuning the various notch filters available can be found on the Notch Filtering wiki page. A optimum tune will be obtained on the D terms, below, if the filtering has been optimized first. However, in many circumstances reasonable performance can be obtained with just PID tuning the P terms.

Roll/Pitch tuning

The Q_A_RAT_RLL_x and Q_A_RAT_PIT_x Roll/Pitch Rate parameters which convert the desired rotation rate into a motor output are the most important. If not a tailsitter, then the Q_A_RAT_PIT_FF will be zero and corrections are dominated by P/I/D. In tailsitters, then the FF terms dominate (Pitch axis only) and P/D are primarily for disturbance correction. For tuning tailsitter pitch axis, see Pitch and Yaw Tuning.

The Q_A_ANG_RLL_P and Q_A_ANG_PIT_P Roll/Pitch P converts the desired angle into a desired rotation rate which is then fed to the Rate controller.

- A higher value will make the QuadPlane more responsive to roll/pitch inputs, a lower value will make it smoother
- If set too high, the QuadPlane will oscillate on the roll and/or pitch axis
- If set too low the QuadPlane will become sluggish to inputs

An objective view of the overall Roll and Pitch performance can be seen by graphing the dataflash log’s ATT message’s DesRoll vs Roll and DesPit vs Pitch. The “Roll” (i.e. actual roll) should closely follow the “DesRoll” while in stabilized modes. Pitch should similarly closely follow DesPit.
Alternatively you may wish to try automatically tuning the rate parameters using the QUICKTUNE.

Yaw Tuning

The Angle Yaw and Rate Yaw parameters control the yaw response. With QuadPlanes, these often need tuning to get the desired YAW response, since configurations vary widely. In non-tailsitters, then the Q_A_RAT_YAW_FF will be zero and corrections are dominated by P/I/D. But in tailsitters, the FF term dominates and P/D are primarily for disturbance correction. For tuning a tailsitter yaw axis, see Pitch and Yaw Tuning.
Similar to roll and pitch, if either Q_A_RAT_YAW_P or Q_A_ANG_YAW_P is too high the QuadPlane’s heading will oscillate. If they are too low, the QuadPlane may be unable to maintain its heading.
The Q_A_ANG_YAW_P is the gain on the error between the autopilots desired heading and actual heading which is fed into the Rate controller to demand a rotation rate. The Q_A_RAT_YAW_P is the gain applied to the difference between demanded rotation rate and actual.
The Q_YAW_RATE_MAX parameter controls how quickly QuadPlane rotates based on a pilot’s yaw input in stabilized modes.

Altitude Tuning

The QHOVER (altitude hold) related tuning parameters are related to the vertical position controller and the motor thrust scaling, which linearizes the throttle to motor thrust response to improve the position controllers response.
The Q_P_POSZ_P parameter is used to convert the altitude error (the difference between the desired altitude and the actual altitude) to a desired climb or descent rate. A higher rate will make it more aggressively attempt to maintain it’s altitude but if set too high leads to a jerky throttle response.
The Q_P_VELZ_P (which normally requires no tuning) converts the desired climb or descent rate into a desired acceleration up or down.
The Q_P_ACCZ_P, Q_P_ACCZ_I, and Q_P_ACCZ_D PID gains convert the acceleration error (i.e the difference between the desired acceleration and the actual acceleration) into a motor output. The 1:2 ratio of P to I (i.e. I is twice the size of P) should be maintained if you modify these parameters. These values should never be increased but for very powerful QuadPlane VTOL motors you may get better response by reducing both by 50% (i.e P to 0.5, I to 1.0).

Loiter Tuning

Generally if Roll and Pitch are tuned correctly, the GPS and compass are set-up and performing well and vibration levels are acceptable, Loiter does not require much tuning but please see the Loiter Mode page for more details on tunable parameters including the horizontal speed.

In-flight Tuning

Many parameters can be tuned while in flight.

6.5.2 Tuning Process Instructions

Setting the aircraft up to be ready for tuning

The following parameters should be set correctly based on the specifications of your aircraft.

Step 1: Battery and expo settings

It is very important to ensure that the thrust curve of your VTOL motors is as linear as possible. A linear thrust curve means that changes in the actual thrust produced by a motor is directly proportional to the thrust. If your thrust curve is badly non-linear then you will never produce a good tune, and in some cases may end up with such a bad tune that your vehicle can become completely unstable and crash.

There are 3 common causes of a non-linear thrust curve.

- voltage sag as throttle is increased or the forward motor is engaged. This is very common in QuadPlanes
- incorrect end-point setup in the PWM range you use to your ESCs (see "Motors setup" below)
- non-linearity in the thrust produced by your propeller, ESC and motor combination

Start with setting up the voltage range to cope with voltage sag.

- Q_M_BAT_IDX: index of the battery to use for voltage measurements on VTOL power system. Zero is the first battery, one for 2nd battery etc
- Q_M_BAT_VOLT_MAX: 4.2v x No. Cells for LiPo
- Q_M_BAT_VOLT_MIN: 3.3v x No. Cells for LiPo
- Q_M_OPTIONS = 0 (default). The default is to use sag compensated voltage for the above and during tuning computations. It can be set to 1 to use raw voltage instead of sag compensated voltage, which may improve tuning results for light vehicles.

Note that Q_M_BAT_IDX needs to be for the correct battery for your VTOL motors. If you have a separate battery for forward motors and VTOL motors then make sure you use the right one.

Next setup the thrust expo. If you are setting up a professional aircraft then you should invest in a thrust stand so you can accurately measure the true thrust for your motor/ESC/propeller combination as you vary the throttle. Then you will adjust the expo value along with the endpoints (given by motors setup below) so that the thrust between the endpoints is as linear as possible. Do not trust manufacturer data for the thrust curve as they are frequently inaccurate. See Motor Thrust Scaling for details on thrust scaling.

If you are setting up a hobby grade vehicle then you can use the graph below to estimate the correct Q_M_THST_EXPO value for your aircraft.

Q_M_THST_EXPO: 0.55 for 5 inch props, 0.65 for 10 inch props, 0.75 for 20 inch props.

Step 2: Motors setup

The motor parameters define the PWM output range sent to the ESCs. This is critical to ensure that the entire range of throttle values used in flight is within the linear range of your propulsion system.

For standard PWM based ESCs you should adjust Q_M_PWM_MIN until it is approximately 20 microseconds below the minimum value that causes the motors to just start spinning. If you are using digital motor outputs (such as DShot) then this is not necessary and the default of 1000 should be used.

You should then adjust Q_M_PWM_MAX to the value where the ESCs stop producing more thrust. Note that this is commonly a bit below the default maximum of 2000. To find the value you should test with propellers removed, and use the motor test facility of your GCS to find the lowest PWM value which produces the motors maximum RPM. You should be able to tell at what PWM the motors stop producing more thrust by listening to the sound made at different PWM values, or you can use a tachometer.

The Q_M_SPIN_MIN and Q_M_SPIN_MAX values are used to select a sub-range of the outputs to your motors which is linear. For hobby users the defaults are usually good, but for professional vehicles you should use the thrust stand data to determine the right range to produce linear thrust after the expo is applied.

- Q_M_PWM_MAX: Check ESC manual for fixed range or 2000us
- Q_M_PWM_MIN: Check ESC manual for fixed range or 1000us
- Q_M_SPIN_ARM: use the motor test feature
- Q_M_SPIN_MAX: 0.95
- Q_M_SPIN_MIN: use the motor test feature
- Q_M_THST_HOVER: 0.25, or below the expected hover thrust percentage (low is safe)

Step 3: PID Controller Initial Setup

The settings below are meant to get your PID controller acceleration and filter settings into the right approximate range for your vehicle. These parameters are critical to the tuning process.

- INS_ACCEL_FILTER: 10Hz to 20Hz
- INS_GYRO_FILTER: 80Hz for 5 inch props, 40Hz for 10 inch props, 20Hz for 20 inch props
- Q_A_ACCEL_P_MAX: 110000 for 10 inch props, 50000 for 20 inch props, 20000 for 30 inch props
- Q_A_ACCEL_R_MAX: 110000 for 10 inch props, 50000 for 20 inch props, 20000 for 30 inch props
- Q_A_ACCEL_Y_MAX: 7500 for 6 inch props,6750 for 10 inch props, 4500 for 20 inch props, 2250 for 30 inch props
- Q_A_RAT_YAW_P: 0.5 x Q_A_ACCEL_Y_MAX / 4500
- Q_A_RAT_PIT_FLTD: INS_GYRO_FILTER / 2
- Q_A_RAT_PIT_FLTT: INS_GYRO_FILTER / 2
- Q_A_RAT_RLL_FLTD: INS_GYRO_FILTER / 2
- Q_A_RAT_RLL_FLTT: INS_GYRO_FILTER / 2
- Q_A_RAT_YAW_FLTE: 0 for vectored yaw; 2.5 for other types of QuadPlanes
- Q_A_RAT_YAW_FLTT: INS_GYRO_FILTER / 2

The initial tune of the aircraft should be done in the aircraft's most agile configuration. This generally means that the aircraft will be at its minimum take off weight with fully charged batteries.

Step 4: Pilot's preparation for first flight

The first takeoff of an untuned VTOL vehicle is the most dangerous seconds of the aircraft's life. This is where the aircraft could be very unstable causing a sudden increase in power when then results in the aircraft jumping into the air, or it may be so poorly tuned that you have insufficient control over the aircraft once it is airborne. The pilot should be extremely diligent during the tuning flights to avoid a situation that could result in injury or damage.

There are several things that the pilot can do to minimize the risk during the early tuning process:

(1) The pilot should conduct a motor number and orientation check (see Checking the motor numbering with the Mission Planner Motor test). Care should be taken to ensure that the correct frame type is selected. Incorrect frame type can result in a very fast yaw rotation or complete loss of control. Take note of the output percentage required to spin the propellers and ensure that:

- Q_M_SPIN_ARM is set high enough to spin the motors cleanly.
- Q_M_SPIN_MIN is set high enough to spin the motors with a minimal level of thrust.

(2) All flights after a significant tuning change should be done in QSTABILIZE. QSTABIILIZE provides the pilot with significantly more control over the aircraft in the event that the attitude controllers are unstable.

(3) The pilot should not take off in QHOVER until the altitude controller has been tested in flight. This should be done by taking off in QSTABILIZE and switching to QHOVER. Although QHOVER is rarely a problem unless the aircraft has a very low hover throttle.

(4) For the initial flights the pilot should ensure that these parameters are set:
- Q_A_THR_MIX_MAN to 0.1
- Q_M_THST_HOVER to 0.25 (or lower than the expected hover throttle)

(5) Use a radio and calibrate the radio correctly (see Radio Control Calibration).
(6) Configure an ARM/DISARM switch and test it (see Auxiliary Functions).
(7) Do tuning flights in low-wind condition and normal weather (no rain and between 15°C/59°F and 25°C/77°F).
(8) Practice QSTABILIZE flight in simulator or on a low-end drone first. You should be confident to be able to takeoff and land with your untuned aircraft.

Tuning Process
Step 5: First Flight
The first take off is the most dangerous time for any QuadPlane. Care must be taken to ensure the aircraft is not destroyed in the first seconds of flight and nobody is injured.
- Ensure that all spectators are at a safe distance.
- Ensure the pilot is at a safe distance and position.
- The pilot should refresh themselves on the method used to disarm the aircraft (using Auxiliary Functions for Motor Interlock or Arm/Disarm may be beneficial).

This flight will allow to setup your aircraft in a "flyable for tuning" state.
(1) Ensure the aircraft is in QSTABILIZE mode
(2) Arm the aircraft
(3) Immediately disarm the aircraft to ensure your disarm procedure is correct
(4) Arm the aircraft
(5) Slowly increase the throttle looking for signs of oscillation. (long or flexible landing gear may cause some landing gear oscillation that will only go away after the aircraft leaves the ground)
(6) As soon as the aircraft lifts off the ground immediately put the aircraft back down as gently as possible
(7) Disarm the aircraft
(8) Evaluate what you observed to decide if you need to make adjustments to the tuning parameters or if it is safe to take off again
(9) Arm and increase the throttle to initiate a takeoff
(10) Hover at approximately 1m altitude and apply small (5 degrees) control inputs into roll and pitch
(11) Immediately land if any oscillation is observed
Next section will explain how to remove the oscillations.

Step 6: Initial aircraft tune
The first priority when tuning a QuadPlane is to establish a stable tune, free of oscillations, that can be used to do further tests.
(1) Arm the aircraft in QSTABILIZE
(2) Increase the throttle slowly until the aircraft leaves the ground
(3) If the aircraft starts to oscillate immediately abort the takeoff and/or land the aircraft, and:
(4) Reduce all the following parameters by 50%

a. Q_A_RAT_PIT_P
b. Q_A_RAT_PIT_I
c. Q_A_RAT_PIT_D
d. Q_A_RAT_RLL_P
e. Q_A_RAT_RLL_I
f. Q_A_RAT_RLL_D

This process is repeated until the aircraft can hover without oscillations being detectable visually or audibly.
If the aircraft has very long or flexible landing gear then you may need to leave the ground before ground resonance stops.
Be aware that in this state the aircraft may be very slow to respond to large control inputs and disturbances. The pilot should be extremely careful to put minimal stick inputs into the aircraft to avoid the possibility of a crash.

Step 7: Test QHOVER
This test will allow to test the altitude controller and ensure the stability of your aircraft.

(1) Check Q_M_HOVER_LEARN is set to 2. This will allow the controller to learn by itself the correct hover value when flying.

Note
the Hover throttle value is only "learned" when the attitude is not being commanded by the pilot, or autopilot (ie QLOITER,etc.), to exceed 5 degrees from neutral for two seconds.

(2) Take off in QSTABILIZE and increase altitude to 5m. Switch to QHOVER and be ready to switch back to QSTABILIZE. If the aircraft is hovering at a very low hover throttle value you may hear a reasonably fast oscillation in the motors. Ensure the aircraft has spent at least 30 seconds in hover to let the hover throttle parameter converge to the correct value. Land and disarm the aircraft.
(3) Set these parameters on ground and preferably disarm (A confident pilot could set them in flight with GCS):

- Q_P_ACCZ_I to 2 x Q_M_THST_HOVER
- Q_P_ACCZ_P to Q_M_THST_HOVER

If the QuadPlane in QHOVER starts to move up and down, the vertical position and velocity controllers may need to be reduced by 50%. These values are: Q_P_POSZ_P and Q_P_VELZ_P.

Note
If the Q_M_THST_HOVER learned should be ~0.3-0.6. Higher values indicate that insufficient thrust is available, either due to motor system design, obstructed prop air flow by the fuselage or wings, or excessive yaw bias (see next section)

Step 8: Yaw Bias
A common problem in QuadPlanes is excessive amount of VTOL power being used to maintain yaw hold instead of providing lift. This can be caused by:

- small misalignment of the VTOL motors
- frame twist (often caused by wing twist) as thrust is applied

- obstructed prop air flow by wings in TVBS type tailsitters making vectored yaw by motor tilt less effective. This can also cause enough reduction in normal thrust to make hovering and VTOL climb difficult.

If too much power is needed to maintain yaw then the aircraft could lose yaw control during transitions, or could lose roll and pitch stability. The most common symptom is a high hover throttle point, or even the inability to rise into a hover at high throttle stick position. For larger QuadPlanes it is common to need to deliberately tilt the motors by a couple of degrees to increase yaw authority.

Note
for an X frame type (Q_FRAME_TYPE = 1), the motors should be tilted outwards. For an H frame (Q_FRAME_TYPE = 3) they should be tilted inwards.

You should check the amount of thrust being used to maintain yaw by looking at the RATE YOut value in your hover logs. If it is over 10% (a value of 0.1) when hovering in no wind with no pilot input,then you have a problem with yaw asymmetry that should be fixed. Just hovering in place may look fine and you may not see the problem until you examine the log.

Fixing yaw asymmetry can involve mechanical improvements such as stiffening the airframe to resist twisting, making sure prop flow is unobstructed by the wings on TVBS frames,or correcting/adjusting motor tilt angles
Some QuadPlanes will benefit from being setup as H frames instead of X frames. Which works best depends on the way the motor mounts twist when under thrust. If you have a persistent problem with yaw control then consider trying to change the frame type between X and H, however a quadplane with motors mounted on booms secured to the wings would normally be setup as an X frame.

Step 9: Notch Filtering
After your have QHOVER flying without oscillations the next step is to get get a good notch filter setup to reduce noise to the VTOL PID controllers. A good set of notch filtering parameters is critical to a good tune.
To get a notch filter setup you need to hover your QuadPlane for 2 minutes with no pilot input and with INS_LOG_BAT_MASK set to 1. This will enable FFT logging which will guide the correct setup of the notch filters. You should then carefully read the Managing Gyro Noise with the Dynamic Harmonic Notch Filters documentation and setup a harmonic notch to remove the noise from your gyros.
When setting up your filtering you should consider the cause of any oscillation you find. On most aircraft the vibrations you find will be directly caused by a multiple of the RPM, but on some aircraft a frame resonance or resonance in the autopilot mount may be the cause. Understanding the cause of any resonances is critical to reducing noise enough to get a good tune.

Step 10: Manual tuning of Roll and Pitch
While you may be tempted to jump straight to autotuning, this is not recommended. Most QuadPlanes need some manual tuning of roll and pitch before they can handle an autotune. If you jump straight to an autotune then your aircraft may become unstable enough to crash. A good manual tune will also reduce the amount of time an autotune will take, which can be critical given the small VTOL hover times of many QuadPlanes.
Before starting the manual tune you should go back and check you have fully completed the steps above, and ensure you have a good notch filter setup to remove noise from the gyros.

Hover the aircraft in QSTABILIZE or QHOVER modes, in low wind, with good sky view and good GPS lock. You should adjust the rate gains as described below, using small "twitches" on the sticks after each change to try to trigger oscillation.
If oscillations start do not make large or sudden stick inputs. Reduce the throttle smoothly to land the aircraft while using very slow and small roll and pitch inputs to control the aircraft position.
The parameters you will be adjusting are:

- Q_A_RAT_RLL_D
- Q_A_RAT_RLL_P and Q_A_RAT_RLL_I
- Q_A_RAT_PIT_D
- Q_A_RAT_PIT_P and Q_A_RAT_PIT_I

Note
If the VTOL motors do not tilt, then the Q_A_RAT_PIT_FF and Q_A_RAT_YAW_FF will be zero and corrections are dominated by P/I/D. But if pitch or yaw control is primarily by tilting the motors, then the FF terms dominate and P/D are primarily for disturbance correction. For tuning a tilted motor controlled axis, see Pitch and Yaw Tuning.
Start with the roll parameters, then move onto the pitch.
(1) Increase the D term in steps of 50% until oscillation is observed
(2) Reduce the D term in steps of 10% until the oscillation disappears
(3) Reduce the D term by a further 25%
(4) Increase the P term in steps of 50% until oscillation is observed
(5) Reduce the P term in steps of 10% until the oscillation disappears
(6) Reduce the P term by a further 25%

Each time the P term is changed in the above steps you should set the corresponding I term equal to the P term. Those parameters can be changed on ground and preferably disarmed. Alternatively, a confident pilot could set them in flight with a GCS, or use the transmitter tuning option. See Transmitter Based Tuning
Note that it is common that once you have properly setup notch filtering that you will be able to increase the D value a lot from the default value. Increases of 10x over the default are not uncommon. Being able to use a larger D gain is one of the main advantages of good notch filtering, and can produce a much better tune.
After you have gone through the above steps you should carefully look at your logs to ensure you don't have a hidden oscillation. The structure of QuadPlanes sometimes means that oscillations may not be externally visible. You should use the RATE, PIQR and PIQP messages to look for oscillations.

Step 11: Evaluating the aircraft tune
You need to evaluate the aircraft's tune to see if the previous steps have resulted in a tune which is good enough for a transition flight or for autotuning.
(1) Take off in QHOVER or QSTABILIZE
(2) Apply small roll and pitch inputs. Start with 5 degree inputs and releasing the stick to centre, pitch, left, right, roll forward back, then all 4 points on the diagonal
(3) Increase inputs gradually to full stick deflection
(4) Go to full stick deflection, quickly momentarily, and let the sticks spring back to centre

If the aircraft begins to overshoot significantly or oscillate after the stick input, halt the tests before the situation begins to endanger the aircraft. The aircraft may require more manual tuning before autotuning can be run.

To test the stabilization loops independent of the input shaping, set the parameter: Q_A_RATE_FF_ENAB to 0.

(1) Take off in QHOVER or QSTABILIZE
(2) Hold a roll or pitch input
(3) Release the stick and observe the overshoot as the aircraft levels itself
(4) Gradually increase the stick deflection to 100%

Halt the tests if the aircraft overshoots level significantly or if the aircraft oscillates and go back to manual tuning.

Set Q_A_RATE_FF_ENAB to 1 after the tests are complete.

Step 12: Autotuning

Often, the default params or a good manual tune will be sufficient. However, autotuning can usually improve the tune.

If the aircraft appears stable enough to attempt autotuning and you have sufficient battery to last through an autotuning session then you can autotune using one of two methods:

- QUICKTUNE
- QAUTOTUNE Mode (no longer the recommended method, and is not compiled into most firmware).

Using the QAUTOTUNE mode to Automate Tuning

Follow the instructions in the QAUTOTUNE page.

You should use QAUTOTUNE on one axis at a time (setting Q_AUTOTUNE_AXES for the axis you want to tune). An autotune of a single axis will typically take 5 to 8 minutes, but will take longer if your manual tune is not good enough. If you do not have enough battery for at least 8 minutes of vertical flight then QAUTOTUNE is not recommended.

There a number of problems that can prevent QAUTOTUNE from providing a good tune. Some of the reason QAUTOTUNE can fail are:

- High levels of gyro noise.
- Incorrect value of Q_M_THST_EXPO.
- Flexible frame or payload mount.
- Overly flexible vibration isolation mount.
- Non-linear ESC response.
- Very low setting for Q_M_SPIN_MIN.
- Overloaded propellers or motors.
- Autotuning a Tailsitter’s pitch or yaw axis, or vectored yaw axis on TiltRotor, since they require feed-forward.

If QAUTOTUNE has failed you will need to re-do a manual tune.

Some signs that QAUTOTUNE has been successful are:

- An increase in the values of Q_A_ANG_PIT_P and Q_A_ANG_RLL_P.
- Q_A_RAT_PIT_D and Q_A_RAT_RLL_D are larger than Q_AUTOTUNE_MIN_D.

QAUTOTUNE will attempt to tune each axis as tight as the aircraft can tolerate. In some aircraft this can be unnecessarily responsive. A guide for most aircraft:

- Q_A_ANG_PIT_P should be reduced from 10 to 6
- Q_A_ANG_RLL_P should be reduced from 10 to 6
- Q_A_ANG_YAW_P should be reduced from 10 to 6
- Q_A_RAT_YAW_P should be reduced from 1 to 0.5
- Q_A_RAT_YAW_I: Q_A_RAT_YAW_P x 0.1

These values should only be changed if QAUTOTUNE produces higher values. Small aerobatic aircraft may prefer to keep these values as high as possible.

Step 13: Setting the input shaping parameters

QuadPlane has a set of parameters that define the way the aircraft feels to fly. This allows the aircraft to be set up with a very aggressive tune but still feel like a very docile and friendly aircraft to fly.

The most important of these parameters is:

- Q_A_RAT_YAW_P: yaw rate x 45 degrees/s
- Q_ANGLE_MAX: maximum lean angle
- Q_A_ACCEL_P_MAX: Pitch rate acceleration
- Q_A_ACCEL_R_MAX: Roll rate acceleration
- Q_A_ACCEL_Y_MAX: Yaw rate acceleration
- Q_A_ANG_LIM_TC: Aircraft smoothing time

QAUTOTUNE mode tuning will set the Q_A_ACCEL_P_MAX, Q_A_ACCEL_R_MAX and Q_A_ACCEL_Y_MAX parameters to their maximum based on measurements done during the QAUTOTUNE tests. These values should not be increased beyond what QAUTOTUNE suggests without careful testing. In most cases pilots will want to reduce these values significantly.

The Quick VTOL Tune LUA Applet will not adjust these from defaults and you may adjust them to get the feel you desire.

For aircraft designed to carry large directly mounted payloads, the maximum values of Q_A_ACCEL_P_MAX, Q_A_ACCEL_R_MAX and Q_A_ACCEL_Y_MAX should be reduced based on the minimum and maximum takeoff weight (TOW):

- Q_A_ACCEL_P_MAX x (min_TOW / max_TOW)
- Q_A_ACCEL_R_MAX x (min_TOW / max_TOW)
- Q_A_ACCEL_Y_MAX x (min_TOW / max_TOW)

Q_A_RAT_YAW_P should be set to be approximately 0.5 x Q_A_ACCEL_Y_MAX / 4500 to ensure that the aircraft can achieve full yaw rate in approximately half a second.

Q_A_ANG_LIM_TC may be increased to provide a very smooth feeling on the sticks at the expense of a slower reaction time.

Aerobatic aircraft should keep the Q_A_ACCEL_P_MAX, Q_A_ACCEL_R_MAX and Q_A_ACCEL_Y_MAX provided by QAUTOTUNE and reduce Q_A_ANG_LIM_TC to achieve the stick feel desired by the pilot.

The full list of input shaping parameters are:

- Q_A_RAT_YAW_P
- Q_ANGLE_MAX
- Q_A_ACCEL_P_MAX
- Q_A_ACCEL_R_MAX
- Q_A_ACCEL_Y_MAX
- Q_A_ANG_LIM_TC
- Q_A_RATE_P_MAX
- Q_A_RATE_R_MAX
- Q_A_RATE_Y_MAX
- Q_A_SLEW_YAW
- Q_P_JERK_XY
- Q_P_JERK_Z
- Q_LOIT_ACC_MAX

- Q_LOIT_ANG_MAX
- Q_LOIT_BRK_ACCEL
- Q_LOIT_BRK_DELAY
- Q_LOIT_BRK_JERK
- Q_LOIT_SPEED

6.5.3 Yaw Tuning for Tilt Vectored Yaw Configurations

Tuning the yaw axis is a bit different if tilt vectored yaw is utilized. Tilt Vectored Tailsitters and Quadplanes like Tilt-Tricopter configurations use tilting of the motors to accomplish yaw will need a slightly different tuning process since the yaw response is not being driven by motor rotation speed differentials. These systems will need the FF term determined and set before tuning D and P terms for yaw.

- First, follow Steps 1 - 4 of the normal QuadPlane Tuning Process Setup.
- Normally, the vehicle is stable enough with the default PIDs to do a first test hover in QSTABILIZE or QHOVER. Do a short hover flight with logging enabled such that the Harmonic Notch Filters can be setup. Its important to remove as much motor noise as possible in order to get a good tune using a throttle based harmonic notch filter.
- Once the notch filters are set, do another hover flight but briefly do short, but sharp yaw stick movements in both directions. Do not endanger the vehicle, but try to get several short full stick movements right and left. You should be able to hold full yaw stick each direction for a second or so, returning to neutral for a second in-between direction reversals.
- Download the dataflash log for analysis. In order to determine the Q_A_RAT_YAW_FF term, use a log analyzer like https://plot.ardupilot.org and setup the following plots on the same scale, using the "Add Expression" button:
  PIQY.FF+PIQY.P+PIQY.D
  X * (PIQY.Act) , where X is 0.2 to start
- Next adjust the X value above until the magnitudes of both plots are about equal. This will now be value for the Q_A_RAT_YAW_FF term. Set the Q_A_RAT_YAW_I term to equal this.
- Now you can hover again, and begin increasing the Q_A_RAT_YAW_D term, either iteratively, or using Transmitter Based Tuning, until it oscillates and then reduce it to 1/2 to 1/3 that value.
- Then increase the Q_A_RAT_YAW_P term, until it oscillates and then reduce it 1/2 to 1/3 that value.

6.5.4 Tailsitter VTOL Tuning

Tuning a tailsitter is different than tuning a normal SLT (Separate Lift Thrust) or Tilt-Rotor Quadplane. Those QuadPlanes tune very similarly to a Multirotor since the attitude in VTOL is controlled by motor speed/thrust in all axes (the exception being YAW in vectored yaw tilt rotor QuadPlanes).

In most tailsitters, VTOL attitude is usually controlled by some combination of fixed wing control surfaces and, in some configuratons, motor tilt for pitch and yaw. Roll is usually controlled by motor/speed thrust and can be tuned, and even AutoTuned, like a multicopter and follows the normal QuadPlane tuning for that axis. Most of the instructions for tuning setup and phases are the same for Tailsitters, except as described below:

Pitch and Yaw Tuning

For pitch and yaw, control is provided by the fixed wing control surfaces, sometimes in conjunction with motor tilt, depending on type of tailsitter. These axes required a tuning approach more similar to normal fixed wing manual tuning, since the FF (Feed-Forward) component of the PID loop is the primary control path, with P and D PID terms providing disturbance corrections. The tuning process is as follows, starting from the default PID values:

- First, follow Steps 1 - 4 of the normal QuadPlane Tuning Process Setup.
- Normally, the vehicle is stable enough with the default PIDs to do a first test hover in QSTABILIZE or QHOVER. Do a short hover flight with logging enabled such that the Harmonic Notch Filters can be setup. Its important to remove as much motor noise as possible in order to get a good tune using a throttle based harmonic notch filter.
- Once the notch filters are set, do another hover flight but briefly do short, but sharp pitch stick movements in both directions. Do not endanger the vehicle, but try to get several short full stick movements to the front and to the back. Do the same for yaw, but you should be able to hold full yaw stick each direction for a second or so, returning to neutral for a second in-between direction reversals.
- Download the dataflash log for analysis. In order to determine the Q_A_RAT_PIT_FF and Q_A_RAT_YAW_FF terms, use a log analyzer like https://plot.ardupilot.org and setup the following plots on the same scale, using the "Add Expression" button:
  PIQP.FF+PIQP.P+PIQP.D
  X * (PIQP.Act) , where X is 0.2 to start
- Next adjust the X value above until the magnitudes of both plots are about equal. This will now be value for the Q_A_RAT_PIT_FF term. Set the Q_A_RAT_PIT_I term to equal this.
- Now do the same for the YAW axis using:
  PIQY.FF+PIQY.P+PIQY.D
  X * (PIQY.Act) , where X is 0.2 to start
- Now you can hover again, and begin increasing the Q_A_RAT_PIT_D term, either iteratively, or using Transmitter Based Tuning, until it oscillates and then reduce it to 1/2 to 1/3 that value.
- Then increase the Q_A_RAT_PIT_P term,, until it oscillates and then reduce it 1/2 to 1/3 that value.
- Do the same for the YAW axis.

Roll Tuning

This should allow you to get a reasonable tune for Pitch and Yaw. Roll is tuned like STEP 10 for Roll in QuadPlane. Roll axis can even be AutoTuned using QAUTOTUNE, if restricted to only the roll axis using Q_AUTOTUNE_AXES.

VTOL Gain Scaling for Redundant Actuators

Some tailsitters have redundant actuators for a given axis. Vectored thrust tailsitters may have both tilting motors for yaw as well as elevons. Copter tailsitters may have fixed wing control surfaces that produce pitch or yaw in addition to the copter style motors. In some cases, it would be desired to have those fixed wing control surfaces provide more attitude control in VTOL than the motors, reducing the thrust/throttle levels needed for that control.

The following parameters allow the adjustment of how much control is produced the fixed wing control surfaces for each axis. Larger values apply more gain to the control surfaces, this will give the overall system more gain so the Q_A_RAT_ pitch and yaw PID gains may have to be reduced. To reduce the response of the motors, one would for example, half the PID P/D/I/FF rate gains and use a control surface scale factor of two. This would result in the control surfaces responding as before but with the motor outputs halved.

Default value is 1, which results in no behavior change from the past. These gains are only active in VTOL modes or under Q assist.

- Q_TAILSIT_VT_P_P Scales from Pitch PID output to control surfaces

- Q_TAILSIT_VT_R_P Scales from Roll PID output to control surfaces
- Q_TAILSIT_VT_Y_P Scales from Yaw PID output to control surfaces

6.5.5 VTOL QUICKTUNE

Quick means of obtaining a good tune for Quadplanes in VTOL modes are provided. The process slowly increases the relevant gains until it detects an oscillation. It then reduces the gains by 60% and moves onto the next gain. Once all the gains have been tuned the tune completes and the user can decide to save or discard the new gains.

The script attempts to automatically tune the P/I and D gain of each axis enabled for tuning when an two or three position RC switch, whose RCx_OPTION is "181", is moved to the "tune" position. It will, by default, also adjust some PID loop filter values based on the INS_GYRO_FILTER setting.
The advantage over QAUTOTUNE is that QUICKTUNE is safer because the vehicle does not need to move or twitch and QAUTOTUNE can occasionally result in instablity. Therefore QAUTOTUNE is not longer recommended for use, except by experts.
The disadvantage is that QUICKTUNE cannot find the vehicle's maximum rotational accelerations or tune the attitude angle outer loops from their default or pre-tune adjusted (Tuning Process Instructions) values. However, tuning only the inner rate loops usually will yield a stable, safe flying vehicle.

Setup

- Set QWIK_ENABLE = "1" to enable QUICKTUNE.
- Set QWIK_AXES to which axes (Roll/Pitch/Yaw).

Activation RC Switch

Set up a two or three position RC switch with RCx_OPTION` = "181". If it is a two position switch set QWIK_OPTIONS bit 0 to "1", and you probably want to set the QWIK_AUTO_SAVE parameter to autosave the tune once completed.
With a three position switch, moving the switch to "high" (>1800us) is the "save" position which will save the current tune parameters, even if the tune is not completed yet. Moving the switch to the middle position activates the tuning process ("tune"). Moving the switch to the "low" position (<1200us), stops the tuning and reverts the parameters to their values before tuning began.

Note
RC AUX switches only operate on transitions of the switch. Their position at boot does nothing, so if a switch is "high" at boot, in order to get the "high" function, it must be moved to another position and then back "high".
With a two position switch, "high" is the "tune" position, and "low" stops/reverts tuning. In order to save parameters, you must have set the QWIK_AUTO_SAVE parameter or use a GCS AUX switch facility.

Tuning Flight

- Wait for a calm day and go to an open area with good GPS reception
- Use an OSD, TX OSD (using Yaapu), or GCS. This is where output from the tune will appear
- Move the RC switch to the low position OR push MP's Aux Function's "Low" button
- Arm and takeoff in QLOITER mode and climb to a height of about 3m
- Begin the tune by moving the RC switch to the "tune" position OR push MP's Aux Function's "Mid" button

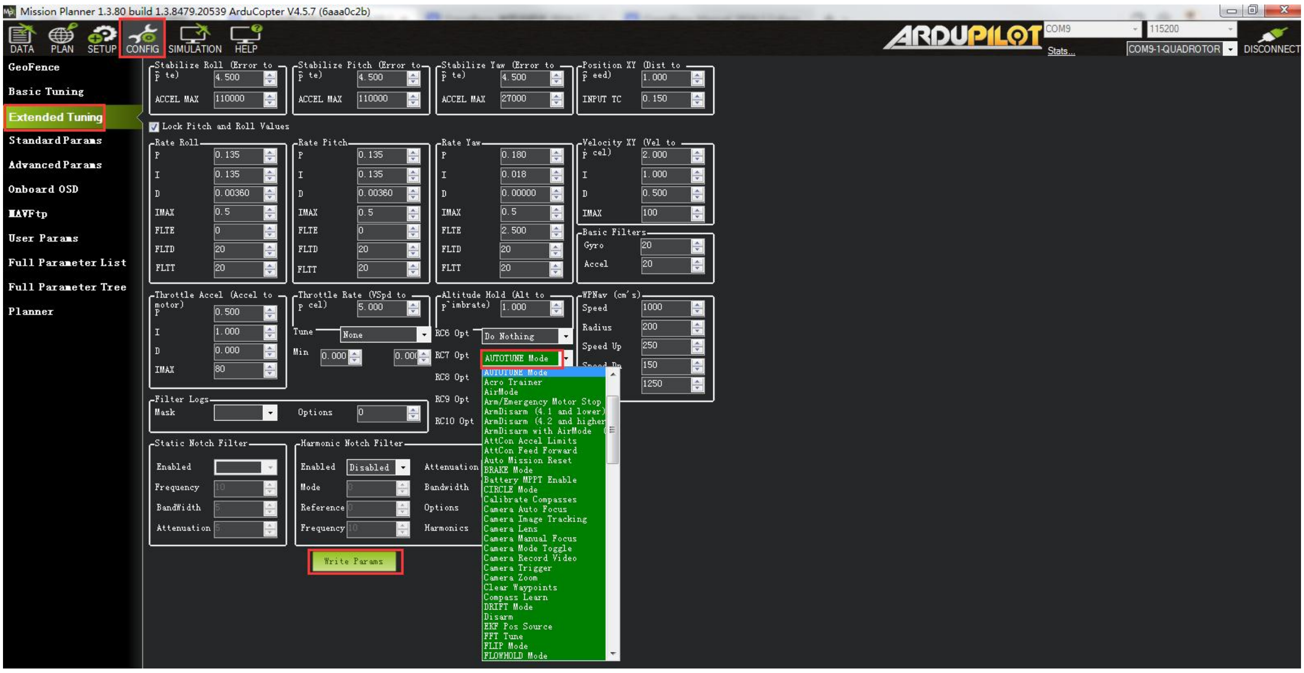
- Monitor the progress of the tune using the GCS’ s Messages tab
- If necessary reposition the vehicle using the RC transmitter. This will temporarily pause tuning. Tuning will resume a few seconds after the RC sticks are returned to their center position
- If the vehicle begins oscillating violently you can cancel the tune by moving the RC switch to the low position OR push MP’ s Aux Function’ s “Low” button. If the vehicle rocks or pitches more than QWIK_ANGLE_MAX the tune will automatically abort.
- Once the tune has completed accept the new gains by moving the RC aux switch to the “save” position, wait for the QWIK_AUTO_SAVE timeout, OR push MP’ s Aux Function’ s “High” button
- Land and disarm the vehicle

Advanced Configuration
Additional advanced parameters are shown below, but normally do not need to be changed and, then only by experienced users:
- QWIK_AUTO_FILTER
- QWIK_DOUBLE_TIME
- QWIK_GAIN_MARGIN
- QWIK_OSC_SMAX
- QWIK_YAW_P_MAX
- QWIK_YAW_D_MAX
- QWIK_RP_PI_RATIO
- QWIK_Y_PI_RATIO
- QWIK_REDUCE_MAX
- QWIK_ANGLE_MAX

7. AutoTune

AutoTune attempts to automatically tune the Stabilize P, Rate P and D, and maximum rotational accelerations to provide the highest response without significant overshoot. Copter needs to be “basically” flyable in AltHold mode before attempting to use AutoTune as the feature needs to be able to “twitch” the copter in the roll and pitch axis.
Position Hold during AutoTune is available in Copter 3.5 (and higher).

Setup before flying
1. Set up one flight mode switch position to be AltHold.
2. Set an Auxiliary Function Switch to Autotune to allow you to turn the auto tuning on/off with the a switch.
3. Remove the camera gimbal or any other parts of the frame that could wobble in flight.
4. Select which combination of axis (roll, pitch, yaw) you wish to tune using the AUTOTUNE_AXES parameter.
5. Set the autotune’ s aggressiveness using the AUTOTUNE_AGGR parameter (0.1=agressive, 0.075=medium, 0.050=weak), normally start with the default 0.1.
6. For large copters (with props at least 13inch or 33cm diameter) set the Rate Roll and Pitch filters to 10hz (in Copter-3.3 these are RATE_RLL_FILT_HZ and RATE_PIT_FILT_HZ, in Copter-3.4 they are ATC_RAT_RLL_FILT, ATC_RAT_PIT_FILT).
7. It is recommended to enable battery voltage scaling of PID gains.



How to invoke AutoTune

1. Wait for a calm day and go to a large open area.
2. Ensure the ch7 or ch8 switch is in the LOW position.
3. Take off and put the copter into AltHold mode at a comfortable altitude.
4. Face the vehicle so that it will twitch at 90degrees from the direction the wind is blowing (i.e. if tuning Roll first, point the vehicle into the wind).
5. Set the ch7/ch8 switch to the HIGH position to engage auto tuning:

 (1) You will see it twitch about 20 degrees left and right for a few minutes, then it will repeat forward and back.

 (2) Use the roll and pitch stick at any time to reposition the copter if it drifts away (it will use the original PID gains during repositioning and between tests). When you release the sticks, it will continue auto tuning where it left off.

 (3) Move the ch7/ch8 switch into the LOW position at any time to abandon the autotuning and return to the origin PIDs.

 (4) Make sure that you do not have any trim set on your transmitter or the autotune may not get the signal that the sticks are centered.

6. When the tune completes the copter will change back to the original PID gains.
7. Put the ch7/ch8 switch into the LOW position then back to the HIGH position to test the tuned PID gains.
8. Put the ch7/ch8 switch into the LOW position to fly using the original PID gains.
9. If you are happy with the autotuned PID gains, leave the ch7/ch8 switch in the HIGH position, land and disarm to save the PIDs permanently.

If you DO NOT like the new PIDS, switch ch7/ch8 LOW to return to the original PIDs. The gains will not be saved when you disarm.

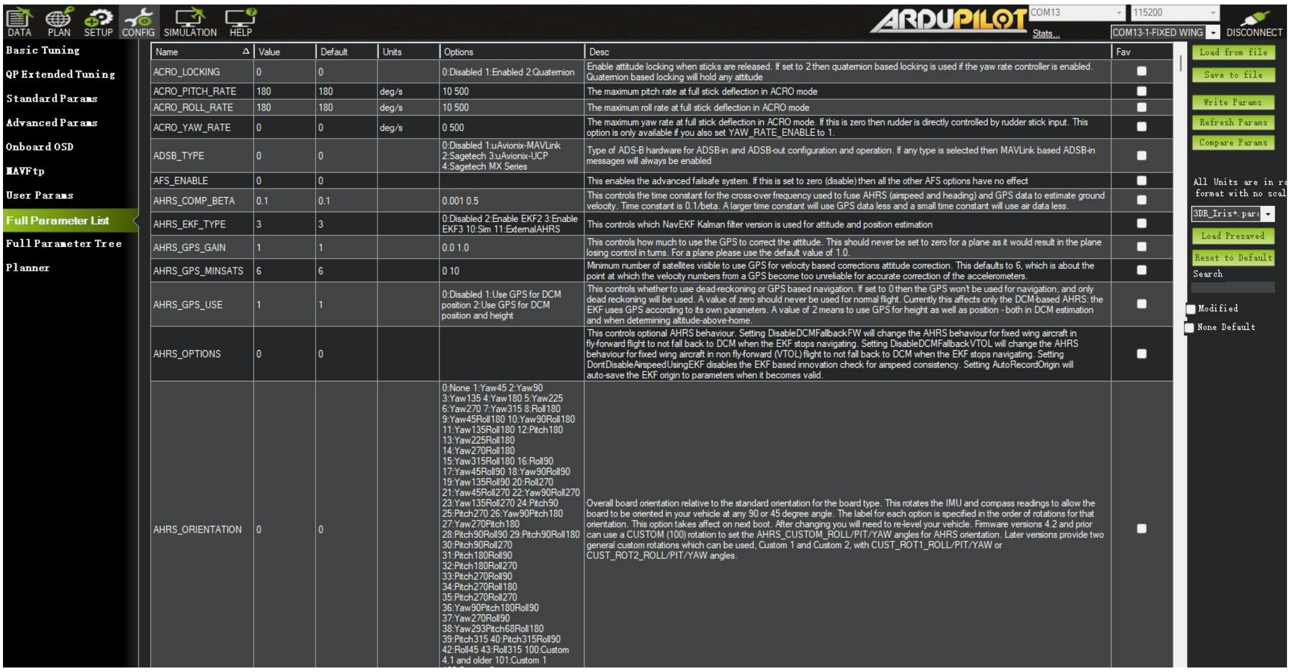
If you find after performing an AutoTune that the vehicle feels overly twitchy when flying Stabilize, AltHold or PosHold (but ok in more autonomous modes like Loiter, RTL, Auto) try reducing the RC_FEEL parameter to 0.25. This smooths out the pilot’ s input. Alternatively try reducing the AUTOTUNE_AGGR parameter (it should always be in the range 0.05 to 0.10) and try again.

If the vehicle feels sloppy after the AutoTune, try increasing the AUTOTUNE_AGGR parameter as high as 0.10 and attempt the autotune again.

8. Parameter Setting

8.1 Parameter Interface Introduction

All of the parameters of PIX6 can setup in Mission Planner, please do not change the parameters during the flight.



Parameters on the left:

GeoFence: Refer to Chapter 5.6 GeoFence.

Basic Tuning: Set Roll/Pitch sensitivity.

Extended Tuning: Adjust PID, 7 and 8 channel function.

Standard Params: Provide some basic settings such as logs, additional functions, channel functions, etc.

Advanced Params: Provide some advanced function settings such as PID.

Onboard OSD: Refer to Chapter 5.7 Onboard OSD.

MAVFtp: In firmware versions 4.1 and above, integrated FTP (File Transfer Protocol) is implemented, allowing access to the SD card (if there is one) and the internal flash file system through this interface. (It is not recommended to use this system to download logs. Please refer to Chapter 8 to download the log, which is faster).

User Params: Quickly set the functions of the auxiliary channel of the transmitter.

All parameter trees: Related function parameters are displayed closely. After a function is expanded, the function-related parameters are displayed.

Planner: Related settings of Mission Planner.

Parameters on the right:

Load from file: load the files with the parameters have setup already.

Save to file: save the file with the parameters to your computer.

Write Params: write the parameters that have modified to PIX6.

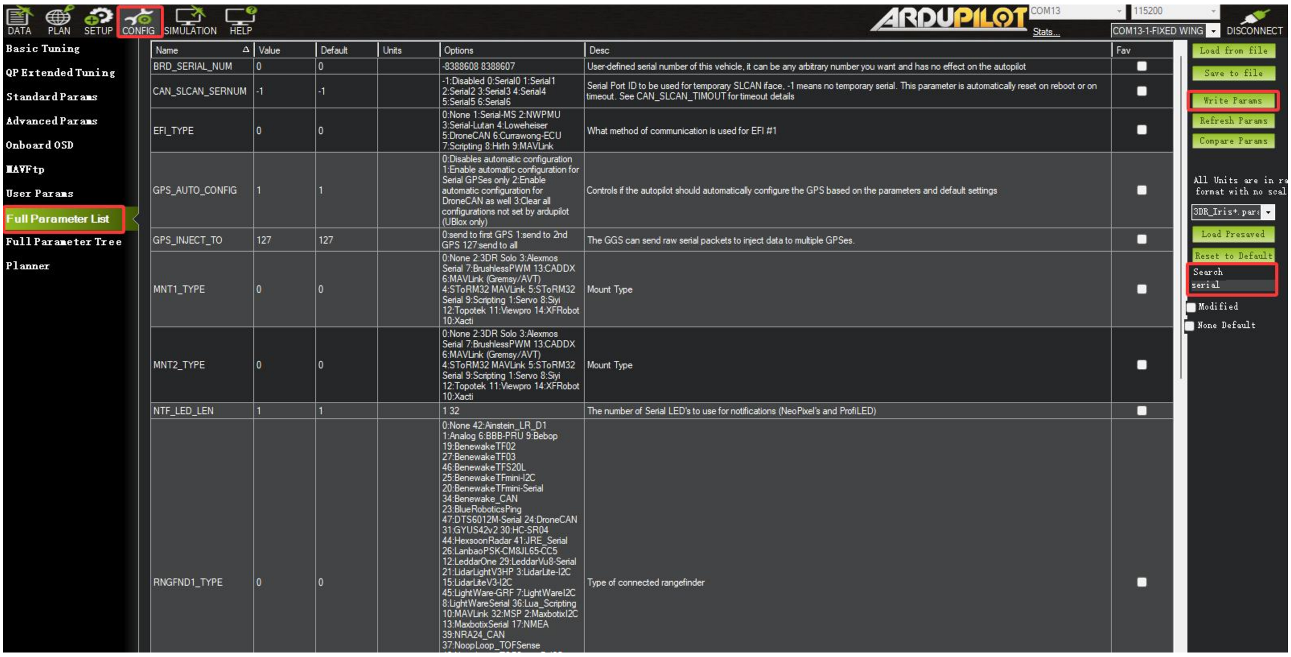
Refresh Params: exhibit the newest parameters which have modified no the Mission Planner.

Compare Params: compare the current and the previous parameters.

Load Presaved: load the parameters that Radiolink upgrade the files which design for 210-250 frame racing drone to PIX6.
Reset to default: reset all the parameters to default files. Please recalibrate and re-setup all the parameters after reset.
Search: write down the name of parameters you want to setup, much same as the keyboard shortcuts function.

8.2 Parameter Adjustment

All settings of the flight controller can be set or adjusted. You can enter Full Parameter List to search the parameter you want to modify and then modify it. After the modification, please remember to click Write Params on the right.

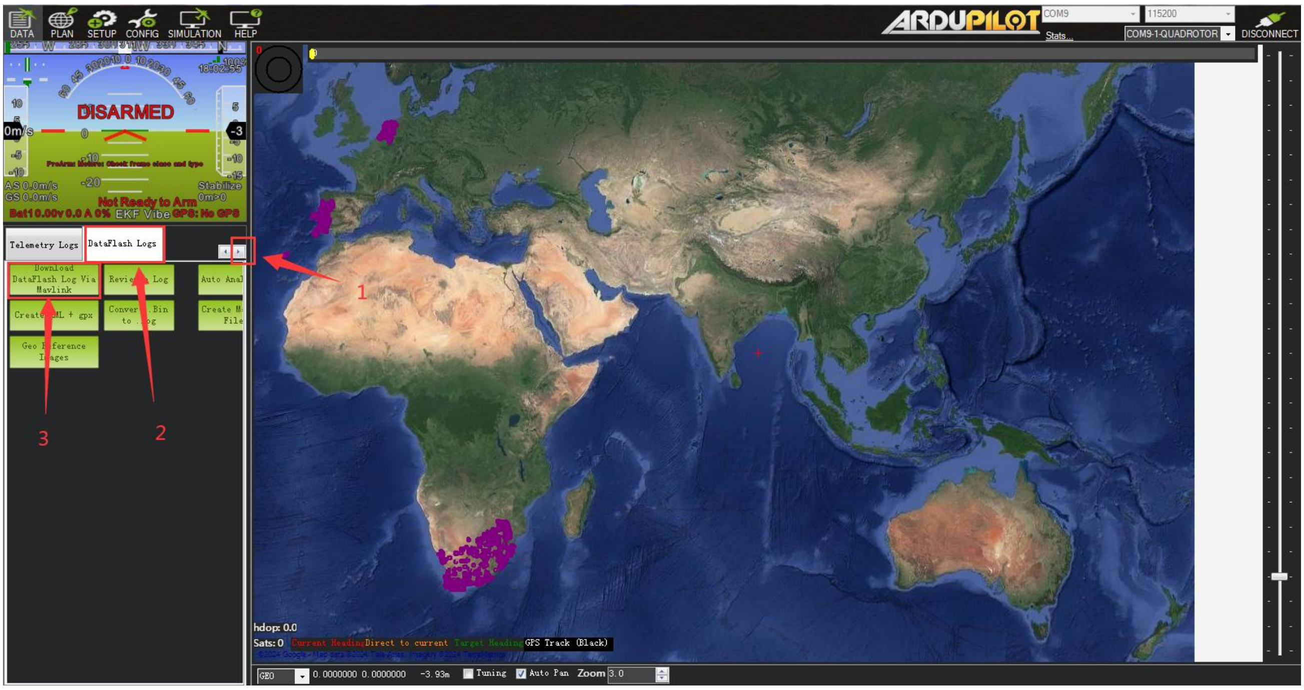


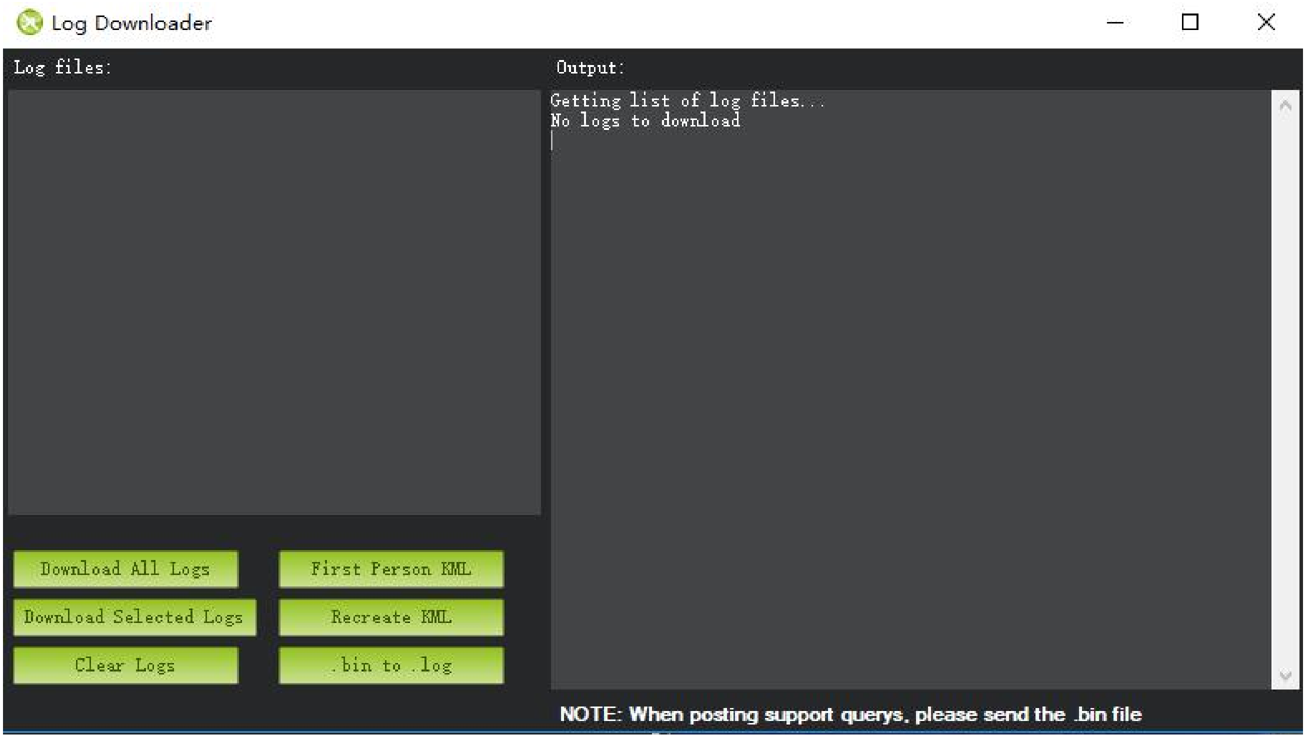
8.3 Manual Parameter Adjustment

The default parameters of the flight controller may not be applicable for your aircraft and require further manual adjustment. The manual adjustment document is provided below. You can make further fine adjustments according to it. I hope everyone will fly perfectly.
[PID Paramater Adjustment Setup Tutorial]

9. Download DataFlash Log

Use the below method to download flight logs to conduct problem analysis and view flight trajectories, etc.
Connect the flight controller to Mission Planner. After the connection, perform the following operations to download the logs.





Download All Logs: Download all flight logs.
Download Selected Logs: Download the selected logs.

For more after-sales service:
Please send mail to: after_service@radiolink.com.cn